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SCIENTECH.

CONSTRUCTION AS-BUILT AND MONITORING REPORT FOR THE SUBSURFACE REMEDIATION SYSTEM

Leica, Inc. Site
Eggert and Sugar Roads
Town of Cheektowaga, Erie County, NY
Site ID Number: 915156

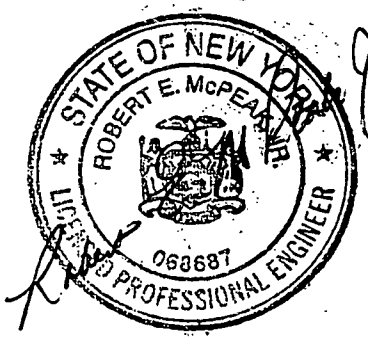
Prepared for:

New York State Department of Environmental Conservation
Division of Hazardous Waste Remediation, Region 9
270 Michigan Avenue
Buffalo, New York 14203-2999

and

Leica Microsystems, Inc.
P.O. Box 123
Buffalo, New York 14240-0123

March 2000
Revised February 2001
Revised May 2001



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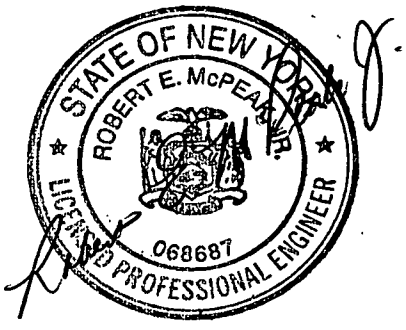

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Project Number	Prepared By	Date
31128	Mark Cambra	5/09/01

Approvals

Title	Signature	Date
Senior Department Manager		5/10/01

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1 INTRODUCTION

SCIENTECH, Inc. (formerly SCIENTECH NES, Inc. or NES, Inc. hereafter referred to as SCIENTECH) was contracted by Leica Microsystems, Inc., (Leica) to design, install, and operate the remedial system proposed at the former Leica Optical Site (Site) in Cheektowaga, New York. After delineation of the contaminated area within the Supplemental Area C, SCIENTECH prepared the design and installed the remedial system. The remedial system integrates the technologies of dual vacuum extraction (DVE) and air injection to simultaneously remediate VOCs from both soil and groundwater in the overburden material.

Also, concurrent with soil and shallow groundwater remediation, SCIENTECH was contracted by Leica to design, install, and operate a bedrock groundwater pump and treat system consistent with conceptual designs approved by NYSDEC to address the contamination present in the bedrock aquifer.

The design report entitled, "Construction and Operation of Remediation System Project Design, 95% Submittal," was submitted to the New York State Department of Environmental Conservation (NYSDEC) on January 20, 1999. The design was approved by the NYSDEC by letter dated March 3, 1999. On March 23, 1999, SCIENTECH submitted a New York Licensed Professional Engineer stamped and signed design report entitled, "Construction and Operation of Remediation System Project Design Final Submittal," (the "Design Report") to the NYSDEC for use during construction and implementation. A preconstruction meeting was held on April 13, 1999, with the NYSDEC and Leica representatives.

Installation activities were initiated on April 21, 1999. The subsurface remediation system was installed by December 1999 and is currently operating. This document provides As-built drawings and additional information in regard to the maintenance and monitoring efforts at the site during system operation.

2 SITE DESCRIPTION

The site is located in Cheektowaga, New York (Figure 1). Previous site investigations indicate that the subsurface has been contaminated with chlorinated and aromatic hydrocarbons as a result of past operations at the facility. Three separate areas of contamination were identified: the former drum storage area, the northeastern source area, and the southeastern area. These areas are designated Areas A, B, and C, respectively, as shown on Figure 2. Supplemental Area C is adjacent to Area C. The contaminants of concern consist of the chlorinated hydrocarbons: vinyl chloride, 1,1-dichloroethene, 1,2-dichloroethene (cis and trans), 1,1-dichloroethane, 1,2-dichloroethane, trichloroethene, and 1,1,1-trichloroethane and the aromatic hydrocarbons: benzene, toluene, ethyl benzene, and xylene (BTEX).

The analytical results, presented in the Additional Investigation Report, prepared by SCIENTECH (latest revision September 1998, "Investigation Report"), indicate that the contaminated soil extends to the west and northeast of the original Area C designation as delineated by the Supplemental Area C.

As discussed in the Investigation Report, within the area of Supplemental Area C, an interval of fill and debris ranging from 0.5 to 4 feet in thickness is underlain by a dry to wet, red/brown, stiff, hard clay. In some areas, the clay displays thin silt varves. In some areas, the fill material (fill layer) contains dark-stained soil with a petroleum odor. The varved clay layer (clay layer), identified as

native soils in previous investigations, extends to a depth of approximately 11 to 14 feet below grade level. The clay is firm and stiff with little or no odor. Beneath the clay, a 1-foot layer of a wet, gray, loose, fine to medium sandy silt is present (sandy-silt layer (ss)). The sandy silt layer, in certain areas, also contained a petroleum odor. The top of carbonate bedrock was encountered from 12 to 15 feet below grade level. The thin glacial till layer identified during previous investigations was not observed during the supplemental investigation.

SCIENTECH also discovered that the contamination is not generally present within the clay layer, but it is isolated within the layers above and beneath the clay. It is apparent that the clay is an aquaclude and has prevented the contamination within the fill layer (mostly xylene) from migrating downward and the contamination within the silty sand layer (mostly chlorinated solvents) from migrating upward.

This soil stratigraphy observed in Supplemental Area C was also observed in Areas B and C during the installation of the remediation system. Area A consisted of four feet of fill material as expected.

3 SYSTEM DESIGN

SCIENTECH has prepared the final design of the subsurface remediation system. As detailed in the Final Submittal of the "Construction and Operation of Remediation System, Project Design", the subsurface overburden remediation system integrates the technologies of dual vacuum extraction and air injection to simultaneously remediate VOCs from both soil and groundwater in the overburden material. Concurrent with soil and shallow groundwater remediation, SCIENTECH has also designed a bedrock groundwater pump and treat system consistent with conceptual designs approved by NYSDEC to address the contamination present in the bedrock aquifer. The major design parameters for the remediation system are discussed below.

3.1 WELL SPACING AND DESIGN

Based on our experience with vacuum extraction in similar soils and the results observed during the pilot study (results presented in the Pilot Study Final Report, December, 1996, prepared by NES, Inc.), a zone of influence of approximately 30 to 40 feet (radius) in both the lower silty-sand interval and the fill interval is anticipated. SCIENTECH has taken a conservative approach and set the well spacing based on a 30 foot on-center distance between wells in the fill layer and also in the silty-sand layer. This approach provides a reasonable design safety factor and also allows for the operation of the DVE wells in various configurations, reducing the possibility of no or low flow zones.

Silty-Sand Layer

Boreholes were advanced at the 30-foot grid spacing nodes and an extraction well was placed in each borehole. The well contains a vertical well screen fully penetrating the silty-sand layer (approximately 2 feet in length). Approximately 2 feet of bentonite was used to separate the screen interval from the soils above. The remaining borehole was filled with auger cuttings since PID screening indicated that the material was suitable (<25 ppm). This design eliminates the preferential airflow that would occur from the zone of high permeability soils (i.e. the fill layer) if the wells were screened over the entire subsurface interval.

The silty-sand interval below the clay unit was used as the main dewatering aquifer, since it is expected to yield a larger quantity of groundwater than the clay and fill layers. This larger quantity will produce greater drawdowns and zones of influence for capture of the groundwater plume. Each of these DVE wells in the silty-sand layer were equipped with vacuum-entrainment groundwater recovery tubing, which does not require down-hole pumps or controls.

Fill Layer

The horizontal vapor extraction wells within the fill layer are approximately 30 feet in length. The horizontal wells were placed in trenches approximately 2 to 3 feet below ground surface and spaced 30 feet apart. These horizontal wells were connected to the vapor extraction unit through horizontal manifold piping, which was installed approximately 3 to 4 feet below grade.

The material unearthed during the installation of the vertical DVE wells was placed in a bermed, polyethylene-lined area for treatment near the Vapor Extraction. Perforated pipes were placed horizontally within the material that is being treated using vapor extraction. The material is covered with polyethylene during the Vapor Extraction treatment process. After the material has been remediated to RAOs, it will be released to Leica for use as fill material on-site or for transport to an off-site disposal facility.

Most material unearthed during placement of horizontal extraction wells and manifold pipes was used to backfill the trench and remediated in that location. Any excess soil was placed in the lined area and treated as described above.

3.2 VACUUM SYSTEM

The vacuum level required to induce airflow in the soils is a function of the permeability of the soil. In order to provide an efficient application of vacuum to the subsurface, two vacuum blowers are being used to separately address the two main subsurface zones (the fill and silty-sand) requiring remediation. Both vacuum units are positive displacement, rotary blowers with electric motors. The capacities of the blowers have been increased to account for the increased area of contamination. Each system is capable of producing up to approximately 1000 standard cubic feet per minute (scfm) at 12 inches of mercury vacuum. This 1000 scfm airflow produces approximately 15 scfm per well in each of the two layers (fill and silty-sand).

Each of the vacuum extraction systems is equipment with an air water separator, which removes the water within the system. The separated water is pumped to the air stripper for treatment prior to discharge.

3.3 AIR INJECTION

The air injection system consists of injection points, a manifolded air delivery system and an air compressor. Injection probes were installed into the silty-sand layer within Areas B and C to assist with VOC transport and dewatering efforts.

Airflow of 325 cfm at pressures of up to 20 pounds per square inch (psi) is being used for the continuous air injection operations. These air injection points were installed near the middle of the 30 foot grid node. The compressor produces an airflow of approximately 5 cfm per air injection point in the silty-sand layer.

3.4 BEDROCK GROUNDWATER PUMP AND TREAT SYSTEM

To address the contaminated bedrock aquifer, two (2) bedrock well pumps are utilized. The first pump was placed in existing well MW-16A and a second pump was placed in a new bedrock well installed approximately 150 to 200 feet west of MW-13A. Similar to MW-16A, the new bedrock well is 6 inches in diameter and extends approximately 40 feet below grade.

The pneumatic pumps are each capable of removing seven (7) to ten (10) gallons per minute of groundwater within the bedrock aquifer. The air injection compressor supplies compressed air to the pneumatic pumps.

3.5 EXTRACTED VAPOR TREATMENT

The quantity of contaminants within the subsurface was estimated using analytical data collected during the investigation in conjunction with other data collected during previous investigations. Assuming a soil density of 2,200 pounds per cubic yard within the overburden material and a porosity of 50% within the bedrock aquifer, the following estimates were calculated:

- 900 pounds of VOCs were present in the fill layer;
- 1,700 pounds of VOCs were present in the silty-sand layer; and
- 460 pounds of VOCs were present in the bedrock.

With these concentrations present within the different layers of the subsurface, SCIENTECH activated the vacuum extraction and groundwater recovery systems sequentially. Care was taken to prevent contaminants from being drawn from areas of higher concentration in the silty-sand layer to the deeper bedrock areas. In order to avoid this potential problem, SCIENTECH removed the high level of contaminant present within the subsurface soils and shallow groundwater. After installation, SCIENTECH activated the extraction system within the silty-sand and fill layers first to remove the heaviest contamination. The vapor stream and groundwater removed was monitored several times per week to determine when the initial concentrated contamination has been removed. Once the most concentrated contamination was removed and the extracted vapor concentrations stabilized, the bedrock aquifer pumping system was activated. All three vapor streams (vacuum extraction from the fill layer, vacuum extraction from the silty-sand layer, and air-stripping off-gas) are treated using activated carbon. Remediating the subsurface by this sequence will minimize the potential for cross contamination into the bedrock Five (5) vapor phase carbon canisters were mobilized to the site with additional carbon brought on site as needed. Each canister contains 3,000 pounds of carbon and is capable of treating approximately 400 pounds of VOCs from the vapor stream. The treatment system utilizes the carbon vessels in three parallel trains with each vapor stream traveling through two vessels prior to discharging to the atmosphere. Each treatment train contains a primary treatment vessel to remove the bulk of the contaminants from the air stream and a secondary treatment vessel for polishing and as a backup. The secondary vessel will remove any contaminants that pass the first vessel, therefore minimizing the presence of VOCs escaping into the atmosphere.

Subsequently, when field screening of the vapor stream after the primary vessel indicates that the carbon is saturated, the carbon from the primary vessel will be removed for regeneration, the secondary vessel will then become the primary vessel, and regenerated carbon will be used in the new secondary vessel. The air emissions discharged after treatment by activated carbon is negligible. Treatment by activated carbon typically provides removal efficiencies in excess of 99%. SCIENTECH monitors the air emissions from each of the vapor streams to prevent release of VOCs to the atmosphere above allowable levels.

4 SYSTEM INSTALLATION

Installation of the subsurface remediation system was initiated on April 21, 1999. The first field activity was the installation of the vertical vapor extraction wells and sparge points. Soil samples

collected during the well installation activities were analyzed using EPA Method 8260 and compared to the Site-Adjusted Remedial Action Objectives (ARAOs) calculated previously and shown below.

VOCs (ug/Kg)	Fill	Clay	Sandy/Silt
Benzene	232	87	116
1,1-Dichloroethane	600	225	300
1,2-Dichloroethane	280	105	140
Ethylbenzene	22,000	8,250	11,000
Methylene Chloride	420	158	210
Toluene	6,000	2,250	3,000
1,1,1-Trichloroethane	3,040	1,140	1,520
Trichloroethene	2,520	945	1,260
Vinyl Chloride	456	171	228
Xylene (Total)	4,800	1,800	2,400

Respectively, the system layout was modified to exclude extraction wells and sparge points in areas with soils below these ARAOs based on the new data. These modifications were described in the monthly status report (May 1999) prepared by SCIENTECH on June 11, 1999 (ES - 1641) and are represented on the As-built drawings (Figures 3 and 4). Although these ARAOs have been calculated, the remedy is attempting to achieve the RAOs established in the Record of Decision dated March 1997, as reasonably practical. Following is a brief summary of field activities.

- In May 1999, SCIENTECH installed the vertical vent wells and new bedrock well located in Area C (designated MW-11A) and initiated the subsurface system installation in Area C.
- In June 1999, SCIENTECH installed the horizontal vent wells in Area A and continued installing the horizontal vent wells in Area C.
- In July 1999, SCIENTECH installed the remainder of the horizontal vent wells in Area C and started connecting the wells to the main manifold that leads to the treatment shed.
- In August 1999, SCIENTECH completed the connection of the wells from Area C to the main manifold that leads to the treatment shed. SCIENTECH installed the extraction and injection piping within the loading area of Area B and started installing the remainder of the system. SCIENTECH also constructed the bermed, polyethylene-lined treatment area for placement and treatment of material unearthed during the well and trench installation activities.
- In September 1999, SCIENTECH installed the extraction and injection piping within Area B and connected that piping to the main manifold that leads to the treatment shed.
- In November 1999, SCIENTECH installed the extraction and injection piping within Area C and the equipment was connected to the system. The shallow horizontal well extraction system was activated and the vertical deep well extraction system was tested.
- In December 1999, SCIENTECH completed the installation of the subsurface remediation system. The vapor extraction system (both horizontal and vertical) and the bedrock groundwater pump and treat system were operational.

In Area A, the two horizontal vapor extraction wells were installed essentially as planned and are shown on the As-built drawing (Figure 3).

In Area B, 10 horizontal vapor extraction wells, 12 vertical vapor extraction wells, 12 sparge points, and the bedrock well pump were installed essentially as planned in the locations illustrated on the As-built drawing (Figure 3). The bedrock well pump was installed in MW-16A

In Area C and Supplemental C, 46 horizontal vapor extraction wells, 39 vertical vapor extraction wells, 44 sparge points, the bedrock well, and the bedrock well pump were installed essentially as planned in the locations illustrated on the As-built drawing (Figure 4). The bedrock well pump was installed in MW-11A.

The wells, points, and pumps were manifolded together as planned and connected to the appropriate equipment. Figures 5 and 6 depict the location of the treatment sheds and the layout of the associated equipment.

5 SYSTEM OPERATION AND MAINTENANCE

With the installation of the subsurface system complete, the system will operate continuously (excluding periods when undergoing repairs/maintenance, as required) until the RAOs or other criteria, approved by the NYSDEC, are met. The RAOs for this project are provided in Section 3 of this report for reference.

The design and operational parameters of the remediation system are outlined as follows:

- Within the vacuum extraction systems, the vacuum is increased incrementally as the water is removed from the subsurface piping and surrounding area. This process is continued until the vacuum reaches an operating pressure between 7-9 inches of mercury at the blowers;
- The air injection system is maintained at 5-8 pounds per square inch of air pressure measured after the regulator; and
- The air pressures for the two bedrock well pumps are regulated down to 40 psi at the wells. The pumps are self-actuating therefore there are no other timers or regulators that need to be set.

5.1 OPERATION AND MAINTENANCE

System and equipment maintenance will be performed in accordance with the manufacturers' recommendations throughout the duration of the remedial efforts. A list of normal yearly spare parts and the maintenance sections of the equipment manuals for the remediation system have been compiled and are included as Attachment 1. The general maintenance schedule is summarized in the following table. Equipment manuals should be reviewed for proper maintenance procedures.

Maintenance Schedule					
Maintenance	Approximate Schedule				
	Each Day	Each Week	Each Month	Each 6 Months	Each Year
Blower Skid: Check belts (adjust belts as needed)			3		
Blower: Oil changes (add oil as needed)				3	
Blower: Greasing shaft bearings (do not over grease)		3			
Blower Motor: Greasing				3	
Compressor: Air filter change (check auto sentry controller)	3				
Compressor: Change oil separator (check auto sentry controller)	3				
Compressor: Check reservoir oil level	3				
Compressor: Check for proper load/unload	3				
Compressor: Check discharge pressure/temperature	3				
Compressor: Check dirt accumulation on cooler		3			
Compressor: Change oil filter element			3		
Compressor: Change compressor lubricant (aeon 9000 sp)					3
Compressor: Check relief valve					3
Compressor: Motor lubrication				3	
Air Filter Replacement (Replace at 10 PSI pressure drop)					3
Pumps: Mechanical Seal (check for leakage and replace as required)		3			
Pumps: Motor lubrication				3	

5.2 ROUTINE INSPECTIONS

The site will be inspected quarterly in conjunction with the monitoring events. The site will be inspected for:

- integrity of groundwater monitoring wells;
- integrity of each vapor extraction system;
- integrity of the bedrock groundwater dewatering system;
- condition of MSD and compressor; and
- adequacy of access control for the system.

5.3 MISCELLANEOUS MAINTENANCE REQUIREMENTS

5.3.1 Groundwater Monitoring Wells

Monitoring wells, which are found to be damaged during the quarterly inspections such that representative ground water samples cannot be obtained, will be repaired or replaced. Repair measures will be based on case-specific evaluation. Any well damaged beyond repair or rendered inoperative will be replaced with a new well of similar depth and construction. Well installationand decommissioning will be conducted in accordance with the applicable state regulations

5.3.2 Access Control

The vapor extraction systems are housed in C-containers at the site. Each container is provided with access through a double door. These doors are to remain locked at all times unless someone is working in the container. SCIENTECH presumes that these containers will not need repair or maintenance during the period of the remedial effort; however, locks may need to be replaced periodically.

SCIENTECH does not anticipate the need for any additional maintenance to be conducted; however, if any additional activity becomes necessary, the maintenance will be conducted as necessary and added to the schedule shown above.

The Site Inspection and Maintenance list (included in Attachment 2) will be posted at the site. The Monthly Site Inspection and Maintenance Checklist (also included in Attachment 2) will be completed monthly.

6 MONITORING PLAN

Both Groundwater and Air Monitoring will be conducted at the Site. The following sections provide detailed information related to this monitoring.

6.1 GROUNDWATER MONITORING – BASIS OF PLAN

The proposed monitoring plan is designed to accomplish the following objectives:

1. To monitor the two hydrogeologic units beneath the site;
2. To monitor the groundwater both upgradient and downgradient of the site; and
3. To evaluate the groundwater quality over time to assess the effectiveness of the remedial action.

There are 30 groundwater monitoring wells present at the site, two of which are inaccessible (well logs are included as Attachment 3). These monitoring wells address both hydrogeological units beneath the site (the overburden zone and the bedrock zone). The overburden wells are designated as MW-1, 3, 4, 5, 6, 7, 8[1], 9, 10, 11, 12, 13, 14, 15, 16[2], 18, 19, 20, 21, 22, and 23 and are located as depicted on Figure 7. The bedrock wells are designated as MW-1A, 2A, 5A, 6A, 11A, 13A, 14A, 15A, 16A, and 17A. These wells are also depicted on Figure 7.

6.2 BASE-LINE MONITORING RESULTS

6.2.1 Groundwater Elevation Monitoring

Groundwater measurements were taken on December 14, 1999. All accessible wells were monitored for groundwater depth. Using previous survey data, SCIENTECH calculated the groundwater elevation at each well. Tables 1 and 2 summarize the results of these measurements and calculations. The data from Table 1 were used to create Figures 8 and 9, which depict groundwater elevations and flow within the different strata. Figures 8 and 9 illustrate that gradients in the overburden material and bedrock are in the southeast direction.

[1] Inaccessible, buried under a stockpile of debris
[2] Inaccessible, buried under new pavement

6.2.2 Groundwater Sampling and Analyses

As discussed with NYSDEC (letter dated December 10, 1999), the overburden wells MW- 4[3], 6, 7, 10, 14, 15, 18[4], and 22 and the bedrock wells MW-6A, 14A, 15A, and 16A were sampled on December 14 - 20, 1999 (initial base-line evaluation). The groundwater samples were analyzed for Volatile Organic Compounds (VOCs) using EPA Method 8260. Analysis was performed by Columbia Analytical Services of Rochester, New York.

Tables 3 and 4 present the results of these analyses. The groundwater analyses demonstrate that the overburden groundwater quality in the southeast corner of Area C has been adversely impacted by elevated concentrations of cis-1,2-dichloroethene (MW-4, 6, 7, 10, and 14), trichloroethene (MW-4), and vinyl chloride (MW-6, 7, 10, and 14). Monitoring wells located in the vicinity (but southeast and south) of Area B (MW-15 and 18) did not indicate an adverse impact to the overburden groundwater quality; however, the NYSDEC has indicated that MW- 16, which is located within Area B which has historically exhibited groundwater contamination, will need to be located and repaired or a new well installed in the same area.

The groundwater analysis also demonstrated that the groundwater quality within the bedrock aquifer is adversely impacted with elevated concentrations of cis-1,2-dichloroethene in all four bedrock monitoring wells (MW-6A, 14A, 15A, 16A). Groundwater samples collected from MW-16A, which is located in Area B, indicate that the bedrock groundwater in that area also contains elevated concentrations of 1,1,1-trichloroethane, trichloroethene, and xylene. Groundwater samples collected from MW-15A, which is located between Areas B and C, indicate that the bedrock groundwater in that area contains elevated concentrations of trans-1,2-dichloroethene, trichloroethene, and vinyl chloride. Groundwater samples collected from MW-6A, which is located northwest (upgradient, using previous survey data) of Area C, indicate that the bedrock groundwater in that area contains elevated concentrations of vinyl chloride and total xylenes.

This data will serve as the initial base-line data indicating groundwater quality in the area before it is effected by the remediation system.

6.3 ELEMENTS OF THE PROPOSED MONITORING PLAN

The groundwater monitoring plan contains the following key elements:

- collection of groundwater elevation measurements; and
- collection and laboratory analysis of groundwater samples.

In an effort to monitor the effectiveness of the groundwater treatment system, treatment system influent (MW-11A and 16A) and effluent samples (groundwater discharge) will be collected and analyzed on a quarterly basis.

6.3.1 Groundwater Elevation Monitoring

The objective for collecting groundwater elevation measurements is to gain knowledge of the groundwater flows and hydraulic gradients of the two hydrogeologic units at the site. Groundwater elevation monitoring will be conducted quarterly for the first two years following activation of the system and annually from year two to year five. Groundwater elevations will be measured in all accessible monitoring wells as discussed above. Groundwater elevation measurements will be

[3] A groundwater sample was collected from MW-4 because MW-11 did not contain any collectable liquid.
[4] A groundwater sample was collected from MW-18 because MW-16 is inaccessible.

recorded on the Groundwater Sampling Record included in Attachment 4. This information will be used to generate groundwater flow maps and evaluate hydraulic gradients. A groundwater elevation-monitoring schedule after the first five years will be determined at that time in communication with the NYSDEC.

6.3.2 Groundwater Sampling and Analyses

The purpose of groundwater sampling and analysis is to evaluate the groundwater quality over time to assess the effectiveness of the remedial action.

Monitoring wells MW-6, 7, 10, 11[5], 14, 16R, 22, 6A, 11A, 14A, 15A, and 16A will be monitored quarterly for the first two years following activation of the system.

Groundwater samples will be analyzed for VOCs using EPA Method 8260. After the soil and shallow groundwater remediation system is considered complete as described in Section 6 (approximately two years), monitoring wells MW-6, 7, 10, 11[5], 14, 15, 16R, 22, 6A, 11A, 14A, 15A, and 16A will be monitored annually for the following three years. A groundwater quality monitoring schedule after the first five years will be determined at that time in communication with the NYSDEC.

The proposed sampling frequency, sampling parameters, and/or selected wells may be modified based on the results of the previous sampling events, but only with written permission from the NYSDEC.

SCIENTECH will monitor the overburden and bedrock remediation systems on a regular basis. System monitoring will be conducted more frequently during the initial months of operation and less during later stages of the remediation. This allows closer monitoring of the remedial activities during the initial operations, when changes are occurring at a faster rate. During continued operations and monitoring the following tasks will be accomplished:

6.4 AIR MONITORING

Air quality will be monitored at specific locations using site screening or laboratory analysis for VOCs of concern to determine the pre-treatment contaminant removal effectiveness of the horizontal vapor extraction systems (HVES1), vertical vapor extraction systems (VVES1), the groundwater treatment system air discharge (GTS1), and each of the vapor treatment systems (HVES2, VVES2, GTS2). Figure 5 provides an As-built Drawing and Process Flow Diagram of the Equipment Layout that includes the aforementioned air sampling locations. The monitoring methods and frequency are summarized below.

Monitoring Method	Number of Samples	Analysis	Frequency
Vapor Screening	6	Field Screen (PID)	Quarterly
Laboratory Analysis	6	TO-14 modified	Yearly

Screening results will be recorded on the Air Sample Screening Record included in Attachment 4.

[5] If no collectable liquid is present in MW-11, a groundwater sample will be collected from MW-4.

6.5 SAMPLE CONTAINER PREPARATION

Sample containers for groundwater samples will be properly washed and decontaminated by the laboratory prior to use. The containers will be tagged and Chain of Custody (COC) initiated before shipping to the sampling site in coolers. The types of containers and preservation techniques are shown in Attachment 5. All bottles will need to have preservatives added prior to being filled. Following sample collection, the bottles will be placed on ice in the shipping cooler. The samples will be cooled to 4° C but not frozen.

New sample containers will be provided from the laboratory for air samples. The containers will be tagged and COC initiated before shipping to the sampling site in boxes or coolers. The types of containers and preservation techniques are shown in Attachment 5. The Tedlar bags should not contain any preservative. Following sample collection, the bags will be placed in the shipping container (box or cooler), but not cooled; therefore, the air samples will not be shipped with the groundwater samples.

6.6 FIELD PROCEDURES

6.6.1 Groundwater Monitoring

The following is a step-by-step sampling procedure to be used to collect the groundwater samples. Well sampling procedures will be recorded on the Groundwater Sampling Record included in Attachment 3.

- Assemble all field equipment necessary for sample collection (see Attachment 6 for a list of necessary equipment).
- Inspect equipment to ensure it is working properly.
- Select up gradient well (ex. MW-1s) as the initial sampling location.
- Prior to purging and sampling, measure the static water level from the surveyed well elevation mark on the top of the casing with a water level indicator. Water levels will be measured to nearest 0.01 foot and recorded on the Groundwater Sampling Record (included in Attachment 4).
- Decontaminate the water level indicator. (See Section 6.7 for decontamination procedures.)
- Purge the well by removing a minimum of three well volumes of water. Purging will be conducted with a bailer or a stainless steel centrifugal pump and dedicated polyethylene tubing. The centrifugal pump will be equipped with a gate valve on its discharge. If the well goes dry before the required volumes are removed, the well may be sampled when it recovers sufficiently. The purged water from all on-site wells should be collected and disposed of in the sanitary sewer located on Vine Street adjacent to the site. Purged water from off-site wells may be disposed on the ground surface a minimum of ten feet away from the well in a downhill location. Sample collection must be performed within 24 hours of purging the well.
- Collect samples from each well with a dedicated bailer lowered by a dedicated nylon line. Sample description and location will be noted on the Groundwater Sampling Record (Attachment 3).
- Fill sample containers to be analyzed for VOCs. Sample containers will be labeled in accordance with historic monitoring well titles shown on Figure 7. Care should be taken to obtain a sample with the least amount of turbidity possible (<50 ntu).

- The groundwater samples will be placed in a laboratory cooler, packed on ice and driven directly to or shipped overnight to the laboratory. Quality assurance blanks will be sent with each sample shipment. COC procedures will be strictly followed as outlined in Section 6.8.

6.6.2 Air Monitoring

The following is a step-by-step sampling procedure to be used to collect the air samples.

- Assemble all field equipment necessary for sample collection (see Attachment 6 for a list of necessary equipment).
- Inspect equipment to ensure it is working properly.
- Connect plastic tubing to the first pump and the Tedlar bag. Open the stopcock on the Tedlar bag and allow air to flow in. Fill the bag to the consistency of a soft pillow– do not overfill to prevent popping during transport. Close the stopcock and repeat the procedure with new tubing and a new bag on each of the other pumps.
- Label sample bags and place in a laboratory cooler (without ice), or a heavy shipping box with packing materials. The air samples should be driven directly to or shipped overnight to the laboratory. COC procedures will be strictly followed as outlined in Section 6.8.

6.7 EQUIPMENT DECONTAMINATION

Testing and sampling equipment will be decontaminated prior to coming into contact with each sampling point or sample media. Decontamination procedures will comply with SCIENTECH SOP for "Decontamination of Field Equipment" (document number 82A8499) included as Attachment 7.

6.8 FIELD SAMPLE CUSTODY

Evidence of sample traceability and integrity is provided by COC procedures. These procedures document the sample traceability from the selection and preparation of the sample containers by the laboratory, to sample collection, to sample shipment, to laboratory receipt and analysis. A sample is considered to be in a person's custody if the sample is:

- In a person's possession;
- Maintained in view after possession is accepted and documented;
- Locked and tagged with Custody Seals so that no one can tamper with it after having been in physical custody; or
- In a secured area which is restricted to authorized personnel only.

A COC record (Attachment 8) accompanies the sample containers from selection and preparation at the laboratory, during shipment to the field for sample containment and preservation, and during return to the laboratory. Triplicate copies of the COC must be completed for each sample set collected.

The COC lists the field personnel responsible for taking samples, the project name and number, the name of the analytical laboratory to which the samples are sent, and the method of sample shipment.

The COC also lists a unique description of every sample bottle in the set. If samples are split and sent to different laboratories, a copy of the COC record will be sent with each sample.

The REMARKS space is used to indicate if the sample is a matrix spike, matrix spike duplicate or matrix duplicate. Since they are not specific to any one sample point, trip and field blanks are indicated on separate rows. Once all bottles are properly accounted for on the form, the sampler will write his or her signature and the date and time on the first RELINQUISHED BY@ space. The sampler will also write the method of shipment, the shipping cooler identification number, and the shipper air bill number on the top of the COC. Mistakes will be crossed out with a single line and initialed by the author.

One copy of the COC is retained by sampling personnel and the other two copies are put into a sealable plastic bag and taped inside the lid of the shipping cooler. The cooler lid is closed, custody seals provided by the laboratory are affixed to the latch and across the back and front lids of the cooler, and the person relinquishing the sample signs his name across the seal. The seal is taped, and the cooler is wrapped tightly with clear packing tape. It is then relinquished by field personnel to personnel responsible for shipment, typically an overnight carrier. The COC seal must be broken to open the container. Breakage of the seals before receipt at the laboratory may indicate tampering. If tampering is apparent, the laboratory will contact the designated person, and the sample will not be analyzed.

6.9 SAMPLE ANALYSIS

The following table illustrates the proposed sampling plan for the site:

Time period	Frequency	Parameters	Locations	# Samples per Sampling Event
First & Second Years[7] (4 monitoring events each year)	Quarterly	VOCs (EPA Method 8260)	MW-6, 7, 10, 11[6], 14, 16R, 22, 6A, 11A, 14A, 15A, 16A, and system effluent (groundwater discharge)	12 water
		VOCs (PID)	Each vapor extraction system	6 air
First & Second Year[7] (1 monitoring event each year)	Annually	VOCs (EPA Method TO-14 modified)	Each vapor extraction system	6 air
Third Year to completion of monitoring	Annually	VOCs (EPA Method 8260)	MW-6, 7, 10, 11[6], 14, 15, 16R, 22, 6A, 11A, 14A, 15A, and 16A	12 water

[6] If no collectable liquid is present in MW-11, a groundwater sample will be collected from MW-4.
[7] Air monitoring will continue until the remediation system is shut down

Note: Monitoring parameters and frequencies may be modified based on the outcome of the routine monitoring results.

Sampling will be conducted on quarterly basis for the first two years during the remedial activities. There after, only an annual sampling event is anticipated which will vary by season (i.e.: spring, summer, fall, winter) to evaluate seasonal groundwater changes.

After five years, the parameter list and monitoring well sampling locations will be reevaluated based on the post-closure sampling results.

Samples will be analyzed by a laboratory approved by the New York State Department of Health (NYSDOH) Environmental Laboratory Approval Program (ELAP) in all categories of solid and hazardous waste and certified for Contract Laboratory Protocols (CLP). Reduced laboratory deliverables (Category A package in lieu of Category B) submittals maybe requested because of the long term sampling that will be conducted as part of this O&M plan.

6.10 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance/Quality Control (QA/QC) samples will include "Trip Blanks," collected in addition to water and vapor samples. The trip blanks will be prepared and handled in accordance with SCIENTECH SOP for "Collection of Quality Control Samples" (document number 82A8498) included as Attachment 9.

6.11 HEALTH AND SAFETY

A Health and Safety Plan is provided in Attachment 10 which includes information on chemical and physical hazards anticipated during maintenance and monitoring at the site, personnel protection and monitoring equipment, accident prevention and contingency plan, sample handling, monitoring well decommissioning, and decontamination.

6.12 DATA EVALUATION AND REPORTING

The results of each monitoring event will be summarized quarterly in a letter report. Analytical results will be evaluated quarterly with respect to background levels detected in monitoring wells during the Remedial Investigation, and applicable NYSDEC and NYSDOH standards and guidance values. Analytical results showing an increase in contamination must be reported to the NYSDEC project manager within 14 days of such determination. Background will be determined from the review of contaminant levels in an upgradient well.

An annual summary report will be prepared which compares background levels, individual sampling round results and applicable water quality standards. Included in the report will be a table with the following information:

- Sample identification number
- Sample collection date
- Well identification including description of upgradient wells
- Analytical results
- Method Detection Limits (MDL)

- Chemical Abstracts Service (CAS) numbers for all compounds
- Applicable water quality standards

Delineation of samples with exceedances of background levels, standards, guidance values, or statistical triggers.

A summary and discussion of all exceedances of background levels, standards, values, or statistical triggers and any proposed modifications to the sampling and analysis schedule will also be included.

Reports will be submitted to the NYSDEC office responsible for this project, which is:

Mr. Gerald Rider, P.E.
Chief, Operation, Maintenance & Support Section
New York State Department of Environmental Conservation
50 Wolf Road
Albany, NY 12233-7010
(518) 457-0927

7 SITE CLOSURE

As stated in the Design Report, when the system performance monitoring data indicate that recovered VOC concentrations are negligible or as low as reasonably achievable, soil samples will be collected and analyzed by EPA Method 8260 to demonstrate an area-wide average less than or equal to the Remedial Action Objectives (RAOs) has been achieved for each area. Prior to sample collection, SCIENTECH will notify NYSDEC that verification samples will be collected. At that time, a specific soil verification sampling plan that provides the number of samples to be collected to verify compliance including the location and depth of each sample will be submitted. After NYSDEC approval, SCIENTECH will collect the soil samples for analysis. Once compliance has been verified for a specific area, that area will be disconnected from the soil and shallow groundwater remediation systems and considered closed. The vertical vapor extraction wells will be abandoned in accordance with NYSDEC guidelines after the area is disconnected from the overburden remediation system and considered closed.

The bedrock remediation system (bedrock groundwater removal and treatment) will probably operate for a longer period of time than the overburden remediation system. Therefore, demobilization activities will likely not include the bedrock recovery wells (MW-11A and MW-16A), related equipment or associated subsurface piping. The bedrock remediation system will continue to operate until the RAOs are achieved within the bedrock aquifer.

8 REPORTING AND RECORD KEEPING

This section describes the reporting and record keeping that will be during the duration of the remedial effort. Groundwater data will be reported to NYSDEC on a quarterly basis. An annual report summarizing monitoring and maintenance activities will also be submitted to NYSDEC. Copies of the quarterly and annual reports will be sent to NYSDEC at each of the following locations:

Mr. Gerald Rider, P.E.
Chief, Operation, Maintenance & Support Section
New York State Department of Environmental Conservation
50 Wolf Road

Albany, New York 12233-7010
(518) 457-0927

Mr. Gregory P. Sutton, P.E.
Project Engineer
New York State Department of Environmental Conservation - Region 9
270 Michigan Avenue
Buffalo, New York 14203-2999

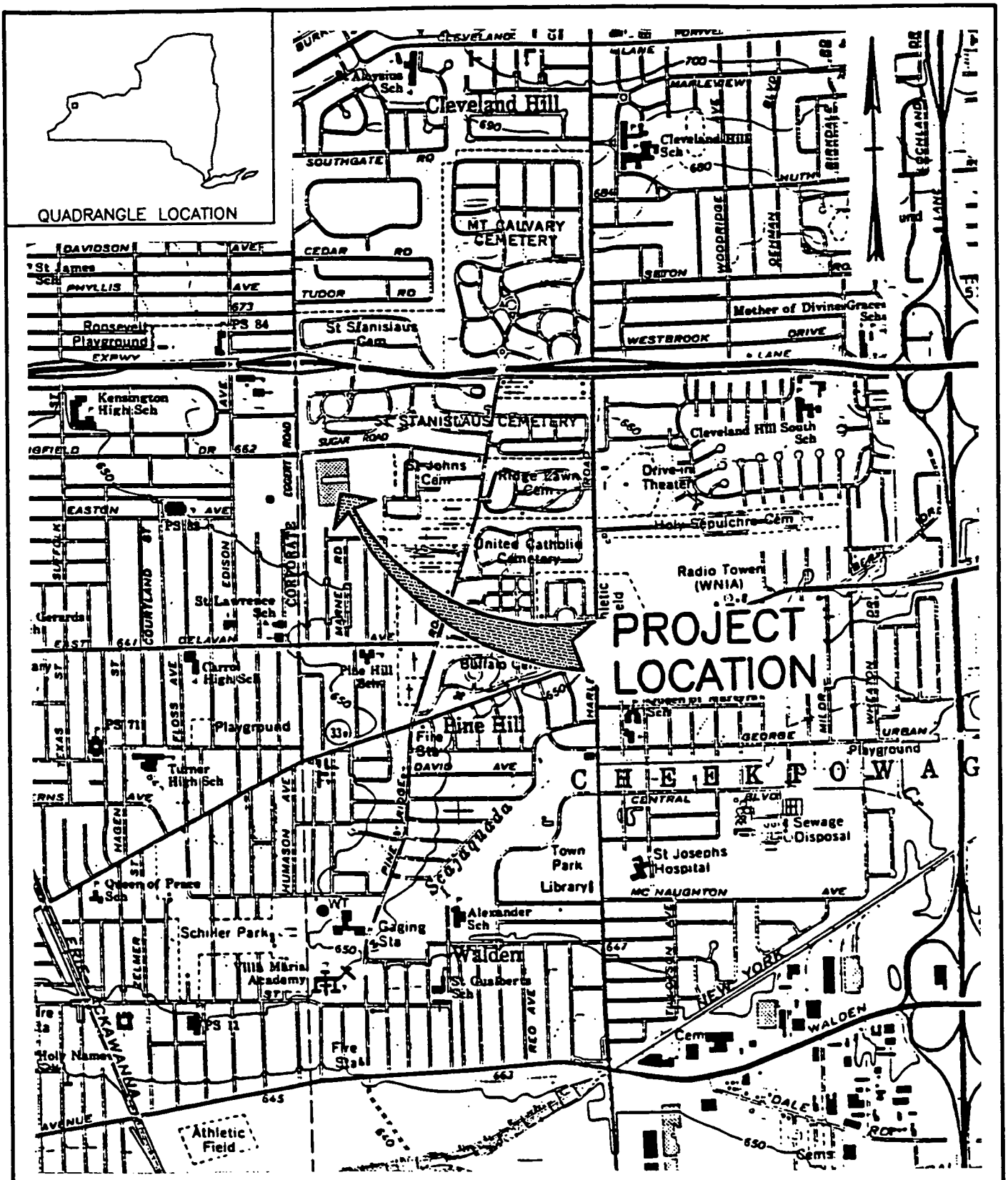
Dr. G. Anders Carlson
Director of Environmental Exposure
New York State Health of Department
2 University Place
Room 205
Albany, New York 12203-3399

8.1 ANNUAL REPORT

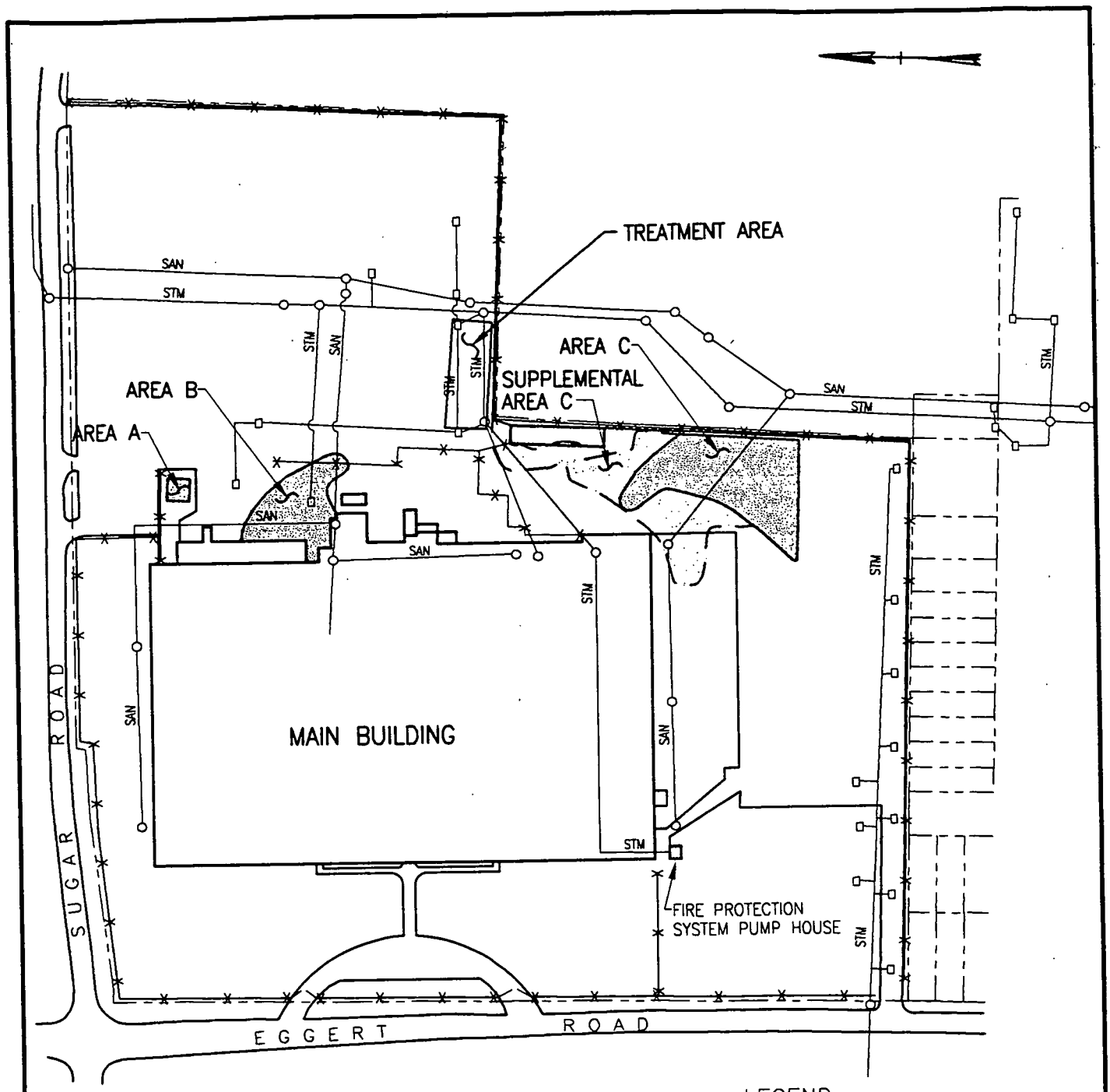
The annual report will contain a summary of water quality information from the quarterly monitoring events with special note of any changes in water quality that occurred throughout the year. This report will also include a summary of the field vapor screening information from the quarterly events and the analytical results from the laboratory analysis of air samples. The report outline will be based on the data reporting regulations in 6NYCRR Part 360-2.11(c)(4)(iv), including tables showing collection data, analytical results and applicable NYSDEC and NYSDOH standards and guidance values, a summary of contravention of water quality standards and a discussion of results. The annual report will also evaluate the effectiveness of the remedial system and provide any recommendations for operational changes and/or modifications.

8.2 RECORD KEEPING

Records of data, drawings, and calculations concerning any work proposed or completed at the site are kept on permanent file by SCIENTECH. For example, wells will be monitored and data recorded on a data sheet. This and other investigative results are incorporated into reports that will be maintained by NYSDEC. Included in the reports are appendices with copies of data sheets, log books, and laboratory analysis results. A record of the cost for the monitoring and maintenance of the site will also be kept.



DOCUMENT CONTROL NO.	PROJECT	LEICA, INC. EGGERT & SUGAR ROADS CHEEKTOWAGA, NEW YORK	SCIENTECH NES, Inc. 44 Shelter Rock Road Danbury, CT 06810 (203) 796-5000	PROJECT #: 3948-100 FILENAME: 3948100A SCALE: NTS DATE: 2/25/98 BY: AD CK: FIGURE # 1
REVISION NO.	DRAWING	SITE VICINITY MAP U.S.G.S. QUADRANGLE; BUFFALO, NY NE		



LEGEND:

- PROPERTY LINE
- FENCE
- MANHOLE
- CATCH BASIN
- SAN SANITARY LINE
- STM STORM LINE

DOCUMENT CONTROL NO.	PROJECT	LEICA, INC. EGGERT & SUGAR ROADS CHEEKTOWAGA, NEW YORK	SCIENTECH NES, Inc. 44 Shelter Rock Road Danbury, CT 06810 (203) 796-5000	PROJECT # 3948-100 FILENAME: 3948100A SCALE: 1" = 200' DATE: 11/5/98 BY: AD CK: MC FIGURE # 2
REVISION NO.	DRAWING	SITE PLAN		

KEY:
VEF – VAPOR EXTRACTION (FILL LAYER)
VES – VAPOR EXTRACTION (SILTY-SAND LAYER)
AI – AIR INJECTION
CA – COMPRESSED AIR (TO PNEUMATIC PUMP)
BD – BEDROCK AQUIFER DISCHARGE LINE (FROM PUMPS)
PVC – POLYVINYL CHLORIDE PIPE
BI – BLACK IRON PIPE
X – NO PIPE REQUIRED

PIPE CALL OUT

PROCESS TYPE	PIPE SIZE	PIPE TYPE

AREA A

AREA B

PIPE CALL OUT
VEF – 3"PVC
VES – X
AI – X
CA – X
BD – X

PIPE CALL OUT
VEF – 3"PVC
VES – 3"PVC
AI – 3"PVC
CA – 1 1/2"PVC
BD – 1 1/2"PVC

PIPE CALL OUT
VEF – 3"PVC
VES – 3"PVC
AI – 3"PVC
CA – X
BD – X

PIPE CALL OUT
VEF – 3"PVC
VES – 3"PVC
AI – 3"PVC
CA – X
BD – X

MW-16A

PLATFORM

EXIST. BEDROCK WELL (PUMP TO BE INSTALLED)

MAIN BUILDING

PIPE CALL OUT
VEF – 3"PVC
VES – 3"PVC
AI – 3"PVC
CA – 1 1/2"PVC
BD – 1 1/2"PVC

PIPE CALL OUT
VEF – 4"PVC
VES – 4"PVC
AI – 3"PVC
CA – 1 1/2"PVC
BD – 1 1/2"PVC

PIPE CALL OUT
VEF – 4"PVC
VES – 4"PVC
AI – 3"BI
CA – 1 1/2"BI
BD – 1 1/2"PVC

PIPE CALL OUT
VEF – 3"PVC

TREATMENT PILE

LEGEND:
PROPERTY LINE
FENCE
MANHOLE
CATCH BASIN
BEDROCK PUMPING WELL
APPROX. LIMITS OF REMEDIATION AREA
VERT. VAPOR EXTRATION WELL
HORIZ. VAPOR EXTRACTION WELL, AIR INJECTION PIPING & AIR INJECTION WELL
AIR INJECTION PIPING & AIR INJECTION WELL
HORIZ. VAPOR EXTRACTION WELL ONLY
VAPOR EXTRATION & AIR INJECTION PIPING MANIFOLD

DOCUMENT CONTROL NO.

REVISION NO.

LEICA, INC.
EGGERT & SUGAR ROADS
CHEEKTOWAGA, NEW YORK

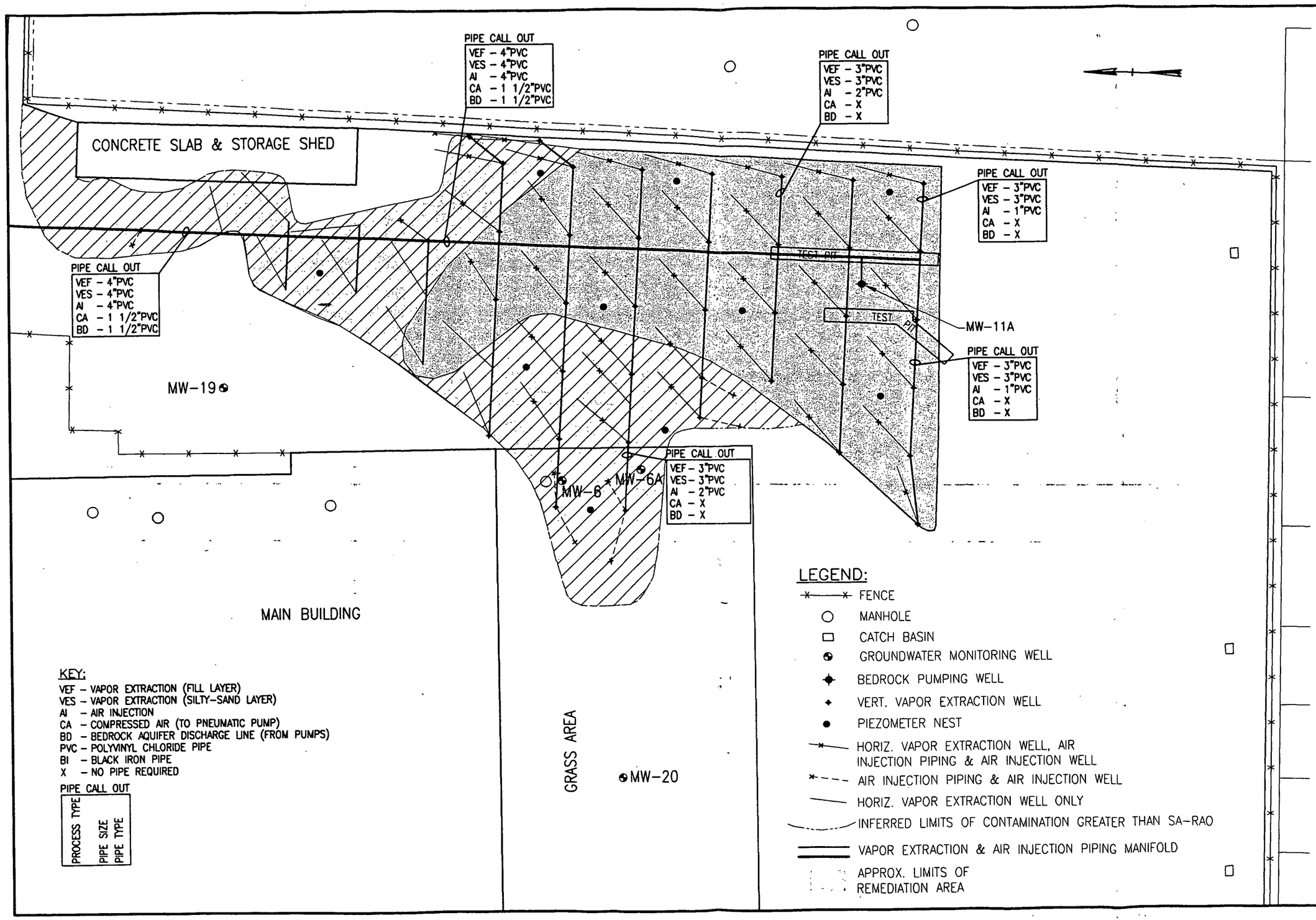
AS-BUILT DRAWING – AREAS A & B

PROJECT

DRAWING

SCIENTECH NES, Inc.
44 Shelter Rock Road
Danbury, CT 06810
(203) 796-5000

PROJECT NO.: 3948-100
FILE NAME: 3948100H
SCALE: 1" =40'
DATE: 4/3/00
BY: AD
CK:
FIGURE # 3



DOCUMENT CONTROL NO.

REVISION NO.

AS–BUILT DRAWING – AREA C

LEICA, INC.
EGGERT & SUGAR ROADS
CHEEKTOWAGA, NEW YORK

PROJECT

DRAWING

SCIENTECH NES, Inc.
44 Shelter Rock Road
Danbury, CT 06810
(203) 796–5000

PROJECT NO.: 3948–100

FILE NAME: 3948100H

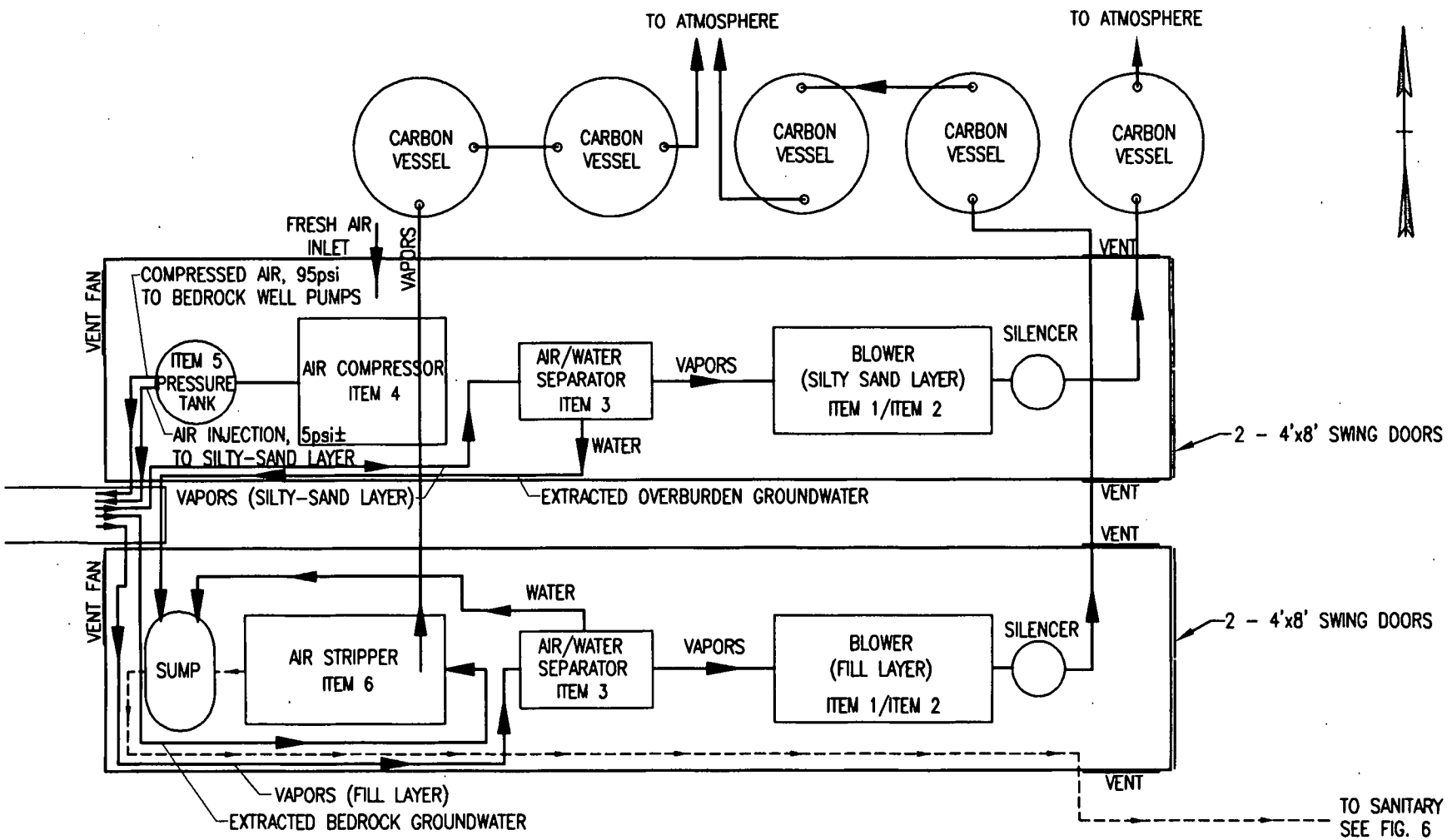
SCALE: 1" = 40'

DATE: 3/27/00

BY: AD

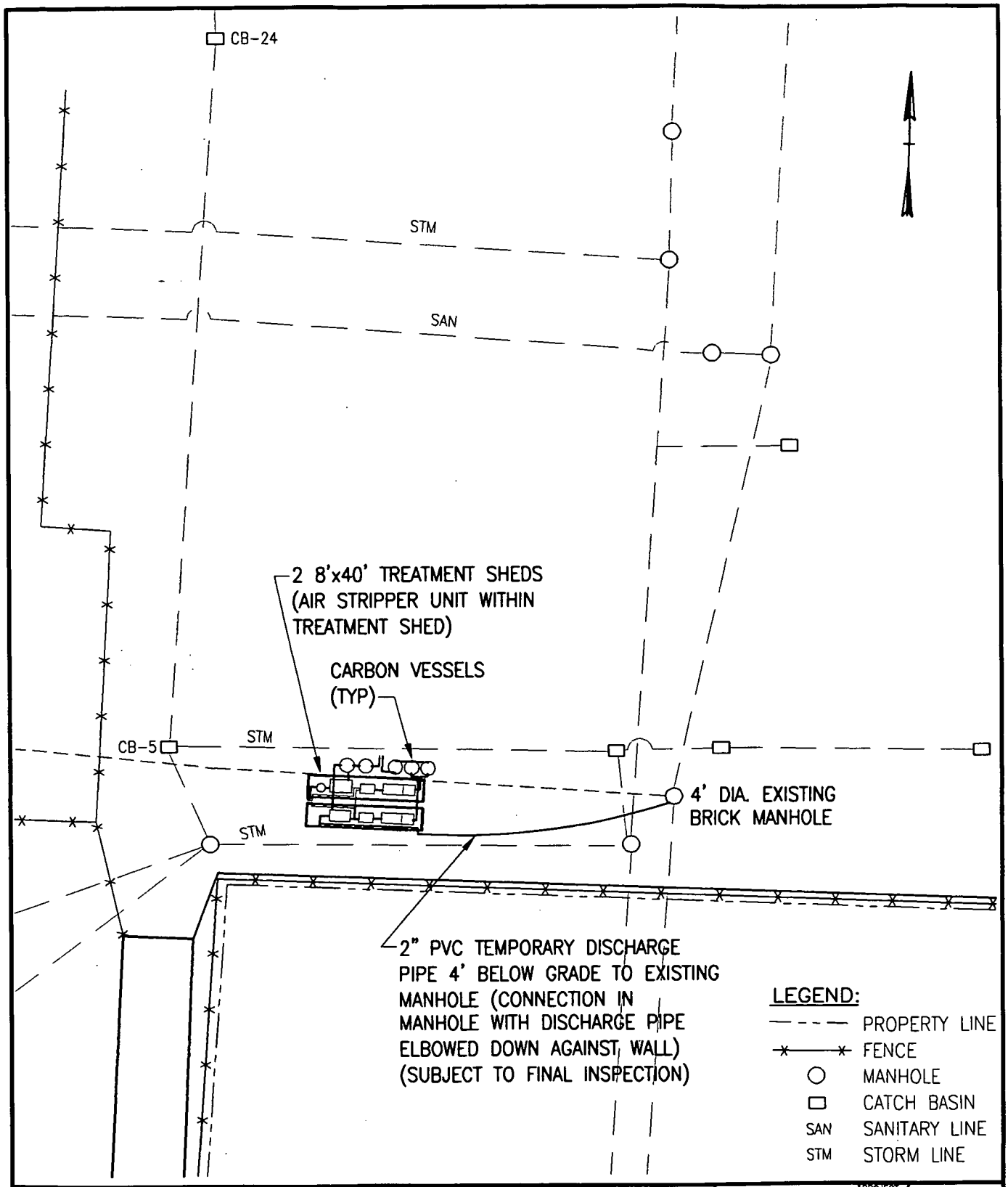
CK:

FIGURE # 4

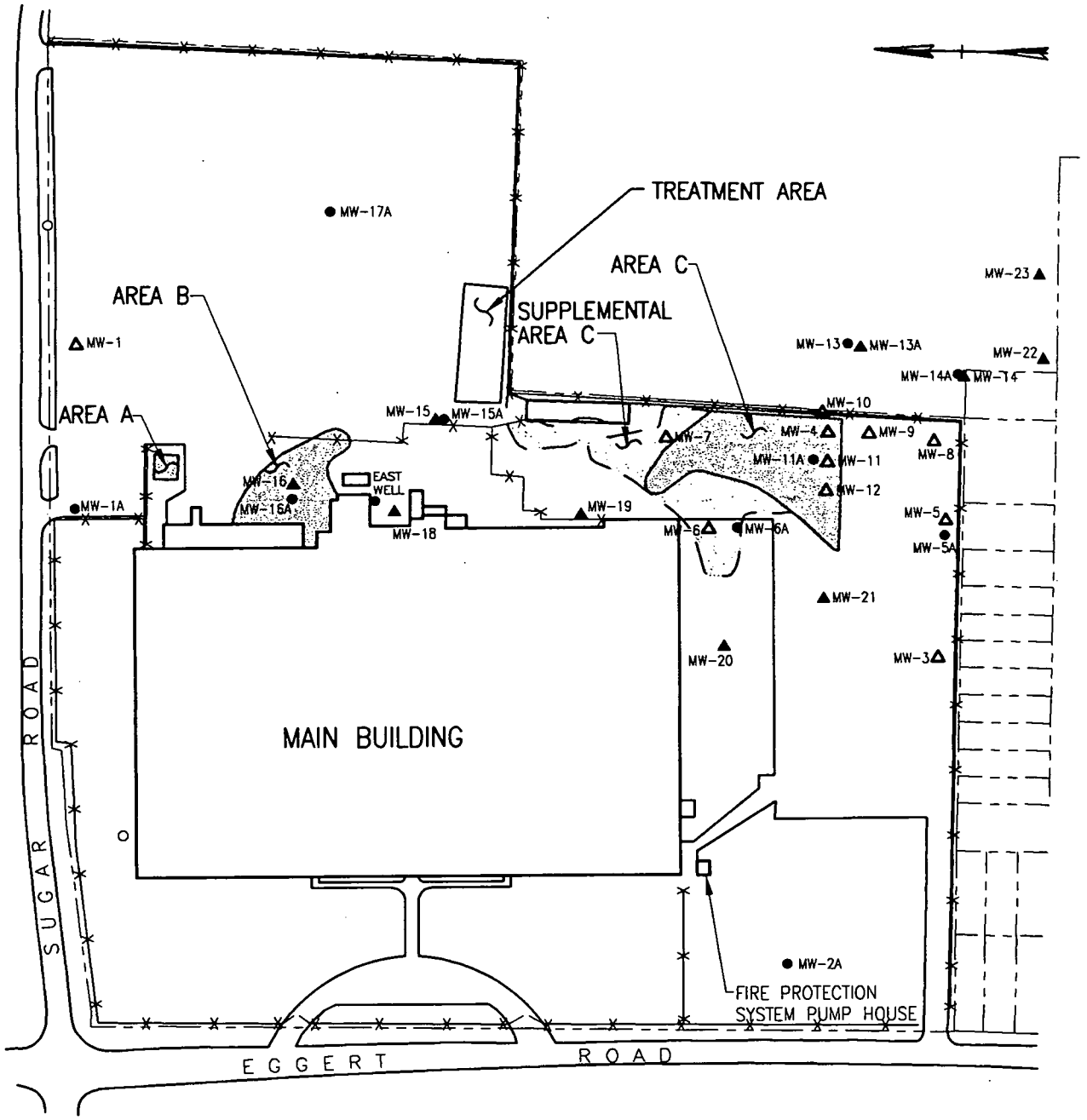


NOTE:
NUMBERED ITEMS REFER TO
CORRESPONDING ITEMS IN ATTACHMENT 1.

REVISIONS		PROJECT	LEICA, INC. CHEEKTOWAGA, NY	SCIENTECH NES, Inc. 44 Shelter Rock Road Danbury, CT 06810 (203) 796-5000	PROJECT # 3947-100
NO.	DATE				FILENAME: 3947100E
		DRAWING	AS-BUILT DRAWING EQUIPMENT LAYOUT		SCALE: 1" =6' DATE: 4/4/00
					BY: AD CK:
					FIGURE # 5



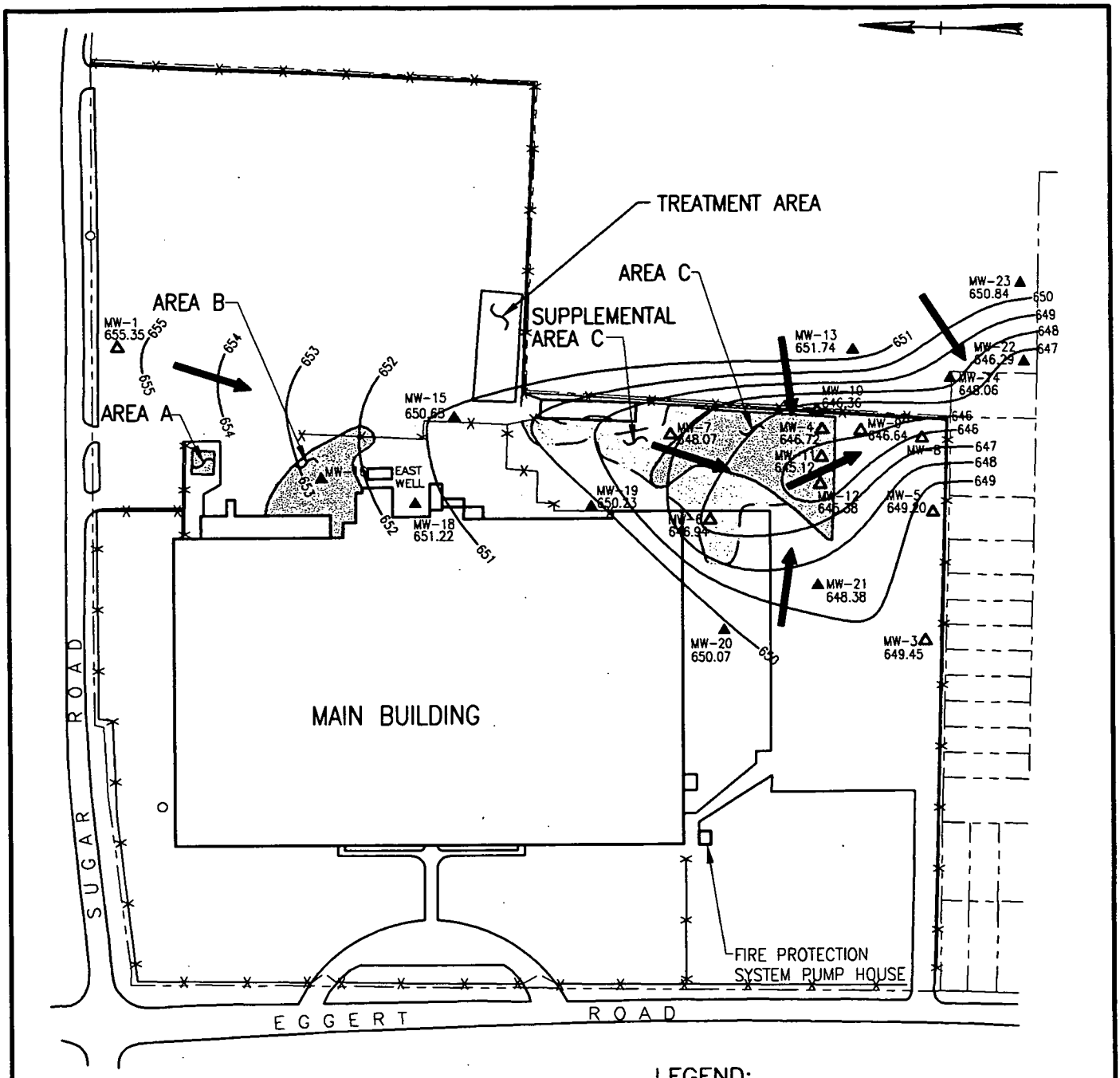
DOCUMENT CONTROL NO.	PROJECT	LEICA, INC. EGGERT & SUGAR ROADS CHEEKTOWAGA, NEW YORK	SCIENTECH NES, Inc. 44 Shelter Rock Road Danbury, CT 06810 (203) 796-5000	PROJECT # 3947-100 FILENAME: 3947100C SCALE: 1" =50' DATE: 3/27/00 BY: AD CK: MC FIGURE # 6
REVISION NO.	DRAWING	AS-BUILT DRAWING TREATMENT SHED LAYOUT		



LEGEND:

- PROPERTY LINE
- FENCE
- ▲ OVERBURDEN MONITORING WELL
- ● BEDROCK MONITORING WELL

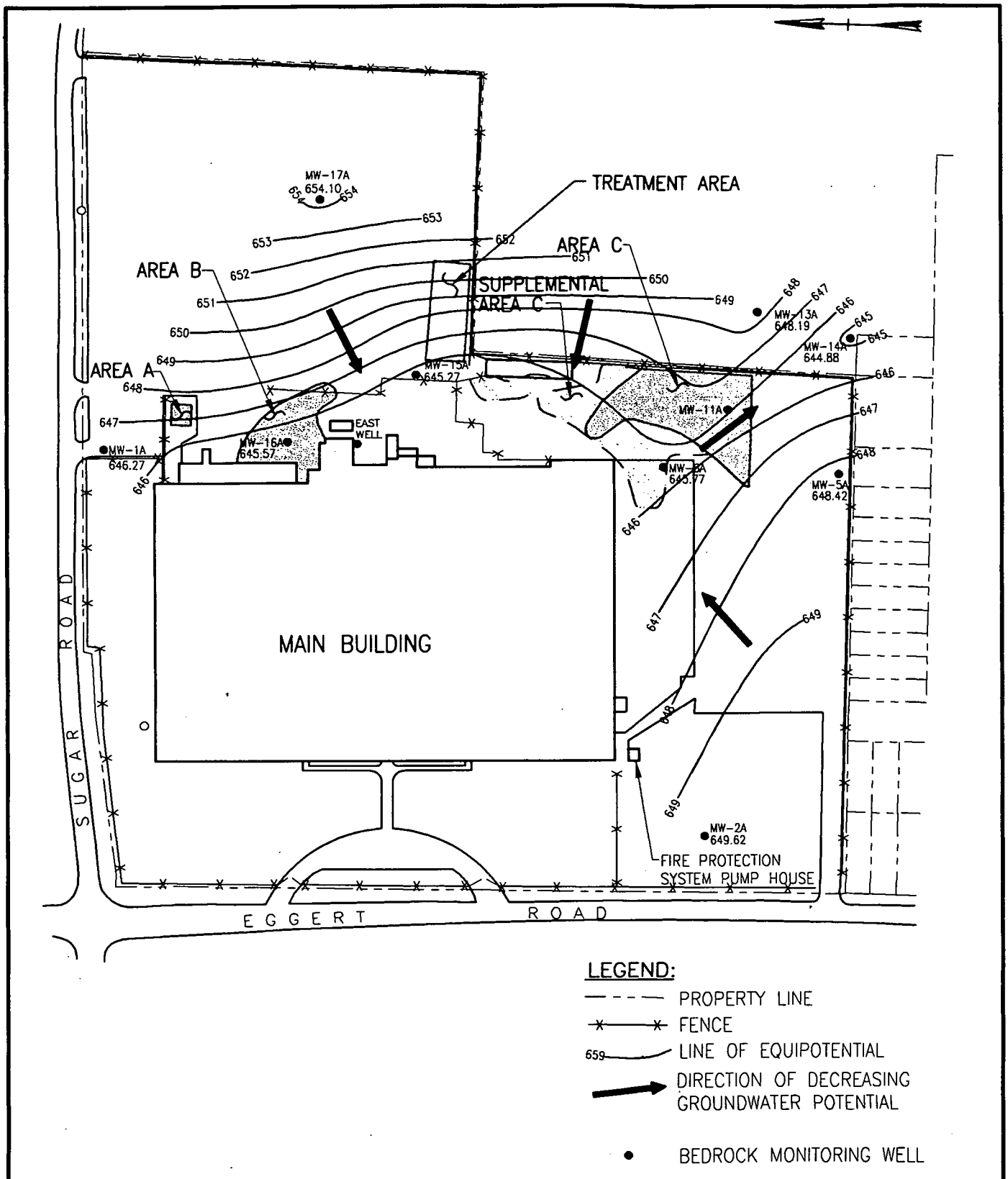
DOCUMENT CONTROL NO.	PROJECT	LEICA, INC. EGGERT & SUGAR ROADS CHEEKTOWAGA, NEW YORK	SCIENTECH NES, Inc. 44 Shelter Rock Road Danbury, CT 06810 (203) 796-5000	PROJECT #: 3948-100 FILENAME: 3948200A SCALE: 1" =200' DATE: 3/27/00 BY: AD CK: MC FIGURE # 7
REVISION NO.	DRAWING	GROUNDWATER MONITORING WELL LOCATIONS		



LEGEND:

- PROPERTY LINE
- FENCE
- 659 LINE OF EQUIPOTENTIAL
- DIRECTION OF DECREASING GROUNDWATER POTENTIAL
- ▲▲ OVERBURDEN MONITORING WELL

DOCUMENT CONTROL NO.	PROJECT	LEICA, INC. EGGERT & SUGAR ROADS CHEEKTOWAGA, NEW YORK	SCIENTECH NES, Inc. 44 Shelter Rock Road Danbury, CT 06810 (203) 796-5000	PROJECT # 3948-100 FILENAME: 3948200A SCALE: 1" =200' DATE: 3/27/00 BY: AD CK: MC FIGURE # 8
REVISION NO.	DRAWING	OVERBURDEN GROUNDWATER FLOW MAP DECEMBER 14, 1999		



DOCUMENT CONTROL NO.	PROJECT	LEICA, INC. EGGERT & SUGAR ROADS CHEEKTOWAGA, NEW YORK	SCIENTECH NES, Inc. 44 Shelter Rock Road Danbury, CT 06810 (203) 796-5000	PROJECT # 3948-100 FILENAME: 3948200A SCALE: 1" =200' DATE: 3/27/00 BY: AD CK: MC FIGURE # 9
REVISION NO.	DRAWING	BEDROCK GROUNDWATER FLOW MAP DECEMBER 14, 1999		

Prepared by:MC
Date:03/27/2000
Checked by:
Date: 3-28-00

TABLE 1
LEICA INC. GROUNDWATER MONITORING REPORT

GROUNDWATER WELL MEASUREMENTS
DECEMBER 14, 1999

Well Number	Riser Elev. (Feet)	Depth to Water (Feet)	Water Elev. (Feet)
1	662.38	7.03	655.35
1A	663.48	17.21	646.27
2A	657.02	7.40	649.62
3	655.94	6.49	649.45
4	655.57	8.85	646.72
5	654.80	5.60	649.20
5A	654.84	6.42	648.42
6	660.84	13.90	646.94
6A	659.38	13.61	645.77
7	658.21	10.14	648.07
8	656.11		
9	654.99	8.35	646.64
10	655.48	9.12	646.36
11	656.08	10.96	645.12
12	656.93	11.55	645.38
13	654.66	2.92	651.74
13A	655.13	6.94	648.19
14	653.38	5.32	648.06
14A	653.70	8.82	644.88
15	658.35	7.70	650.65
15A	658.51	13.24	645.27
16	659.89		
16A	659.95	14.38	645.57
17A	659.18	5.08	654.10
18	662.51	11.29	651.22
19	660.84	10.61	650.23
20	659.12	9.05	650.07
21	657.72	9.34	648.38
22	652.51	6.22	646.29
23*	656.25	5.41	650.84

* Riser elevation is estimated
All Elevations are referenced to Mean Sea Level

Prepared by:MC
Date:03/27/2000
Checked by: AD
Date: 3-28-00

TABLE 2
LEICA INC. GROUNDWATER MONITORING REPORT

GROUNDWATER WELL PURGING
DECEMBER 14 - 20, 1999

Well Number	Riser Elev. (Feet)	Depth of Well (Feet)	Depth to Water (Feet)	Water Elev. (Feet)	Water Height in Well (Feet)	Diameter of Well (inches)	Water Volume in Well (Gallons)	Volume Removed from Well (Gallons)
4	655.57	12.1	8.85	646.72	3.25	2.00	0.5	1.6
6	660.84	14.8	13.90	646.94	0.90	2.00	0.1	0.4
6A	659.38	35	13.61	645.77	21.39	4.00	13.7	41.1
7	658.21	12.27	10.14	648.07	2.13	2.00	0.3	1.0
10	655.48	10.04	9.12	646.36	0.92	2.00	0.1	0.4
11	656.08	11.3	10.96	645.12	0.34	2.00	0.1	0.2
14	653.38	10.5	5.32	648.06	5.18	2.00	0.8	2.5
14A	653.70	34.37	8.82	644.88	25.55	4.00	16.4	49.1
15	658.35	10.82	7.70	650.65	3.12	2.00	0.5	1.5
15A	658.51	35.45	13.24	645.27	22.21	4.00	14.2	42.7
16A	659.95	33.06	14.38	645.57	18.68	4.00	12.0	35.9
18	662.51	12.80	11.29	651.22	1.51	2.00	0.2	0.7
22	652.51	10.2	6.22	646.29	3.98	2.00	0.6	1.9

Prepared by:MC
Date:3/27/00
Checked by:
Date:3/27/00

TABLE 3
LEICA INC GROUNDWATER MONITORING REPORT
GROUNDWATER MONITORING
DECEMBER 1999

SHALLOW WELL VOC'S
(Concentrations in ug/L)

ANALYTE	MW-4	MW-6	MW-6	MW-7	MW-7	MW-10	Method Detection Limit
Dilution*	**1000**	**1.0**	**10.0**	**2.0**	**10.0**	**100.0**	
acetone	ND	ND	ND	ND	ND	ND	20
benzene	ND	ND	ND	120	140	ND	5.0
bromodichloromethane	ND	ND	ND	ND	ND	ND	5.0
bromoform	ND	ND	ND	ND	ND	ND	5.0
bromomethane	ND	ND	ND	ND	ND	ND	5.0
2-butanone (MEK)	ND	ND	ND	ND	ND	ND	10
carbon disulfide	ND	ND	ND	ND	ND	ND	10
carbon tetrachloride	ND	ND	ND	ND	ND	ND	5.0
chlorobenzene	ND	ND	ND	ND	ND	ND	5.0
chloroethane	ND	ND	ND	ND	ND	ND	5.0
chloroform	ND	ND	ND	ND	ND	ND	5.0
chloromethane	ND	ND	ND	ND	ND	ND	5.0
dibromochloromethane	ND	ND	ND	ND	ND	ND	5.0
1,1-dichloroethane	ND	ND	ND	ND	ND	ND	5.0
1,2-dichloroethane	ND	ND	ND	ND	ND	ND	5.0
1,1-dichloroethene	ND	8.1	ND	ND	ND	ND	5.0
cis-1,2-dichloroethene	110,000	1200 E	1,200	930 E	900	16,000	5.0
trans-1,2-dichloroethene	ND	13	ND	72	64	ND	5.0
1,2-dichloropropane	ND	ND	ND	ND	ND	ND	5.0
cis-1,3-dichloropropene	ND	ND	ND	ND	ND	ND	5.0
trans-1,3-dichloropropene	ND	ND	ND	ND	ND	ND	5.0
ethlybenzene	ND	ND	ND	ND	ND	ND	5.0
2-hexanone	ND	ND	ND	ND	ND	ND	10
methylene chloride	ND	ND	ND	ND	ND	ND	5.0
4-methyl-2-pentanone (MIBK)	ND	ND	ND	ND	ND	ND	10
styrene	ND	ND	ND	ND	ND	ND	5.0
1,1,2,2-tetrachloroethane	ND	ND	ND	ND	ND	ND	5.0
tetrachloroethene	ND	ND	ND	ND	ND	ND	5.0
toluene	ND	ND	ND	16	ND	ND	5.0
1,1,1-trichloroethane	ND	ND	ND	ND	ND	ND	5.0
1,1,2-trichloroethane	ND	ND	ND	ND	ND	ND	5.0
trichloroethene	41,000	8.6	ND	ND	ND	ND	5.0
vinyl chloride	ND	100	120	1,700 E	1,600	5,800	5.0
m+p xylene	ND	ND	ND	ND	ND	ND	5.0
o-xylene	ND	ND	ND	ND	ND	ND	5.0
TOTAL VOC'S	151,000	1,329.70	1,320	2,718	2,564	21,800	

ND - analyte Not Detected

*Dilution x Method Detection Limit = Detection limit for sample (e.g., Detection Limit for Acetone in MW-4 = 1000 x 20 = 20,000)

E = Exceeds Calibration Range

\\NES-NT\DEPT\DEPT020\3947-3948-LEICA\DELVDSGN\GW Monitoring\TABLE3.xls

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Checked by:
Date:3/27/00

TABLE 3
LEICA INC GROUNDWATER MONITORING REPORT
GROUNDWATER MONITORING
DECEMBER 1999

SHALLOW WELL VOC'S
(Concentrations in ug/L)

ANALYTE	MW-14	MW-14	MW-15	MW-18	MW-22	Method Detection Limit
Dilution*	**1.0**	**2.0**	**1.0**	**1.0**	**1.0**	
acetone	ND	ND	ND	ND	ND	20
benzene	ND	ND	ND	ND	ND	5.0
bromodichloromethane	ND	ND	ND	ND	ND	5.0
bromoform	ND	ND	ND	ND	ND	5.0
bromomethane	ND	ND	ND	ND	ND	5.0
2-butanone (MEK)	ND	ND	ND	ND	ND	10
carbon disulfide	ND	ND	19	11	76	10
carbon tetrachloride	ND	ND	ND	ND	ND	5.0
chlorobenzene	ND	ND	ND	ND	ND	5.0
chloroethane	ND	ND	ND	ND	ND	5.0
chloroform	ND	ND	ND	ND	ND	5.0
chloromethane	ND	ND	ND	ND	ND	5.0
dibromochloromethane	ND	ND	ND	ND	ND	5.0
1,1-dichloroethane	ND	ND	19	ND	ND	5.0
1,2-dichloroethane	ND	ND	ND	ND	ND	5.0
1,1-dichloroethene	ND	ND	ND	ND	ND	5.0
cis-1,2-dichloroethene	370E	360	ND	ND	ND	5.0
trans-1,2-dichloroethene	10	ND	ND	ND	ND	5.0
1,2-dichloropropane	ND	ND	ND	ND	ND	5.0
cis-1,3-dichloropropene	ND	ND	ND	ND	ND	5.0
trans-1,3-dichloropropene	ND	ND	ND	ND	ND	5.0
ethlybenzene	ND	ND	ND	ND	ND	5.0
2-hexanone	ND	ND	ND	ND	ND	10
methylene chloride	ND	ND	ND	ND	ND	5.0
4-methyl-2-pentanone (MIBK)	ND	ND	ND	ND	ND	10
styrene	ND	ND	ND	ND	ND	5.0
1,1,2,2-tetrachloroethane	ND	ND	ND	ND	ND	5.0
tetrachloroethene	ND	ND	ND	ND	ND	5.0
toluene	ND	ND	ND	ND	ND	5.0
1,1,1-trichloroethane	ND	ND	ND	ND	ND	5.0
1,1,2-trichloroethane	ND	ND	ND	ND	ND	5.0
trichloroethene	ND	ND	ND	ND	ND	5.0
vinyl chloride	140	150	ND	ND	ND	5.0
m+p xylene	ND	ND	ND	ND	ND	5.0
o-xylene	ND	ND	ND	ND	ND	5.0
TOTAL VOC'S	520	510	38	11	76	

ND - analyte Not Detected

*Dilution x Method Detection Limit = Detection limit for sample (e.g., Detection Limit for Acetone in MW-4 = 1000 x 20 = 20,000)

E = Exceeds Calibration Range

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Date:3/27/00
Checked by:
Date:3/27/00

TABLE 4
LEICA INC GROUNDWATER MONITORING REPORT
GROUNDWATER MONITORING
DECEMBER 1999

BEDROCK WELL VOC'S
(Concentrations in ug/L)

ANALYTE	MW-6A	MW-14A	MW-15A	MW-15A	MW-16A	Trip Blank	Method Detection Limit
Dilution	**20.0**	**1.0**	**1.0**	**5.0**	**500.0**	**1.0**	
acetone	ND	ND	ND	ND	ND	ND	20
benzene	ND	ND	ND	ND	ND	ND	5.0
bromodichloromethane	ND	ND	ND	ND	ND	ND	5.0
bromoform	ND	ND	ND	ND	ND	ND	5.0
bromomethane	ND	ND	ND	ND	ND	ND	5.0
2-butanone (MEK)	ND	ND	ND	ND	ND	ND	10
carbon disulfide	ND	14	ND	ND	ND	ND	10
carbon tetrachloride	ND	ND	ND	ND	ND	ND	5.0
chlorobenzene	ND	ND	ND	ND	ND	ND	5.0
chloroethane	ND	ND	ND	ND	ND	ND	5.0
chloroform	ND	ND	ND	ND	ND	ND	5.0
chloromethane	ND	ND	ND	ND	ND	ND	5.0
dibromochloromethane	ND	ND	ND	ND	ND	ND	5.0
1,1-dichloroethane	ND	ND	14	ND	ND	ND	5.0
1,2-dichloroethane	ND	ND	ND	ND	ND	ND	5.0
1,1-dichloroethene	ND	ND	ND	ND	ND	ND	5.0
cis-1,2-dichloroethene	3,900	26	950 E	830	9,400	ND	5.0
trans-1,2-dichloroethene	ND	ND	93	72	ND	ND	5.0
1,2-dichloropropane	ND	ND	ND	ND	ND	ND	5.0
cis-1,3-dichloropropene	ND	ND	ND	ND	ND	ND	5.0
trans-1,3-dichloropropene	ND	ND	ND	ND	ND	ND	5.0
ethlybenzene	ND	ND	13	ND	ND	ND	5.0
2-hexanone	ND	ND	ND	ND	ND	ND	10
methylene chloride	ND	ND	ND	ND	ND	ND	5.0
4-methyl-2-pentanone (MIBK)	ND	ND	ND	ND	ND	ND	10
styrene	ND	ND	ND	ND	ND	ND	5.0
1,1,2,2-tetrachloroethane	ND	ND	ND	ND	ND	ND	5.0
tetrachloroethene	ND	ND	ND	ND	ND	ND	5.0
toluene	ND	ND	ND	ND	ND	ND	5.0
1,1,1-trichloroethane	ND	ND	ND	ND	56,000	ND	5.0
1,1,2-trichloroethane	ND	ND	ND	ND	ND	ND	5.0
trichloroethene	ND	ND	65	48	17,000	ND	5.0
vinyl chloride	240	13	390 E	270	ND	ND	5.0
m+p xylene	120	ND	ND	ND	8,400	ND	5.0
o-xylene	ND	ND	ND	ND	3,800	ND	5.0
TOTAL VOC'S	4,260	53	1,498	1,220	94,600	ND	

ND - analyte Not Detected
*Dilution x Method Detection Limit = Detection limit for sample (e.g., Detection Limit for Acetone in MW-6A = 20 x 20 = 400)
E = Exceeds Calibration Range
\\NES-NT\DEPT\DEPT020\3947-3948-LEICA\DELVDSGN\GW Monitoring\Table4.xls

ATTACHMENT 1

Catalog Cut-sheets and Maintenance Schedule

Tomlin Equipment Company and

Carbtrol Corporation

ITEM #	ITEM DESCRIPTION	MANUFACTURER	MODEL #
1	Rotary Vane Vacuum Pump	Roots Dresser	718 URAI
2	Horizontal Electric Motor	U.S. Motors	364T
3	Liquid Separator/Silencer	EM Products/Tomlin Equipment Corp.	LIS-6
4	Rotary Screw Air Compressor	Gardner Denver	EBM*L
5	Air Receiver Tank	Silvan Industries	Silvan STD Model 36"
6	Multiple Stage Diffuser	Carbtrol Corporation	MSD-6-100

ITEM 1

Roots Dresser Rotary Vane Vacuum Pump

Ancillaries

Inlet Vacuum Air Filters

Rotary Positive Air Silencers

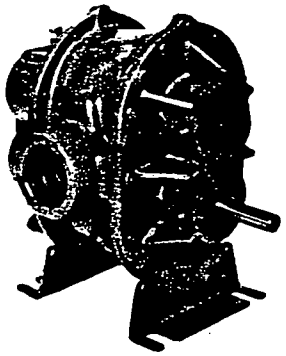
Expansion Joints and Flanges

Cast Iron Safety Valves

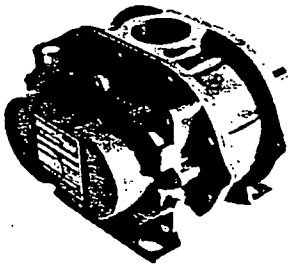
Temperature Controls

Vacuum Gauges

Thermometers



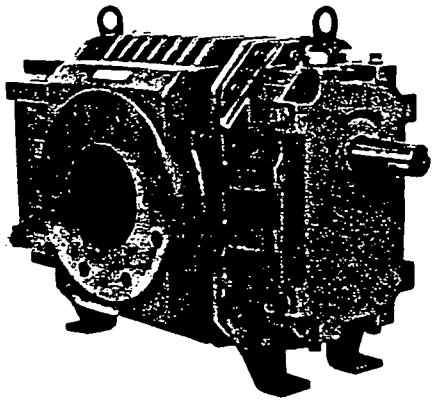
Rotary Positive Blowers
Gas Pumps
Vacuum Pumps

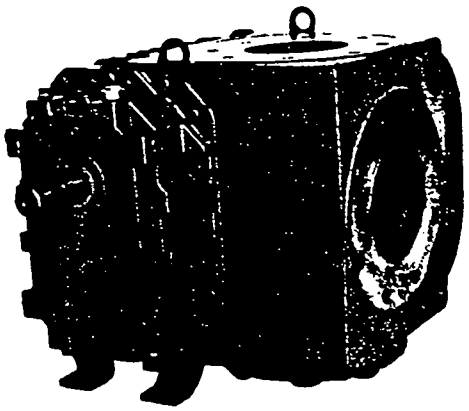


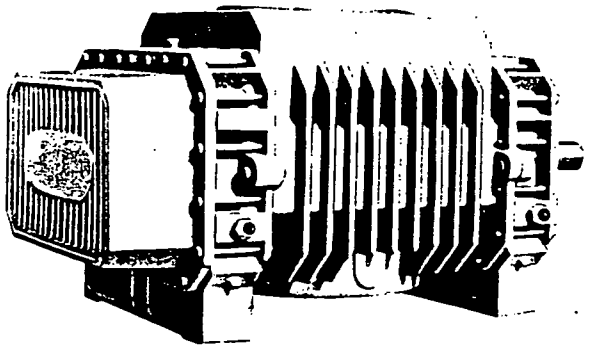
- *discharge pressures to 30 psig*
- *vacuums to 27" Hg*
- *capacities to 5600 cfm*

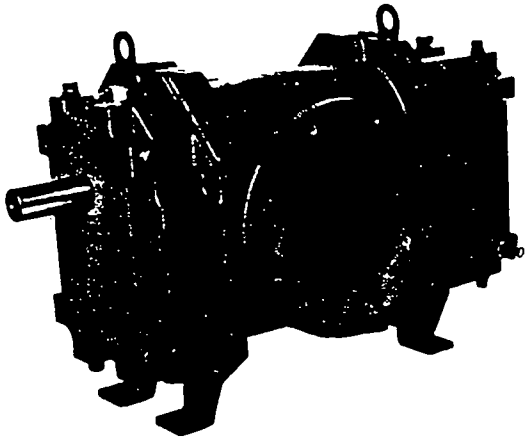
(Larger units available – see page 25)

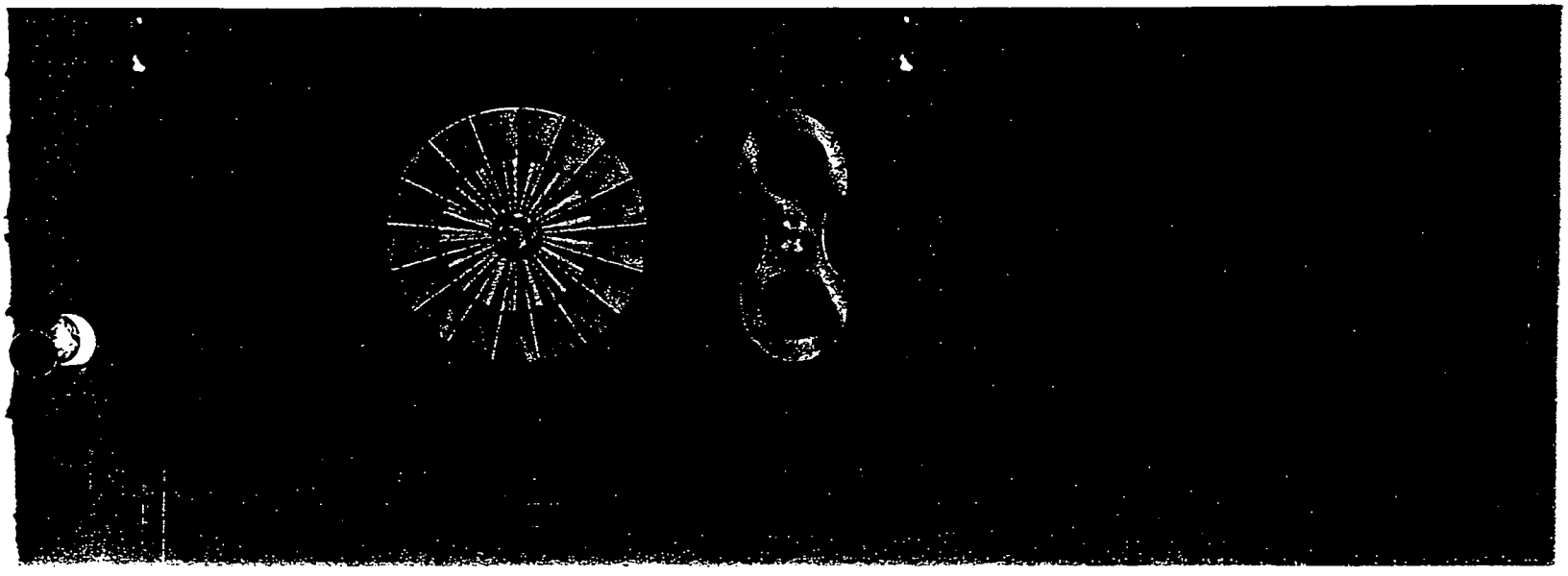
ROOTS DRESSER











BACKGROUND

The Roots rotary positive blower originated in Connersville, Indiana in 1854. Two brothers, Francis and Philander Roots, operated a woolen mill in the small southeastern Indiana town. They constantly made inprovements on their operating machinery to produce better products with increased productivity.

The rotary blower principle was devised while redesigning a water wheel. Although the water wheel did not function as planned, it occurred to the two inventors that the design could be used as a blast blower for their cupola. It worked so well in this capacity that the brothers began to manufacture the "Roots" blower in their woolen mill workshop.

Being the original, since 1854, means more years of experience in product manufacturing, product improvement and application expertise. Roots familiarity with all types of applications assures proven, dependable products designed to satisfy specific requirements. As the leading producer in the world, Roots, from a wide selection of models and frame sizes, can provide the most efficient, economical and dependable blower, gas pump or vacuum pump to meet the needs of nearly any application.

CONFIGURATIONS

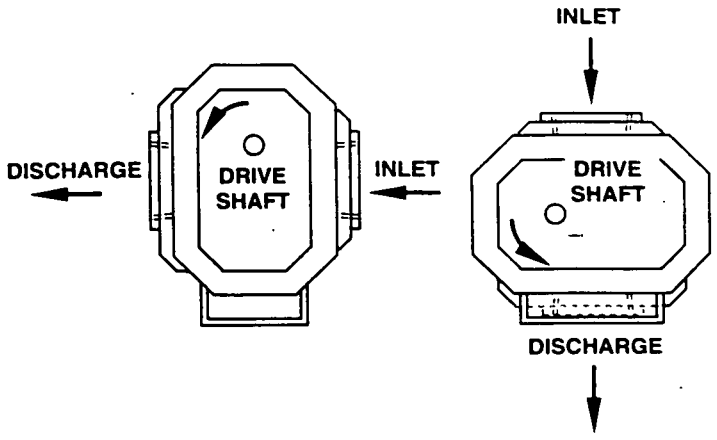
Orientation drawings for inlet and discharge connections are viewed from the drive end. Roots offers two basic configurations to meet nearly any piping arrangement or installation requirement:

1. **Vertical configuration**

   In the vertical configuration, one impeller is mounted above the other. On most units, the drive is from the end opposite the timing gears. Inlet and discharge connections are on the side of the machine, providing a horizontal air flow.

2. **Horizontal configuration**

   The impellers are located side by side. On most units, the drive is from the end opposite the timing gears. Inlet and discharge connections are on the top and bottom of the machine providing a vertical air flow. The driver can usually be specified for connection to either the left hand or right hand blower shaft.



VERTICAL CONFIGURATION
Impellers mounted one on top of the other

HORIZONTAL CONFIGURATION
Impellers mounted side by side

MODEL FEATURES TABLE

MODEL	PAGE NUMBER	REVERSIBLE ROTATION	REMOVABLE MOUNTING FEET	WHISPAIR DESIGN	WATER SEALED UNIT	COMPLETELY PACKAGED UNIT
Universal RAI blower	4-5	X	X			
Universal RAI-J blower	6-7		X	X		
RAM blower	8-9	X	X			
RAM-J blower	10-11		X	X		
RAM-J vacuum pump	12-13		X	X	X	
RAM-J dry vacuum pump	14-15		X			
RAM-J gas pump	10-11		X	X		
DVJ dry vacuum pump	16-17		X	X		
RAM-J high-pressure blower	18-19		X	X		
RCS blower	20-21	X	X			
RCS-J blower	20-21		700 FRAMES ONLY	X		
XLP tri-lobe blower	22-23		X	X		
RootsPak packaged blower	24				X	X

ACCESSORIES

Available accessories for Roots blowers, gas pumps and vacuum pumps include driver, relief valve, inlet and discharge silencer, inlet filter, check valve, extended base, V-belt drive or flexible coupling and drive guards.

Contact your Authorized Roots Distributor or Roots Sales Representative for details concerning your specific application or installation.

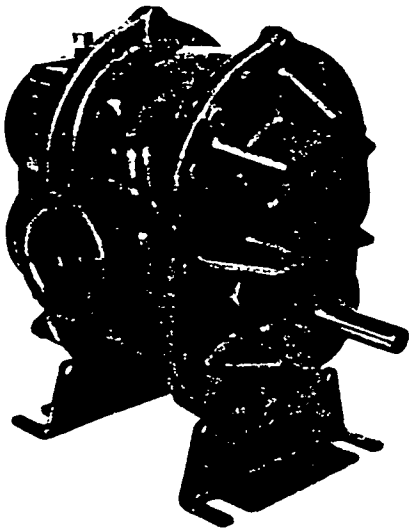
UNIVERSAL RAI® PERFORMANCE TABLE

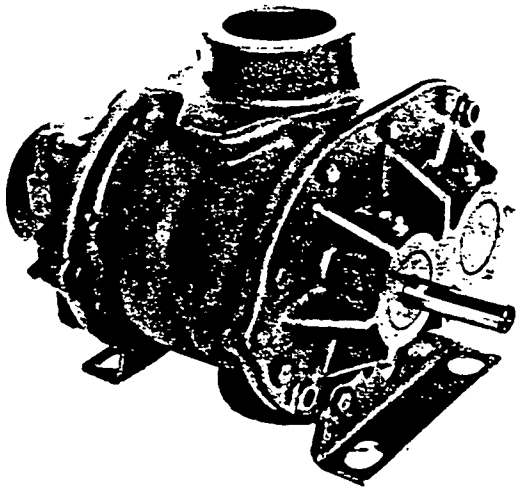
FRAME SIZE	SPEED RPM	1 PSI		2 PSI		3 PSI		4 PSI		5 PSI		6 PSI		7 PSI		10 PSI		11 PSI		12 PSI		15 PSI		MAX. VACUUM		
		CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	"Hg	CFM	BHP
22	1160	10	0.2	7	0.3	4	0.3	2	0.4															4	6	0.3
	3600	49	0.6	46	0.8	43	1.1	41	1.3	39	1.6	38	1.8	36	2.1	32	2.8	31	3.1	29	3.3			14	28	2.0
	5275	76	0.8	73	1.2	70	1.6	68	1.9	66	2.3	64	2.7	63	3.1	59	4.2	57	4.5	56	4.9			15	53	3.1
24	1160	24	0.3	19	0.4	15	0.6	11	0.8	8	0.9													6	12	0.6
	3600	102	0.8	97	1.3	93	1.8	89	2.3	86	2.8	83	3.3	81	3.8									14	69	3.8
	5275	156	1.2	150	1.9	146	2.7	143	3.4	140	4.2	137	4.9	135	5.6									15	119	5.8
32	1160	40	0.4	34	0.6	30	0.9	27	1.1	24	1.3	21	1.6	19	1.8									10	18	1.3
	2800	113	1.0	108	1.6	104	2.1	101	2.7	98	3.2	95	3.8	93	4.3	86	6.0	84	6.5	82	7.1	77	8.7	15	78	4.5
	3600	149	1.3	144	2.0	140	2.7	137	3.4	134	4.1	131	4.8	129	5.5	122	7.7	120	8.4	118	9.1	113	11.2	15	114	5.8
33	1160	55	0.5	48	0.8	43	1.1	39	1.4	35	1.7	31	2.1	28	2.4									10	27	1.7
	2800	156	1.2	149	2.0	144	2.7	140	3.5	136	4.2	132	5.0	129	5.7	120	8.0	118	8.7	116	9.5			14	113	5.6
	3600	205	1.6	199	2.5	193	3.5	189	4.5	185	5.4	181	6.4	178	7.4	170	10.3	167	11.2	165	12.2			15	159	7.6
36	1160	95	0.7	85	1.2	78	1.7	72	2.3	66	2.8	61	3.3	57	3.8									10	55	2.7
	2800	262	2.0	253	3.3	245	4.5	239	5.8	234	7.0	229	8.3	224	9.5									12	213	7.9
	3600	344	2.9	334	4.5	327	6.1	321	7.7	315	9.3	310	10.9	306	12.5									15	278	12.7
42	860	38	0.4	32	0.6	28	0.9	24	1.1	21	1.3	18	1.5	15	1.8									8	19	1.1
	1760	92	0.8	87	1.3	82	1.8	78	2.2	75	2.7	72	3.1	69	3.6	62	5.0	60	5.5	58	5.9			14	56	3.5
	3600	204	1.7	198	2.6	194	3.6	190	4.5	186	5.5	183	6.4	181	7.4	173	10.2	171	11.2	169	12.1	163	15.0	15	164	7.6
45	860	79	0.6	68	1.1	60	1.5	53	2.0	48	2.4	42	2.9	37	3.4									8	46	1.9
	1760	188	1.3	177	2.2	169	3.1	162	4.1	156	5.0	151	5.9	146	6.9	133	9.6							12	134	5.8
	3600	410	3.4	400	5.3	392	7.2	385	9.1	379	11.0	374	12.9	369	14.8	356	20.5							15	339	15.0
47	860	105	0.8	92	1.4	82	2.0	73	2.6	66	3.2	59	3.8	53	4.4									8	63	2.5
	1760	249	1.6	236	2.8	225	4.0	217	5.3	209	6.5	203	7.7	196	8.9									12	181	7.5
	3600	542	4.5	529	7.0	519	9.5	510	12.0	503	14.3	496	17.0	490	19.5									15	452	19.8
53	700	72	0.6	63	1.0	56	1.4	51	1.8	46	2.2	42	2.6	38	3.0									10	36	2.2
	1760	211	1.7	203	2.7	196	3.7	191	4.7	186	5.7	181	6.7	177	7.7	167	10.8	163	11.8	160	12.8			14	158	7.5
	2850	355	3.3	346	5.0	340	6.6	334	8.2	329	9.9	325	11.5	321	13.2	310	18.1	307	19.7	304	21.3	295	26.2	15	296	13.2
56	700	123	0.9	110	1.6	100	2.2	92	2.9	85	3.6	78	4.3	72	4.9									10	70	3.5
	1760	358	2.6	345	4.6	335	6.0	326	7.7	319	9.4	312	11.1	306	12.8	290	17.9							14	276	12.3
	2850	598	5.2	585	8.0	575	10.7	567	13.5	560	16.2	553	19.0	547	21.7	531	30.0							15	510	21.9
59	700	187	1.2	170	2.2	158	3.2	147	4.2	138	5.1	130	6.1											8	135	4.1
	1760	529	3.9	513	6.4	500	8.9	490	11.4	480	13.8	472	16.3	464	18.8									12	445	15.6
	2850	881	7.8	865	11.8	852	15.8	842	19.9	832	23.9	824	27.9	816	31.9									15	770	32.1
65	700	140	1.0	126	1.8	116	2.6	107	3.3	100	4.1	93	4.8	86	5.5	70	7.8							12	71	4.7
	1760	400	3.4	387	5.3	377	7.2	368	9.1	360	11.0	353	12.8	347	14.7	330	20.4	325	22.3	320	24.2	307	29.8	16	300	15.8
	2350	546	5.2	532	7.7	522	10.3	513	12.8	506	15.3	499	17.8	492	20.3	475	27.4	470	30.4	466	32.9	452	40.5	16	445	21.6
68	700	224	1.5	203	2.7	187	3.9	172	5.1	160	6.3	149	7.5	139	8.7									10	135	6.2
	1760	643	4.9	621	7.9	605	10.9	591	14.0	579	17.0	567	20.0	557	23.1	530	32.2	522	35.2	515	38.2			15	495	23.5
	2350	876	7.3	855	11.4	838	15.4	824	19.5	812	23.5	801	27.6	790	31.6	763	43.8	755	47.8	748	51.9			16	715	34.0
615	700	420	2.6	380	4.8	351	7.1	323	9.3	301	11.6	279	13.8											8	292	9.1
	1760	1205	8.1	1164	13.9	1133	19.5	1107	25.2	1084	30.8	1063	36.5											12	997	35.0
	2350	1641	11.9	1601	19.3	1570	27.0	1544	34.6	1521	43.2	1500	49.8											12	1433	47.5
76	575	195	1.3	179	2.3	168	3.3	158	4.3	150	5.4	142	6.4	134	7.4	115	10.4							12	117	6.2
	1400	526	4.0	511	6.4	500	9.0	490	11.5	481	13.9	473	16.4	466	18.8	447	26.3	441	28.7	436	31.2	421	38.6	16	413	20.4
	2050	788	6.9	772	10.5	761	14.2	751	17.8	742	21.4	734	25.0	727	28.6	708	39.5	703	43.1	697	46.7	682	57.6	16	674	30.6
711	575	362	2.2	336	4.0	316	5.9	299	7.7	284	9.6	271	11.4	258	13.3	226	18.8							12	228	11.2
	1400	970	6.5	944	11.0	925	15.5	908	20.0	893	24.5	880	29.0	867	33.5	835	47.1							15	793	34.4
	2050	1450	10.9	1424	17.5	1404	24.1	1387	30.7	1373	37.3	1359	43.9	1347	50.5	1315	70.3							16	1256	54.6
718	575	600	3.3	563	6.3	534	9.3	510	12.3	489	15.4	470	18.4											10	446	15.0
	1400	1590	9.7	1553	17.0	1524	24.3	1500	31.6	1479	39.0	1460	46.3											12	1398	44.6
	2050	2370	15.7	2333	26.9	2304	37.2	2280	47.9	2259	58.6	2240	69.4											12	2178	66.4

Notes: 1. Pressure ratings based on inlet air at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.
2. Vacuum ratings based on inlet air at standard temperature of 68°F, discharge pressure of 30" Hg and specific gravity of 1.0.

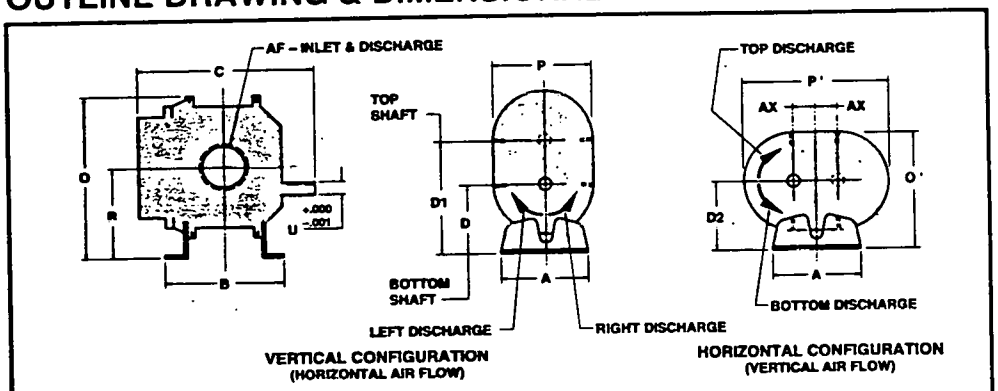
ROOTS Universal RAI-J™
WHISPAIR® ROTARY POSITIVE BLOWERS

FRAMES 33J THRU 56J





OUTLINE DRAWING & DIMENSIONAL TABLE



NOTES:
1. All dimensions are in inches.
2. Do not use for construction.

Frame Size	A	B	C	Drive shaft location D	D1	D2	O	O'	P	P'	R	U	Keyway	AF Inlet & Discharge Diameter	AX	Approx. Net Wt. (Lbs.)
33J	7.25	7.63	12.13	5.00	8.50	5.00	12.81	10.00	10.00	12.13	6.75	.750	.188 X .094	2.0 NPT	1.75	84
36J	7.25	10.00	14.63	5.00	8.50	5.00	12.81	10.50	11.00	12.13	6.75	.750	.188 X .094	2.5 NPT	1.75	112
45J	8.00	10.00	15.50	6.25	10.25	6.25	15.06	12.25	12.00	13.63	8.25	.875	.188 X .094	2.5 NPT	2.00	119
47J	8.00	11.75	17.63	6.25	10.25	6.25	15.06	12.25	12.00	13.63	8.25	.875	.188 X .094	3.0 NPT	2.00	138
56J	10.50	11.00	18.00	6.25	11.25	6.75	17.38	14.00	14.50	17.25	8.75	1.125	.250 x .125	4.0 NPT	2.50	180

BASIC BLOWER DESCRIPTION

Patented Universal RAI-J™ Whispair® blowers are heavy duty rotary blowers in a compact, sturdy design engineered for continuous service when operated within speed and pressure/vacuum ratings.

The basic model features a grey iron casing with a computer-designed cast relief for noise and shock suppression, carburized and ground alloy steel spur timing gears secured to steel shafts with a taper mounting and locknut, and grey iron involute impellers. Oversized anti-friction bearings are used, with a cylindrical roller bearing at the drive shaft to withstand V-belt pull.

Detachable rugged steel mounting feet permit easy in-field adaptability to either vertical or horizontal installation requirements. Because of the detachable mounting feet, these units can be easily adapted to any of four drive shaft positions – right hand, left hand, bottom or top.

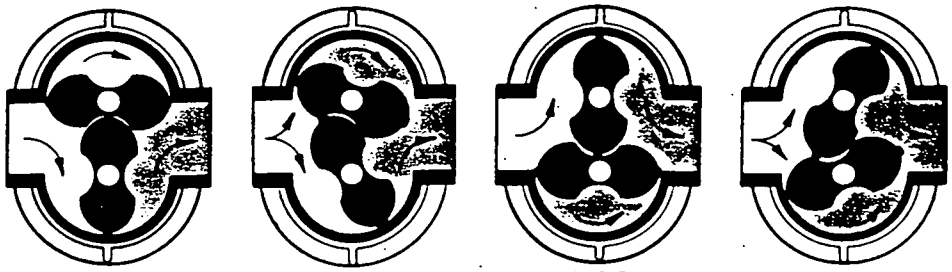
The Universal RAI-J incorporates thrust control, and has grease lube on the drive end and splash oil lube on the gear end. Roots exclusive "Figure 8" gearbox design improves oil distribution and lengthens bearing and gear life.

All Universal RAI-J blowers are covered by an uncontested warranty that guarantees repair or replacement of any unit that malfunctions for any reason. This protects you for a full 18 months from date of original start-up or 24 months from date of shipment, whichever occurs first.

Uncontested Warranty

For details, see page 3.

ROOTS ROTARY POSITIVE DISPLACEMENT PRINCIPLE



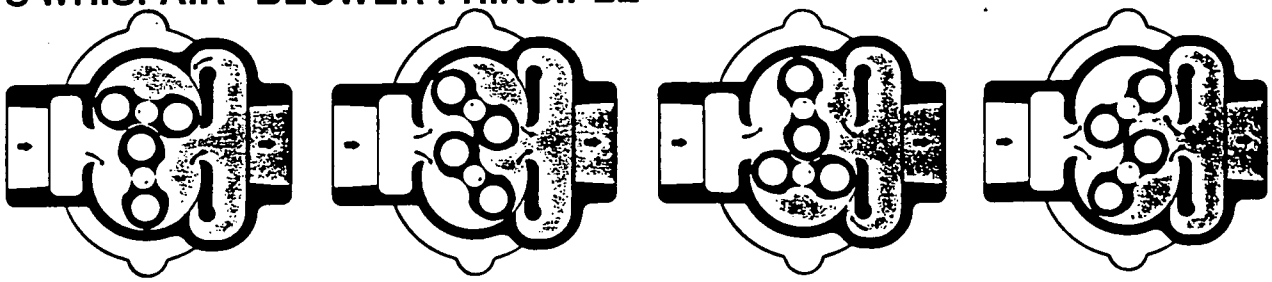
POSITION 1 POSITION 2 POSITION 3 POSITION 4

The schematic above shows the operation of a rotary positive blower.

The basic unit consists of two figure-eight shaped impellers mounted on parallel shafts. These impellers rotate in opposite directions within an elongated cylindrical housing. As each impeller passes the inlet, it traps a definite volume of air and carries it around the casing to the discharge, where it is expelled. The cycle repeats four times with every revolution.

All rotary positive blowers have close tolerances between the impellers, headplates and casing to minimize back-slippage of air and to improve efficiency.

ROOTS WHISPAIR® BLOWER PRINCIPLE



POSITION 1 POSITION 2 POSITION 3 POSITION 4

The Whispair® blower operates on the same basic principle as all other rotary positive displacement blowers with one important advantage – units with the Whispair design offer reduced pulsation, operating noise and power loss by utilizing an exclusive wrap-around plenum to control pressure equalization. Whispair blowers (shown above) have a proprietary jet to feed backflow in the direction of impeller movement, aiding rotation and lowering power requirements.

Incoming air is trapped by the impellers and moved through the machine as in the basic rotary positive displacement principle. As pressure builds against the wrap-around plenum due to system resistance, the Whispair blower jet equalizes the pressure between the trapped air and the discharge area. This action reduces shock and feeds the backflow in the direction of rotation.

As the impeller completes its cycle, it discharges the trapped air, which now has the same pressure as the discharge line. Backflow is controlled, resulting in reduced pulsation compared to the conventional blower. This improves efficiency, reduces noise level, and increases bearing and gear life.

Made in the U.S.A.

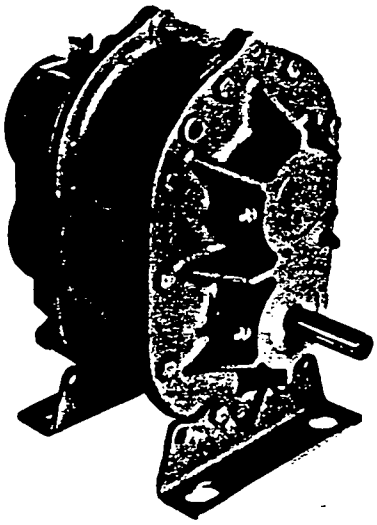
Uncontested Warranty

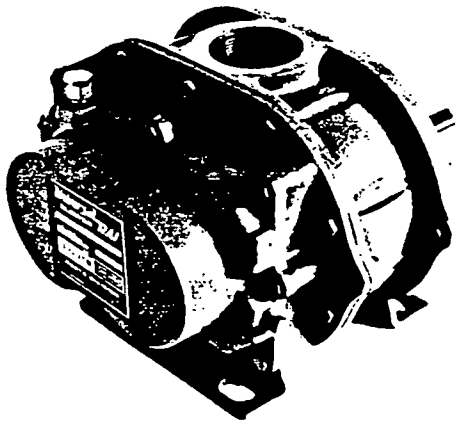
Roots is the leader in blower warranties – the first to introduce an *uncontested* warranty that guarantees repair or replacement of any Universal RAI®, Universal RAI-J™ or RAM™ series unit that malfunctions *for any reason*. We'll protect you or your customer for a full 18 months from date of original start-up or 24 months from date of shipment, whichever occurs first.

ISO 9001 CERTIFIED
ROOTS QUALITY SYSTEM

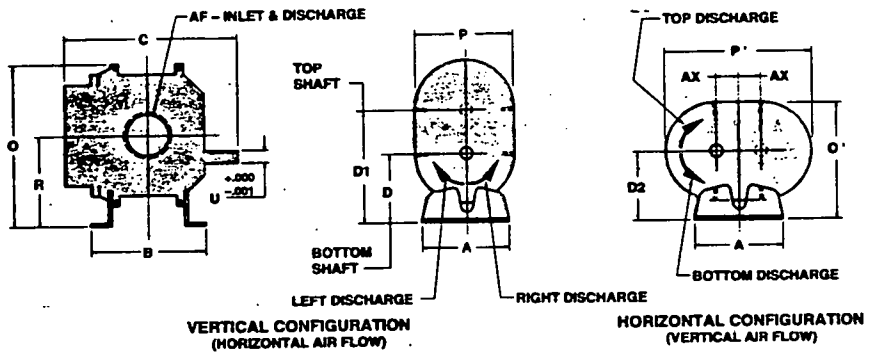
ROOTS Universal RAI®
ROTARY POSITIVE BLOWERS

FRAMES 22 THRU 718





OUTLINE DRAWING & DIMENSIONAL TABLE



NOTES:
1. All dimensions are in inches.
2. Do not use for construction.

Frame Size	A	B	C	Drive shaft location D	D1	D2	O	O'	P	P'	R	U	Keyway	AF Inlet & Discharge Diameter	AX	Approx. Net Wt. (Lbs.)
22	5.13	5.00	9.75	3.75	6.25	3.75	9.63	6.88	6.25	9.25	5.00	.625	.188 x .094	1.0 NPT	1.25	32
24	5.13	7.00	11.75	3.75	6.25	3.75	9.63	6.88	6.25	9.25	5.00	.625	.188 x .094	2.0 NPT	1.25	43
32	7.25	6.75	11.25	5.00	8.50	5.00	12.81	8.88	7.75	12.13	6.75	.750	.188 x .094	1.25 NPT	1.75	69
33	7.25	7.63	12.13	5.00	8.50	5.00	12.81	8.88	7.75	12.13	6.75	.750	.188 x .094	2.0 NPT	1.75	74
36	7.25	10.00	14.63	5.00	8.50	5.00	12.81	8.88	7.75	12.13	6.75	.750	.188 x .094	2.5 NPT	1.75	102
42	8.00	7.25	13.00	6.25	10.25	6.25	15.06	10.63	8.75	13.63	8.25	.875	.188 x .094	1.5 NPT	2.00	88
45	8.00	10.00	15.50	6.25	10.25	6.25	15.06	10.63	8.75	13.63	8.25	.875	.188 x .094	2.5 NPT	2.00	109
47	8.00	11.75	17.63	6.25	10.25	6.25	15.06	10.50	8.50	13.63	8.25	.875	.188 x .094	3.0 NPT	2.00	128
53	10.50	8.38	15.38	6.25	11.25	6.75	17.38	11.88	10.25	17.25	8.75	1.125	.250 x .125	2.5 NPT	2.50	143
56	10.50	11.00	18.00	6.25	11.25	6.75	17.38	12.25	11.00	17.25	8.75	1.125	.250 x .125	4.0 NPT	2.50	170
59	10.50	14.00	21.18	6.25	11.25	6.75	17.38	12.25	11.00	17.25	8.75	1.125	.250 x .125	4.0 NPT	2.50	204
65	11.00 *	10.00	18.38	8.75	14.75	8.75	21.63	15.13	12.75	19.75	11.75	1.375	.312 x .156	3.0 NPT	3.00	245
68	11.00 *	13.00	21.38	8.75	14.75	8.75	21.63	15.13	12.75	19.75	11.75	1.375	.312 x .156	5.0 NPT	3.00	285
615	11.00 *	20.00	28.38	8.75	14.75	8.75	21.63	16.25	15.00	19.75	11.75	1.375	.312 x .156	6.0 FLG	3.00	425
76	14.00 **	11.75	19.94	11.00	18.00	11.00	26.13	20.69	19.38	23.25	14.50	1.562	.375 x .188	4.0 NPT	3.50	400
711	14.00 **	16.75	25.19	11.00	18.00	11.00	26.13	19.50	17.00	23.25	14.50	1.562	.375 x .188	6.0 FLG	3.50	530
718	14.00 **	23.75	32.19	11.00	18.00	11.00	26.13	19.50	17.00	23.25	14.50	1.562	.375 x .188	8.0 FLG	3.50	650

* 17.00 in horizontal configuration
** 21.00 in horizontal configuration

BASIC BLOWER DESCRIPTION

Universal RAI® blowers are heavy duty rotary blowers in a compact, sturdy design engineered for continuous service when operated within speed and pressure/vacuum ratings.

The basic model features a grey iron casing, carburized and ground alloy steel spur timing gears secured to steel shafts with a taper mounting and locknut, and grey iron involute impellers. Oversized anti-friction bearings are used, with a cylindrical roller bearing at the drive shaft to withstand V-belt pull.

Detachable rugged steel mounting feet permit easy in-field adaptability to either vertical or horizontal installation requirements. Because of the detachable mounting feet, these units can be easily adapted to any of four drive shaft positions – right hand, left hand, bottom or top. All frame sizes are center-timed to allow rotation in either direction.

The Universal RAI incorporates thrust control, and has grease lube on the drive end and splash oil lube on the gear end. Roots exclusive "Figure 8" gearbox design improves oil distribution and lengthens bearing and gear life.

All Universal RAI blowers are covered by an uncontested warranty that guarantees repair or replacement of any unit that malfunctions for any reason. This protects you for a full 18 months from date of original start-up or 24 months from date of shipment, whichever occurs first.

Also available in 6 sizes are RootsPak™ factory-engineered, completely assembled packaged units incorporating 17 frame sizes of Universal RAI rotary positive blowers. For complete information on these units, please turn to pages 8 thru 11.

Uncontested Warranty

For details, see page 3.

UNIVERSAL RAI-J™ PERFORMANCE TABLE

FRAME SIZE	SPEED RPM	4" Hg VACUUM CFM	4" Hg VACUUM BHP	6" Hg VACUUM CFM	6" Hg VACUUM BHP	8" Hg VACUUM CFM	8" Hg VACUUM BHP	10" Hg VACUUM CFM	10" Hg VACUUM BHP	12" Hg VACUUM CFM	12" Hg VACUUM BHP	14" Hg VACUUM CFM	14" Hg VACUUM BHP	15" Hg VACUUM CFM	15" Hg VACUUM BHP	MAX. PRESSURE PSI	MAX. PRESSURE CFM	MAX. PRESSURE BHP
33J	1160	47	0.8	40	1.1	33	1.4	27	1.7							7	28	2.4
	2800	148	2.0	141	2.7	134	3.4	128	4.1	121	4.9	113	5.6			12	116	9.5
	3600	197	2.7	190	3.6	184	4.6	177	5.3	170	6.3	163	7.2	159	7.6	12	165	12.4
36J	1160	83	1.2	74	1.7	65	2.2	55	2.7							7	57	3.8
	2800	251	3.2	241	4.4	232	5.7	223	6.6	213	7.9	202	9.1			7	224	9.5
	3600	332	4.4	323	6.0	313	7.6	304	8.7	294	10.3	284	11.9	278	12.7	7	306	12.5
45J	860	66	1.1	56	1.5	46	1.9									7	37	3.4
	1760	175	2.2	164	3.1	154	4.0	144	4.9	134	5.8					10	133	9.6
	3600	398	5.2	387	7.1	377	8.9	367	10.3	356	12.2	345	14.1	339	15.0	10	356	20.5
47J	860	89	1.3	76	1.9	63	2.5	51	3.0							7	53	4.4
	1760	233	2.9	220	4.1	207	5.3	194	6.3	181	7.5					7	196	9.0
	3600	526	6.9	513	9.3	500	11.8	488	13.6	474	16.1	460	18.5	452	19.8	7	490	19.5
56J	700	108	1.5	95	2.2	82	2.9	70	3.5							7	72	4.9
	1760	342	4.3	329	5.9	316	7.6	304	9.0	291	10.6	276	12.3			10	290	17.9
	2850	583	7.9	570	10.6	557	13.2	545	15.2	532	17.9	517	20.6	510	21.9	10	531	30.0

Notes: 1. Vacuum ratings based on inlet air at standard temperature of 68°F, discharge pressure of 30" Hg and specific gravity of 1.0.
2. Pressure ratings based on inlet air at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.

LOWER AIR PULSATION

Patented Whispair blowers operate with up to 50% less pressure pulsation than conventional blowers due to the pressure equalizing effect of the Whispair design.

In conventional blowers, as the impeller opens up to the outlet port, the higher pressure air in the discharge line rapidly expands into the lower pressure pocket formed by the impeller and the blower case. The resulting shock wave strikes the advancing surface of the impeller at sonic velocity. Four pressure pulses occur each revolution, transmitting shock loads to the gears and bearings.

LONGER BEARING LIFE

The pre-pressurization of the low pressure pocket through the Whispair cavity smooths the pulsations and results in less shock being transmitted through the impellers to the bearings, resulting in approximately 20% longer bearing life.

LOWER VIBRATION

The reduction in the magnitude of the pressure pulsation results in smoother operation.

LOWER NOISE

The pressure pulses, inherent in the rotary-lobe design, are also the major source of blower noise. The rapid backflow of air into the blower from the discharge line, four times per revolution, results in high noise levels in the conventional blower. The Whispair design controls the backflow of air into the blower, reducing noise by approximately 5 dB vacuum, 3 dB pressure.

ROOTS RAM™
ROTARY POSITIVE BLOWERS

FRAMES 404 THRU 624

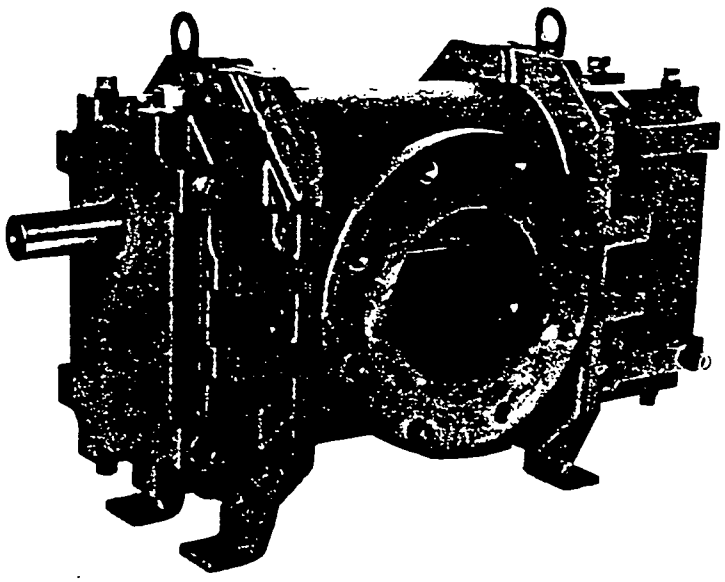
BASIC BLOWER DESCRIPTION

RAM rotary blowers are heavy-duty units designed with integral-shaft ductile iron impellers having an involute profile. The headplates and rigid, one-piece casing are grey iron, while the drive end cover and gear cover are aluminum. Carburized and ground alloy steel spur timing gears are taper mounted on the shafts, secured with a locknut. Cylindrical roller bearings are used on all units.

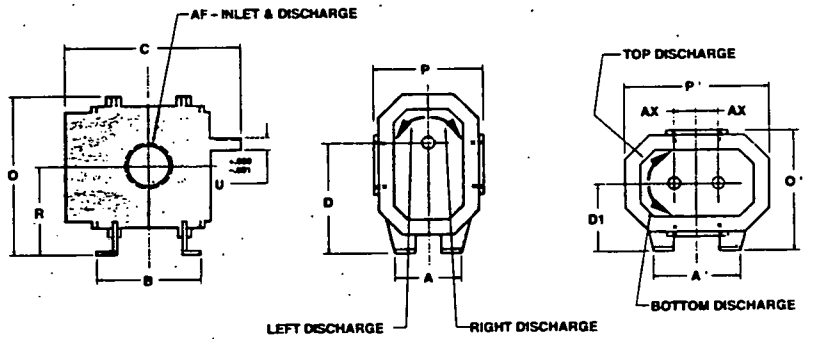
Piston rings reduce air leakage through the shaft openings in the headplates, and lip-type oil seals prevent lubricant from entering the air chamber. RAM rotary blowers incorporate thrust control, with splash oil lubrication at both ends of the blower.

All frame sizes are designed with detachable rugged steel mounting feet which permit in-field adaptability to either vertical or horizontal installation requirements.

The top shaft is extended for drive on side outlet blowers, and either shaft can be extended for drive on top or bottom outlet blowers. All frame sizes are center-timed to allow rotation in either direction.



OUTLINE DRAWING & DIMENSIONAL TABLE



VERTICAL CONFIGURATION (HORIZONTAL AIR FLOW)

HORIZONTAL CONFIGURATION (VERTICAL AIR FLOW)

NOTES:
1. All dimensions are in inches.
2. Do not use for construction.

Frame Size	A	A'	B	C	Drive shaft location D	Drive shaft location D1	O	O'	P	P'	R	U	Keyway	AF Inlet & Discharge Diameter	AX	Approx. Net Wt. (Lbs.)
404	7.00	11.50	8.00	18.50	11.25	6.75	16.63	12.75	12.00	15.25	9.00	1.500	.375 X .188	3.0 NPT	2.25	200
406	7.00	11.50	10.00	20.50	11.25	6.75	16.63	12.75	12.00	15.25	9.00	1.500	.375 X .188	4.0 NPT	2.25	230
409	7.00	11.50	13.00	23.50	11.25	6.75	16.63	12.50	11.00	15.25	9.00	1.500	.375 X .188	4.0 NPT	2.25	27[illegible]
412	7.00	11.50	16.00	26.50	11.25	6.75	16.63	12.50	11.00	15.25	9.00	1.500	.375 X .188	6.0 FLG	2.25	33[illegible]
418	7.00	11.50	22.00	32.50	11.25	6.75	16.63	12.50	11.00	15.25	9.00	1.500	.375 X .188	8.0 FLG	2.25	410
616	10.00	16.00	21.44	32.44	15.00	9.00	22.00	16.25	14.50	20.00	12.00	2.000	.500 X .250	8.0 FLG	3.00	650
624	10.00	16.00	29.44	40.44	15.00	9.00	22.00	16.25	14.50	20.00	12.00	2.000	.500 X .250	10.0 FLG	3.00	775

RAM PERFORMANCE TABLE

FRAME SIZE	SPEED RPM	4 PSI		6 PSI		8 PSI		10 PSI		12 PSI		15 PSI		18 PSI		MAX. VACUUM		
		CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	"Hg	CFM	BHP
404	1750	149	3.6	139	5.3	130	7.0	123	8.7	116	10.4	107	12.0			14.0	115	5.9
	2950	281	7.0	271	9.8	262	12.6	255	15.4	248	18.2	239	22.4	231	26.6	15.0	240	11.2
	4000	396	8.3	386	14.2	378	17.9	370	21.6	364	25.3	355	30.9	347	37.0	16.0	353	15.9
406	1750	225	5.4	210	8.0	198	10.5	187	13.0	177	15.6	163	19.6			14.0	173	9.0
	2950	426	10.5	411	14.7	398	18.9	387	23.1	377	27.3	363	33.6	351	40.0	15.0	365	16.9
	4000	601	15.0	586	20.1	574	26.0	562	31.9	552	37.0	539	46.5	526	54.0	16.0	531	23.6
409	1750	338	8.5	315	12.0	296	15.8	279	20.0	264	23.5	244	29.2			14.0	259	13.5
	2950	638	15.2	615	21.5	596	27.8	579	34.1	564	40.4	544	49.8	525	59.4	15.0	546	24.8
	4000	900	24.0	878	30.0	859	38.1	842	46.8	827	55.0	806	67.9	788	79.0	16.0	795	35.1
412	1750	450	11.0	420	16.0	394	21.0	372	26.0	352	32.0	325	39.0			14.0	343	17.9
	2950	849	19.9	819	28.3	794	36.6	772	45.0	752	53.4	724	66.0			15.0	728	32.7
	4000	1199	28.8	1169	39.9	1144	51.0	1121	62.2	1101	73.3	1074	90.0			16.0	1059	46.5
418	1750	675	16.5	630	24.0	592	31.7	559	39.0							14.0	515	26.8
	2950	1275	29.5	1230	42.1	1192	54.7	1159	67.3							15.0	1092	48.9
	4000	1800	42.9	1755	59.7	1717	73.4	1684	93.1							16.0	1590	69.7
616	1170	718	16.9	672	24.9	633	32.9	599	40.9	568	49.0					13.0	579	25.9
	1750	1176	26.2	1130	38.2	1091	50.1	1056	62.0	1025	73.9					14.0	1013	42.0
	3000	2162	48.9	2116	68.7	2077	88.5	2043	108.3	2012	128.0	1970	157.7			16.0	1946	81.7
624	1170	1077	25.4	1008	37.5	950	49.5	899	61.5							13.0	869	39.0
	1750	1764	39.9	1695	57.8	1637	75.7	1585	93.6							14.0	1519	63.4
	3000	3244	77.6	3175	107.3	3117	137.0	3065	166.7							16.0	2920	124.6

Notes: 1. Pressure ratings based on inlet air at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.
2. Vacuum ratings based on inlet air at standard temperature of 68°F, discharge pressure of 30" Hg and specific gravity of 1.0.

Uncontested Warranty

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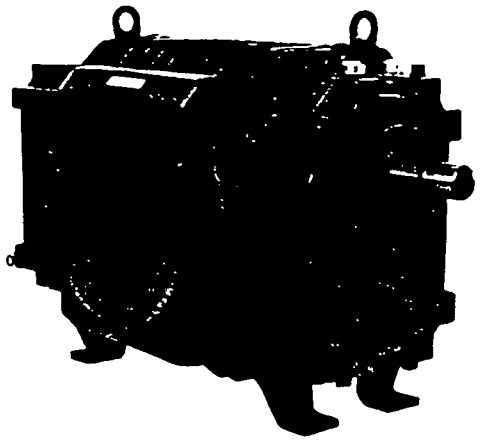
ROOTS RAM™ WHISPAIR®
ROTARY POSITIVE BLOWERS & GAS PUMPS

FRAMES 404J THRU 624J



BASIC BLOWER DESCRIPTION

RAM Whispair® rotary blowers are heavy-duty units designed with integral-shaft ductile iron impellers having an involute profile. Whispair blowers reduce noise and power loss by utilizing an exclusive wrap-around plenum and proprietary Whispair jet to control pressure equalization – feeding backflow in the direction of impeller movement, thereby aiding rotation.

The headplates and rigid, one-piece casing are grey iron, while the drive end cover and gear cover are aluminum. Carburized and ground alloy steel spur timing gears are taper mounted on the shafts, secured with a locknut. Cylindrical roller bearings are used.

Piston rings reduce air leakage through the shaft openings in the headplates, and lip-type oil seals prevent lubricant from entering the air chamber. RAM rotary blowers incorporate thrust control, with splash oil lubrication at both ends of the blower. A hydrodynamic seal on the drive shaft prevents shaft seal oil leaks.

All frame sizes are designed with detachable rugged steel mounting feet which permit in-field adaptability to either vertical or horizontal installation requirements.

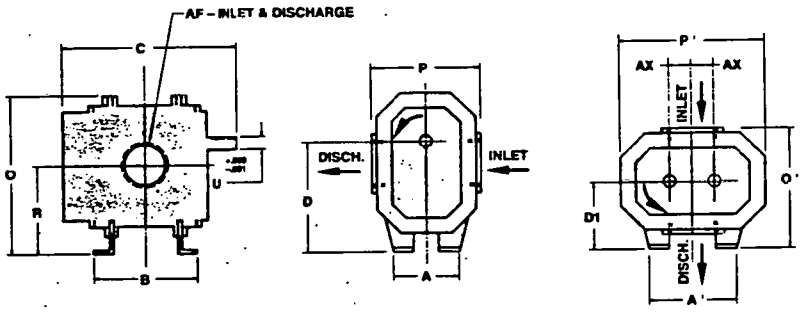
The top shaft is extended for drive on side outlet blowers, and either shaft can be extended for drive on top or bottom outlet blowers.

BASIC GAS PUMP DESCRIPTION

The RAM Whispair line of standard rotary positive gas pumps is intended for use with non-corrosive gases. Basic design features are the same as for RAM Whispair blowers. Stainless steel construction is available for corrosive gases and optional O-ring material is also available.

Piston ring seals form a labyrinth between the compression chamber and cored vent cavities. The vent cavities are plugged for purge or drain. Special long-life mechanical seals and viton O-rings are installed at each bearing to control gas and oil leakage, and are suitable for vacuum or pressure service. Each seal incorporates a unique geometry that promotes the flow of oil, air and vapor across the back of the stainless steel seat to enhance cooling and extend seal life.

OUTLINE DRAWING & DIMENSIONAL TABLE



NOTES:
1. All dimensions are in inches.
2. Do not use for construction.

VERTICAL CONFIGURATION (HORIZONTAL AIR FLOW)

HORIZONTAL CONFIGURATION (VERTICAL AIR FLOW)

Frame Size	A	A'	B	C	Drive shaft location D	Drive shaft location D1	O	O'	P	P'	R	U	Keyway	AF Inlet & Discharge Diameter	AX	Approx. Net Wt. (Lbs.)
404J	7.00	11.50	8.00	18.50	11.25	6.75	16.63	12.75	12.00	15.25	9.00	1.500	.375 X .188	3.0 NPT	2.25	200
406J	7.00	11.50	10.00	20.50	11.25	6.75	16.63	12.75	12.00	15.25	9.00	1.500	.375 X .188	4.0 NPT	2.25	230
409J	7.00	11.50	13.00	23.50	11.25	6.75	16.63	12.50	11.00	15.25	9.00	1.500	.375 X .188	4.0 NPT	2.25	270
412J	7.00	11.50	16.00	26.50	11.25	6.75	16.63	12.50	11.00	15.25	9.00	1.500	.375 X .188	6.0 FLG	2.25	330
418J	7.00	11.50	22.00	32.50	11.25	6.75	16.63	12.50	11.00	15.25	9.00	1.500	.375 X .188	8.0 FLG	2.25	410
616J	10.00	16.00	21.44	32.44	15.00	9.00	22.00	16.25	14.50	20.00	12.00	2.000	.500 X .250	8.0 FLG	3.00	650
624J	10.00	16.00	29.44	40.44	15.00	9.00	22.00	16.25	14.50	20.00	12.00	2.000	.500 X .250	10.0 FLG	3.00	775

RAM PERFORMANCE TABLE

FRAME SIZE	SPEED RPM	4 PSI		6 PSI		8 PSI		10 PSI		12 PSI		15 PSI		18 PSI		MAX VACUUM		
		CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	"Hg	CFM	BHP
404J	1750	149	3.6	139	5.3	130	7.0	123	8.7	116	10.4	107	12.0			14.0	115	5.9
	2950	281	7.0	271	9.8	262	12.6	255	15.4	248	18.2	239	22.4	231	26.6	15.0	240	10.9
	4000	396	8.3	386	14.2	378	17.9	370	21.6	364	25.3	355	30.9	347	37.0	16.0	353	15.9
406J	1750	225	5.4	210	8.0	198	10.5	187	13.0	177	15.6	163	19.6			14.0	173	9.0
	2950	426	10.5	411	14.7	398	18.9	387	23.1	377	27.3	363	33.6	351	40.0	15.0	365	16.4
	4000	601	15.0	586	20.1	574	26.0	562	31.9	552	37.0	539	46.5	526	54.0	16.0	531	23.6
409J	1750	338	8.5	315	12.0	296	15.8	279	20.0	264	23.5	244	29.2			14.0	259	13.5
	2950	638	15.2	615	21.5	596	27.8	579	34.1	564	40.4	544	49.8	525	59.4	15.0	546	24.4
	4000	900	24.0	878	30.0	859	38.1	842	46.8	827	55.0	806	67.9	788	79.0	16.0	795	35.1
412J	1750	450	11.0	420	16.0	394	21.0	372	26.0	352	32.0	325	39.0			14.0	343	17.1
	2950	849	19.9	819	28.3	794	36.6	772	45.0	752	53.4	724	66.0			15.0	728	32.3
	4000	1199	28.8	1169	39.9	1144	51.0	1121	62.2	1101	73.3	1074	90.0			16.0	1059	46.5
418J	1750	675	16.5	630	24.0	592	31.7	559	39.0							14.0	515	26.5
	2950	1275	29.5	1230	42.1	1192	54.7	1159	67.3							15.0	1092	48.4
	4000	1800	42.9	1755	59.7	1717	73.4	1684	93.1							16.0	1590	69.7
616J	1170	718	16.9	672	24.9	633	32.9	599	40.9	568	49.0					13.0	579	25.9
	1750	1176	26.2	1130	38.2	1091	50.1	1056	62.0	1025	73.9					14.0	1013	42.0
	3000	2162	48.9	2116	68.7	2077	88.5	2043	108.3	2012	128.0	1970	157.7			16.0	1946	81.7
624J	1170	1077	25.4	1008	37.5	950	49.5	899	61.5							13.0	869	39.0
	1750	1764	39.9	1695	57.8	1637	75.7	1585	93.6							14.0	1519	63.4
	3000	3244	77.6	3175	107.3	3117	137.0	3065	166.7							16.0	2920	124.6

Notes: 1. Pressure ratings based on inlet air at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.
2. Vacuum ratings based on inlet air at standard temperature of 68°F, discharge pressure of 30" Hg and specific gravity of 1.0.

RAM Whispair blower notes:

1. Pressure ratings based on inlet air at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.
2. Vacuum ratings based on inlet air at standard temperature of 68°F, discharge pressure of 30" Hg and specific gravity of 1.0.

RAM Whispair gas pump notes:

1. Pressure ratings based on inlet gas at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.
2. Estimated acfm for specific gravity of 0.6
   Multiply tabulated cfm by:
   4 - 10 psig – 0.90
   12 - 15 psig – 0.85
3. Consult Factory for performance of units with stainless steel construction.

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ROOTS RAM™ WHISPAIR®
WATER-SEALED VACUUM PUMPS

FRAMES 406J THRU 624J
BASIC VACUUM PUMP DESCRIPTION

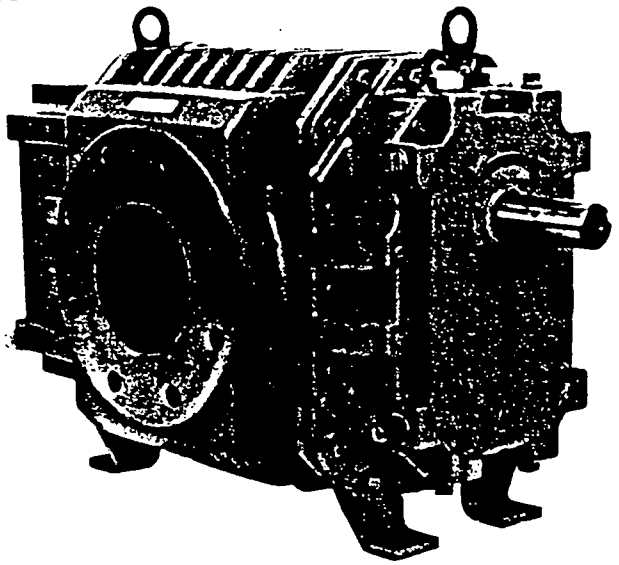
RAM Whispair water-sealed rotary vacuum pumps are heavy-duty units designed with integral-shaft ductile iron impellers. Whispair vacuum pumps reduce noise and power loss by utilizing an exclusive wrap-around plenum and proprietary Whispair jet to control pressure equalization – feeding backflow in the direction of impeller movement, thereby aiding rotation.

The headplates and rigid, one-piece casing are grey iron, while the drive end cover and gear cover are aluminum. Carburized and ground alloy steel spur timing gears are taper mounted on the shafts, secured with a locknut. Cylindrical roller bearings are used.

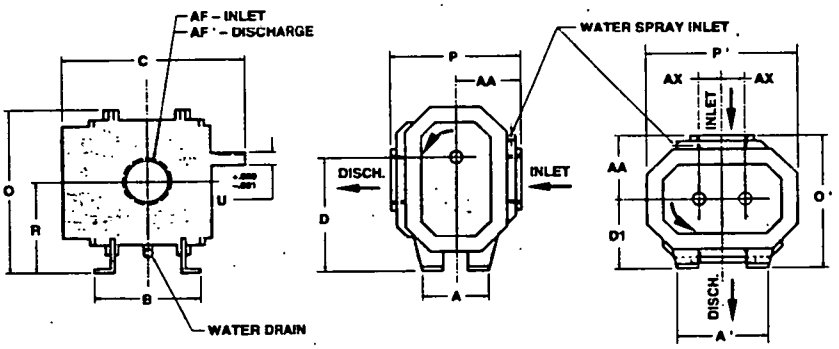
Piston rings reduce air leakage through the shaft openings in the headplates, and lip-type oil seals prevent lubricant from entering the air chamber. RAM Whispair vacuum pumps incorporate thrust control, with splash oil lubrication at both ends of the units. A hydrodynamic seal on the drive shaft prevents shaft seal oil leaks.

All frame sizes are designed with detachable rugged steel mounting feet which permit in-field adaptability to either vertical or horizontal installation requirements.

The top shaft is extended for drive on side outlet vacuum pumps, and either shaft can be extended for drive on bottom outlet vacuum pumps. An inlet spray nozzle and seal water flow meter are supplied for water injection.



OUTLINE DRAWING & DIMENSIONAL TABLE



NOTES:
1. All dimensions are in inches.
2. Do not use for construction.

VERTICAL CONFIGURATION (HORIZONTAL AIR FLOW)

HORIZONTAL CONFIGURATION (VERTICAL AIR FLOW)

Frame Size	A	A'	B	C	Drive shaft location D	Drive shaft location D1	O	O'	P	P'	R	U	Keyway	AF Inlet Diameter	AF' Discharge Diameter	AA	AX	Approx. Net Wt. (Lbs.)
406J	8.00	11.00	10.75	20.50	11.25	7.50	16.63	14.75	14.50	15.25	9.00	1.500	.375 X .188	4.0 NPT	4.0 NPT	7.25	2.25	300
409J	8.00	11.00	13.75	23.50	11.25	7.50	16.63	14.75	14.50	15.25	9.00	1.500	.375 X .188	5.0 NPT	5.0 NPT	7.25	2.25	350
412J	8.00	11.00	16.75	26.50	11.25	7.50	16.63	13.50	13.00	15.25	9.00	1.500	.375 X .188	6.0 FLG	5.0 FLG	6.00	2.25	400
418J	8.00	11.00	22.75	32.50	11.25	7.50	16.63	14.50	14.00	15.25	9.00	1.500	.375 X .188	8.0 FLG	6.0 FLG	7.00	2.25	500
616J	10.00	16.00	21.44	32.44	15.00	9.00	22.00	16.50	16.25	20.00	12.00	2.000	.500 X .250	8.0 FLG	6.0 FLG	7.50	3.00	800
624J	10.00	16.00	29.44	40.44	15.00	9.00	22.00	17.50	17.50	20.00	12.00	2.000	.500 X .250	10.0 FLG	8.0 FLG	8.75	3.00	1000

RAM WATER-SEALED VACUUM PUMP PERFORMANCE TABLE

FRAME SIZE	SPEED RPM	10" Hg VAC. CFM	10" Hg VAC. BHP	15" Hg VAC. CFM	15" Hg VAC. BHP	16" Hg VAC. CFM	16" Hg VAC. BHP	20" Hg VAC. CFM	20" Hg VAC. BHP	22" Hg VAC. CFM	22" Hg VAC. BHP	24" Hg VAC. CFM	24" Hg VAC. BHP
406J	1530	181	6.4	160	9.0	154	9.6	118	11.7	87	12.7	33	13.8
	2325	301	10.9	276	14.8	269	15.6	228	18.8	191	20.4	127	21.9
	3200	436	17.1	408	22.5	400	23.5	353	27.8	311	29.9	240	32.0
409J	1530	284	9.2	257	13.2	249	13.9	201	17.1	160	18.6	88	20.3
	2325	458	14.8	423	20.9	413	22.1	353	26.8	300	29.5	311	31.6
	3200	653	22.4	611	31.1	600	32.7	528	39.0	466	42.4	359	45.4
412J	1530	379	11.9	342	17.2	331	18.2	268	22.4	213	24.5	118	26.6
	2325	610	19.3	563	27.2	550	28.8	470	35.1	400	38.3	280	41.4
	3200	870	29.0	815	39.6	800	41.7	705	50.2	620	54.4	475	58.7
418J	1530	570	17.4	513	25.3	500	26.9						
	2325	815	27.7	845	39.4	825	41.9						
	3200	1305	40.9	1230	56.8	1200	59.9						
616J	1160	796	20.7	746	30.2	734	32.0	661	39.6	596	43.4	504	47.1
	1750	1245	32.7	1175	46.7	1160	49.6	1075	60.9	975	66.4	855	72.1
	2400	1703	48.3	1634	67.1	1623	70.9	1523	85.9	1434	93.5	1238	101.1
624J	1160	1192	30.1	1117	44.2	1100	47.1						
	1750	1840	46.7	1755	67.7	1725	71.9						
	2400	2552	67.1	2448	95.2	2431	100.9						

Note: 1. Vacuum ratings based on inlet air at standard temperature of 68°F, discharge pressure of 30" Hg and specific gravity of 1.0.

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ROOTS RAM™ WHISPAIR®
DRY VACUUM PUMPS

FRAMES 406, 412 AND 616 DVJ
BASIC DRY VACUUM PUMP DESCRIPTION

The Roots RAM Whispair dry vacuum pump has an exclusive discharge jet plenum design which allows cool, atmospheric air to flow into the casing. This unique design permits continuous operation at vacuum levels to blank-off with a single stage unit, without water injection.

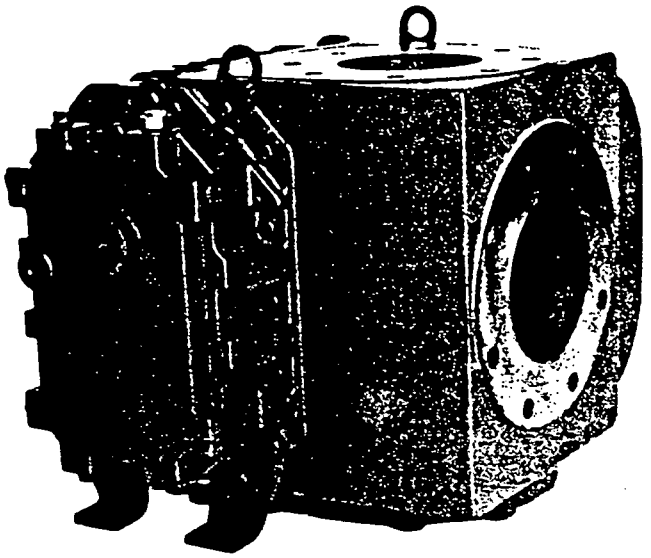
Standard dry vacuum pumps are limited to approximately 16" Hg vacuum because operation at higher vacuum levels can cause extreme discharge temperatures resulting in casing and impeller distortion. The RAM vacuum pump's cooling design eliminates the problems caused by high temperatures at vacuum levels beyond 16" Hg.

RAM Whispair dry vacuum pumps are heavy-duty units designed with integral-shaft ductile iron impellers. Whispair vacuum pumps reduce noise and power loss by utilizing an exclusive wrap-around plenum and proprietary Whispair jet to control pressure equalization – feeding backflow in the direction of impeller movement, thereby aiding rotation.

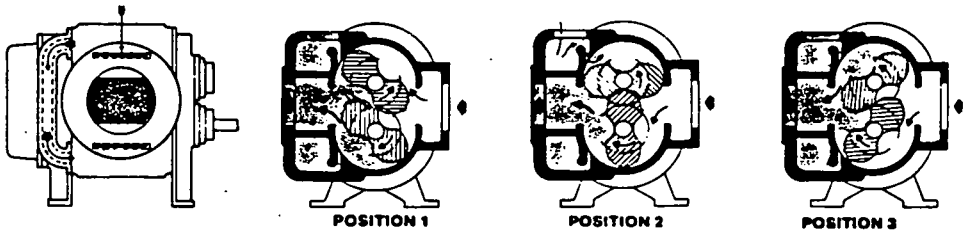
The casing and headplates are grey iron, while the drive end cover and gear cover are die cast aluminum. Carburized and ground alloy steel spur timing gears are taper mounted on the shafts, secured with a locknut. Cylindrical roller bearings are used, with splash lubrication at both the gear end and the drive end.

Piston rings reduce air leakage through the headplate bores and lip-type oil seals prevent lubricants from entering the air chamber. RAM Whisper dry vacuum pumps can also be equipped with mechanical seals for gas applications.

Detachable rugged steel mounting feet permit in-field adaptability to either vertical or horizontal installation requirements.



OPERATING PRINCIPLE



Shaded blue areas indicate air pressure variations from intake to atmospheric discharge.

Position 1:
Incoming air is trapped between the impellers and the case, producing a vacuum in the application system. Simultaneously, air is discharged (left) from the vacuum pump.

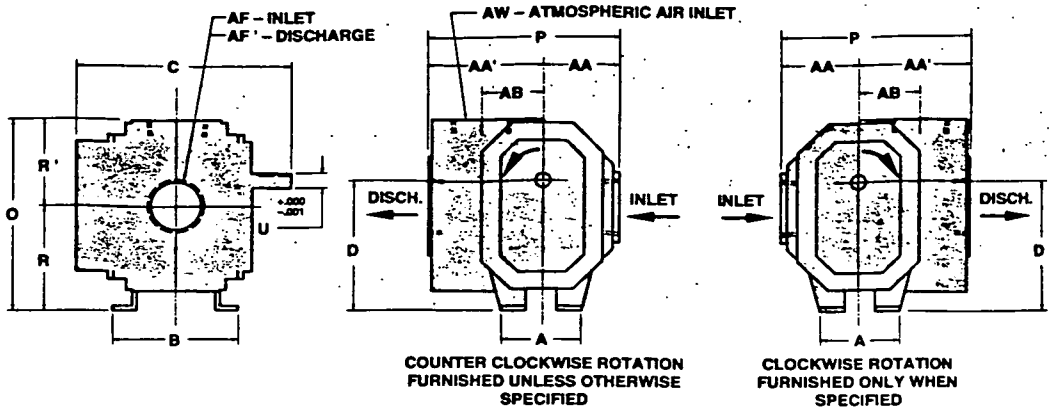
Position 2:
As the upper impeller passes the jet plenum, atmospheric air flows into the space between the impeller and the case. This cools the trapped air, aids impeller movement, and reduces discharge shock and power loss.

Position 3:
The trapped air is then moved to the discharge fla (left). Backflow is reduced, sulting in lower discharge noise relative to conventional rotary vacuum pumps.

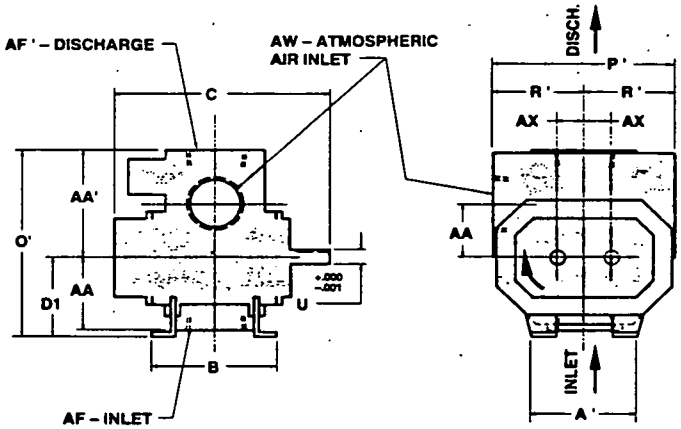
RAM WHISPAIR DRY VACUUM PUMP
OUTLINE DRAWING & DIMENSIONAL TABLE

ROOTS DRESSER

VERTICAL CONFIGURATION (HORIZONTAL AIR FLOW)



HORIZONTAL CONFIGURATION (VERTICAL AIR FLOW)



NOTES:
1. All dimensions are in inches.
2. Do not use for construction.

FRAME SIZE	A	A'	B	C	D	D1	O	O'	P	P'	R	R'	U	KEYWAY	AA	AA'	AB	AF	AF'	AW	AX	WGT.
406J	8.00	11.00	10.75	20.50	11.25	7.50	16.38	18.00	17.75	14.75	9.00	7.38	1.500	.375 X .188	7.25	10.50	6.75	4 NPT	5 NPT	4 NPT	2.25	365
412J	8.00	11.00	16.75	26.50	11.25	7.50	16.63	19.25	17.75	15.25	9.00	7.63	1.500	.375 X .188	6.00	11.75	6.50	6 FLG	6 FLG	5 FLG	2.25	575
616J	10.00	16.00	21.44	32.50	15.00	9.00	21.63	22.75	21.25	19.25	12.00	9.63	2.000	.500 X .250	7.50	13.75	6.75	8 FLG	10 FLG	8 FLG	3.00	975

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Uncontested Warranty

RAM WHISPAIR DRY VACUUM PUMP
PERFORMANCE TABLE

ROOTS DRESSER

FRAME SIZE	SPEED RPM	MAXIMUM FREE AIR CFM	12" Hg VAC. CFM	12" Hg VAC. BHP	16" Hg VAC. CFM	16" Hg VAC. BHP	20" Hg VAC. CFM	20" Hg VAC. BHP	24" Hg VAC. CFM	24" Hg VAC. BHP	27" Hg VAC. CFM	27" Hg VAC. BHP
406J	2320		288	10.3	258	13.5	216	16.7	135	20.0	*	23.0
	2695		350	12.2	320	15.8	278	19.5	198	23.2	*	27.0
	3564		496	16.9	465	21.4	423	26.2	343	30.9	143	34.5
	4000	668	569	19.5	538	24.4	496	29.6	416	34.8	216	38.8
412J	2320		576	20.2	516	26.6	432	33.1	270	39.6	*	45.0
	2695		700	23.7	640	31.1	556	38.6	396	46.1	*	52.0
	3564		992	32.2	930	41.7	846	51.4	686	61.2	286	68.5
	4000	1332	1138	36.7	1076	47.1	992	58.0	832	68.9	432	77.0
616J	1750		1015	36.0	901	48.0	748	59.0	448	71.0	*	80.0
	2124		1310	44.0	1196	58.0	1043	72.0	743	86.0	*	97.0
	2437		1556	51.0	1443	67.0	1290	83.0	990	99.0	244	111.0
	2860		1890	60.0	1777	79.0	1623	98.0	1324	117.0	578	131.0
	3000	2367	2001	63.0	1887	85.0	1734	103.0	1434	123.0	688	138.0

Notes: 1. Vacuum ratings based on inlet and jet air at standard temperature of 68°F, discharge and jet pressure of 30" Hg and specific gravity of 1.0.
2. Refer to Factory for performance guarantee above 24" HgV.

* Denotes blank-off

ROOTS DVJ WHISPAIR®
DRY VACUUM PUMPS

FRAMES 2504J AND 721J

BASIC DRY VACUUM PUMP DESCRIPTION

GENERAL

Roots model DVJ Whispair® dry vacuum pumps have an exclusive discharge jet plenum design which allows cool, atmospheric air to flow into the casing. This unique design permits continuous operation at vacuum levels to blank-off with a single stage unit, without water injection.

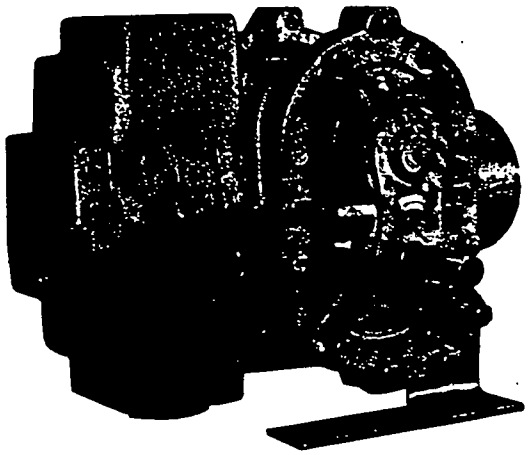
Standard dry vacuum pumps are limited to approximately 16" Hg vacuum because operation at higher vacuum levels can cause extreme discharge temperatures resulting in casing and impeller distortion. The DVJ's cooling design eliminates the problems caused by high temperatures at vacuum levels beyond 16" Hg.

DVJ Whispair dry vacuum pumps are heavy-duty units designed with integral-shaft ductile iron impellers. Whispair vacuum pumps reduce noise and power loss by utilizing an exclusive wrap-around plenum and proprietary Whispair jet to control pressure equalization – feeding backflow in the direction of impeller movement, thereby aiding rotation.

FRAME 2504J

The headplates, gear housing and rigid, one-piece casing are grey iron. Carburized and ground alloy steel spur timing gears are taper mounted on the shafts, secured with a locknut. Ball bearings are used, with splash lubrication at the gear end and grease lubrication at the drive end. Lip-type seals restrict oil leakage into the air stream.

Detachable rugged steel mounting feet permit in-field adaptability to either vertical or horizontal installation requirements.

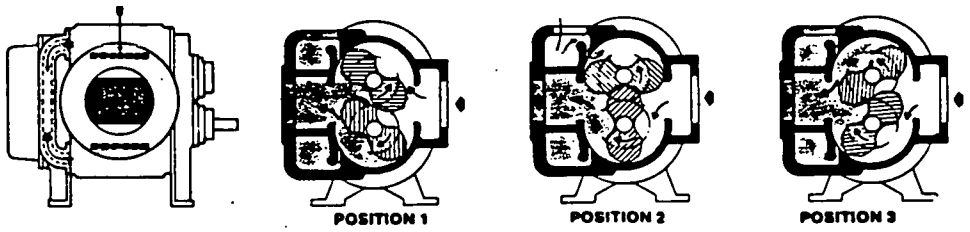


FRAME 721J

The headplates, gear cover, drive end cover and rigid, one-piece casing are grey iron. Carburized and ground alloy steel spur timing gears are taper mounted on the shafts, secured with a locknut. Cylindrical roller bearings are used, with splash lubrication at both the gear end and the drive end. Lip-type seals restrict oil leakage into the air stream.

Frame size 721J is designed with detachable rugged steel mounting feet which permit in-field adaptability to either vertical or horizontal installation requirements.

OPERATING PRINCIPLE



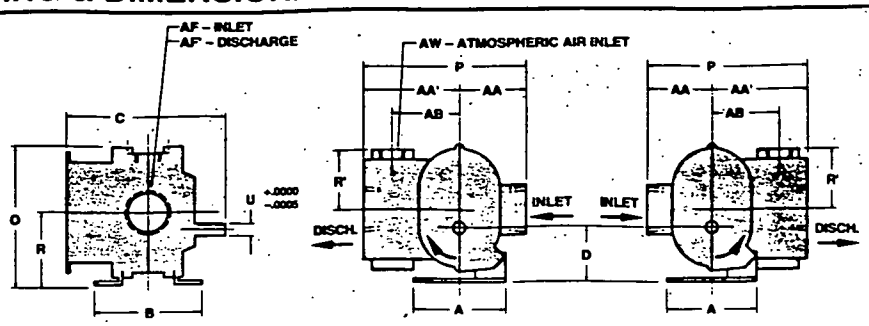
Shaded blue areas indicate air pressure variations from intake to atmospheric discharge.

Position 1:
Incoming air is trapped between the impellers and the case, producing a vacuum in the application system. Simultaneously, air is discharged (left) from the vacuum pump.

Position 2:
As the upper impeller passes the jet plenum, atmospheric air flows into the space between the impeller and the case. This cools the trapped air, aids impeller movement, and reduces discharge shock and power loss.

Position 3:
The trapped air is then moved to the discharge flange (left). Backflow is reduced, resulting in lower discharge noise relative to conventional rotary vacuum pumps.

DVJ OUTLINE DRAWING & DIMENSIONAL TABLE

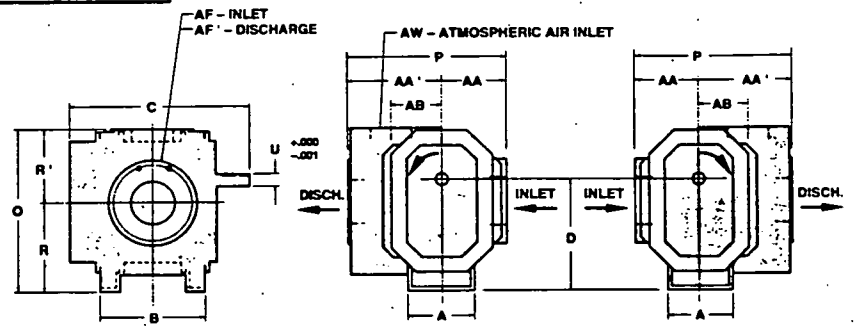


FRAME 2504J
VERTICAL CONFIGURATION

CLOCKWISE ROTATION FURNISHED UNLESS OTHERWISE SPECIFIED

COUNTER CLOCKWISE ROTATION FURNISHED ONLY WHEN SPECIFIED

HORIZONTAL CONFIGURATIONS AVAILABLE UPON REQUEST



FRAME 721J
VERTICAL CONFIGURATION

COUNTER CLOCKWISE ROTATION FURNISHED UNLESS OTHERWISE SPECIFIED

CLOCKWISE ROTATION FURNISHED ONLY WHEN SPECIFIED

NOTES:
1. All dimensions are in inches.
2. Do not use for construction.

Frame Size	A	A'	B	C	Drive shaft location D	Drive shaft location D1	O	O'	P	P'	R	R'	U	Keyway	AA	AA'	AB	AF Inlet Diameter	AF' Discharge Diameter	AW	AX	Approx. Net Wt. (Lbs.)
2504J	6.50	6.50	7.50	11.38	4.00	4.00	9.88	11.63	12.38	8.75	5.25	4.38	.7500	.188 X .094	4.75	7.63	4.75	2.5 NPT	2.5 NPT	2 NPT	1.25	65
721J	19.00	26.00	27.00	39.38	17.00	10.00	24.88	25.25	24.25	22.75	13.50	11.38	2.375	.625 X .313	9.00	15.25	5.50	12 FLG	12 FLG	12 FLG	3.50	1750

ROOTS DRESSER

DVJ PERFORMANCE TABLE

FRAME SIZE	SPEED RPM	12" Hg VAC. CFM	12" Hg VAC. BHP	16" Hg VAC. CFM	16" Hg VAC. BHP	20" Hg VAC. CFM	20" Hg VAC. BHP	24" Hg VAC. CFM	24" Hg VAC. BHP	27" Hg VAC. CFM	27" Hg VAC. BHP
2504J	2400	47	2.1	37	2.8	22	3.5				
	2655	56	2.3	45	3.1	31	3.9				
	2990	67	2.6	57	3.5	42	4.4				
	3540	86	3.2	75	4.2	60	5.2				
	3985	101	3.6	90	4.7	75	5.9				
	4515	119	4.1	108	5.4	93	6.7				
	4970	135	4.6	124	6.0	109	7.4				
721J	1180	1137	43.0	975	57.0	755	971.0	323	85.0	*	97.0
	1770	1967	67.0	1804	88.0	1585	108.0	1153	129.0	83	145.0
	2200	2572	85.0	2409	111.0	2190	136.0	1758	162.0	688	181.0
	2600	3135	104.0	2972	133.0	2750	163.0	2321	193.0	1250	215.0

Notes: 1. Vacuum ratings based on inlet and jet air at standard temperature of 68°F, discharge and jet pressure of 30" Hg and specific gravity of 1.0.
2. Refer to Factory for performance guarantee above 24" HgV.

* Denotes blank-off

ROOTS RAM™ WHISPAIR®
HIGH-PRESSURE ROTARY POSITIVE BLOWERS

FRAME 406 DPJ

BASIC BLOWER DESCRIPTION

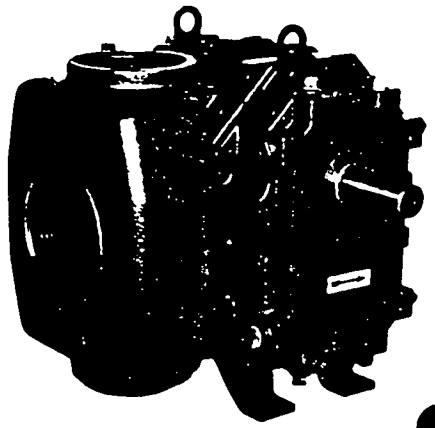
The Roots RAM Whispair rotary blower has an exclusive discharge jet plenum design which allows cool, pressurized system air to flow into the cylinder. This unique design permits operation at high pressure levels with a single stage unit.

The RAM high pressure blower is designed for continuous operation at discharge pressures up to 30 psig. It has no valves, vanes or Teflon rings. Discharge temperatures can often range up to 370°F, providing usable heat for your process or for building heat.

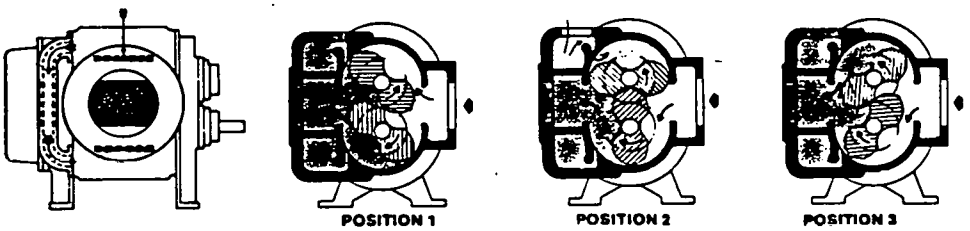
The basic model is designed using integral-shaft ductile iron impellers with an involute profile. The casing and headplates are grey iron, while the drive end cover and gear cover are die cast aluminum. Carburized and ground alloy steel spur timing gears are taper mounted on the shafts, secured with a locknut. Cylindrical roller bearings are splash lubricated at both the gear end and drive end.

Piston rings reduce air leakage through the headplate bores and lip-type oil seals prevent lubricants from entering the air chamber. A hydrodynamic seal on the drive shaft prevents shaft seal oil leaks.

All units are designed with rugged steel mounting feet which permit in-field adaptability to either vertical or horizontal installation requirements.



OPERATING PRINCIPLE



Shaded blue areas indicate air pressure variations from intake to pressurized discharge.

Position 1:
Incoming air is trapped by the impellers. Simultaneously, pressurized air is being discharged.

Position 2:
As the upper impeller passes the jet plenum, cooled, pressurized air flows into the space between the impeller and cylinder. This cools the trapped air, helps control thermal growth and allows higher discharge pressures.

Position 3:
The trapped air is then moved to the discharge flange (left). Backflow is reduced, resulting in lower operating noise level and reduced shock loading on the impellers.

Uncontested Warranty

RAM™ helps Roots to continue as the industry leader in warranties – the first to introduce an *uncontested* warranty procedure that guarantees to repair or replace any defective RAM unit that has not been mistreated. We'll protect you and your customer for a full 18 months after installation (not to exceed 24 months after shipment).

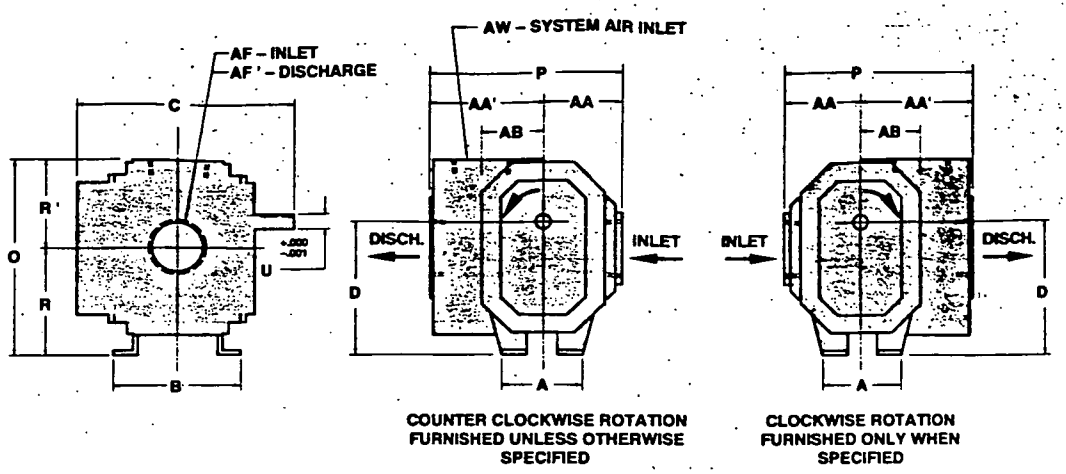
RAM WHISPAIR HIGH-PRESSURE BLOWER PERFORMANCE TABLE

FRAME SIZE	SPEED RPM	15 PSI CFM	15 PSI BHP	20 PSI CFM	20 PSI BHP	25 PSI CFM	25 PSI BHP	30 PSI CFM	30 PSI BHP
406	4000	545	46	525	60	510	75	495	88
	3070	390	35	370	46	355	57	340	68
	2320	265	26	245	35	230	43	215	52
	1750	170	20	150	26	134	32	118	39

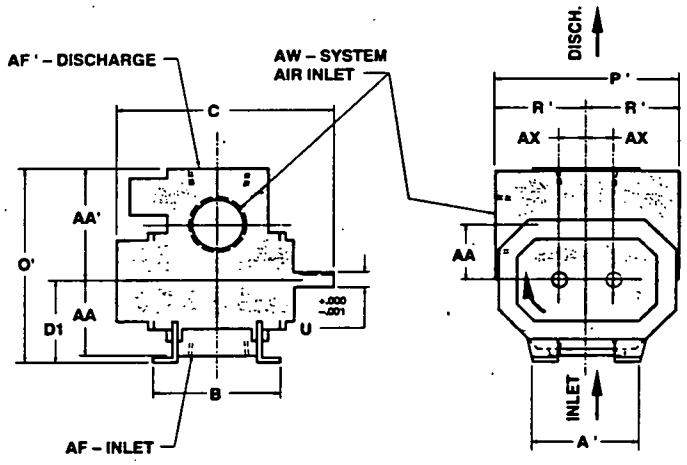
NOTES: Ratings based on inlet air at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.

RAM WHISPAIR HIGH-PRESSURE BLOWER
OUTLINE DRAWING & DIMENSIONAL TABLE

VERTICAL CONFIGURATION
(HORIZONTAL AIR FLOW)



HORIZONTAL CONFIGURATION
(VERTICAL AIR FLOW)



NOTES:
1. All dimensions are in inches.
2. Do not use for construction.

FRAME SIZE	A	A'	B	C	D	D1	O	O'	P	P'	R	R'	U	KEYWAY	AA	AA'	AB	AF	AF'	AW	AX	WGT.
406	8.00	11.00	10.75	20.50	11.25	7.50	16.38	18.00	17.75	14.75	9.00	7.38	1.500	.375 X .188	7.25	10.50	6.75	4 NPT	5 NPT	4 NPT	2.25	365

ROOTS RCS-J WHISPAIR® & RCS
ROTARY POSITIVE BLOWERS

RCS-J FRAMES 715J THRU 832J
RCS FRAMES 817 THRU 827

BASIC BLOWER DESCRIPTION

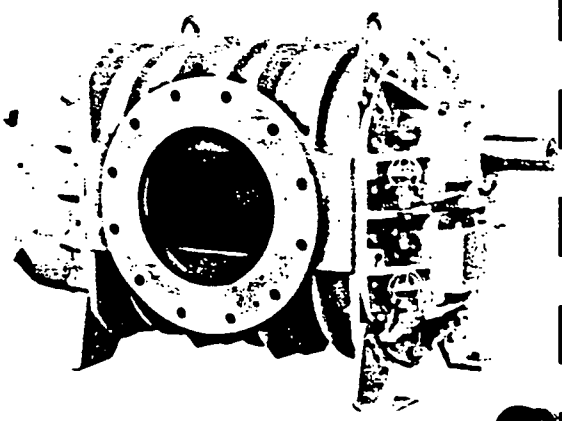
RCS-J Whispair® and RCS rotary blowers are heavy-duty units designed with integral-shaft ductile iron impellers having an involute profile. Whispair blowers reduce noise and power loss by utilizing an exclusive wrap-around plenum and proprietary Whispair jet to control pressure equalization – feeding backflow in the direction of impeller movement, thereby aiding rotation.

The headplates, gear cover, drive end cover and rigid, one-piece casing are grey iron. Carburized and ground alloy steel spur timing gears are taper mounted on the shafts, secured with a locknut. Cylindrical roller bearings are used.

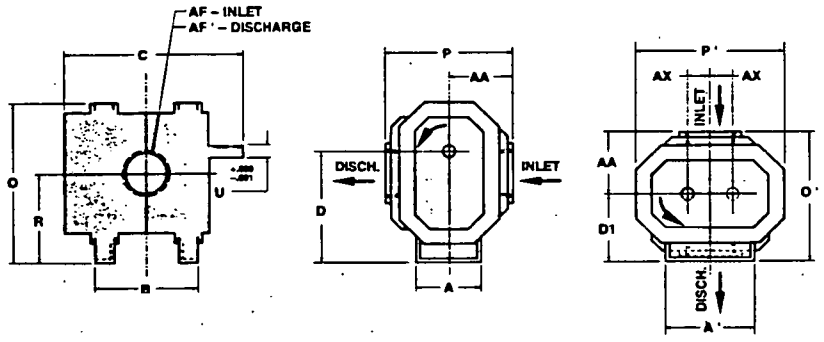
Piston rings reduce air leakage through the shaft openings in the headplates, and lip-type oil seals prevent lubricant from entering the air chamber. These blowers incorporate thrust control, with splash oil lubrication at both ends of the blower.

RCS-J frame sizes 715J and 721J, and RCS blowers are designed with detachable rugged steel mounting feet which permit in-field adaptability to either vertical or horizontal installation requirements.

The top shaft is extended for drive on side outlet blowers, and either shaft can be extended for drive on top or bottom outlet blowers.



OUTLINE DRAWING & DIMENSIONAL TABLE



NOTES:
1. All dimensions are in inches.
2. Do not use for construction.
3. RGS-J gas pumps available in frame sizes 616J and 624J only.

VERTICAL CONFIGURATION (HORIZONTAL AIR FLOW)

HORIZONTAL CONFIGURATION (VERTICAL AIR FLOW)

Frame Size	A	A '	B	C	Drive shaft location D	Drive shaft location D1	O	O '	P	P '	R	U	Keyway	AF Inlet Diameter	AF ' Discharge Diameter	AA	AX	Approx. Net Wt. (Lbs.)
715J	19.00	26.00	21.50	33.88	17.00	10.00	25.13	19.00	18.00	23.25	13.50	2.375	.625 X .313	10.0 FLG	8.0 FLG	9.00	3.50	1100
721J	19.00	26.00	27.00	39.38	17.00	10.00	25.13	19.00	18.00	23.25	13.50	2.375	.625 X .313	12.0 FLG	10.0 FLG	9.00	3.50	1200
817J	13.75	22.00	24.25	38.63	21.00	13.00	30.00	25.75	25.50	25.00	17.00	2.750	.625 X .313	10.0 FLG	10.0 FLG	12.75	4.00	1620
821J	13.75	22.00	27.88	42.25	21.00	13.00	30.00	25.75	25.50	25.00	17.00	2.750	.625 X .313	12.0 FLG	10.0 FLG	12.75	4.00	1800
826J	13.75	22.00	33.13	47.50	21.00	13.00	30.00	25.75	25.50	25.00	17.00	2.750	.625 X .313	12.0 FLG	12.0 FLG	12.75	4.00	2075
832J	13.75	22.00	38.50	52.88	21.00	13.00	30.00	25.75	25.50	25.00	17.00	2.750	.625 X .313	14.0 FLG	12.0 FLG	12.75	4.00	2325
817	19.00	27.00	24.25	38.44	18.00	10.00	28.38	20.38	19.00	25.25	14.00	2.750	.625 X .313	10.0 FLG	10.0 FLG	9.50	4.00	1200
824	19.00	27.00	30.50	44.69	18.00	10.00	28.38	20.38	19.00	25.25	14.00	2.750	.625 X .313	12.0 FLG	12.0 FLG	9.50	4.00	1330
827	19.00	27.00	34.00	48.19	18.00	10.00	28.38	20.38	19.00	25.25	14.00	2.750	.625 X .313	14.0 FLG	14.0 FLG	9.50	4.00	1600

RCS-J / RCS PERFORMANCE TABLE

FRAME SIZE	SPEED RPM	4 PSI		6 PSI		8 PSI		10 PSI		12 PSI		15 PSI		18 PSI		MAX. VACUUM		
		CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	" Hg	CFM	BHP
715J	1180	935	23.0	870	33.4	815	44.0	766	54.6	722	65.0	663	81.0			14.0	705	37.2
	1770	1548	37.3	1483	53.0	1428	68.8	1379	84.5	1335	100.3	1276	123.9			15.0	1281	61.4
	2600	2410	63.4	2345	86.0	2290	108.5	2241	131.0	2198	153.7	2138	187.5			15.0	2144	95.4
721J	1180	1266	30.5	1178	44.8	1103	59.0	1037	73.5	978	87.8	892	109.2			14.0	955	50.0
	1770	2096	49.1	2008	70.4	1933	91.7	1867	113.1	1808	134.4	1727	166.4			15.0	1735	81.7
	2600	3264	81.4	3176	112.0	3101	142.5	3035	173.1	2976	203.7	2895	249.5			15.0	2903	124.8
817J	880	982	24.9	895	36.8	821	48.7	756	60.6									
	1770	2368	55.0	2280	78.5	2206	102.0	2142	125.4	2083	148.9	2004	184.1	2055	219.4	16.0	1962	95.9
	2250	3116	75.6	3028	105.0	2955	134.0	2890	164.0	2830	193.0	2751	237.0	2680	281.0	16.0	2707	126.0
821J	880	1179	29.6	1074	43.9	985	58.1	907	72.4									
	1770	2842	65.7	2738	93.9	2648	122.1	2571	150.3	2500	178.4	2405	220.7			16.0	2354	114.8
	2250	3740	92.3	3635	127.0	3546	163.0	3468	198.0	3398	233.0	3302	286.0			16.0	3249	153.0
826J	880	1473	37.1	1342	55.0	1231	72.8	1134	90.7									
	1770	3554	81.4	3423	116.7	3311	151.9	3214	187.1	3126	222.3					16.0	2944	142.8
	2250	4676	105.0	4545	156.0	4434	200.0	4336	247.0	4248	288.0					16.0	4062	188.0
832J	880	1768	44.4	1610	65.8	1477	87.2	1360	108.6									
	1770	4264	97.5	4107	139.8	3972	182.0	3857	224.3							16.0	3531	168.4
	2250	5610	134.0	5452	186.0	5320	239.0	5202	292.0							16.0	4874	225.0
817	880	982	24.9	895	36.8	821	48.7	756	60.6							12.0	761	35.7
	1770	2368	55.5	2281	79.5	2207	103.5	2142	127.6	2083	151.6	2003	187.7			16.0	1959	101.4
	2250	3116	78.7	3028	109.2	2955	139.8	2890	170.4	2831	200.9	2751	246.8			16.0	2707	137.1
824	880	1326	33.1	1207	49.2	1108	65.4	1020	81.5							12.0	1028	48.2
	1770	3198	74.8	3080	107.2	2980	139.7	2892	172.2	2813	204.7	2705	253.4			16.0	2646	136.8
	2250	4208	105.6	4090	147.2	3990	188.5	3902	229.8	3823	271.1	3715	333.0			16.0	3656	184.9
827	880	1519	37.9	1383	56.4	1269	74.9	1169	93.4							12.0	1178	55.2
	1770	3665	85.5	3529	122.7	3415	159.9	3314	197.1	3223	234.3					16.0	3032	157.0
	2250	4822	120.9	4687	168.2	4572	215.5	4472	262.8	4381	310.1					16.0	4189	212.3

Notes: 1. Pressure ratings based on inlet air at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.
2. Vacuum ratings based on inlet air at standard temperature of 68°F, discharge pressure of 30" Hg and specific gravity of 1.0.
3. 800J frame sizes only – Operation above 15 psi pressure rise, 15" Hg vacuum or 230°F temperature rise requires oil coolers – refer to Factory. Oil cooler not available on 700J frame sizes.

ROOTS XLP® WHISPAIR®
EXTRA LOW PULSE TRI-LOBE BLOWERS

BASIC BLOWER DESCRIPTION

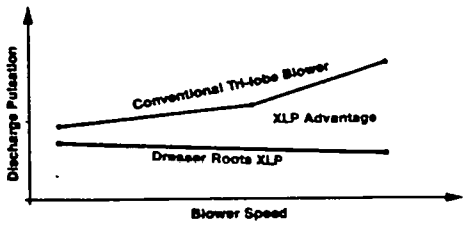
The XLP Whispair® blower has been specially designed to reduce noise and power loss by utilizing the exclusive Roots wrap-around plenum and proprietary double Whispair jet to control pressure equalization. Combining this feature with the three-lobe design results in a high efficiency blower that dramatically reduces in-pipe pulsation and noise levels.

XLP impeller profiles ensure maximum volumetric efficiency with minimum absorbed power without sacrificing torsional rigidity. The conservative load carrying capacity of the large-diameter rolling element bearings contributes to a long operating life. Timing gear life is also extended by a controlled lubrication system.

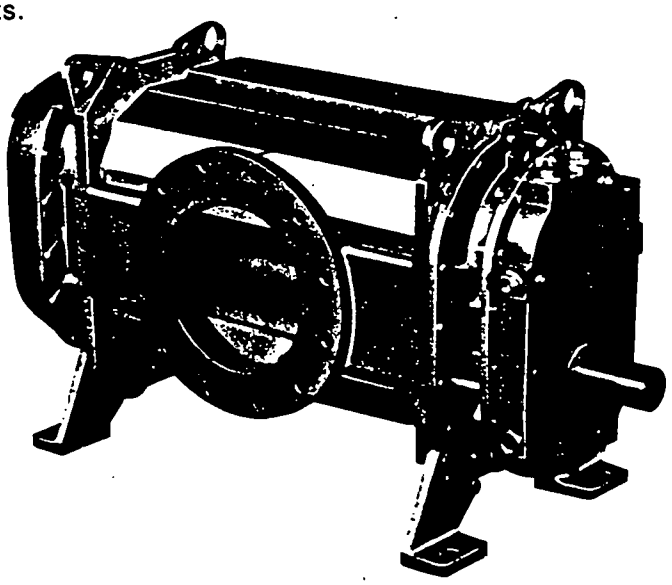
Taper mounted, precision ground and hardened high-grade alloy steel gears ensure smooth, quiet operation.

Cylinder and headplates are made from cast iron; dynamically balanced impellers and integral shafts are manufactured from ductile iron. Roller bearings at the drive and gear ends give long operational life.

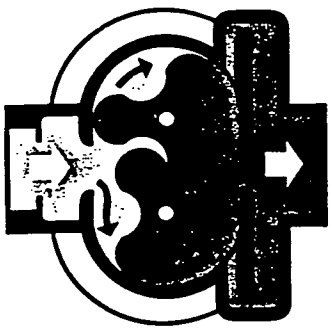
All units are designed with rugged steel mounting feet which permit in-field adaptability to either vertical or horizontal installation requirements.



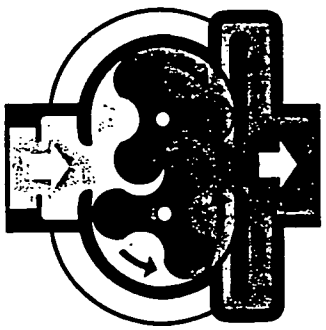
DISCHARGE PRESSURE PULSATION



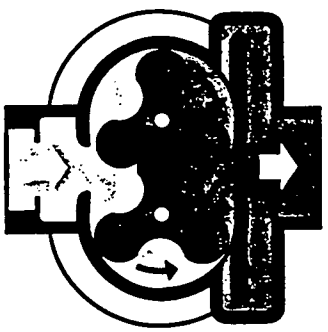
OPERATING PRINCIPLE



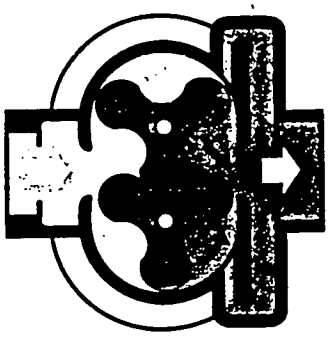
POSITION 1



POSITION 2



POSITION 3



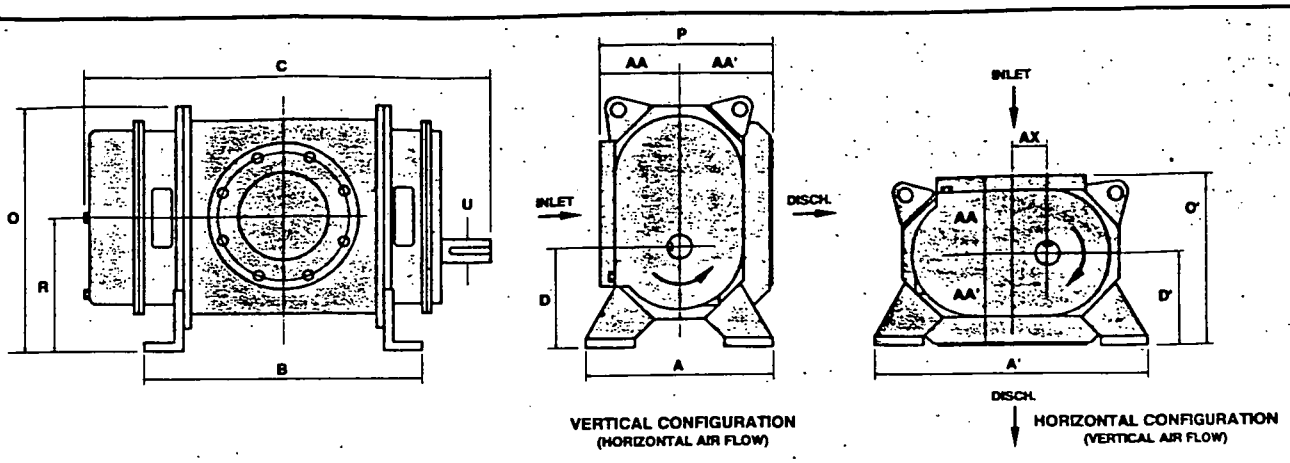
POSITION 4

In addition to the tri-lobe design, Roots XLP Whispair blowers have a proprietary jet to feed backflow in the direction of impeller movement, aiding rotation and lowering power requirements.

Incoming air is trapped by the impellers and moved through the machine as in the basic rotary positive displacement principle. As pressure builds against the wrap-around plenum due to system resistance, the Whispair blower jet equalizes the pressure between the trapped air and the discharge area. This action reduces shock and feeds the backflow in the direction of rotation.

As the impeller completes its cycle, it discharges the trapped air, which now has the same pressure as the discharge line. Backflow is controlled, resulting in reduced pulsation compared to the conventional blower. This improves efficiency, reduces noise level, and increases bearing and gear life.

XLP WHISPAIR OUTLINE DRAWING & DIMENSIONAL TABLE



NOTES:
1. Unless otherwise specified, dimensions are in inches.
2. Do not use for construction.

NOTE: Dimensions in these 3 columns are in millimeters

Frame Size	A	A'	B	C	D	D'	O	O'	P	R	U	Keyway	Inlet & discharge diameter	AA	AA'	AX	Approx. Net Wt. (Lbs.)
110	12.95	19.76	18.11	28.82	7.44	6.50	16.02	12.20	12.40	9.88	45.03/45.011	5.5/5.7	150	5.71	6.69	2.44	169
108	12.95	19.76	23.23	33.74	7.44	6.50	16.02	12.20	12.40	9.88	45.03/45.011	5.5/5.7	150	5.71	6.69	2.44	202
210	17.24	25.98	24.80	37.32	9.84	8.66	24.21	15.94	15.63	12.99	60.03/60.011	7.0/7/2	200	7.28	8.35	3.15	340
208	17.24	25.98	31.10	43.62	9.84	8.66	24.21	15.94	15.63	12.99	60.03/60.011	7.0/7/2	250	7.28	8.35	3.15	375

PERFORMANCE TABLE

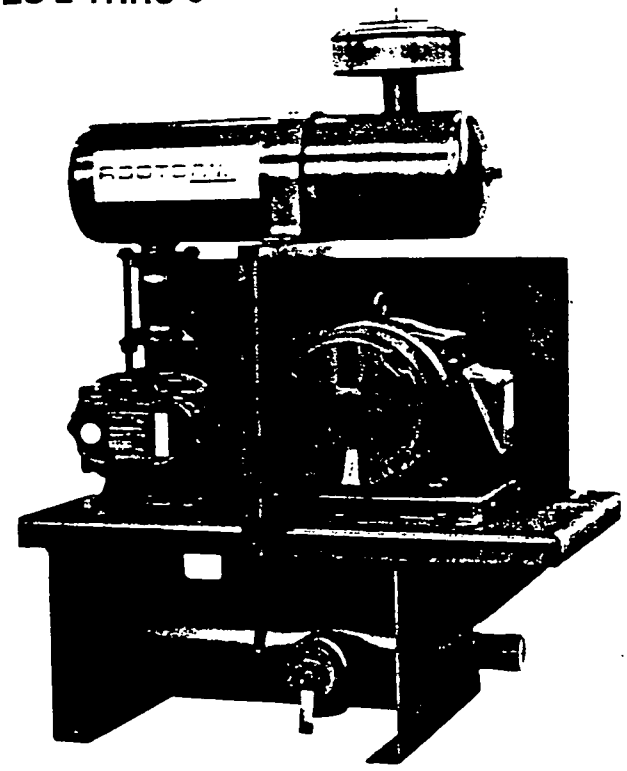
FRAME SIZE	SPEED RPM	2 PSI		6 PSI		10 PSI		12 PSI		15 PSI		MAX. VACUUM		
		CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	" Hg	CFM	BHP
110	1750	576	6.2	511	17.8	467	29.4	448	35.2			8.0	520	11.7
	2950	1032	11.9	967	31.4	923	51.0	904	60.8	878	75.4	12.0	925	30.1
	3650	1298	16.1	1233	40.3	1189	64.5	1170	76.6	1144	94.7	15.0	1146	46.5
108	1750	769	8.3	682	23.8	623	39.2	597	47.0			8.0	694	15.6
	2950	1377	15.7	1291	41.8	1231	67.9	1206	80.9			12.0	1234	40.0
	3650	1732	21.1	1646	53.4	1586	85.7	1561	101.8			15.0	1529	61.9
210	1750	1243	13.9	1131	38.2	1055	62.5	1022	74.7	978	93.0	8.0	1146	25.2
	2300	1681	19.9	1570	51.9	1493	83.9	1460	99.8	1416	123.8	12.0	1496	49.5
	2850	2119	27.3	2008	66.9	1931	106.5	1899	126.3	1855	156.1	15.0	1859	76.7
208	1750	1656	18.4	1507	50.8	1405	83.2	1362	99.4			8.0	1527	33.4
	2300	2240	26.2	2091	68.8	1989	111.4	1946	132.7			12.0	1993	65.7
	2850	2824	35.7	2676	88.5	2573	141.3	2530	167.7			15.0	2476	101.9

Notes: 1. Pressure ratings based on inlet air at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.
2. Vacuum ratings based on inlet air at standard temperature of 68°F, discharge pressure of 30" Hg and specific gravity of 1.0.

ROOTS PAK™

UNIVERSAL RAI® PACKAGED UNITS

DISCHARGE PIPE SIZES 2 THRU 6



BASIC PACKAGE DESCRIPTION

Available through **Authorized Roots Distributors**, RootsPak™ completely assembled, factory-engineered and guaranteed packages incorporate 17 frame sizes of Universal RAI rotary blowers in 3 package arrangements to suit your various installation and application requirements. Flows to 2370 cfm, pressures to 15 psig or vacuums to 16" Hg are possible.

The basic, or type "S", package consists of the blower, V-belt drive, OSHA guard, motor slide base, inlet filter and inlet silencer all mounted on top of a heavy-duty, unitized base/discharge silencer in one compact, easy to install package. A pressure relief valve is mounted on the discharge silencer. A type "F" package is available, with an inlet filter-silencer replacing the separate inlet filter and inlet silencer. For vacuum service, a type "V" package can be supplied with a vacuum relief valve mounted on top of a tee at the blower inlet.

Motor and other accessories are optional. All three arrangements are fully described in the table below and illustrated on the next page.

The combination base/discharge silencer is a rigid, one-piece weldment, reinforced for minimal vibration. The inlet filter is supplied with a 10 micron pleated paper element. All standard components are designed for indoor or outdoor operation.

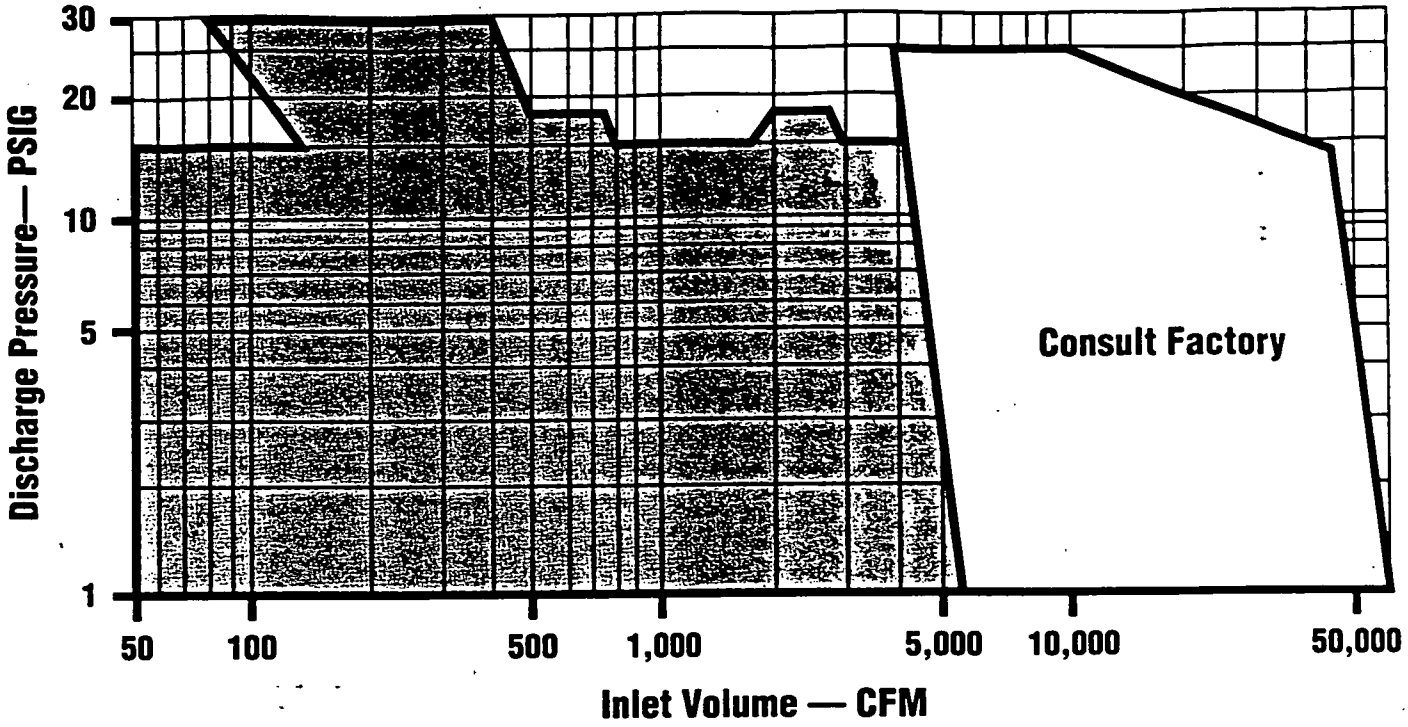
The Universal RAI blower consists of a grey iron casing, carburized and ground alloy steel timing gears secured to steel shafts with a taper mounting and locknut, and grey iron involute impellers. Oversized anti-friction bearings are used, with a cylindrical roller bearing at the drive shaft on all models to provide increased bearing life and to withstand V-belt pull. The Universal RAI features thrust control, with splash oil lube on the gear end and grease lube on the drive end.

For complete RootsPak™ specifications and ordering information, refer to Roots Bulletin S-12X91.

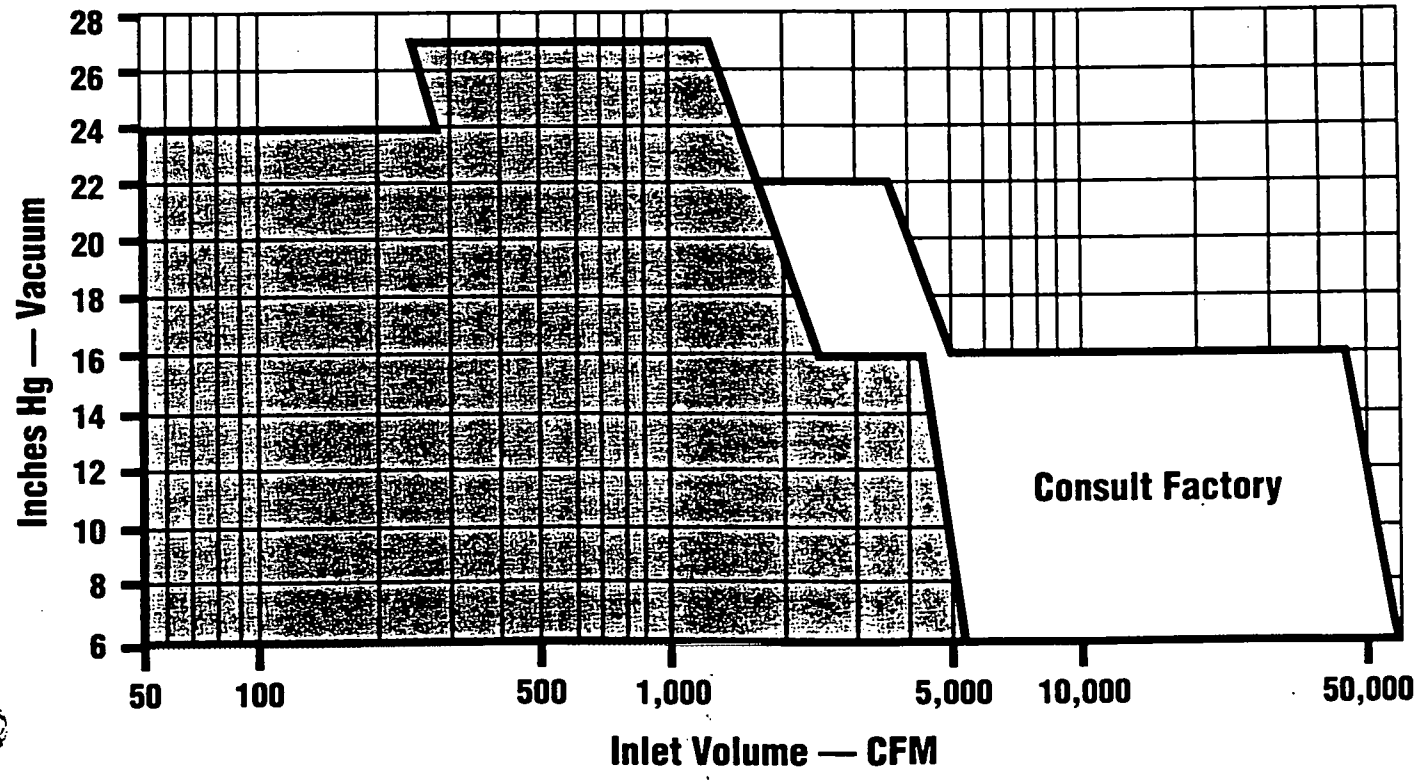
PACKAGE COMPONENTS

TYPE "S" PACKAGE	TYPE "F" PACKAGE	TYPE "V" PACKAGE
Universal RAI blower	Universal RAI blower	Universal RAI blower
Unitized base/discharge silencer	Unitized base/discharge silencer	Unitized base/discharge silencer
Inlet filter with weatherhood	Inlet filter-silencer with weatherhood	V-belt drive
Horizontal inlet silencer & support	V-belt drive	OSHA guard
V-belt drive	OSHA guard	Motor slide base
OSHA guard	Motor slide base	Interconnecting fittings
Motor slide base	Interconnecting fittings	Vacuum relief valve
Interconnecting fittings	Pressure relief valve	Shipped completely assembled
Pressure relief valve	Shipped completely assembled	Domestic shipping preparation
Shipped completely assembled	Domestic shipping preparation	Suitable for indoor/outdoor installation
Domestic shipping preparation	Suitable for indoor/outdoor installation	
Suitable for indoor/outdoor installation		

PRESSURE CAPABILITY FOR ROOTS ROTARY LOBE BLOWERS



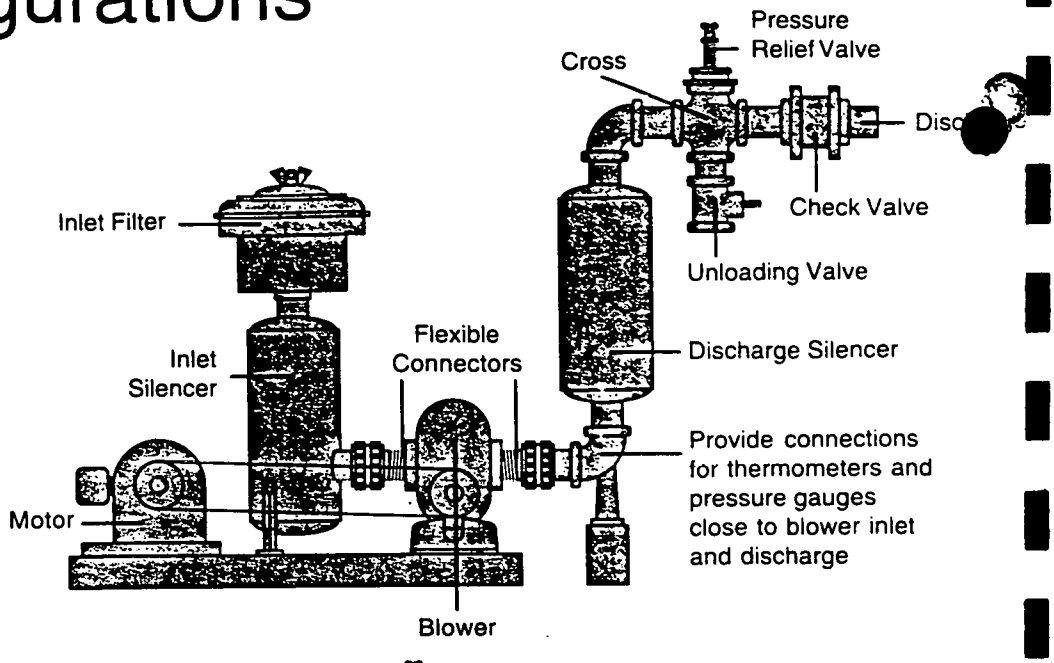
VACUUM CAPABILITY FOR ROOTS ROTARY LOBE BLOWERS & VACUUM PUMPS



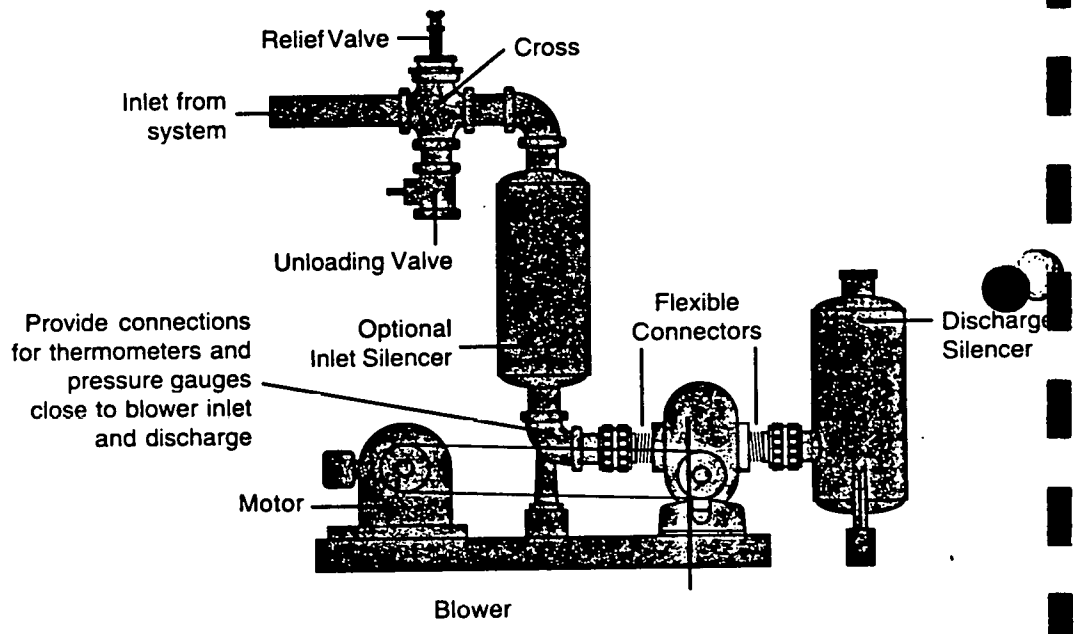
NOTE: Units described in this bulletin are shown as shaded areas in the performance maps above. For larger capacity units in the white areas, please contact Factory.

Typical Configurations

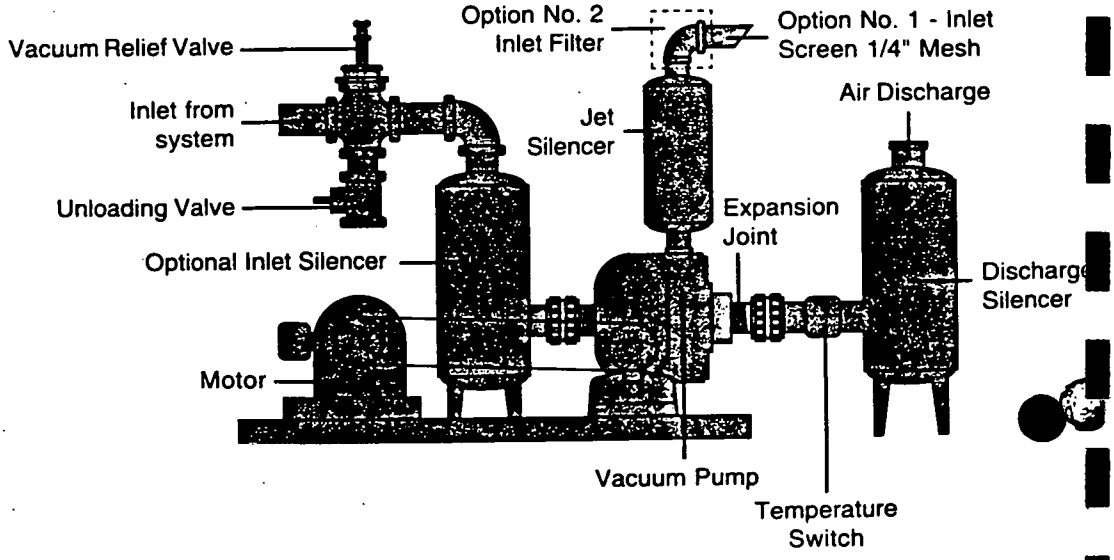
Pressure Application



Vacuum Application



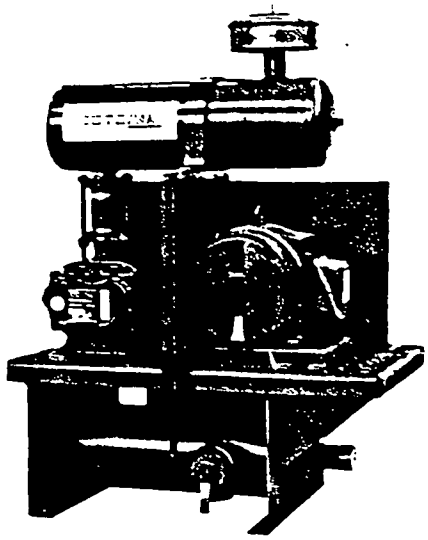
High Vacuum Application

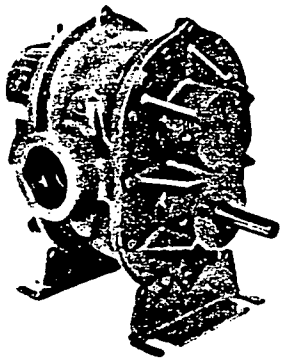


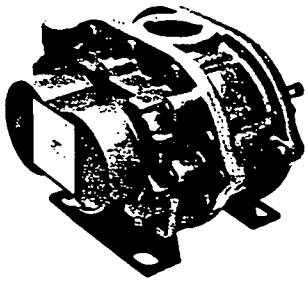
What is an "Authorized Roots Distributor"?

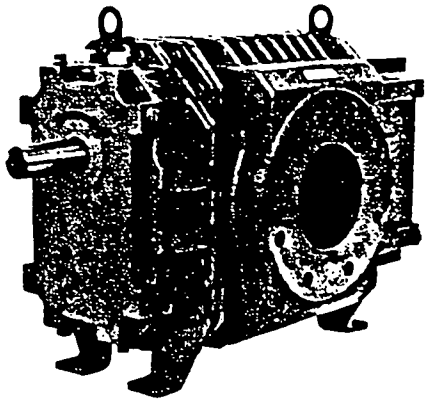
DID YOU KNOW...

- Authorization requires every Roots Distributor's service department to have a minimum of 16 hours factory training at Roots Division's Connersville, Indiana, facility. That's just the beginning!
- Bi-annual factory refreshers on new products and techniques are offered to keep each Authorized Distributor's service department proficient, reducing repair time and costs.
- Roots Authorized Distributors have the special factory-designed tools necessary to do your jobs quickly.
- Authorization requires distributors to maintain facilities for testing of repairs. Authorized Distributor repair work is proven before it ships.
- You get complete Roots warranty service/replacement directly from your Factory Authorized Distributor.



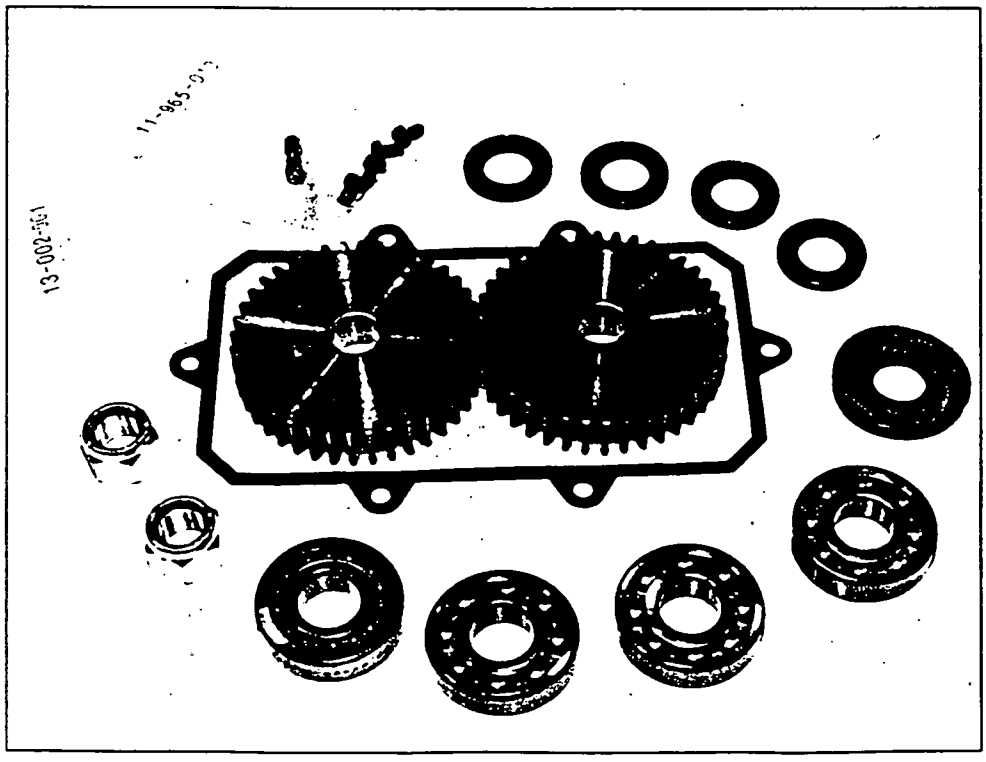






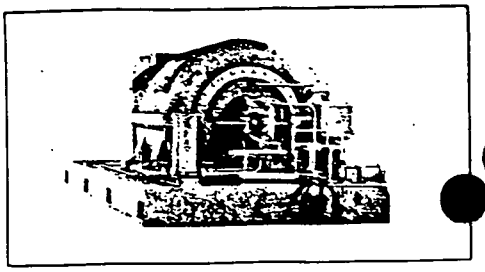
Authorized Roots Distributors are required to carry stock.

- They stock several popular Roots blowers in various arrangements of flow, rotation and shaft location.
- They stock parts kits and timing gears for the popular Roots models.

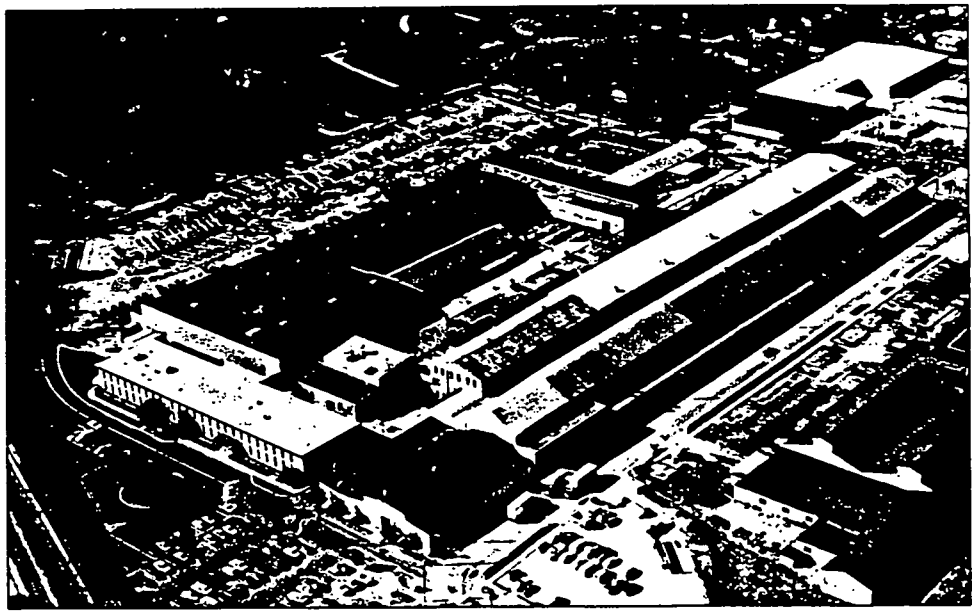


TO FIND your Authorized Roots Distributor look in the Yellow Pages under "Blowers and Blower Systems"

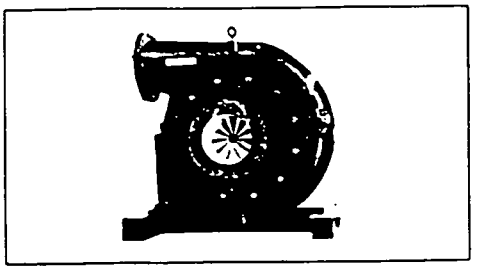
Other Roots products...



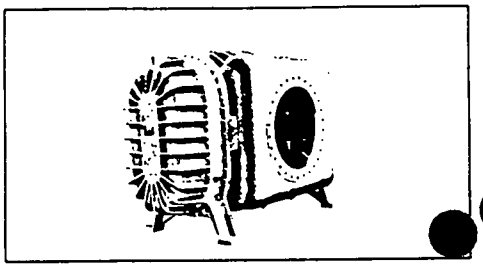
Type H multi-stage centrifugal compressors: polytropic heads to 90,000 feet, pressures to 50 psig, capacities to 125,000 cfm.



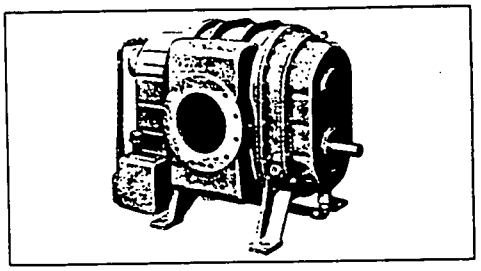
Facilities of Roots Division, Dresser Industries, Inc., where complete design, manufacturing, assembling and testing of rotary blowers and centrifugal compressors takes place.



Single stage centrifugal compressors: pressures to 32 psig, booster pressures to 600 psig, capacities to 250,000 cfm.



Type RAS-J Whispair® rotary blowers: pressures to 20 psig, vacuum to 16" Hg, capacities to 60,000 cfm.



Type RGS-J Whispair® rotary gas pumps: pressures to 20 psig, vacuum to 16" Hg, capacities to 60,000 cfm, case pressures to 200 psig.

For more information on units illustrated in this bulletin or other Roots products and services, write or call us today.

ROOTS DRESSER

DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
TELEPHONE: 765/827-9200

www.rootsblower.com
CONNERSVILLE, INDIANA 47331
FAX: 765/825-7669

The original **ROOTS** *blower*™

B-05X93 **Revised October, 1998** (Was B-5053)
All specifications subject to change without notice

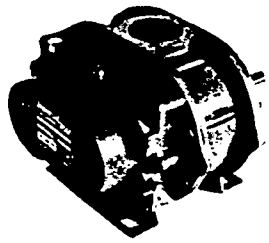
Printed in U.S.A.

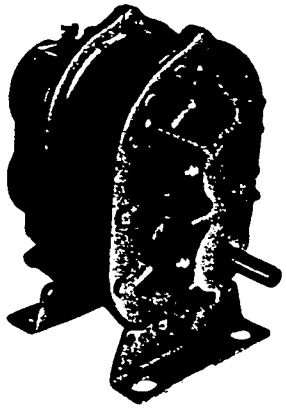
SPECIFICATIONS

Roots Universal RAI®

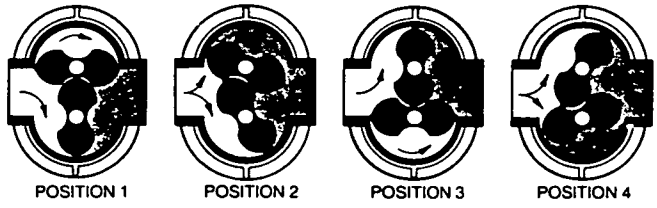
ROTARY POSITIVE BLOWERS

FRAMES 22 THRU 718





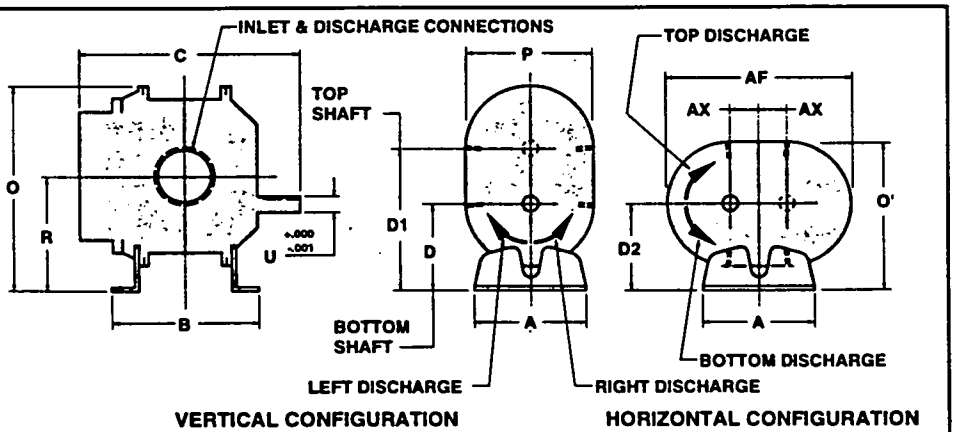
OPERATING PRINCIPLE



Two figure-eight lobe impellers mounted on parallel shafts rotate in opposite directions. As each impeller passes the blower inlet, it traps a definite volume of air and carries it around the case to the blower outlet, where the air is discharged. With constant speed operation, the displaced volume is essentially the same regardless of pressure, temperature or barometric pressure.

Timing gears control the relative position of the impellers to each other and maintain small but definite clearances. This allows operation without lubrication being required inside the air casing.

OUTLINE DRAWING & DIMENSIONAL TABLE



Frame Size	A	B	C	Drive shaft location D Bottom Shaft	D1 Top Shaft	D2 Horiz. Shaft	O	O'	P	R	U	Keyway	Inlet & Disch. Dia.	AF	AX	Approx. Net Wt. (Lbs.)
22	5.13	5.00	9.75	3.75	6.25	3.75	9.63	6.88	6.25	5.00	.625	.188 x .094	1.0 NPT	9.25	1.25	32
24	5.13	7.00	11.75	3.75	6.25	3.75	9.63	6.88	6.25	5.00	.625	.188 x .094	2.0 NPT	9.25	1.25	43
32	7.25	6.75	11.25	5.00	8.50	5.00	12.81	8.88	7.75	6.75	.750	.188 x .094	1.25 NPT	12.13	1.75	69
33	7.25	7.63	12.13	5.00	8.50	5.00	12.81	8.88	7.75	6.75	.750	.188 x .094	2.0 NPT	12.13	1.75	74
36	7.25	10.00	14.63	5.00	8.50	5.00	12.81	8.88	7.75	6.75	.750	.188 x .094	2.5 NPT	12.13	1.75	102
42	8.00	7.25	13.00	6.25	10.25	6.25	15.06	10.63	8.75	8.25	.875	.188 x .094	1.5 NPT	13.63	2.00	88
45	8.00	10.00	15.50	6.25	10.25	6.25	15.06	10.63	8.75	8.25	.875	.188 x .094	2.5 NPT	13.63	2.00	109
47	8.00	11.75	17.63	6.25	10.25	6.25	15.06	10.50	8.50	8.25	.875	.188 x .094	3.0 NPT	13.63	2.00	128
53	10.50	8.38	15.38	6.25	11.25	6.75	17.38	11.88	10.25	8.75	1.125	.250 x .125	2.5 NPT	17.25	2.50	143
56	10.50	11.00	18.00	6.25	11.25	6.75	17.38	12.25	11.00	8.75	1.125	.250 x .125	4.0 NPT	17.25	2.50	170
59	10.50	14.00	21.18	6.25	11.25	6.75	17.38	12.25	11.00	8.75	1.125	.250 x .125	4.0 NPT	17.25	2.50	204
65	11.00*	10.00	18.38	8.75	14.75	8.75	21.63	15.13	12.75	11.75	1.375	.312 x .156	3.0 NPT	19.75	3.00	245
68	11.00*	13.00	21.38	8.75	14.75	8.75	21.63	15.13	12.75	11.75	1.375	.312 x .156	5.0 NPT	19.75	3.00	285
615	11.00*	20.00	28.38	8.75	14.75	8.75	21.63	16.25	15.00	11.75	1.375	.312 x .156	6.0 FLG	19.75	3.00	425
76	14.00**	11.75	19.94	11.00	18.00	11.00	26.13	20.69	19.38	14.50	1.562	.375 x .188	4.0 NPT	23.25	3.50	400
711	14.00**	16.75	25.19	11.00	18.00	11.00	26.13	19.50	17.00	14.50	1.562	.375 x .188	6.0 FLG	23.25	3.50	530
718	14.00**	23.75	32.19	11.00	18.00	11.00	26.13	19.50	17.00	14.50	1.562	.375 x .188	8.0 FLG	23.25	3.50	650

* 17.00 in horizontal configuration
** 21.00 in horizontal configuration

All dimensions in inches

ISO 9001 CERTIFIED
ROOTS QUALITY SYSTEM

BASIC BLOWER DESCRIPTION

Universal RAI blowers are heavy duty rotary blowers designed with detachable rugged steel mounting feet, which permit easy in-field adaptability to either vertical or horizontal installation requirements. The Universal RAI blowers can even be hung from overhead supports.

Because of the detachable mounting feet, these units can be easily adapted to any of four drive shaft positions – right hand, left hand, bottom or top. The compact, sturdy design is engineered for continuous service when operated in accordance with speed and pressure ratings.

The basic model consists of a cast iron casing, carburized and ground alloy steel spur timing gears secured to steel shafts with a taper mounting and locknut, and cast iron involute impellers. Oversized anti-friction bearings are used, with a cylindrical roller bearing at the drive shaft to withstand V-belt pull. The Universal RAI features thrust control, with splash oil lube on the gear end and grease lube on the drive end. After standard tests, the unit is sprayed with a protective paint and boxed or placed on skids.

Available accessories include driver, relief valve, inlet and discharge silencer, inlet filter, check valve, extended base, V-belt or flexible coupling and drive guards.

EVERY GROWING PLANT NEEDS ROOTS

Roots Blower Selection 2.9-97e Thursday September 17, 1998 3:33 pm

Selected Unit

Model:	718 URAI			
Inlet Volume (ACFM):	1695	SCFM: 1028	Gas:	AIR
Inlet Pressure (PSIA):	8.83		K-Value:	1.395
Inlet Temp(Deg.F):	60		Specific Gravity:	0.991
Discharge Pressure (PSIA):	14.90		Molecular Weight:	28.711
Inlet Vacuum (HG):	12.00	100%	Elevation/Feet:	0
Ambient Pressure (PSIA):	14.70		Relative Humidity:	80%
Speed (RPM):	1650	80%	Amb/Jet Temperature:	100
Brake-Horsepower:	54.6			
Temperature Rise (Deg. F):	117	90%		

Discharge Temperature (Deg. F):	177
Discharge Volume (ACFM):	1230
Gear Tip Speed (FPM):	3026
Estimated B10 Bearing Life (HRS):	101000
Estimated Noise Level at 1 Meter (DBA):	90.4

<Esc> Exit, <F7> Cancel, <F8> Previous

Roots Blower Selection 2.9-97e Thursday September 17, 1998 3:33 pm

Select a Unit | Main Menu

Single Unit Performance - Vacuum

Blower Speed (RPM):	1650		
Relative Humidity:	80%	Amb/Jet Temperature:	100
Ambient Pressure (PSIA):	14.70	Elevation/Feet:	0
Inlet Vacuum (HG):	12.00	Inlet Temp(Deg.F):	60
Gas:	AIR	K-Value:	1.395
Molecular Weight:	28.966	Specific Gravity:	1.000
Open Clearances (Y/N):	No	Reduced Clearance (Y/N):	No
Water Injection (Y/N):	No		

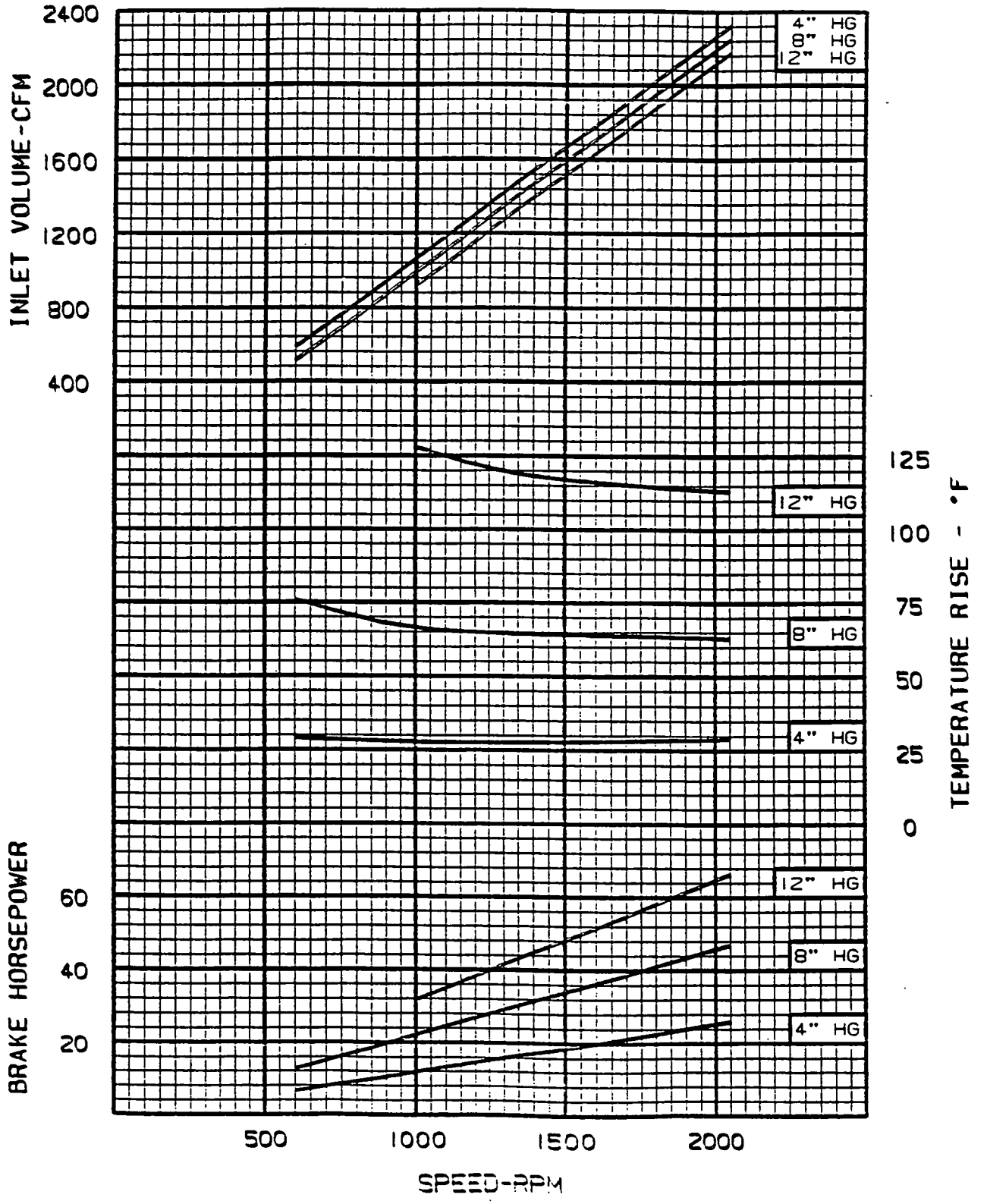
↓ | URAI 718

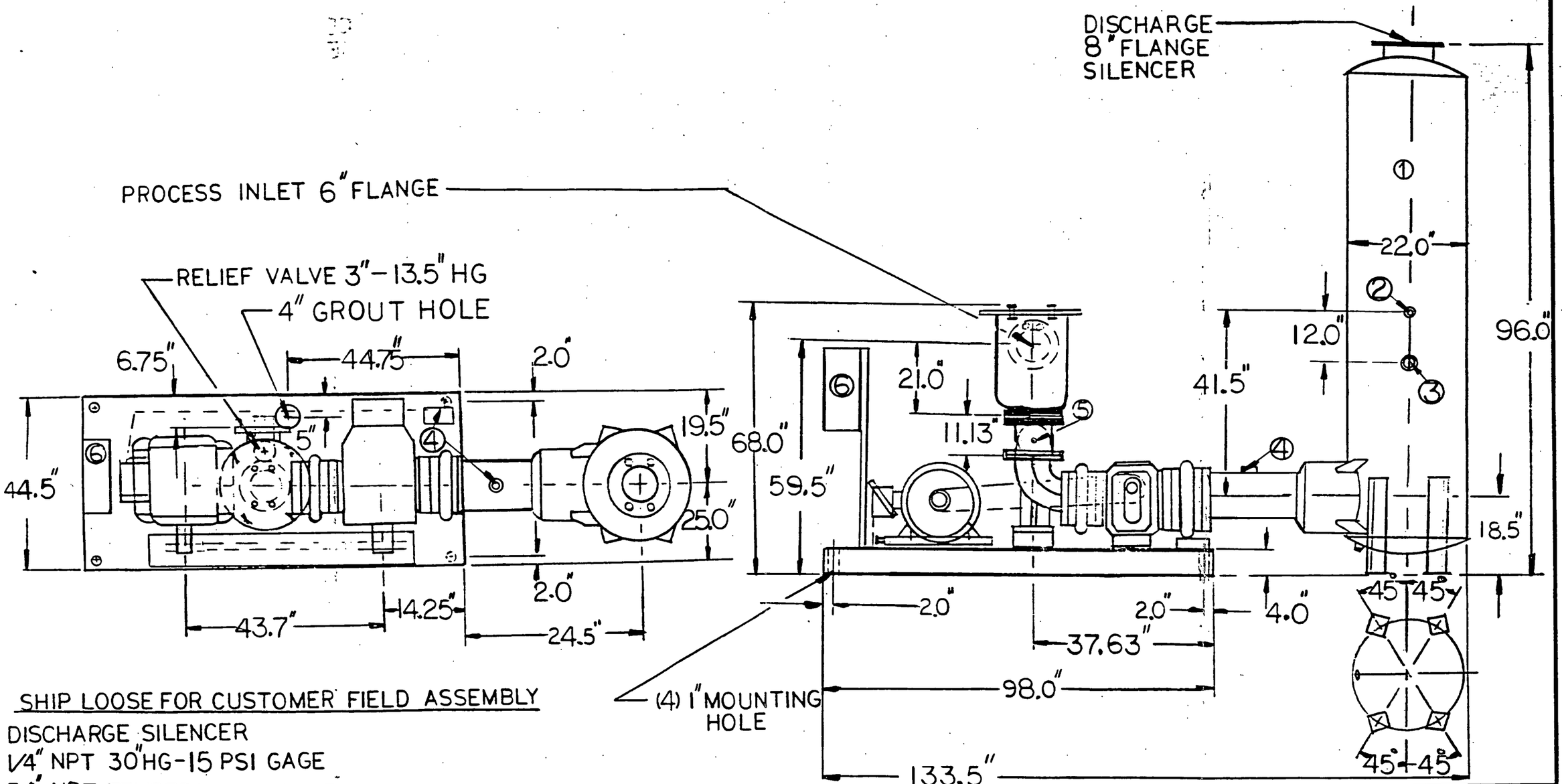
<Esc> Exit, <F7> Cancel, <F10>

DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
CONNERSVILLE,INDIANA 47331
PRINTED IN U.S.A.

PERFORMANCE BASED ON
INLET AIR = 68°F
DISCHARGE PRESSURE = 30" HG ABS.
JULY, 1994

VACUUM PERFORMANCE
FRAME 718 UNIVERSAL RAI BLOWER
MAXIMUM VACUUM=12 IN. HG
MAXIMUM SPEED=2050 RPM





SHIP LOOSE FOR CUSTOMER FIELD ASSEMBLY

① DISCHARGE SILENCER
② 1/4" NPT 30"HG-15 PSI GAGE
③ 3/4" NPT TEMPERATURE GAGE
④ 1/2" NPT HIGH TEMP. SHUTDOWN SWITCH
⑤ 1/4" NPT 30" HG GAGE
⑥ SINGLE POINT ELECTRICAL CONNECTION STARTER

APPROX. WEIGHT: BLOWER SKID 3600#
SILENCER 525#

DRESSER ROOTS 718URAIV

SCALE: NONE	APPROVED BY: TOMLIN EQUIPMENT	DRAWN BY SSR
DATE: 10-7-95		REVISED 6-21-99

NES CORPORATION SPECIAL

T60URAI-12HG	#27238	DRAWING NUMBER TOMNES1

ROOTS DRESSER

ISO 9001 CERTIFIED ROOTS QUALITY SYSTEM

Universal RAI® BLOWER

Universal RAI-J®

INSTRUCTIONS

ROTARY LOBE BLOWERS

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NUMBERS IN ( ) ARE METRIC EQUIVALENTS

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Description. . .Control. . .Protection

OPERATING LIMITATIONS.....2
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DO THESE THINGS To Get The Most From Your Roots Blower

1 Check shipment for damage. If found, file claim with carrier and notify Sales Office.

2 Unpack shipment carefully, and check contents against Packing List. Notify Sales Office if a shortage appears.

3 Store in a clean, dry location until ready for installation, if possible. Lift by methods discussed under INSTALLATION to avoid straining or distorting the equipment. Keep covers on all openings. Protect against weather and corrosion if outdoor storage is necessary.

4 Read LIMITATIONS and INSTALLATION sections in this manual and plan the complete installation.

5 Provide for adequate safeguards against accidents to persons working on or near the equipment during both installation and operation. See SAFETY PRECAUTIONS.

6 Install all equipment correctly. Foundation design must be adequate and piping carefully done. Use recommended accessories for operating protection.

7 Make sure both driving and driven equipment is correctly lubricated before start-up. See LUBRICATION.

8 Read starting check points under OPERATION. Run equipment briefly to check for installation errors and make corrections. Follow with a trial run under normal operating conditions.

9 In event of trouble during installation or operation, do not attempt repairs of Roots furnished equipment. Notify Sales Office or factory, giving all nameplate information plus an outline of operating conditions and a description of the trouble.

10 Unauthorized attempts at equipment repair may void Manufacturer's warranty. Units out of warranty may be repaired or adjusted by the owner. It is recommended that such work be limited to the operation described in this manual, using Factory Parts. Good inspection and maintenance practices should reduce the need for repairs. See Sales Office List on last page for parts and service after warranty period.

OPERATING CHARACTERISTICS

Roots UNIVERSAL RAI® and UNIVERSAL RAI-J® blowers, as covered in this manual, are designated as air blowers, and may be used for handling air in either pressure or vacuum service. They are unsuitable for handling gases because shaft seals are not designed to prevent leakage to atmosphere.

The Roots rotary lobe blower is a positive displacement type unit, whose pumping capacity is determined by size, operating speed and pressure conditions. It employs two double-lobe impellers mounted on parallel shafts and rotating in opposite directions within a cylinder closed at the ends by headplates. As the impellers rotate, air is drawn into one side of the cylinder and forced out the opposite side against the existing pressures. The differential pressure developed, therefore, depends on the resistance of the connected systems.

Effective sealing of the blower inlet area from the discharge area is accomplished by use of very small operating clearances. Resulting absence of moving contacts eliminates the need for any internal lubrication. Clearances between the impellers during rotation are maintained by a pair of accurately machined timing gears, mounted on the two shafts extending outside the air chamber.

Operation of the familiar basic rotary lobe blower is illustrated in FIGURE 1, where air flow is right to left from inlet to discharge with the bottom impeller rotating clockwise. In Position 1 it is delivering a known volume (A) to the discharge, while space (B) between the upper impeller and cylinder wall is being filled. Counterclockwise rotation of this impeller then traps equal volume (B) in Position 2, and further rotation delivers it to the discharge in Position 3. At the same time, another similar volume is forming under the lower impeller, and will be discharged when rotation reaches Position 1 again.

One complete revolution of the driving shaft alternately traps four equal and known volumes of air (two by each impeller) and pushes them through to the discharge. The pumping capacity of a lobe blower operating at a constant speed therefore remains relatively independent of reasonable inlet or discharge pressure variations. To change capacity, it is necessary either to change speed of rotation or vent some of the air.

No attempt should ever be made to control capacity

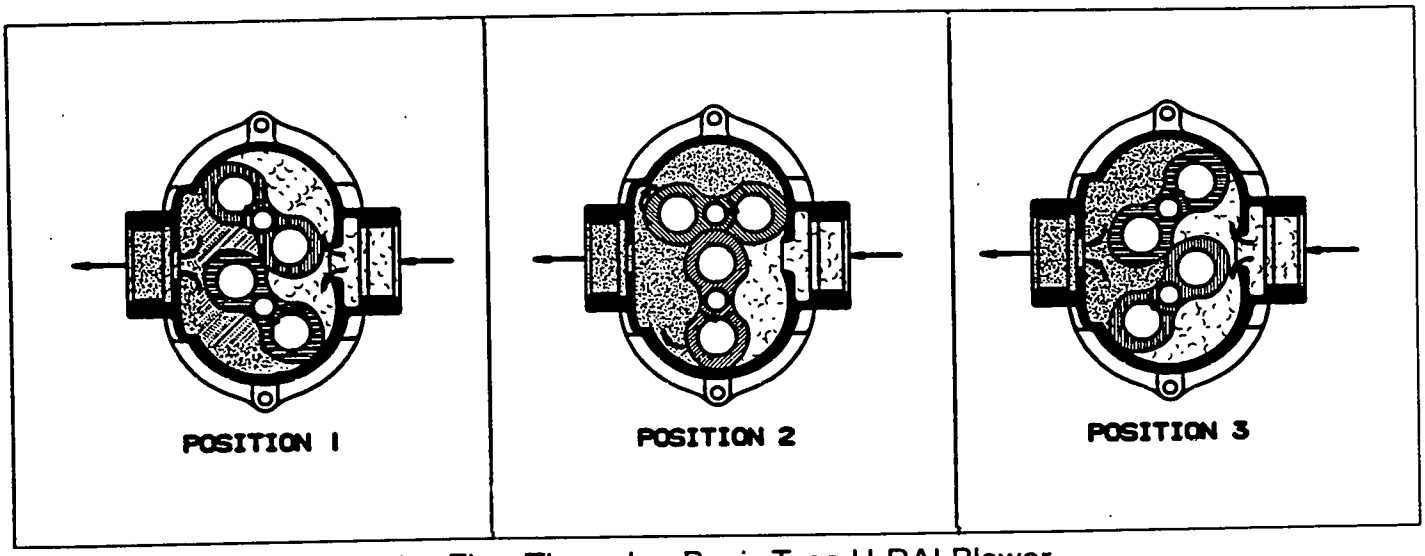


Figure 1 – Flow Through a Basic Type U-RAI Blower

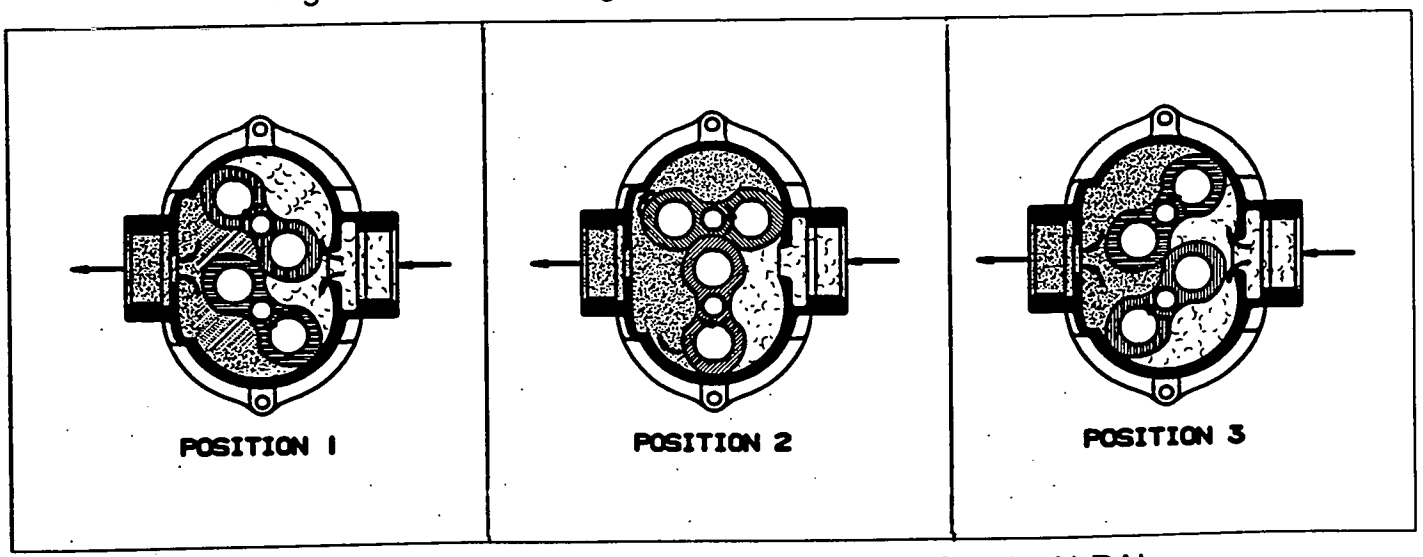


Figure 1A – Blower Operating Principle with Slot Jet U-RAI

by means of a throttle valve in the intake or discharge piping. This increases the power load on the driver, and may seriously damage the blower. Likewise, if a possibility exists that flow to the blower inlet may be cut off during normal operation of a process, then an adequate vacuum relief valve must be installed near the blower. A pressure type relief valve in the discharge line near the blower is also strongly recommended for protection against cut-off or blocking in this line.

When a belt drive is employed, blower speed can usually be adjusted to obtain desired capacity by changing the diameter of one or both sheaves. See pages 18 and 20 for minimum sheave diameter. In a direct coupled arrangement, a variable speed motor or transmission is required, or air may be vented through a manually controlled unloading valve and silencer. If discharge air is returned to the blower inlet, it must be cooled to 100°F (38°C) through a cooling by-pass arrangement.

Before making any change in blower capacity or operating conditions, contact the nearest Distributor for specific information applying to your particular blower. In all cases, operating conditions must be maintained within the approved range of pressures, temperatures and speeds as stated under LIMITATIONS. Also, the blower must not be used to handle air containing liquids or solids, or serious damage to the rotating parts will result.

OPERATING LIMITATIONS

To permit continued satisfactory performance, a Roots UNIVERSAL RAI® blower must be operated within certain approved limiting conditions. The Manufacturer's warranty is, of course, also contingent on such operation.

Maximum limits for pressure, temperature and speed are specified in Table 1 for various sizes of UNIVERSAL RAI® blowers. These limits apply to all blowers of normal construction, having operating clearances as listed in Table 5 when operated under standard atmospheric conditions. **Do not exceed any of these limits.**

Table 1 – Maximum Allowable Operating Conditions

Frame Size	Speed RPM	Inlet Vac. Inches Hg. (kPa)	Temp. Rise Fahr. Deg. (C°)	Press. Rise PSI (kPa)
22	5275	15 (50)	225 (125)	12 (82)
24	5275	15 (50)	210 (117)	7 (47)
32	3600	15 (50)	240 (133)	15 (101)
33/33J	3600	15 (50)	225 (125)	12 (82)
36/36J	3600	15 (50)	225 (125)	7 (47)
42	3600	15 (50)	240 (133)	15 (101)
45/45J	3600	15 (50)	225 (125)	10 (68)
47/47J	3600	15 (50)	225 (125)	7 (47)
53	2850	15 (50)	225 (125)	15 (101)
56/56J	2850	15 (50)	225 (125)	10 (68)
59	2850	15 (50)	225 (125)	7 (47)
65	2350	16 (53)	250 (130)	15 (101)
68	2350	16 (53)	240 (133)	12 (82)
615	2350	12 (40)	130 (72)	6 (40)
76	2050	16 (53)	250 (139)	15 (101)
711	2050	16 (53)	225 (125)	10 (68)
718	2050	12 (40)	130 (72)	6 (40)

Example: The listed maximum allowable temperature rise (increase in air temperature between inlet and discharge) for any particular blower may occur well before its maximum pressure or vacuum rating is reached. This can easily occur at high altitude or at very low speed. Temperature rise then is the limiting condition. In other words, the operating limit is always determined by the maximum rating reached first. It can be any one of the three: pressure, temperature or speed.

Be sure to arrange connections or taps for thermometers and mercury type pressure or vacuum gauges at or near the inlet and discharge connections of the blowers. These, along with a good tachometer, will enable periodic checks of operating conditions to be made easily.

PRESSURE – On pressure service, the pressure rise in pounds per square inch (kPa) (between blower inlet and discharge) must not exceed the figure listed for the specific blower frame size concerned. Also, in any system where the blower inlet is at a positive pressure above atmosphere, the discharge pressure must never exceed 25 PSI (172 kPa) gauge regardless of blower size.

On vacuum service, with the discharge going to atmospheric pressure, the inlet suction or vacuum in inches of mercury (Hg.) (kPa) must not be greater than the values listed for the specific frame size.

TEMPERATURE – Various blower frame sizes are approved only for installations where the following temperature limitations can be maintained in service.

A. Measured temperature rise in Fahrenheit degrees (C°) must not exceed listed values when the inlet is at ambient temperature. Ambient is considered as the general temperature of the space around the blower. This is not outdoor temperature unless the blower is installed outdoors.
B. If inlet temperature is higher than ambient, the listed allowable temperature rise values must be reduced by 2/3 of the difference between the actual measured inlet temperature and the ambient temperature.
C. Average of inlet plus discharge temperature must not exceed 250°F (139°C).

SPEED RANGE – UNIVERSAL RAI® blowers may be operated at speeds up to the maximums listed for various frame sizes. They may be direct coupled to suitable constant speed drivers if pressure/temperature conditions are also within limits. At low speeds, excessive temperature rise may be the limiting factor as noted in the preceding example.

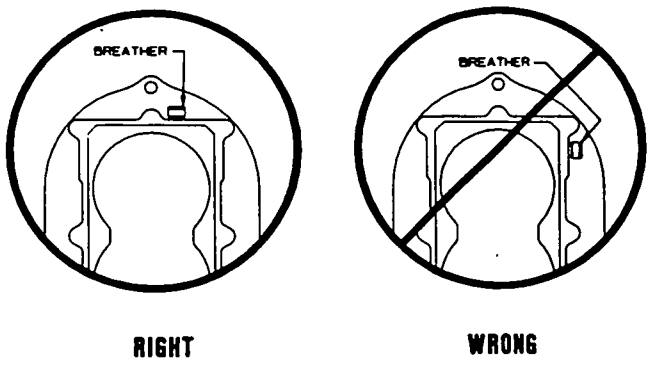


Figure 2 – Breather Installation

BLOWER ORIENTATION

The unique removable feet feature of Roots UNIVERSAL RAI® blowers permit field modification of blower mounting by repositioning blower feet and gear box breather as shown in Figure 3.

Four blower mounting positions are possible:

1. Horizontal mounting, vertical air flow, drive shaft on left.
2. Same as (1) except drive shaft on right.
3. Vertical mounting, horizontal air flow, drive shaft on bottom.
4. Same as (3) except drive shaft on top.

To change blower mounting:

1. Place blower on its feet.
2. Loosen feet capscrews (32).
3. Place blower on a solid base resting on the gear box end with drive shaft on top.
4. Remove feet. (Note – Feet capscrews (32) are longer than cylinder capscrews (26), only capscrews (32) are to be used for feet.)
5. Remove cylinder capscrews (32) where feet are to be re-installed. Install capscrews (26) in the location previously occupied by feet capscrews (32).
6. Install feet using capscrews (32).
7. Place blower on its feet on flat surface.
8. Loosen feet capscrews (32) and square up blower and re-tighten capscrews (32).
9. Gear box has four threaded holes, one with breather and three with pipe plugs. Remove pipe plug (21) from the top most hole. Remove breather (25) and install it in the top most hole. Install pipe plug that was removed from the top hole into the hole previously occupied by the breather. The breather and the pipe plug should be sealed with a thread sealer.

For convenience, the position of the grease fitting (37) and the relief fitting (38) could be interchanged, however each bearing must have one grease fitting (37) and one relief fitting (38).

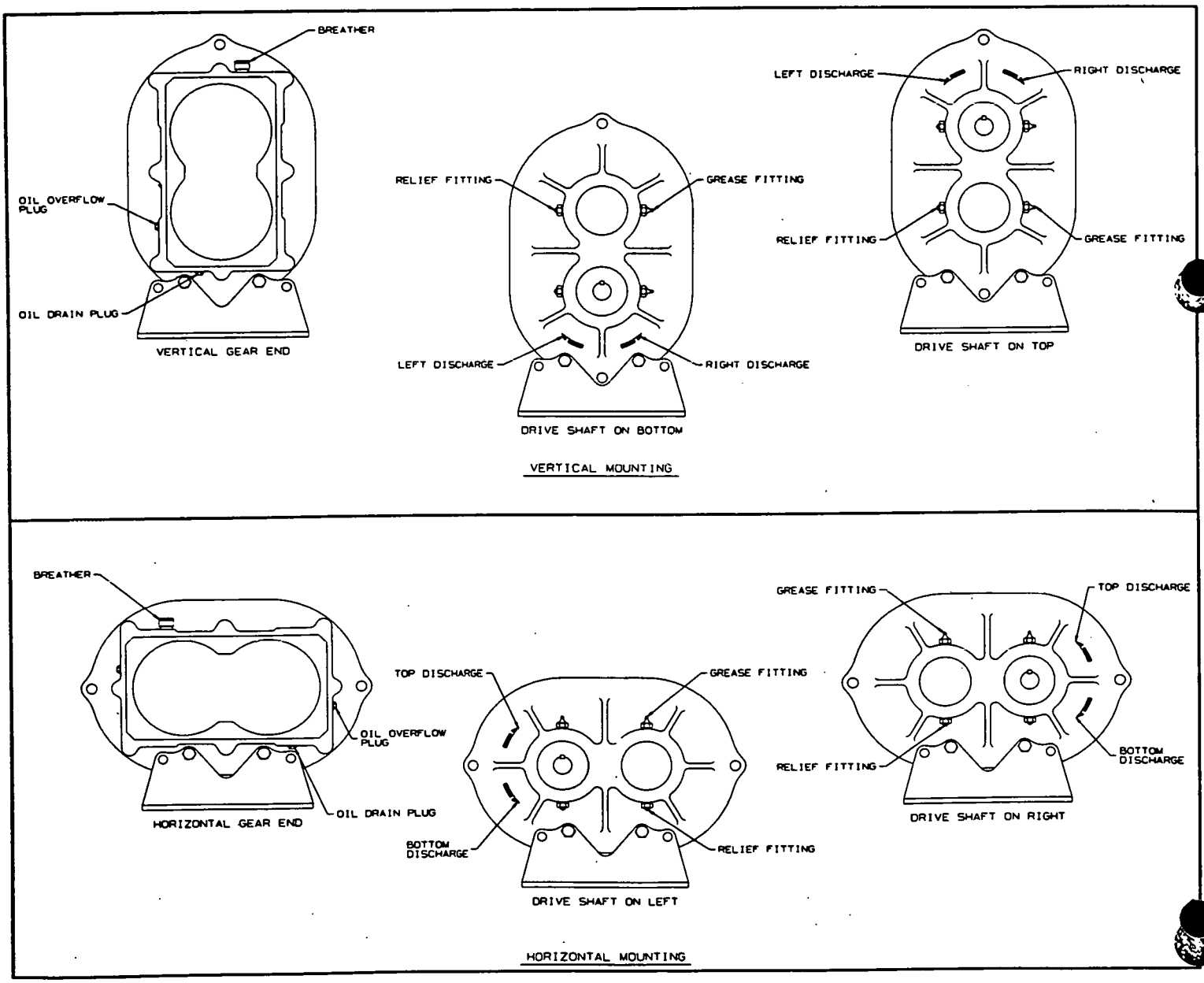


Figure 3 – Blower Orientation and Lubrication Points

INSTALLATION

Roots UNIVERSAL RAI® blowers are internally and externally treated after factory assembly to protect against normal atmospheric corrosion before installation. Maximum period of internal protection is considered to be one year under average conditions, if closing plugs or seals are not removed. **Protection against chemical or salt water atmosphere is not provided.** Avoid opening the blower until ready to start installation, as protection will be lost quickly by evaporation.

NOTE — If there is to be an extended period between delivery (and/or installation) and startup, the following steps should be taken to insure corrosion protection:

1. Coat internals of cylinder and gearbox with Nox-Rust No. VCI10 or equivalent. Repeat once a year or as conditions may require. Motorstor is oil soluble and does not have to be removed before lubricating. If desired, No. VCI10 may be removed from within the cylinder shortly before startup by spraying a fine mist of petroleum solvent through the blower while it is running at a slow speed with open inlet and discharge, or it can remain in the blower if it is not harmful to the operation of the connected system.
2. Fill drive end bearing cavities with grease as specified in Lubrication section.
3. Paint shaft extension, inlet and discharge flanges, and all other exposed surfaces with Nox-Rust X-110 or equivalent.
4. Seal inlet, discharge, and all vent openings with tape. It is not recommended that the unit be set in place, piped to the system, and allowed to remain idle for extended periods. If any part is left open to the atmosphere, the Motorstor vapor will escape and lose its effectiveness.
5. Units are not to be subjected to excessive vibration during storage.
6. Rotate drive shaft three or four revolutions every two weeks.
7. Prior to startup, remove flange covers on both inlet and discharge and inspect internals to insure absence of rust. Check all internal clearances. Also, at this time, remove gearbox and inspect gear teeth for rust.

Because of the completely enclosed blower design, location of the installation is generally not a critical matter. A clean, dry and protected indoor location is to be preferred. However, an outdoor or wet location will normally give satisfactory service. Important requirements are that the correct grade of lubricating oil be provided for expected temperatures, and that the blower be located so that routine checking and servicing can be handled conveniently after installation. Effect of the location on driver and accessory equipment must also be considered.

Supervision of the installation by a Factory Service Engineer is not usually required for these blowers. Workmen with experience in installing light-medium weight machinery should be able to produce satisfactory results. Handling of the equipment needs to be accomplished with care, and in compliance with safe practices. Blower mounting must be solid, without strain or twist, and air piping must be clean, accurately aligned and properly connected.

A bare blower without base should be lifted by a rope sling, with one loop passing under the gearhouse and the other loop under the cylinder.

When a blower is furnished mounted on a baseplate, with or without a driver, use of lifting slings passing under the base flanges is required. Arrange these slings so that no strains are placed on the blower casing or mounting feet, or on any mounted accessory equipment.

Before starting the installation, remove plugs, covers or seals from blower inlet and discharge connections and inspect the interior completely for dirt or foreign material. If cleaning is required, finish by washing the cylinder, headplates and impeller thoroughly with a petroleum solvent such as DuPont Triclene D. After this, turn the drive shaft by hand to make sure that the impellers turn freely at all points. Anti-rust compound on the drive shaft extension may also be removed at this time with the same solvent. Then plug the inlet and discharge connections to keep out dirt until ready to connect the air piping. Washing out is not required if the interior is found to be clean. The corrosion inhibitor used will vaporize and disappear during operation.

Care, plus consideration of all possible problems, will pay dividends when arranging the blower mounting. This is especially true when the blower is a "bare" unit furnished without a baseplate. The convenient procedure may be to mount such a unit directly on a floor or small concrete pad, but this generally produces least satisfactory results. It definitely causes the most problems in leveling and alignment.

Direct use of structural framing members is also not a recommended mounting. If unavoidable, the members must be rigidly reinforced when part of a building, and spring type mountings should not be used. Noise transmission can usually be reduced by use of a cork insulating pad 1 to 2 inches (25 to 50 mm) thickness. The pad should be supported by a full steel plate attached to the structure, with a rigid concrete slab laid on top of the cork to carry the blower and driver.

For a blower without base, it is recommended that a well anchored and carefully leveled steel or cast iron mounting plate be provided at the installation point. The plate should be ¾ to 1¼ inches (19 to 32 mm) thick, with its top surface machined flat, and needs to be large enough to provide leveling areas at one side and one end after the blower is mounted. It should have properly sized studs or tapped holes located to match the blower foot drilling. As an alternative, smaller plates at each end of the blower may be used. This is more complicated, usually makes leveling more difficult, and can produce twist or strains in the blower. Use of a high quality machinist's level is important. With the mounting plate in place and leveled, set the blower on it without bolting and check for rocking. If it is not solid, determine the total thickness of shims required under one foot to stop the rocking. Place half of this under each of the two short feet, and tighten the mounting studs or screws. Rotate the drive shaft to make sure the impellers still turn freely. If the blower is to

be direct coupled to a driving motor, consider the height of the motor shaft and the necessity for it to be aligned very accurately with the blower shaft. Best arrangement is for the blower to be bolted directly to the mounting plate while the driver is on shims of at least ⅛ inch (3 mm) thickness. This allows adjustment of motor position in final shaft alignment by varying the shim thickness.

Satisfactory installation can be obtained by setting the baseplate on a concrete slab that is rigid and free of vibration, and leveling the top of the base carefully in two directions so that it is free of twist. The slab must be provided with suitable anchor bolts. The use of grouting under and inside the base, after it has been carefully leveled by shimming, is recommended.

When blower and driver have been factory mounted on a common baseplate, the assembly will have been properly aligned and is to be treated as a unit for leveling purposes. It is possible for a base mounted assembly to become twisted during shipment thus disturbing the original alignment. For this reason, make the following checks after the base has been leveled and bolted down. Disconnect the drive and rotate the blower shaft by hand. It should turn freely at all points. Loosen the blower foot hold-down screws and determine whether all feet are evenly in contact with the base. If not, insert shims as required and again check for free impeller rotation. Finally, if blower is direct coupled to the driver, check shaft and coupling alignment carefully and make any necessary corrections prior to grouting.

In planning the installation, and before setting the blower, consider how piping arrangements are dictated by the blower design and assembly.

When a blower is DIRECT COUPLED to its driver, the driver RPM must be selected or governed so as not to exceed the maximum speed rating of the blower. Refer to LIMITATIONS for allowable speeds for various blower sizes. A flexible type coupling should always be used to connect the driver and blower shafts.

For engine drives, couplings with proper stiffness must be selected to avoid resonant torisonal vibrations. Also, safe operating speed must be limited to avoid critical speeds.

Coupling halves must be accurately aligned, and a sufficient gap between shaft ends provided, so that side strains and end thrust on either shaft are avoided or minimized. This will require considerable care in the mounting of the driver. The two shafts must be in as near perfect alignment in all directions as possible, and the gap must be established with the motor armature on its electrical center if end play exists. Coupling halves must be fitted to the two shafts such that they can be worked into place by hand. Maximum deviation in offset alignment of the shafts should not exceed .005" (.13 mm) total indicator reading, taken on the two coupling hubs. Maximum deviation from parallel of the inside coupling faces should not exceed .001" (.03 mm) when checked at six points around the coupling.

CAUTION

Couplings as well as sheave bushings must have a slight slide fit with the blower shaft such that they can be installed in place by hand. Any force used to install them will change blower end clearances resulting in blower damage. If an interference fit is desired for the coupling, the coupling hub should be heated and shrunk on the shaft. For engine drives, use "Locktite" between the coupling hubs and the blower/engine shafts and on the threads of the coupling set screws.

When a blower is BELT DRIVEN, a proper selection of sheave diameters can usually be made to adapt any standard driver speed to the required blower speed. This flexibility can sometimes lead to operating temperature problems caused by blower speed being too low. Make sure the drive speed selected is within the allowable range for the specific blower size, as specified under LIMITATIONS.

Belted drive arrangements usually employ two or more V-belts running in grooved sheaves, and a variety of positions are available for the driver. Installation of the driver is less critical than for direct coupling, but its shaft must be level and parallel with the blower shaft. The driver must also be mounted on an adjustable base to permit installing, adjusting and removing the V-belts. To position the driver correctly, both sheaves need to be mounted on their shafts and the nominal shaft center distance known for the belt lengths to be used.

Install the blower sheave (usually the larger one) so that its inner hub face is not more than ¼ inch (7 mm) from the bearing end cover. The shaft fit should be such that the sheave can be worked into place by hand. A tight or driving fit can damage a bearing, and may cause internal blower damage by forcing the impeller out of its normal operating position. A loose fit or wobbly sheave will cause vibration, and may result in shaft breakage.

The driver sheave should also be mounted as close to its bearing as possible, and again should fit the shaft correctly. Position the driver on its adjustable base so that ⅔ of the total movement is available in the direction away from the blower, and mount the assembly so that the face of the sheave is accurately in line with the blower sheave. This position minimizes belt wear, and allows sufficient adjustment for both installing and tightening the belts. After belts are installed, adjust their tension in accordance with the manufacturer's instructions. However, only enough tension should be applied to prevent slippage when the blower is operating under load. *Excessive tightening* can lead to early bearing failures.

Failure to properly align the blower and drive sheaves will result in the impeller being forced against one of the headplates during operation causing serious damage to the blower.

In the absence of belt manufacturer's instructions for tensioning, the following procedures may be used.

1. With the belts loose, pull the slack on all of them to the bottom side of the drive.
2. Adjust motor position to tighten belt until they appear to be seating in the sheave grooves.
3. Thump the belts with your fist. If they feel dead, tighten them more until they vibrate and feel springy when struck.
4. Run-in the drive for a short period, after preparing the blower as instructed in a following paragraph. While running, adjust until only a very slight bow appears in the slack side of the belts.
5. Stop the motor and compare the tensions of the individual belts by pressing down firmly with one hand on the top surface. It should be possible to deflect each

belt only to the point where its top surface is even with the bottoms of the other undeflected belts.

6. A new set of belts should be first tensioned about ⅓ greater than normal to allow for stretch and wear-in. Before putting the drive into normal operation, increase the tension as obtained above by a small amount. Recheck after each 8 hour operating period during the first 50 hours, and adjust as necessary.

Before operating the drive under power to check initial belt tension, first remove covers from the blower connections. Make sure the interior is still clean, then rotate the shaft by hand. Place a screen over the inlet connection to prevent anything being sucked into the blower while it is operating, and avoid standing in line with the discharge opening. Put oil in the gearhouse per instructions under LUBRICATION.

Before connecting piping, remove any remaining antirust compound from blower connections. Piping must be clean and should be sized so that the air velocity will not exceed 75 feet per second (23 m per second). Pipe used should be no smaller than blower connections. In addition, make sure it is free of dirt, scale, cuttings, weld beads, or foreign materials of any kind.

To further guard against damage to the blower, especially when an inlet filter is not used, install a substantial screen of 16 mesh backed with hardware cloth at or near the inlet connections. Make provisions to clean this screen of collected debris after a few hours operation. It should be removed when its usefulness has ended, as the wire will eventually deteriorate and small pieces going into the blower may cause serious damage.

Pipe threads or flanges must meet the blower connections accurately and squarely. Do not attempt to correct misalignment by springing or cramping the pipe. In most cases this will distort the blower casing and cause impeller rubbing. In severe cases it can prevent operation or result in a broken drive shaft. For similar reasons, piping should be supported near the blower to eliminate dead weight strains. Also, installation of flexible connectors or expansion joints is recommended.

Figure 4 represents in diagram form a blower installation with all accessory items that might be required under various operating conditions. Inlet piping should be completely free of valves or restrictions. When a shut-off valve (not shown) cannot be avoided, make sure a full size vacuum relief is installed near the blower inlet. This will protect against blower overload caused by accidental closing.

Need for an inlet silencer will depend on blower speed and pressure, as well as sound-level requirements in the general surroundings. An inlet filter is normally recommended, especially in dusty or sandy locations, for blower protection. A discharge silencer is also normally suggested. Specific recommendations on silencing can be obtained from the nearest Sales Office. Silencers should be mounted as close to blower as possible.

Discharge piping requires a pressure relief valve, and should include a manual unloading valve to permit starting the blower under no-load conditions. Reliable pressure/vacuum gauges and good thermometers at both inlet and discharge are recommended to allow making the important checks on blower operating conditions. If the demand is constant, but somewhat lower than the blower output, excess may be blown off through the manual unloading valve.

In multiple blower installations when two or more units discharge into a common header, use of check valves is recommended. These should be of a direct acting or free swinging type, with one valve located in each blower

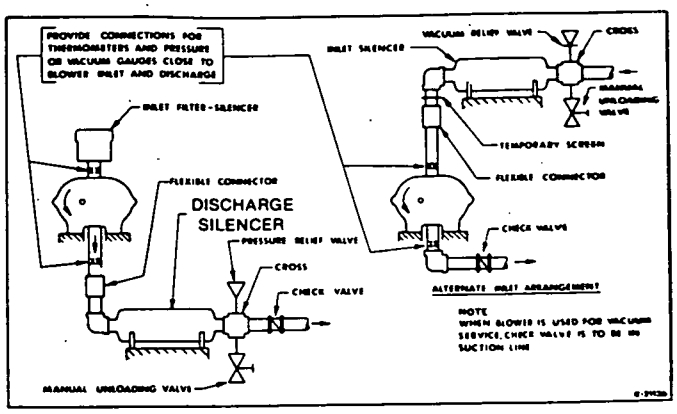


Figure 4 — Installation with Accessories

discharge line. Properly installed, they will protect against damage from reverse rotation caused by air backflow through an idle blower.

After piping is completed, and before applying power, rotate the drive shaft by hand again. If it does not move with uniform freedom, look for uneven mounting, piping strain, excessive belt tension or coupling misalignment. Do not operate the blower more than briefly at this time because of possible inadequate oil supply in the gearhouse. Read LUBRICATION section.

LUBRICATION

A simple but very effective lubrication system is employed on UNIVERSAL RAI® blowers. At the drive shaft end the bearings are grease lubricated using hydraulic pressure relief fittings. These relief fittings vent any excess grease, preventing pressure build-up on the seals. A restriction plug and metering orifice prevent loss of lubricant from initial surges in lubricant pressure but permit venting excess lubricant under steadily rising pressures.

The blind end bearings and timing gears are enclosed by a gearhouse located opposite the drive end of the blower. In a side outlet blower, the lower timing gear functions as an oil slinger, carrying lubricant to the upper timing gear and providing splash lubrication for the bearings. Pressure within the gearbox is vented through the breather vent plug (25).

The above description also applies in general to the top or bottom outlet style blower, the principal difference being that both gears dip into the oil sump.

Before starting blower, be sure oil has been put in gearhouse, as **ALL OIL WAS DRAINED FOLLOWING SHOP TESTS.** For recommended lubrication oil see Table 2. Use a good grade industrial type rust, oxidation, and foam inhibited, non-detergent oil such as Mobil DTE BB, Texaco R&O 220, Amoco 220 or equal. Also, Roots synthetic oil has proven to be an excellent lubricant.

Table 2 — Recommended Oil Grades

Ambient Temperature ° F.	Viscosity Range SSU at 100° F.	ISO No.
(°C)	(38°C)	
Above 90° (32°)	1000 - 1200	320
32° to 90° (0° to 32°)	700 - 1000	220
0° to 32° (−18° to 0°)	500 - 700	150
Below 0° (−18°)	300 - 500	100

To fill the gearbox, remove the breather plug and the oil overflow plug (Fig. 3). Fill the reservoir up to the overflow hole. Place the breather and the overflow plug back into their respective holes.

Table 3 — Oil Sump Capacities

Frame Size	Capacity, Fl. Oz. (Liters) Vertical	Horizontal
22	3.4 (.1)	6.1 (.18)
24	3.4 (.1)	6.1 (.18)
32	8.5 (.25)	16.0 (.47)
33	8.5 (.25)	16.0 (.47)
36	8.5 (.25)	16.0 (.47)
42	12.7 (.37)	22.8 (.67)
45	12.7 (.37)	22.8 (.67)
47	12.7 (.37)	22.8 (.67)
53	16.0 (.47)	27.6 (.82)
56	16.0 (.47)	27.6 (.82)
59	16.0 (.47)	27.6 (.82)
65	28.3 (.84)	52.1 (1.54)
68	28.3 (.84)	52.1 (1.54)
615	28.3 (.84)	52.1 (1.54)
76	32.3 (.96)	59.5 (1.76)
711	32.3 (.96)	59.5 (1.76)
718	32.3 (.96)	59.5 (1.76)

Proper lubrication is usually the most important single consideration in obtaining maximum service life and the most satisfactory operation from the unit. Unless operating conditions are quite severe, a weekly check of gearhouse oil level and necessary addition of lubricant should be sufficient. However, oil should be changed after initial 100 hours of operation. Thereafter, a complete oil change normally is made after 1000 operating hours, or less, depending on the type of oil and oil operating temperature.

Shaft bearings at the drive end of the blower are grease lubricated and each bearing housing is equipped with pressure type grease fittings and pressure type relief fittings. When servicing drive end bearings, use a NLGI #2 premium grade, petroleum base grease with high temperature (300° service temperature) and moisture resistance and good mechanical stability. Using a pressure gun, force new lubricant into each drive end bearing housing until traces of clean grease comes out of the relief fitting.

After a long shutdown, it is recommended that the grease relief fittings be removed, the old grease flushed out with kerosene or #10 lubricating oil, drained thoroughly, and bearings refilled with new grease. Be sure grease relief fittings are reinstalled. Grease should be added using hand operated grease gun to the drive end bearings at varying time intervals depending on duty cycle and RPM. Table 4 has been prepared as a general greasing schedule guide based on average operating conditions. More frequent intervals may be necessary depending on the grease operating temperature and under unusual circumstances.

Table 4 — Suggested Bearing Lubrication Intervals

Speed in RPM	Operating Hours Per Day		
	8	16	24
	Greasing Intervals in Weeks		
750 - 1000	7	4	2
1000 - 1500	5	2	1
1500 - 2000	4	2	1
2000 - 2500	3	1	1
2500 - 3000	2	1	1
3000 and up	1	1	1

OPERATION

Before operating a blower under power for the first time, check the unit and the installation thoroughly to reduce the likelihood of avoidable troubles. Use the following procedure list as a guide, but consider any other special conditions in the installation.

1. **Be certain** that no bolts, tools, rags or dirt have been left in the blower air chamber.
2. **Be certain** that inlet piping is free of debris. If an outdoor intake without filter is used, be sure the opening is located so it cannot pick up dirt and is protected by a strong screen or grille. Use of the temporary protective screen at the blower as described under **INSTALLATION** is strongly recommended.
3. **Recheck** blower leveling, drive alignment and tightness of all mounting bolts if installation is not recent. If belt drive is used, adjust belt tension correctly.
4. Turn drive shaft by hand to make sure impellers still rotate without bumping or rubbing at any point.
5. **Make sure** oil level in blower gearbox is correct.
6. Check lubrication of driver. If it is an electric motor, be sure that power is available and that electrical overload devices are installed and workable.
7. Open the manual unloading valve in the discharge air line. If a valve is in the inlet piping, be sure it is open.
8. Bump blower a few revolutions with driver to check that direction of rotation is correct, and that both units coast freely to a stop.

After the preceding points are cleared, blower is ready for trial operation under "no-load" conditions as set up under Item 7. The following procedure is suggested to cover this initial operating test period.

a. Start blower, let it accelerate to full speed, then shut off. Listen for knocking sounds, both with power on and as speed slows down.
b. Repeat above, but let blower run 2 or 3 minutes. Check for noises, and vibrations of 5 mils or greater.
c. Operate blower for about 10 minutes unloaded. Check oil levels. Feel cylinder and headplate surfaces for development of spots too hot to touch, indicating impeller rubs. Be aware of any noticeable increase in vibration.

Assuming that all trials have been satisfactory, or that necessary corrections have been made, the blower should now have a final check run of at least one hour under normal operating conditions. After blower is re-

started, gradually close the discharge unloading valve to apply working pressure. At this point it is recommended that a good pressure gauge or manometer be connected into the discharge line if not already provided, and that thermometers be in both inlet and discharge lines. Readings from these instruments will show whether pressure or temperature ratings of the blower are being exceeded.

During the final run, check operating conditions frequently and observe the oil levels at reasonable intervals. If excessive noise or local heating develops, shut down immediately and determine the cause. If either pressure rise or temperature rise across the blower exceeds the limit specified in this manual shut down and investigate conditions in the piping system or in the process to which air is being supplied. Refer to the **TROUBLE SHOOTING CHECKLIST** for suggestions on various problems that may appear.

The blower should now be ready for continuous duty operation at full speed. During the first few days make periodic checks to determine whether all conditions remain steady, or at least acceptable. This may be particularly important if the blower is supplying air to a process system where conditions can vary. At the first opportunity, stop the blower and clean the temporary inlet protective screen. If no appreciable amount of debris has collected, the screen may be removed. See comments under **INSTALLATION**. At this same time, verify leveling, coupling alignment or belt tension, and mounting bolt tightness.

Should operating experience prove that blower capacity is a little too high for the actual air requirements, a small excess may be blown off continuously through the manual unloading vent valve. Never rely on the pressure relief valve as an automatic vent. Such use may cause the discharge pressure to become excessive and can also

TROUBLE SHOOTING CHECKLIST

TROUBLE	ITEM	POSSIBLE CAUSE	REMEDY
No Air Flow	1	Speed too low	Check by tachometer and compare with speed shown on Roots Order Acknowledgment.
	2	Wrong rotation	Compare actual rotation with Figure 3. Change driver if wrong.
	3	Obstruction in piping	Check piping, screen, valves, silencer, to assure an open flow path.
Low capacity	4	Speed too low	See item 1. If belt drive, check for slippage and readjust tension.
	5	Excessive pressure	Check inlet vacuum and discharge pressure, and compare these figures with specified operating conditions on Order.
	6	Obstruction in piping	See item 3.
	7	Excessive slip	Check inside of casing for worn or eroded surfaces causing excessive clearances.
Excessive Power	8	Speed too high	Check speed and compare with Roots Order Acknowledgement.
	9	Pressure too high	See item 5.
	10	Impellers rubbing	Inspect outside of cylinder and headplates for high temperatures areas, then check for impeller contacts at these points. Correct blower mounting, drive alignment.
Overheating of Bearings, or Gears	11	Inadequate lubrication	Restore correct oil levels in gearbox and lubricate.
	12	Excessive lubrication	Check gear oil level. If incorrect, drain and refill with clean oil of recommended grade.
	13	Excessive pressure rise	See item 5.
	14	Coupling misalignment	Check carefully. Realign if questionable.
	15	Excessive belt tension	Readjust for correct tension.
	16	Speed too low	Speeds lower than the minimum recommended will overheat the entire blower.
Vibration	17	Misalignment	See item 14.
	18	Impellers rubbing	See item 10.
	19	Worn bearings/gears	Check gear backlash and condition of bearings.
	20	Unbalanced or rubbing impellers	Scale or process material may build up on casing and impellers, or inside impellers. Remove build-up to restore original clearances and impeller balance.
	21	Driver or blower loose	Tighten mounting bolts securely.
	22	Piping resonances	Determine whether standing wave pressure pulsations are present in the piping. Refer to Sales Office.

result in failure of the valve itself. If blower capacity appears to be too low, refer to the **TROUBLE SHOOTING CHECKLIST** first. If no help is found there it may be possible to increase the blower speed. Before attempting this change, contact the nearest Distributor for recommendations. Be prepared to furnish data on actual air requirements and operating pressure/temperature conditions.

VIBRATION ASSESSMENT CRITERIA

With measurements taken at the bearing locations on the housings, an unfiltered vibration of 1.0 in/sec peak is considered an appropriate assessment guide line for rotary lobe blowers rigidly mounted on stiff foundations.

If the blower is operating above this level then the installation must be fully evaluated to determine the source or cause of the vibration. And, the cause corrected.

In general, blower vibration levels should be monitored on a regular basis and the vibration trend observed for progressive or sudden change in level. If such a change occurs, the cause should be determined through spectral analysis.

SAFETY PRECAUTIONS

For equipment covered specifically or indirectly in this instruction book, it is important that all personnel observe safety precautions to minimize the chances of injury. Among many considerations, the following should particularly be noted:

- **Blower casing and associated piping or accessories may become hot enough to cause major skin burns on contact.**
- **Internal and external rotating parts of the blower and driving equipment can produce serious physical injuries. Do not reach into any opening in the blower while it is operating, or while subject to accidental starting. Cover external moving parts with adequate guards.**
- **Disconnect power before doing any work, and avoid by-passing or rendering inoperative any safety or protective devices.**
- **If blower is operated with piping disconnected, place a strong coarse screen over the inlet and avoid standing in the discharge air stream.**
- **Stay clear of open inlet piping (suction area) of pressure blowers, and the open discharge blast from vacuum blowers.**
- **Stay clear of the blast from pressure relief valves and the suction area of vacuum relief valves.**
- **Avoid extended exposure in close proximity to machinery which exceeds safe noise levels.**
- **Use proper care and good procedures in handling, lifting, installing, operating and maintaining the equipment.**
- **Casing pressure must not exceed 25 PSI (172 kPa) gauge. Do not pressurize vented cavities from an external source, nor restrict the vents.**
- **Do not use air blowers on explosive or hazardous gases.**
- **Other potential hazards to safety may also be associated with operation of this equipment. All personnel working in or passing through the area should be warned by signs and trained to exercise adequate general safety precautions.**

MAINTENANCE & REPLACEMENTS

A good program of inspection and maintenance servicing, followed consistently, is the most reliable method of minimizing repairs to a blower. A simple record of services and dates will help keep this work on a regular schedule. Basic service needs are lubrication, checking for hot spots or increase in vibration and noise and the recording of operating pressures and temperatures. Above all, **a blower must be operated within its specified rating limits,** to obtain satisfactory service life.

A newly installed blower should be checked frequently during the first month of full-time operation. Attention thereafter may be less frequent, depending on what the early checks have shown. Lubrication is normally the most important consideration. Unless operating conditions are unusually severe, a weekly check of oil levels in the gearbox, with addition of oil as required, should be sufficient. Complete oil changes should be made at intervals of 1000 operating hours, or more frequently if oil condition becomes poor.

Driver lubrication practices should be in accordance with the manufacturer's instructions. If direct connected to the blower through a lubricated type coupling, the coupling should be checked and greased each time blower oil is changed. This will help reduce wear and prevent it from causing vibration. In a belted drive system, check belt tension periodically and inspect for frayed or cracked belts. Refer to tensioning instructions under **INSTALLATION.**

In a new and properly installed blower there are no moving contacts between the two impellers, or between the impeller and cylinder or headplates. Wear is then confined to the bearing which support and locate the shafts, the shaft seals, and the timing gears. All are lubricated, and wear should be nominal if clean oil of the correct grade is always supplied. Seals are subject to deterioration as well as wear, and may require replacement at varying periods.

Shaft bearings have been selected to have optimum life under average conditions with proper lubrication. They are critical in the service life of the blower. Gradual bearing wear may allow a shaft position to change slightly, until rubbing develops between impeller and cylinder headplate. This will cause spot heating, which can be detected by feeling these surfaces. Sudden bearing failure is usually more serious. Since the shaft and impeller are no longer supported and properly located, extensive general damage to the blower casing and gears is likely to occur.

Shaft seals should be considered expendible items, to be replaced whenever drainage from the headplate vent cavity becomes excessive or when the blower is disassembled for any reason. Sealing effectiveness can vary considerably from seal to seal and is also affected by shaft smoothness under the seal lip. Because of these normal variables, minor seal leakage should not be considered an indicator for seal replacement.

Timing gear wear, when correct lubrication is maintained should be negligible over a period of years. Gear teeth are cut to provide the correct amount of backlash, and gears correctly mounted on the shafts will accom-

modate a normal amount of tooth wear without permitting contact between lobes of the two impellers.

However, a high oil level will cause churning and excessive heating, indicated by an unusually high temperature at the bottom of the gear housing. Consequent heating of the gears will result in loss of tooth-clearance or backlash, and rapid wear of the gear teeth usually will develop. Continuation of this tooth wear will eventually produce impeller contacts (knocking), and from this point serious damage will be unavoidable if blower operation is continued. A similar situation can be produced suddenly by gear tooth fracture, which is usually brought on by sustained overloading or momentary shock loads.

Operating problems may also develop from causes other than internal parts failure. Operating clearances within a blower are only a few thousandths of an inch (hundredths of a mm). This makes it possible for impeller interferences or casing rubs to result from shifts in the blower mounting or from changes in piping support. Foreign materials sucked into the blower will also cause trouble, which can only be cured by disconnecting the piping and thoroughly cleaning the blower interior.

If this type of trouble is experienced, and the blower is found to be clean, try removing mounting strains. Loosen blower mounting bolts and reset the leveling and drive alignment. Then tighten mounting again, and make sure that all piping meets blower connections accurately and squarely before reconnecting it.

A wide range of causes for operating troubles are covered in the **TROUBLE SHOOTING CHECKLIST.** The remedies suggested threr in some cases need to be performed by qualified mechanics with a good background of general experience, using procedures detailed in this manual. Major repairs generally are to be considered beyond the scope of maintenance, and should be referred to the nearest Sales Office listed on the last page.

Warranty failures should not be repaired at all, unless specific approval has been ovtained through a Sales Office or the factory before starting work. Unauthorized disassembly within the warranty period may void the warranty.

When a blower is taken out of service it may require internal protection against rusting or corrosion. The need for such protection must be a matter of judgment based on existing conditions as well as length of downtime. Under favorable conditions, protection will probably not be needed if shut-down is not longer than a month. Under atmospheric conditions producing rapid corrosion, the blower should be protected immediately. If blower is to be shut down for an extended period of time, see suggestions for corrosion protection under installation.

It is recommended that major repairs, if needed, be performed at a Dresser authorized service facility. However, it is recognized that this may not always be practical, especially when a spare blower is not available. If a blower is out of the warranty period, mechanical adjustments and parts replacement may be undertaken locally at the owner's option and risk. It is recommended that Factory Parts be used to insure fit and suitability. The maintenance of a small stock of on-hand spare parts can eliminate possible delays. When ordering parts give Item Numbers and their word descriptions from Figures 5 & 6. Also specify quantities wanted and the blower size and serial number from the nameplate.

Repairs or adjustments are best performed by personnel with good mechanical experience and the ability to follow the instructions in this manual. Some operations involve extra care and patience, and a degree of precision work. This is especially true in timing impellers and in handling bearings. Experience indicates that a high percentage of bearing failure is caused by dirt contamination before or during assembly. Therefore, the work area should be cleaned before starting disassembly, and new or re-usable parts protected during progress of the work.

In the following outlines of repair procedures, numbers shown in brackets ( ) correspond to the Item Numbers used in assembly drawing, Figures 11 & 13. It is recommended that the procedure be studied carefully and completely, with frequent reference to the drawings, before starting work. This will produce better efficiency through an understanding of what work is to be done, and the order of doing it. Before disassembly, mark all parts so that they may be returned to original locations or relative positions.

A — Replacing Timing Gears

1. Drain all oil from the gearhouse by removing drain plug (21) in the bottom. Remove gearhouse by taking out all cap screws (23) in its flange. It may be necessary to bump the sides with a wood block or mallet to break the flange joint.
2. Reach through one of the blower pipe connections and place a chalk mark on the strip of one impeller and the mating waist of the other, so that they may easily be returned to their original relative positions.

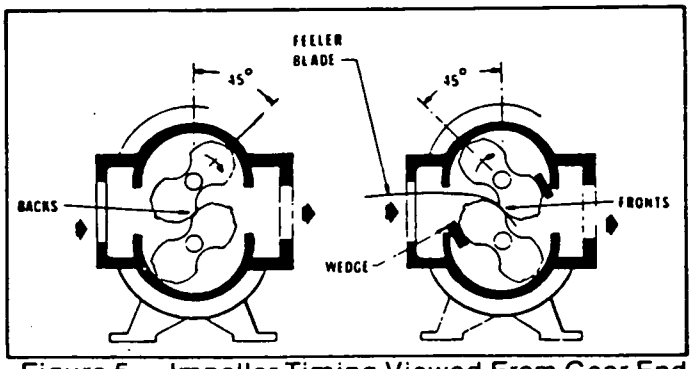


Figure 5 — Impeller Timing Viewed From Gear End

3. GEAR REMOVAL: For this operation, the impellers should be wedged as shown in Figure 5. Back off gear clamping nuts (17) about ¼". Use a puller of the type shown in Figure 10. Position it around the gear per Figure 9. As the puller set screw is torqued, the puller will have a tendency to turn and contact teeth of the other gear. To prevent this contact, hold the puller corner nut with a wrench while torquing the set screw. Once the gear is unseated, remove the puller. Remove gear nuts (17) and the gear. Repeat same procedure for the other gear. NOTE: Do not remove gear nuts (17) completely before the gears are unseated from the taper fits or damage/injury may result.

4. GEAR INSTALLATION: Place impellers in correct position as previously marked. Be sure shafts and gear bores are clean and free of scratches. Clean the shaft tapered fits. Place hardwood wedges as shown in Figure 5. Install drive gear (4) and gear nut (17) so match mark at tooth is at the line of engagement. Tighten the drive gear nut to the torque given in Table 5. Blower assembly must be fastened down for torquing operation.

TABLE 5 — GEAR NUT TORQUE

Gear Size (in.)	Torque	
	lb.-ft.	(kg-m)
2.5	60	(8.3)
3.5	110	(15.2)
4.0	190	(26.3)
5.0	250	(34.6)
6.0	400	(55.3)
7.0	550	(76.1)

5. Installing driven gear (4) - Insert a long, metal feeler gauge between the impellers' lobes at the fronts or backs as shown in Figure 5. Feeler gauge thickness to be a middle value from Table 6 for fronts and backs. Align the gear so the tooth match marks agree with the drive gear, then install nut (17). Tighten lightly with a small wrench, then check front and back clearances against Table 6 for each 45° position. Both fronts and backs should be about the same and within the specified range in Table 6. Adjust gear position, if necessary, then insert the corrected feeler gauge and wedges and use a torque wrench to tighten the gear nut to the torque specified in Table 5. Remove wedges and rotate the drive shaft by hand to make sure there are no gear tight spots or impeller contacts.

   Caution! Keep fingers away from impellers and gears.

6. Check the end clearances between impellers and headplates. Adjust clearances per B-15 below.

7. When clearances are correct, clean and re-install the gearhouse. Check condition of flange gasket (7) and replace if questionable. Fill gearhouse to correct level with proper grade of oil.

B — Replacing Shaft Bearings, and Impellers

Remove coupling or sheave from the drive shaft. Drain and remove gearhouse, and pull the timing gears. If gears are to be re-used, mark them so they may be returned to the same shafts.

1. Break corners and deburr the keyway. Remove bearing end cover at the drive end. Remove bearing clamp plates (34).

2. Make single and double identifying punch marks on the mating edges of headplate and cylinder flanges at the two ends of the blower.

3. At the drive end, drive out the two dowel pins and remove all capscrews holding headplate to cylinder. By inserting jacking screws into the two threaded flange holes, and turning them in evenly, the headplate will be separated from the cylinder. As the headplate comes off the shafts it will bring bearings with it. 2½" and 3½" gear diameter units do not have tapped holes for jack screws in the drive end headplates. Remove dowel pins and all capscrews holding headplate to cylinder and foot on the drive end. Support unit under gear end cylinder flange with the shafts vertical. Using soft metal block against gear end shafts, push them out of gear end headplate.

4. For 2½" and 3½" gear diameter units, support the drive end headplate on the underside, and using soft metal block against drive end, shafts, push them out of drive end headplate.

   For 4", 6" & 7" gear diameter units, from the gear end , using a wood or soft metal block against the ends of the shafts, drive them out of the headplate. If they are to be reused, protect them from damage in this operation.

5. If blower interior surfaces need cleaning, it may be advisable to separate the gear end headplate from the cylinder. Use the same general procedure as employed at the drive end.

6. Working from the back (flat) face of each headplate, push or tap out the bearings and seals. Use a round bar or tube that will pass through the shaft clearance holes in the headplates. All lip seals will be damaged during removal and must be replaced.

7. Clean bearing and seal pockets in headplates and remove burrs or rough edges. (Apply a thin coating of sealant on seal O.D.) Press new seals (27) into gear end headplate using a round tube or bar with recessed end that will bear on the outer metal edge of seal enclosure. Seal lip should point toward the driving tool. Seals to be flush with outboard bore face. Apply a light coat of oil or grease to the seal lips. In a similar fashion, install lip seals into the drive end headplate.

8. Place cylinder on a flat surface. Assemble gear end headplate to cylinder after checking flange punch marks. Drive in the two locating dowel pins before tightening flange screws. Also install gear end foot using the same longer cap screws (32) and washers (41). (on 6" & 7" UNIVERSAL RAI® install both gear and feet.)
9. Place the assembly horizontally on steel blocks with gear end headplate on bottom. The height of the blocks should be sufficient to clear gear end shaft extensions. Assemble impellers into the cylinder with the drive shaft (longer shaft) in same

location as in original assembly. Before starting the shafts through the headplate holes, make sure shaft ends have no sharp or rough edges to damage seal lips. Position impellers at 90° to each other in the cylinder, using lobe-and-waist match marks if original impellers are being re-installed. Install drive end headplate and feet in same manner as gear end.

10. It is recommended that new bearings be used for rebuild. Apply thin film of machine oil on the shaft bearing fit, bearing I.D., and headplate bearing bore. Install drive end bearings into headplate. Use a tube with flanged end that will contact both bearing faces simultaneously. Refer to Fig. 11 for proper bearing depths.

    NOTE: Cylindrical drive bearing should be installed with inner race large shoulder facing outboard.

11. Place blower on its feet on a flat surface. Loosen feet capscrews (32) and square up unit. Re-tighten capscrews (32). Clamp unit down to a solid base for further assembly.

12. Oil the gear end bearing fits as described previously. Install 2½-5" UNIVERSAL RAI® gear end bearings flush with the headplate bearing shoulders using proper drivers. On 6" & 7" UNIVERSAL RAI®, install thrust washer (29) in bearing bores then install gear end bearings so that they protrude 1/16" (1.6mm) above headplate surface.

13. Install bearing clamp plates (34). On 6" & 7" UNIVERSAL RAI®, impeller end clearances are also to be set during this step. Install clamp plates (34) with capscrews (31) making sure that the gap between the clamp plates and the headplate is even all around, at the same time, set end clearances per Table 5.
14. Install gears and time impellers as in (A).

15. For setting end clearances on 2½-5" gear diameter units, special tools, thrust adjuster fork Fig. 7 and thrust adjuster saddle Figure 8 are required. Refer to Fig. 6 for installation of tools. The flat side of the saddle rests against the bearing inner race and the flat side of the fork rests against the back side of the gear. Install a shim, with thickness equal to gear end clearance (Table 6), between the impeller and the gear end headplates. Tap on top of the fork until the shim becomes snug. Remove the shim and check end clearances. To increase gear end clearance, tap on the end of the gear end shaft with a soft metal mallet. On units, UNIVERSAL RAI®, set end clearances for 6" & 7" by turning capscrews (31) evenly in or out.

16. Install drive end cover (5) after packing bearing cavities with suitable grease. Replace drive shaft seal. Lip must point toward (33) the bearing. Exercise care not to damage the lip as it passes over shaft keyway.

17. Install gasket item (7). Install the gear house after cleaning out the inside. Tighten gear box cap screws (23) evenly. Fill with correct grade of oil until oil flows out through oil level hole. Grease drive and bearings. (See Lubrication.)

18. Reinstall coupling or belt sheave making sure that they have a slight slide fit with the shaft and could be installed by hand.

Where repairs involve parts replacement, it is recommended that Factory Parts be used to insure fit and suitability. Delay in making such repairs can be reduced by having spare parts on hand.

When ordering parts, please furnish all information from the blower nameplate.

Repairs or adjustments to blowers should be performed by personnel with a good back ground of general mechanical experience and the ability to follow the detailed instructions in this manual. No special tools are required. Some operations involve extra care and a degree of precision work. This is especially true in timing impellers, and in handling bearings. Experience indicates that a high percentage of bearing failures is caused by dirt contamination before or during assembly. Therefore, clean the work area before starting disassembly, and protect new or reuseable parts during progress of the work. (See page 23 for Repair Kit Information.)

INTERNAL CLEARANCES

References to operating clearances in this manual include only one mention of the specific amount of clearance to be used or expected. For units in good condition this information is not essential in field service work. Situations may arise, however, when it is desirable to compare existing clearances with the correct Engineering values or to re-establish clearances.

Listed in Table 6 are the ranges of impeller clearances used in factory assembly of normal UNIVERSAL RAI® blowers. It should be kept in mind that clearances may change slightly in service, but should never be less than the minimum values listed. Only well qualified personnel should attempt to measure clearances for direct comparison with this data.

Table 6 – Normal Clearances for UNIVERSAL U-RAI® and U-RAI-J® Blowers – Inches (MM)

SIZE	IMPELLER ENDS			CYLINDER		IMPELLER
	TOTAL	DRIVE END MINIMUM	GEAR END MINIMUM	INLET & DISCHARGE	CENTER	FRONTS BACKS
22	.006/.010 (.15-.25)	.003 (.08)	.003 (.08)	.004/.005 (.10-.13)	.002/.003 (.05-.08)	.007/.01 (.18-.25)
24	.006/.010 (.15-.25)	.003 (.08)	.003 (.08)	.004/.005 (.10-.13)	.002/.003 (.05-.08)	.007/.01 (.18-.25)
32	.006/.011 (.15-.28)	.003 (.08)	.003 (.08)	.004/.006 (.10-.15)	.002/.003 (.05-.08)	.01/.012 (.25-.30)
33/33J	.006/.011 (.15-.28)	.003 (.08)	.003 (.08)	.004/.006 (.10-.15)	.002/.003 (.05-.08)	.01/.012 (.25-.30)
36/36J	.006/.011 (.15-.28)	.003 (.08)	.003 (.08)	.004/.006 (.10-.15)	.002/.003 (.05-.08)	.01/.012 (.25-.30)
42	.008/.011 (.20-.28)	.004 (.10)	.004 (.10)	.005/.007 (.13-.18)	.003/.004 (.08-.10)	.009/.012 (.23-.30)
45/45J	.008/.013 (.20-.33)	.004 (.10)	.004 (.10)	.005/.007 (.13-.18)	.003/.004 (.08-.10)	.012/.015 (.30-.38)
47/47J	.008/.013 (.20-.33)	.004 (.10)	.004 (.10)	.005/.007 (.13-.18)	.003/.004 (.08-.10)	.012/.015 (.30-.38)
53	.008/.011 (.20-.28)	.004 (.10)	.004 (.10)	.005/.008 (.13-.20)	.003/.004 (.08-.10)	.011/.013 (.28-.33)
56/56J	.008/.013 (.20-.33)	.004 (.10)	.004 (.10)	.005/.008 (.13-.20)	.003/.004 (.08-.10)	.015/.017 (.38-.43)
59	.008/.013 (.20-.33)	.004 (.10)	.004 (.10)	.005/.008 (.13-.20)	.003/.004 (.08-.10)	.015/.017 (.38-.43)
65	.012/.016 (.30-.40)	.008 (.20)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.010/.014 (.25-.36)
68	.014/.018 (.36-.46)	.010 (.25)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.010/.014 (.25-.36)
615	.014/.018 (.36-.46)	.010 (.25)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.010/.014 (.25-.36)
76	.012/.016 (.30-.40)	.008 (.13)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.013/.015 (.33-.38)
711	.014/.018 (.36-.46)	.010 (.25)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.013/.015 (.33-.38)
718	.014/.018 (.36-.46)	.010 (.25)	.004 (.10)	.006/.008 (.15-.20)	.006/.008 (.15-.20)	.013/.015 (.33-.38)

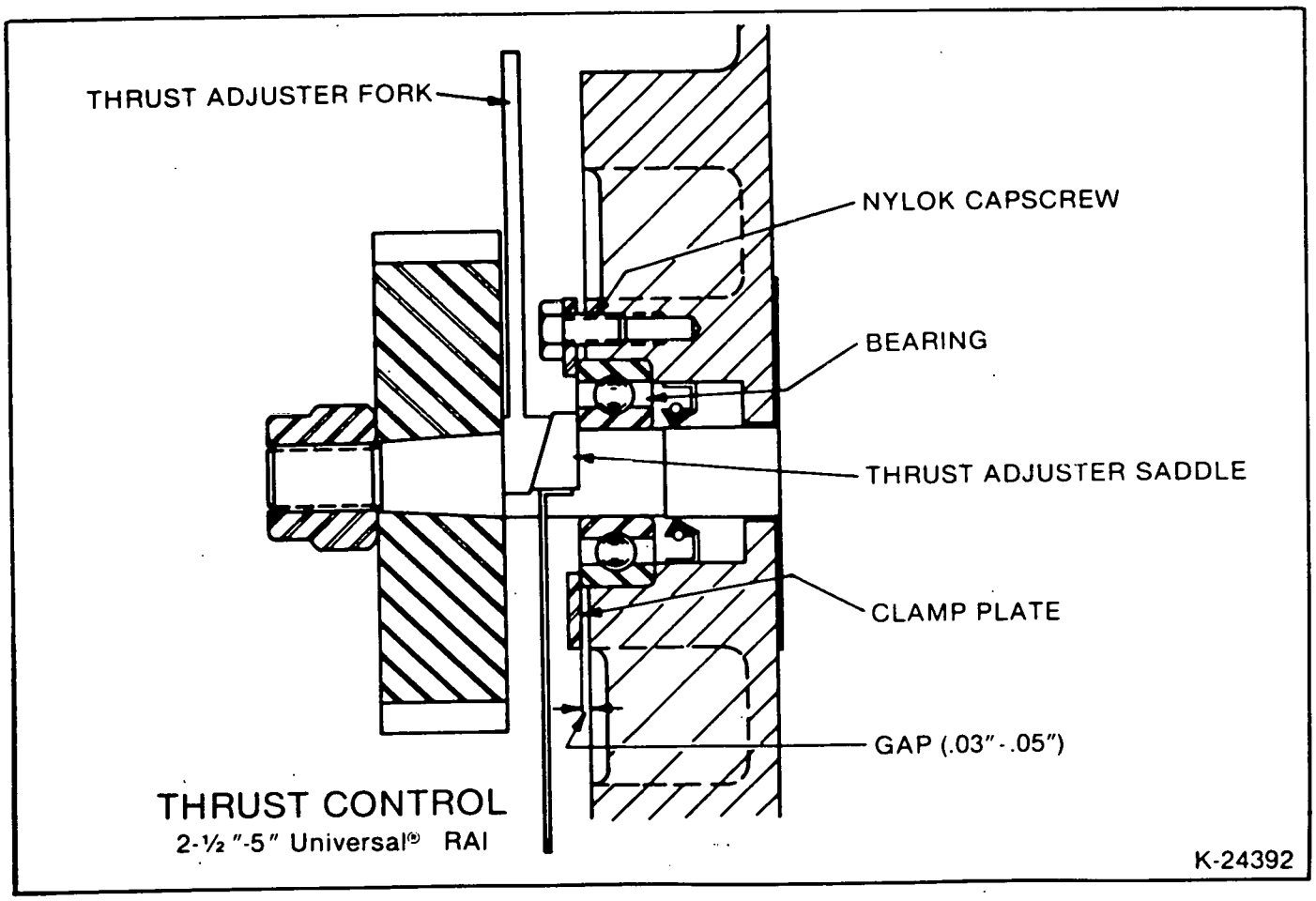
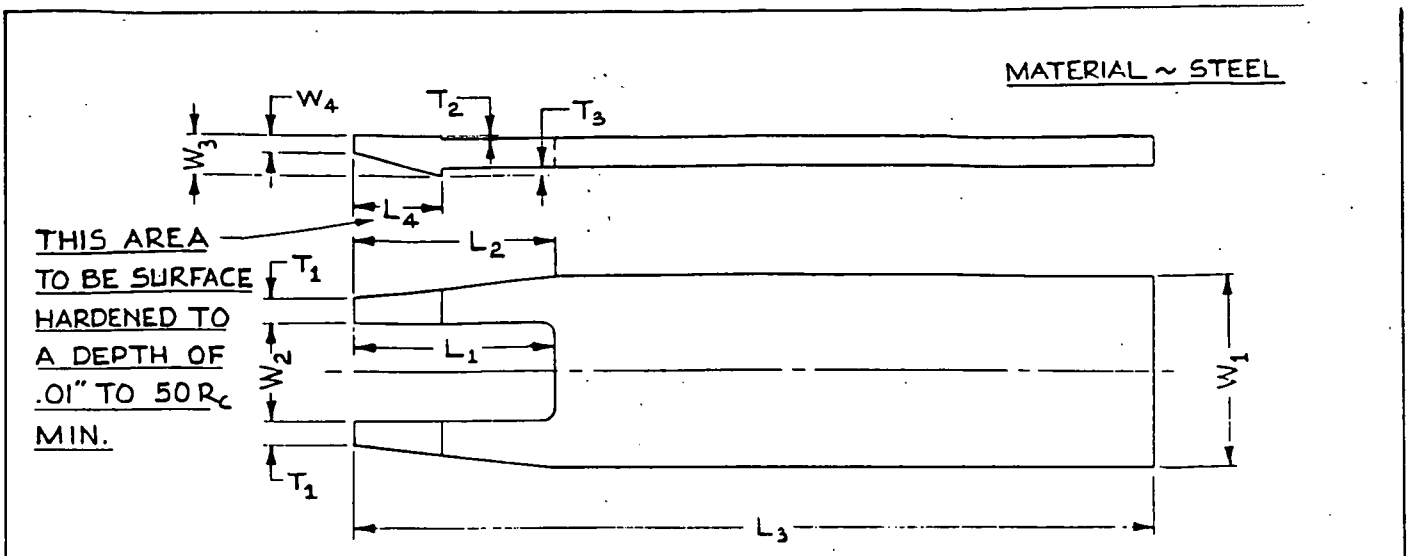
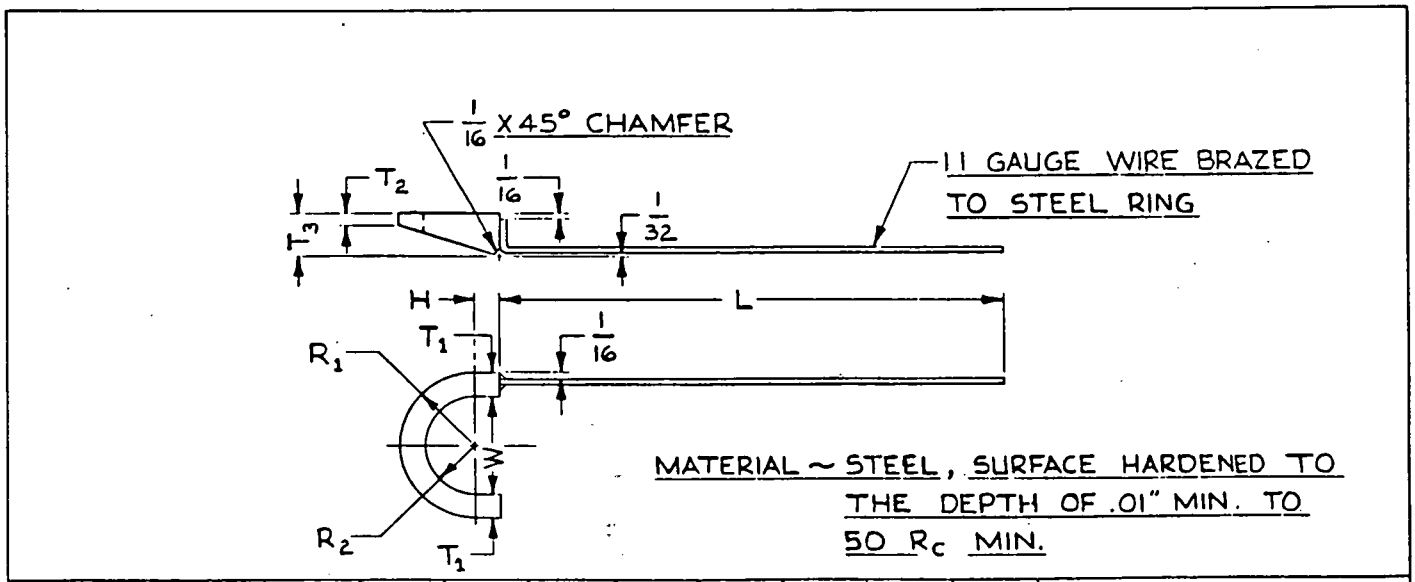


Figure 6 — Thrust Setting, 2½"-5" UNIVERSAL RAI®



PART Nº	BLW. SIZE	L_1	L_2	L_3	L_4	W_1	W_2	W_3	W_4	T_1	T_2	T_3	NOTES
812-973-001	2 1/2"	1 3/4	1 3/4	6 1/2	9/16	1 3/8	11/16	1/4	1/8	7/32	1/32	1/32	
812-973-002	3 1/2"	2	2	7	7/8	1 1/2	13/16	5/16	1/16	7/32	1/32	1/16	
812-973-003	4"	2	2	7 1/2	1	1 3/4	1 1/32	3/8	1/16	1/4	1/32	1/32	
812-973-004	5"	2 1/4	2 1/4	8	7/8	2	1 1/4	13/32	3/16	1/4	1/32	1/16	

Figure 7 — Thrust Adjuster Fork 812-973



PART Nº	BLW. SIZE	R_1	R_2	W	T_1	T_2	T_3	H	L	NOTES
812-974-001	2 1/2"	15/32	11/32	11/16	1/8	1/16	1/4	3/16	3	
812-974-002	3 1/2"	5/8	13/32	13/16	7/32	1/16	5/16	3/16	3 1/2	
812-974-003	4"	49/64	33/64	1 1/32	1/4	1/8	7/16	1/4	4	
812-974-004	5"	7/8	5/8	1 1/4	1/4	1/8	7/16	1/4	5	

Figure 8 — Thrust Adjuster Saddle 812-974

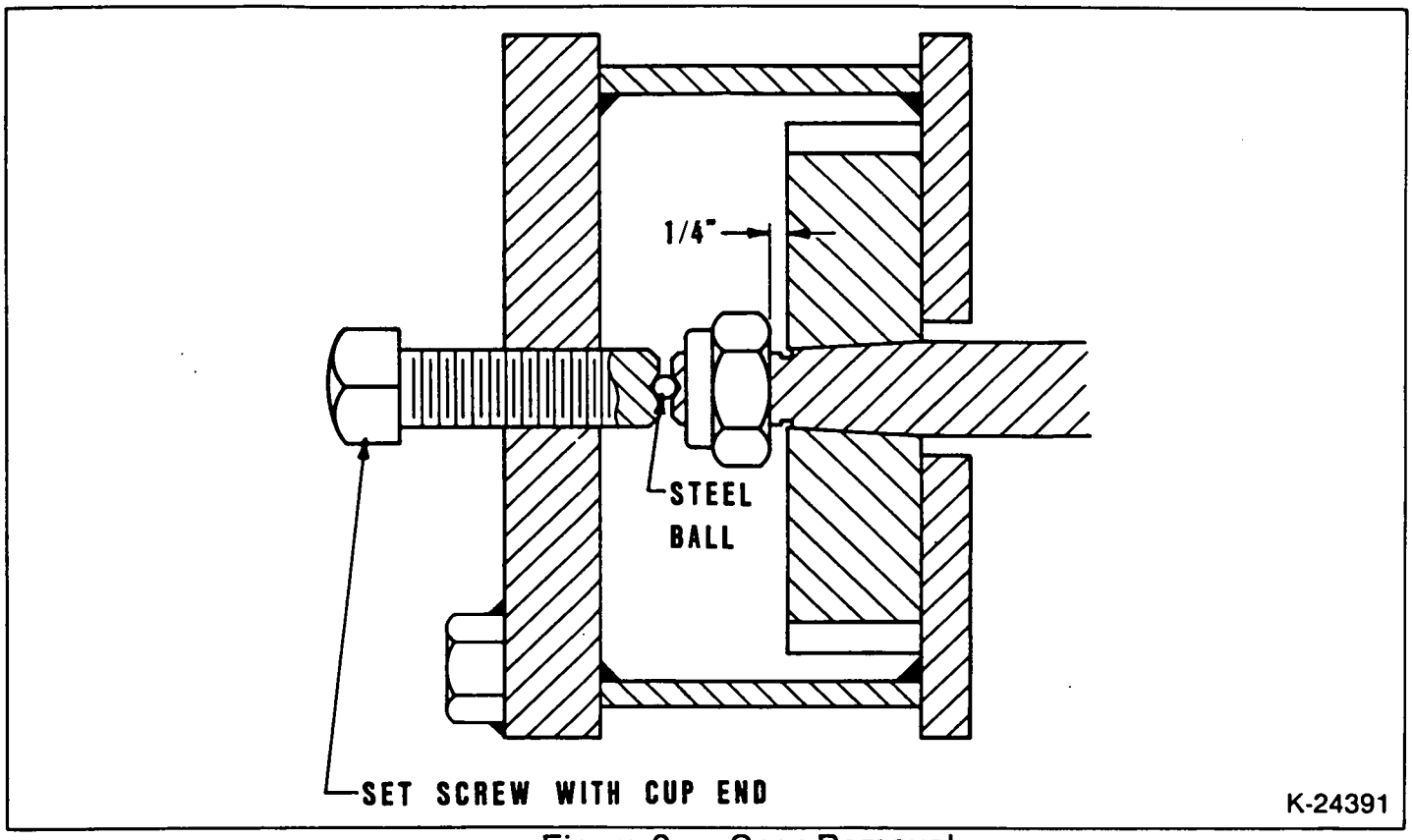
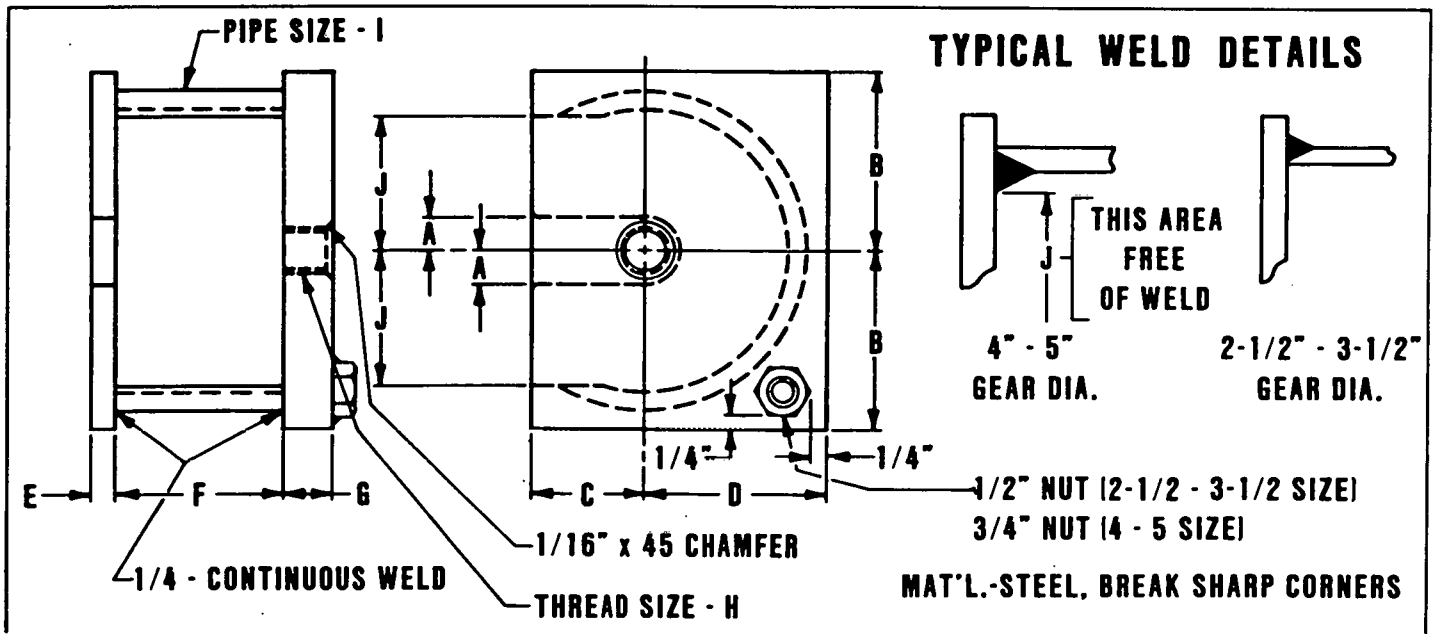
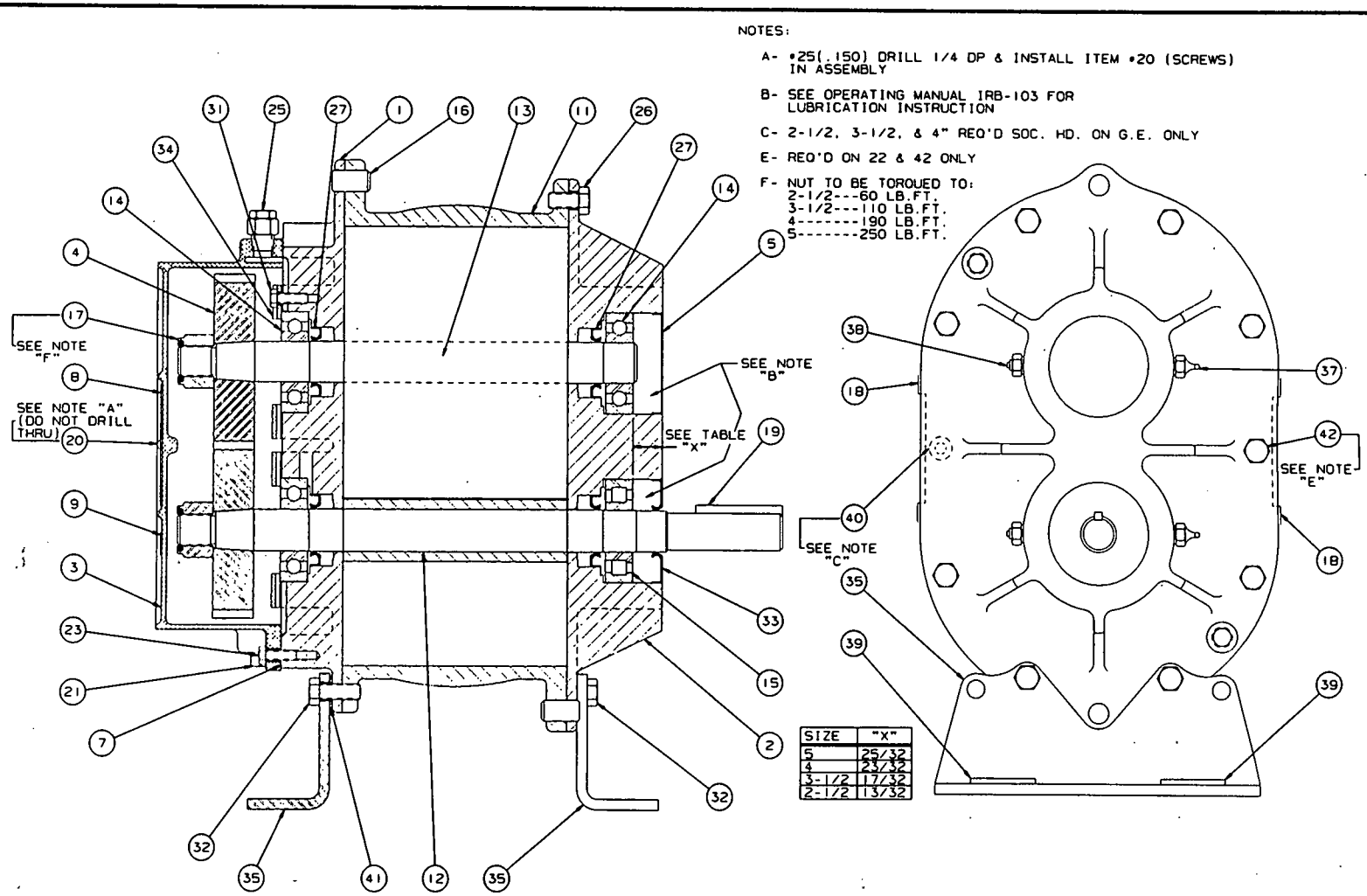


Figure 9 — Gear Removal



BLOWER SIZE	PART NO.	A	B	C	D	E	F	G	H	I	J
2-1/2	812-977-001	3/8	2	1-1/16	2	1/4	2	5/8	7/16-14	3" SCH. - 40	1-3/8
3-1/2	812-977-002	7/16	2-1/2	1-1/4	2-1/2	5/16	2-3/8	3/4	1/2-13	4" SCH. - 40	1-7/8
4	812-977-003	17/32	2-13/16	1-3/4	2-13/16	3/8	2-1/2	3/4	5/8-11	5" SCH. - 40	2-1/8
5	812-977-004	5/8	3-3/8	2	3-3/8	7/16	3	1	3/4-10	6" SCH. - 40	2-11/16

Figure 10 — Gear Pullers for UNIVERSAL RAI® with Tapered Gear Bores 812-977-

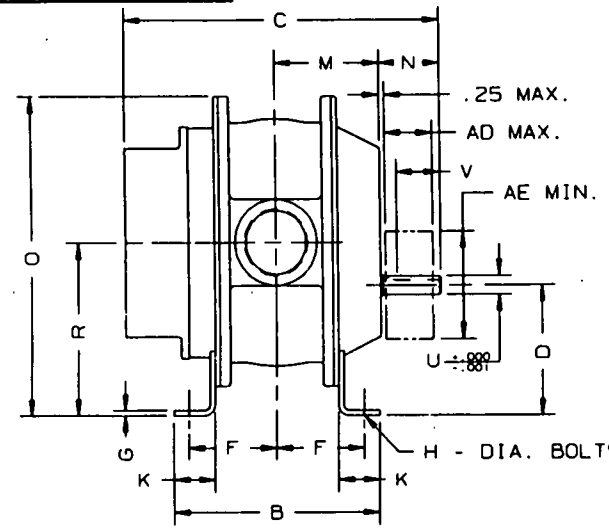


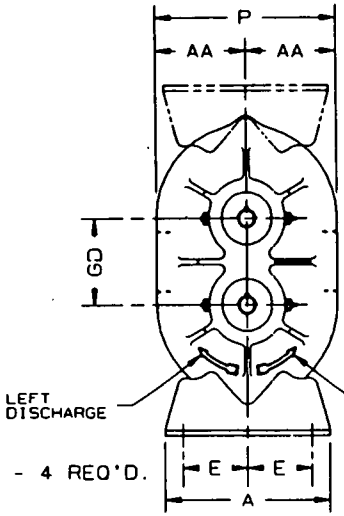
ITEM	PART NAME	ITEM	PART NAME	ITEM	PART NAME	ITEM	PART NAME
1	Headplate Gear End	12	Impeller & Shaft-Drive	21	Plug, Pipe	35	Foot
2	Headplate Drive End	13	Impeller & Shaft-Driven	23	Screw, Hex	37	Fitting, Grease
3	Gearbox	14	Bearing G.E.,-Driven	25	Breather	38	Fitting, Relief
4	Gears	15	Bearing D.E.-Drive	26	Screw, Hex	7	Gasket
5	Cover-Blind	16	Pin, Dowel	27	Seal, Lip	39	Washer Flat
8	Nameplate-Serial Number	17	Gear Nut	31	Screw, Hex	40	Screw Socket
9	Nameplate-Lub	18	Plug Tin	32	Screw, Hex	41	Washer
		19	Key	33	Seal Lip-Drive	42	Screw Hex
11	Cylinder	20	Screw, Self Tap	34	Clamp Plate		

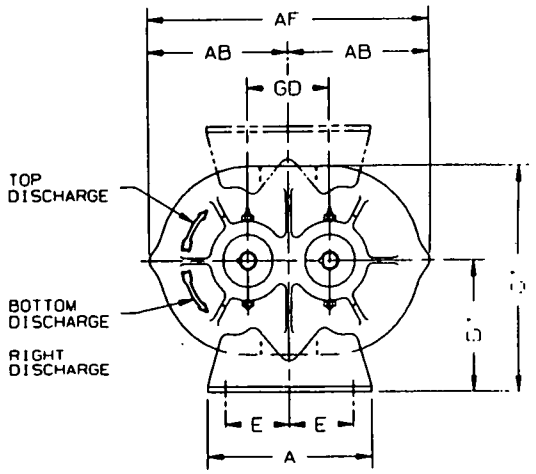
864-720-023

Figure 11 — Assembly of UNIVERSAL RAI® Blowers, 2½"-5" Gear Diameter

FRAME	APPROX. OIL CAPACITY	
	VERTICAL	HORIZONTAL
2-1/2	3.4 FL. OZ.	6.1 FL. OZ.
3-1/2	8.5 FL. OZ.	16 FL. OZ.
4	12.7 FL. OZ.	22.8 FL. OZ.
5	16.0 FL. OZ.	27.6 FL. OZ.







W - INLET & DISCHARGE
AD - SHEAVE WIDTH
AE - SHEAVE DIAMETER

ALL DIMENSIONS IN INCHES

UNIVERSAL RAI BLOWER

FRAME SIZE	GD	A	B	C	D	D'	E MIN.	E MAX.	F MIN.	F MAX.	G	H	K	M	N	O	O'	P	R	U	KEYWAY	W NPT.	V	AA	AB	AD	AE	AF	APPROX. WT. LBS
22	2.5	5.13	5.00	9.75	3.75	3.75	1.50	2.00	2.00	2.00	.25	.38	1.25	2.63	2.50	9.63	6.88	6.25	5.00	.625	.188x.094	1"	1.81	3.13	4.63	1.75	4.00	9.25	32
24	"	"	7.00	11.75	"	"	"	"	"	3.00	"	"	"	3.63	"	"	"	"	"	"	"	2"	"	"	"	"	"	"	"	43
32	3.50	7.25	6.75	11.25	5.00	5.00	2.50	2.88	2.56	2.81	.25	.44	1.75	3.38	2.44	12.81	8.88	7.75	6.75	.750	.188x.094	1-1/4"	1.63	3.88	6.06	1.91	5.00	12.13	69
33	"	"	7.63	12.13	"	"	"	"	3.00	3.25	"	"	"	3.81	"	"	"	"	"	"	"	2"	"	"	"	"	"	"	"	74
36	"	"	10.00	14.63	"	"	"	"	4.18	4.44	"	"	"	5.00	2.56	"	"	"	"	"	"	2-1/2"	1.75	"	"	"	"	"	"	102
42	4.00	8.00	7.25	13.00	6.25	6.25	3.00	3.13	2.50	3.13	.31	.44	2.00	3.68	3.18	15.06	10.63	8.75	8.25	.875	.188x.094	1-1/2"	2.31	4.38	6.81	2.31	5.00	13.63	88
45	"	"	10.00	15.50	"	"	"	"	3.56	4.25	"	"	"	5.06	2.94	"	"	"	"	"	"	2-1/2"	2.13	"	"	"	"	"	"	109
47	"	"	11.75	17.63	"	"	"	"	4.63	5.38	"	"	"	5.94	3.31	"	10.50	8.50	"	"	"	3"	2.50	4.25	"	"	"	"	"	131
53	5.00	10.50	8.38	15.38	6.25	6.75	3.50	3.50	3.18	3.68	.25	.50	1.88	4.50	3.68	17.38	11.88	10.25	8.75	1.125	.25 x .125	2-1/2"	2.75	5.13	8.63	3.06	6.00	17.75	143
56	"	"	11.00	18.00	"	"	"	"	4.25	5.00	"	"	"	5.81	3.38	"	12.25	11.00	"	"	"	4"	2.50	5.50	"	"	"	"	"	170
59	"	"	14.00	21.00	"	"	"	"	6.00	6.50	"	"	"	7.31	3.88	"	"	"	"	"	"	4"	3.00	"	"	"	"	"	"	204

CERTIFIED CORRECT FOR
CUSTOMER ORDER No. _____
ROOTS ORDER No. _____
DATE _____

V-BELT DRIVE DATA
BELTS
DRIVE SHEAVE
DRIVEN SHEAVE
CENTER DISTANCE

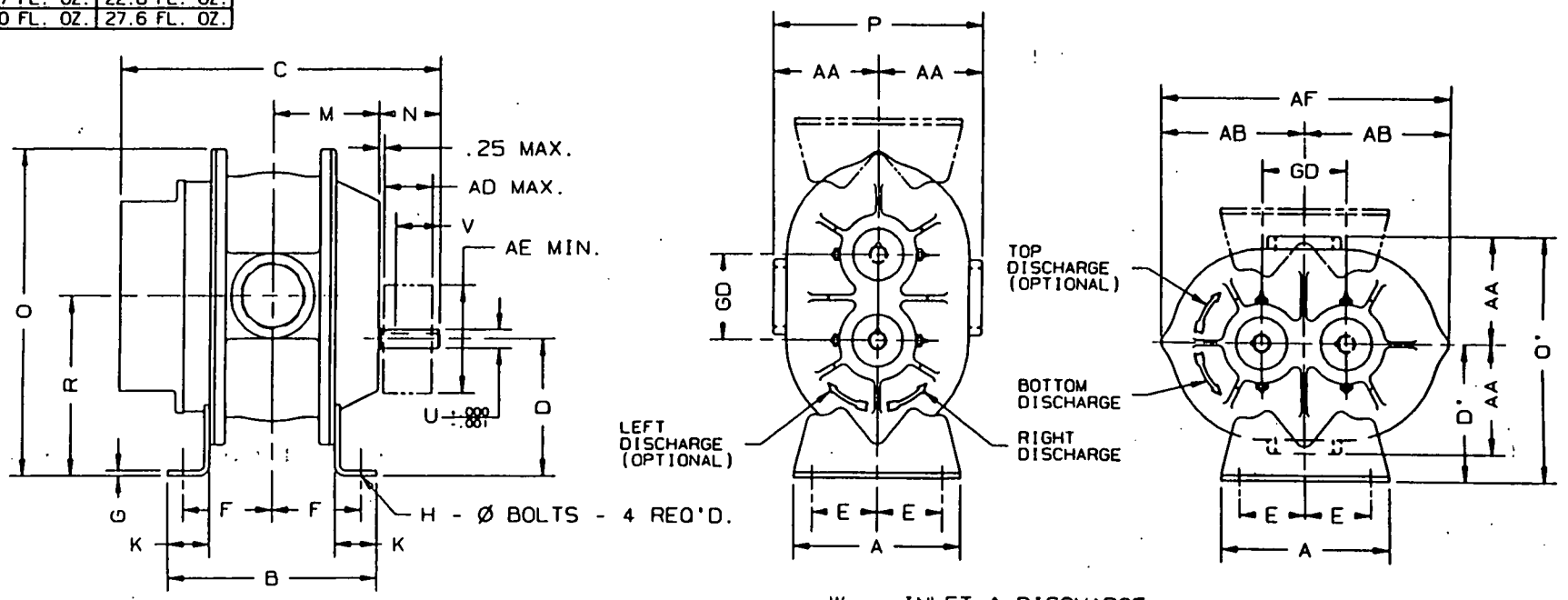
ROOTS DRESSER
DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
CONNERSVILLE, INDIANA 47331

862-795-021

PRINTED IN U.S.A. /PARTS/XXAD REV DIM A 22624/10-11-84 ADDED WEIGHTS/10-23-84 REV DIM F/3-8-85 REV DIM U/5-85 REV AD DIM/REW/10-7-85 REV FRAME 59/REW/6-9-88 ADDED FRAME 3/-RVE/6 22-90 CORRECTED FRAME 3[illegible]

Figure 12 — Dimensional Assembly of UNIVERSAL RAI® Blower (2½"-5")

FRAME	APPROX. OIL CAPACITY	
	VERTICAL	HORIZONTAL
3-1/2	8.5 FL. OZ.	16 FL. OZ.
4	12.7 FL. OZ.	22.8 FL. OZ.
5	16.0 FL. OZ.	27.6 FL. OZ.



UNIVERSAL RAI-J WHISPAIR BLOWER

W - INLET & DISCHARGE
AD - SHEAVE WIDTH
AE - SHEAVE DIAMETER

ALL DIMENSIONS IN INCHES

FRAME SIZE	GD	A	B	C	D	D'	E MIN.	E MAX.	F MIN.	F MAX.	G	H	K	M	N	O	O'	P	R	U	KEYWAY	W NPT.	V	AA	AB	AD	AE	AF	APPROX. WT. LBS
33	3.50	7.25	7.63	12.13	5.00	5.00	2.50	2.88	3.00	3.25	.25	.44	1.75	3.81	2.44	12.81	10.00	10.00	6.75	.750	.188x.094	2"	1.63	5.00	6.06	1.91	5.00	12.13	84
36	"	"	10.00	14.63	"	"	"	"	4.18	4.44	"	"	"	5.00	2.56	"	10.50	11.00	"	"	"	2-1/2	1.75	5.50	"	"	"	"	"	112
45	4.00	8.00	10.00	15.50	6.25	6.25	3.00	3.13	3.56	4.25	.31	.44	2.00	5.06	2.94	15.06	12.25	12.00	8.25	.875	.188x.094	2-1/2"	2.13	6.00	6.81	2.31	5.00	13.63	119
47	"	"	11.75	17.63	"	"	"	"	4.63	5.38	"	"	"	5.94	3.31	"	"	"	"	"	"	3"	2.50	6.00	"	"	"	"	"	138
56	5.00	10.50	11.00	18.00	6.25	6.75	3.50	3.50	4.25	5.00	.25	.50	1.88	5.81	3.38	17.38	14.00	14.50	8.75	1.25	.25x.125	4"	2.50	7.25	8.63	3.06	6.00	17.25	180

CERTIFIED CORRECT FOR
CUSTOMER ORDER No. _____
ROOTS ORDER No. _____
DATE _____

V-BELT DRIVE DATA	
BELTS	
DRIVE SHEAVE	B - ADDED FEET BWS 1/31/94
DRIVEN SHEAVE	A - REMOVED @ REM 12/11/92
CENTER DISTANCE	REVISIONS

ROOTS DRESSER

DRESSER INDUSTRIES, INC
ROOTS DIVISION
900 WEST MOUNT STREET
CONNERSVILLE, INDIANA 47331

DR JHB 9-25-92	CHKD	APP	873-959-021

Figure 12A – Dimensional Assembly of UNIVERSAL RAI-J® Blower (2½"-5")

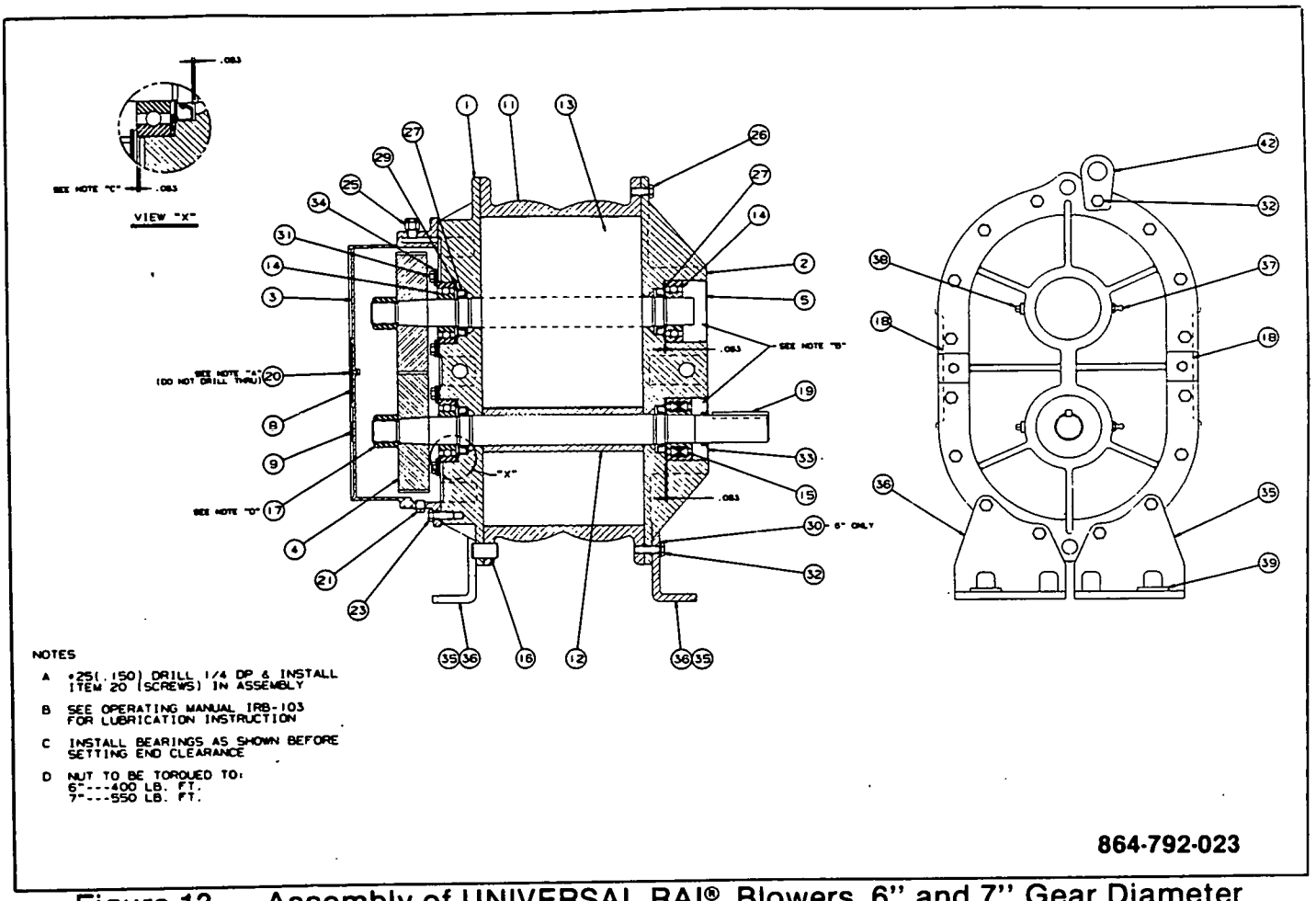
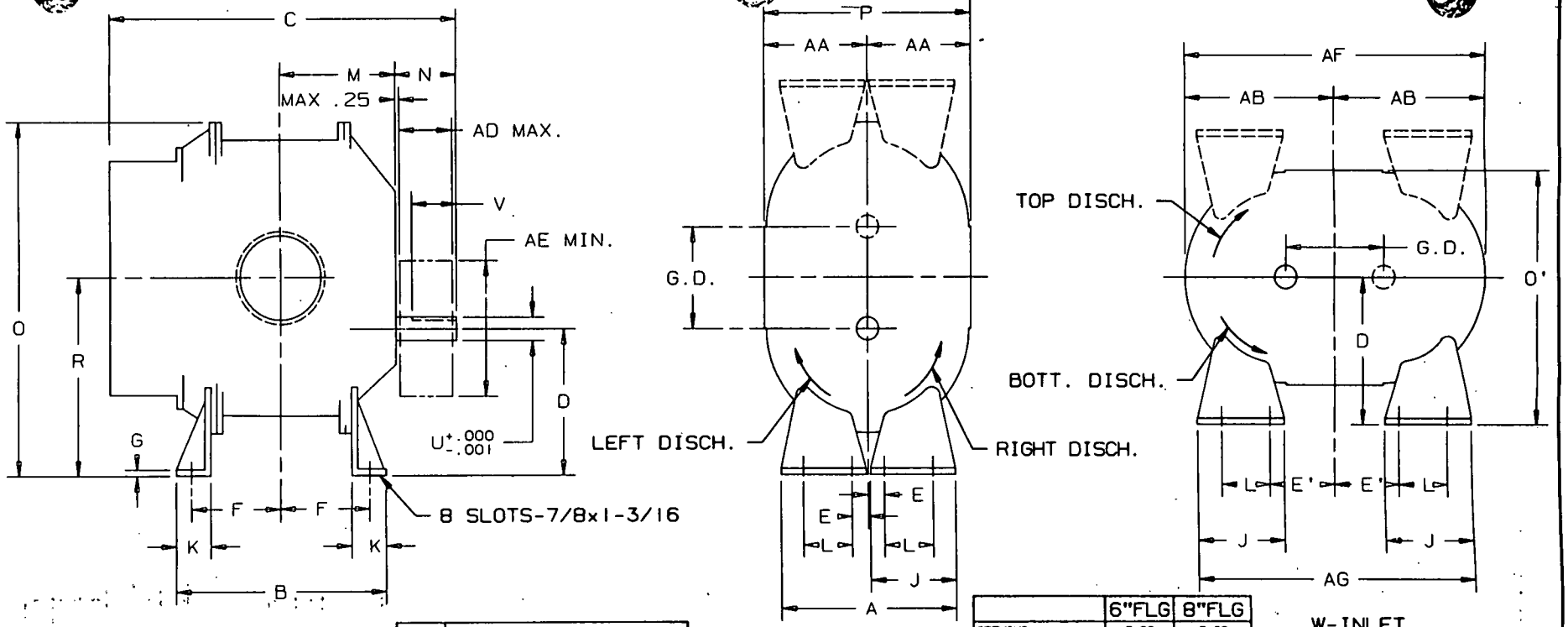


Figure 13 — Assembly of UNIVERSAL RAI® Blowers, 6" and 7" Gear Diameter

PARTS LIST FOR 6"-7" UNIVERSAL RAI®

ITEM	PART NAME	ITEM	PART NAME	ITEM	PART NAME	ITEM	PART NAME
1	Headplate - G.E.	13	Imp & Shaft - Drvn	25	Plug - Vent	36	Foot - Lt. Hand
2	Headplate - D.E.	14	Bearing, Ball	26	Screw, Cap - Hex	37	Fitting, Grease
3	Gearbox	15	Bearing, Roller	27	Seal, Lip	38	Plug - Vent
4	Gear Assembly	16	Pin, Dowel	29	Washer - Wavy Spr.	39	Washer - Oblong
5	Plug - Opening	17	Nut, Stop - Hex	30	Washer	40	Pipe - Tbe. (Close)
7	Gasket, Gearbox	18	Plug - Opening	31	Screw, Cap Hex	41	Coupling - Pipe
8	Nameplate - S/N	19	Key, Square	32	Screw, Cap Hex	42	Lifting Lug
9	Nameplate - Lube	20	Screw, Rd. Hd.	33	Seal, Lip		
11	Cylinder	21	Plug, Pipe - Sq. Hd.	34	Brg: Clamp Plate		
12	Imp & Shaft — Drive	23	Screw, Cap - Hex	35	Foot - Rt. Hand		



UNIVERSAL RAI® BLOWER

UNIT SIZE	APPROX. OIL CAP. VERT.	APPROX. OIL CAP. HORIZ.	G.D.
6"	28.3 FL OZ	52.1 FL OZ	6.00
7"	32.3 FL OZ	59.5 FL OZ	7.00

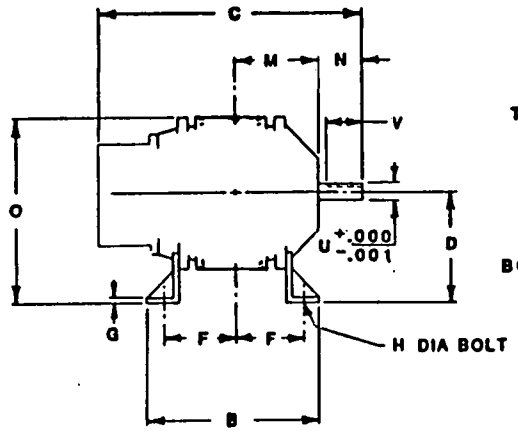
	6"FLG	8"FLG
OPENING	6.00	8.00
BOLT CIRCLE	9.50	11.75
FLANGE O.D.	11.00	13.50
NO. TAPPED HOLES	8	8
SIZE HOLES	3/4-10	3/4-10
TAP DEPTH	1.13	1.13

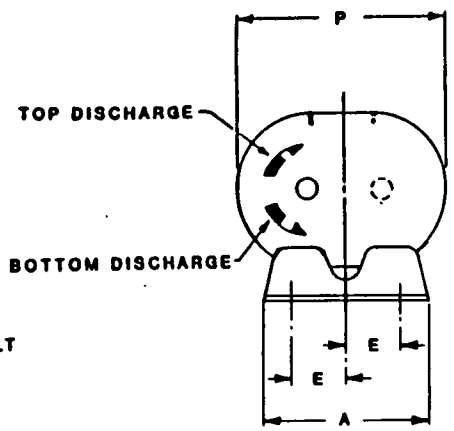
W-INLET
W'-DISCHARGE
AD-SHEAVE WIDTH
AE-SHEAVE DIA.
ALL DIM. IN INCHES

FRAME SIZE	A	B	C	D	E	E'	F	G	J	K	L	M	N	O	O'	P	R	U	V	KEYWAY	W	W'	AA	AB	AD	AE	AF	AG	APPROX WEIGHT
65	11.00	10.00	18.38	8.75	1.00	4.00	3.81	.38	5.38	2.13	3.00	5.63	3.56	21.63	15.13	12.75	11.75	1.375	2.75	.312x.156	3"NPT	3"NPT	6.38	9.88	3.44	8.00	19.75	17.00	245 LBS
68	"	13.00	21.38	"	"	"	5.31	"	"	"	"	7.13	3.69	"	"	"	"	"	"	"	5"NPT	5"NPT	"	"	"	"	"	"	285 LBS
615	"	20.00	28.38	"	"	"	8.81	"	"	"	"	10.63	"	"	16.25	15.00	"	"	"	"	6"FLG	6"FLG	7.50	"	"	"	"	"	425 LBS
76	14.00	11.75	19.94	11.00	2.00	5.50	4.88	.50	6.75	2.38	3.50	5.94	4.06	26.13	20.69	19.38	14.5	1.562	3.00	.375x.188	4"NPT	4"NPT	9.69	11.63	3.75	9.50	23.25	21.00	400 LBS
711	"	16.75	25.19	"	"	"	7.38	"	"	"	"	8.44	4.31	"	19.50	17.00	"	"	"	"	6"FLG	6"FLG	8.50	"	"	"	"	"	530 LBS
718	"	23.75	32.19	"	"	"	10.88	"	"	"	"	11.94	"	"	"	"	"	"	"	"	8"FLG	8"FLG	"	"	"	"	"	"	650 LBS

862-753-021

Figure 14 — Dimensional Assembly of UNIVERSAL RAI® Blower (6" & 7")





W-INLET & DISCHARGE

ALL DIMENSIONS IN INCHES

DIMENSIONS NOT CERTIFIED FOR CONSTRUCTION

NOTE:
UNIVERSAL RAI

1. 45 & 56 U-RAI WILL HAVE TO RUN AT REDUCED SPEED TO DUPLICATE AF PERFORMANCE.
2. LARGER STANDARD SHAFT THAN AF. SEE DIMENSION "U".
3. U-RAI INLET & OUTLET CONNECTIONS ARE LARGER THAN AF ON THE FOLLOWING SIZES: 24, 46, 47, 56 & 59. SEE DIMENSION "W".
4. 45 U-RAI REPLACES 44 AF. 56 U-RAI REPLACES 55 AF.
5. FOR ADDITIONAL INFORMATION CONTACT YOUR SALES REPRESENTATIVE OR THE FACTORY.

FRAME SIZE	A	B	C	D	E	F	H	M	N	O	P	U	V	KEYWAY	W
22 U-RAI	5.13	5.00	9.75	3.75	2.00	2.00	3/8	2.63	2.50	6.88	9.25	.625	1.81	3/16 x 3/32	1" NPT
22 AF	5.50	5.06	9.13	3.75	2.00	2.00	3/8	2.63	1.94	6.88	9.25	.5875	1.31	3/16 x 3/32	1" NPT
24 U-RAI	5.13	7.00	11.75	3.75	2.00	3.00	3/8	3.63	2.50	6.88	9.25	.625	1.81	3/16 x 3/32	2" NPT
24 AF	5.50	7.06	11.13	3.75	2.00	3.00	3/8	3.63	1.94	6.88	9.25	.5875	1.31	3/16 x 3/32	1-1/2" NPT
33 U-RAI	7.25	7.63	12.13	5.00	2.88	3.00	3/8	3.81	2.44	8.88	12.13	.750	1.63	3/16 x 3/32	2" NPT
33 AF	7.25	7.44	12.56	5.00	2.88	3.00	3/8	3.81	2.63	8.88	12.13	.6562	1.66	3/16 x 3/32	2" NPT
36 U-RAI	7.25	10.00	14.63	5.00	2.88	4.18	3/8	5.00	2.56	8.88	12.13	.750	1.75	3/16 x 3/32	2-1/2" NPT
36 AF	7.25	9.81	14.94	5.00	2.88	4.18	3/8	5.00	2.63	8.88	12.13	.6562	1.88	3/16 x 3/32	2-1/2" NPT
42 U-RAI	8.00	7.25	13.00	6.25	3.13	2.94	3/8	3.68	3.18	10.63	13.63	.875	2.31	3/16 x 3/32	1-1/2" NPT
42 AF	8.25	7.13	12.88	6.25	3.13	2.94	3/8	3.68	3.00	10.63	13.63	.7812	2.38	3/16 x 3/32	1-1/2" NPT
45 U-RAI	8.00	10.00	15.50	6.25	3.13	3.56	3/8	5.06	2.94	10.63	13.63	.875	2.13	3/16 x 3/32	2-1/2" NPT
44 AF	8.25	8.83	14.13	6.25	3.13	3.56	3/8	4.31	3.00	10.63	13.63	.7812	2.38	3/16 x 3/32	2" NPT
47 U-RAI	8.00	11.75	17.63	6.25	3.13	5.18	3/8	5.94	3.31	10.50	13.63	.875	2.50	3/16 x 3/32	3" NPT
47 AF	8.25	11.63	17.38	6.25	3.13	5.18	3/8	5.94	3.00	10.63	13.63	.7812	2.30	3/16 x 3/32	2-1/2" NPT
53 U-RAI	10.50	8.38	15.38	6.75	4.25	3.69	3/8	4.50	3.68	11.88	17.25	1.125	2.75	1/4 x 1/8	2-1/2" NPT
53 AF	10.75	8.81	15.44	6.75	4.25	3.69	3/8	4.50	3.63	12.00	17.25	.9687	2.88	1/4 x 1/8	2-1/2" NPT
56 U-RAI	10.50	11.00	18.00	6.75	4.25	4.25	3/8	5.81	3.38	12.25	17.25	1.125	2.50	1/4 x 1/8	4" NPT
55 AF	10.75	9.81	16.56	6.75	4.25	4.25	3/8	5.06	3.63	12.00	17.25	.9687	2.88	1/4 x 1/8	2-1/2" NPT
59 U-RAI	10.50	14.00	21.18	6.75	4.25	6.50	3/8	7.31	3.38	12.25	17.25	1.125	3.00	1/4 x 1/8	4" NPT
59 AF	10.75	14.31	21.06	6.75	4.25	6.50	3/8	7.31	3.63	12.00	17.25	.9687	2.88	1/4 x 1/8	3" NPT

ROOTS DRESSER

DRESSER INDUSTRIES, INC
ROOTS OPERATIONS
900 WEST MOUNT STREET
CONNERSVILLE, INDIANA 47331

PRINTED IN U.S.A.

COMPARING ROOTS UNIVERSAL RAI® TO ROOTS AF

DB 1-7-86
FR
863-813-021

Figure 15

Major Changes when Replacing AF with UNIVERSAL RAI® Blower

Size & Type	Sheave Bushing Dia.	Inlet Size	Disch. Size	Mounting Feet
22 UNIVERSAL RAI®	.625"	1"	1"	Interchangeable
22 AF	.5875"	1"	1"	
24 UNIVERSAL RAI®	.625"	2"	2"	Interchangeable
24 AF	.5875"	1½"	1½"	
32 UNIVERSAL RAI®	.750"	1¼"	1¼"	Special Feet
315 AF	.6562"	¾"	¾"	
33 UNIVERSAL RAI®	.750"	2"	2"	Interchangeable
33 AF	.6562"	2"	2"	
36 UNIVERSAL RAI®	.750"	2½"	2½"	Interchangeable
36 AF	.6562"	2½"	2½"	
42 UNIVERSAL RAI®	.875"	1½"	1½"	Interchangeable
42 AF	.7812"	1½"	1½"	
45 UNIVERSAL RAI®	.875"	2½"	2½"	Reverse Feet
44 AF	.7812"	2"	2"	
47 UNIVERSAL RAI®	.875"	3"	3"	Interchangeable
47 AF	.7812"	2½"	2½"	
53 UNIVERSAL RAI®	1.250"	2½"	2½"	Special Feet
53 AF	.9687"	2½"	2½"	
56 UNIVERSAL RAI®	1.250"	4"	4"	Special Feet
55 AF	.9687"	2½"	2½"	
59 UNIVERSAL RAI®	1.250"	4"	4"	Special Feet
59 AF	.9687"	3"	3"	

*To maintain AF performance with UNIVERSAL RAI®, the blower speed will have to be reduced by sheave change. See Fig. 15 drawing for your specific blower size.

CAUTION CAUTION CAUTION

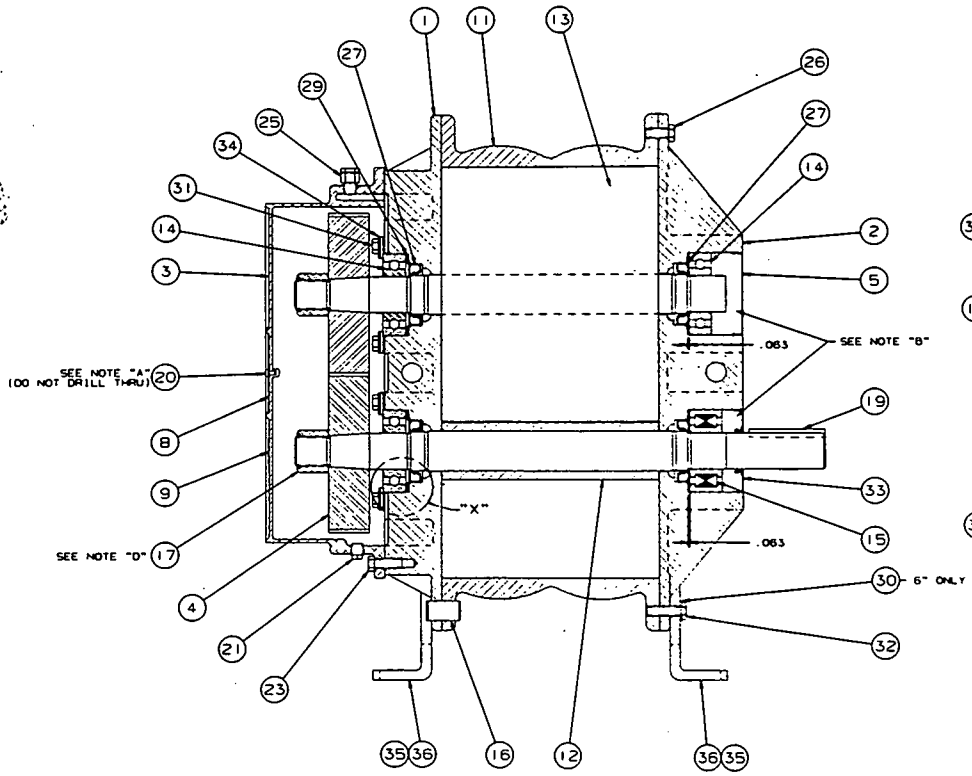
MAKE CERTAIN THAT THE BREATHER IS LOCATED ON TOP AND THE DRAIN PLUG IN THE BOTTOM OF THE GEAR BOX.

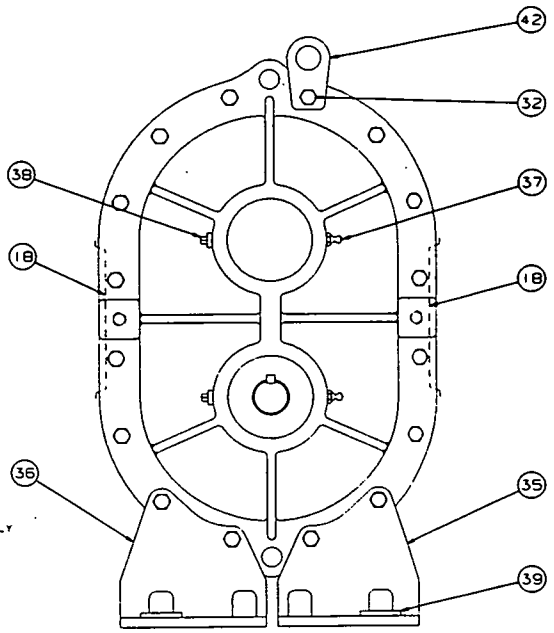
Roots Products are sold subject to the current General Terms of Sale, GTS-5001 as modified by the 18 months Uncontested Warranty Policy and Procedure, WP-5020.

REPAIR KIT INFORMATION

UNIVERSAL RAI®				
REF. NO.	QTY.	PART DESCRIPTION	REPAIR KIT PART NOS.	
			FRAME SIZE	REPAIR KIT NO.
4	1 Pr.	Timing Gear	2"	65-101-ORK
5	1	Plug — Opening	3"	65-104-ORK
7	1	Gasket	4"	65-107-ORK
14	1	Bearing, D.E. — DRVN	5"	65-111-ORK
14	2	Bearing, G.E.	*6"	65-115-ORK
15	1	Bearing, Dr. Shaft	*7"	65-119-ORK
17	1	Gear Nut		
27	2	Seals, D.E.		
27	2	Seals, G.E.		
31	4	Capscrew — Selflock		
33	1	Seal — Dr. Shaft		

*Repair kits for the 6" and 7" UNIVERSAL RAI® do not contain gears.

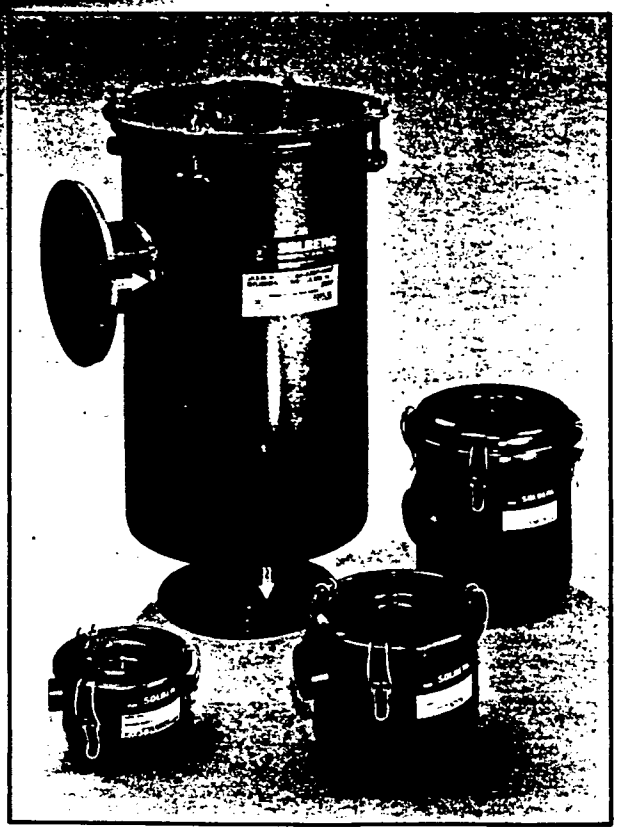




SEE BACK COVER FOR NEAREST SALES OFFICE.

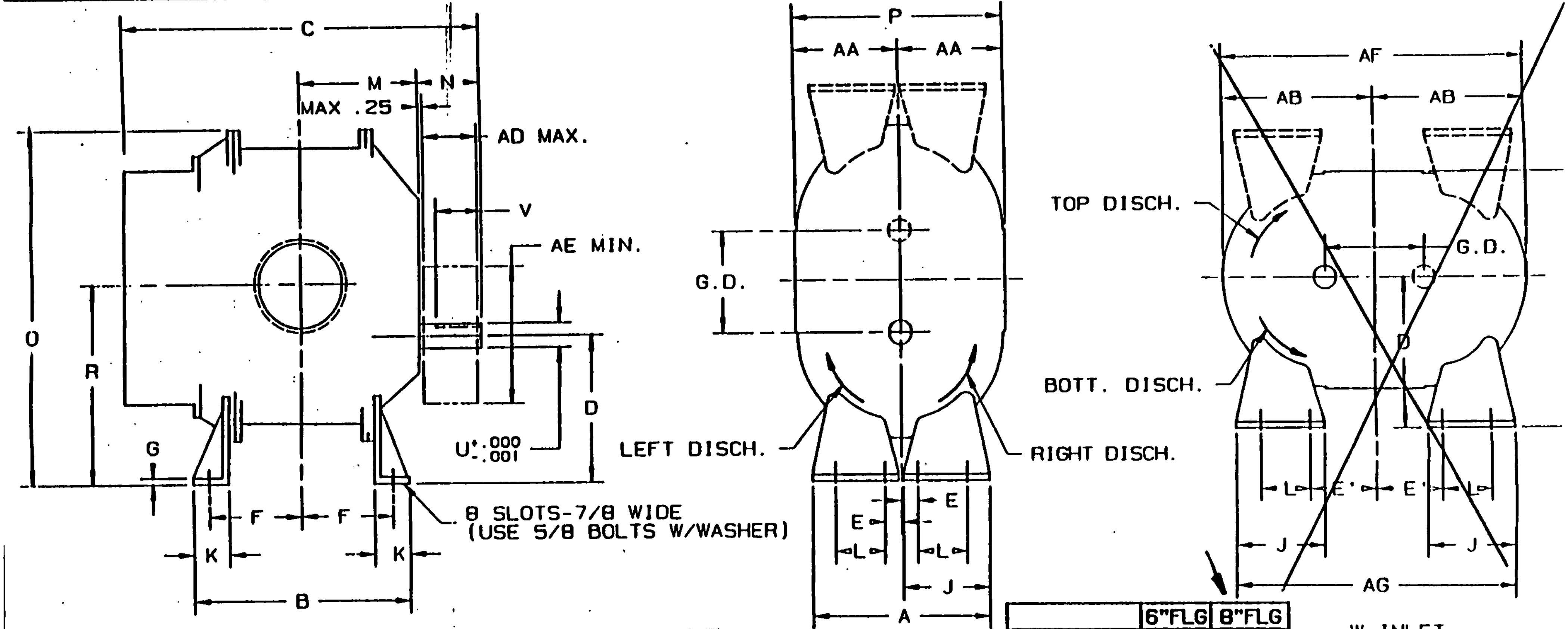
SOLBERG

INLET VACUUM AIR FILTERS



Bulletin CSL-50

Printed on Recycled Paper



	6"FLG	8"FLG
OPENING	6.00	8.00
BOLT CIRCLE	9.50	11.75
FLANGE O.D.	11.00	13.50
NO. TAPPED HOLES	8	8
SIZE HOLES	3/4-10	3/4-10
TAP DEPTH	1.13	1.13

W-INLET
W'-DISCHARGE
AD-SHEAVE WIDTH
AE-SHEAVE DIA.
ALL DIM. IN INCH

UNIT SIZE	APPROX. OIL CAP. VERT.	APPROX. OIL CAP. HORIZ.	G.D.
6"	28.3 FL OZ	52.1 FL OZ	6.00
7"	32.3 FL OZ	59.5 FL OZ	7.00

UNIVERSAL RAI BLOWER

FRAME SIZE	A	B	C	D	E	E'	F	G	J	K	L	M	N	O	O'	P	R	U	V	KEYWAY	W	W'	AA	AB	AD	AE	AF	AG	APPROX. WEIGHT
65	11.00	10.00	18.38	8.75	1.00	4.00	3.81	.38	5.38	2.13	3.00	5.63	3.56	21.63	15.13	12.75	11.75	1.375	2.75	.312x.156	3"NPT	3"NPT	6.38	9.88	3.44	8.00	19.75	17.00	245
68	"	13.00	21.38	"	"	"	5.31	"	"	"	"	7.13	3.69	"	"	"	"	"	"	"	5"NPT	5"NPT	"	"	"	"	"	"	285
615	"	20.00	28.38	"	"	"	8.81	"	"	"	"	10.63	"	"	18.25	15.00	"	"	"	"	6"FLG	6"FLG	7.50	"	"	"	"	"	425
76	14.00	11.75	19.94	11.00	2.00	5.50	4.88	.50	6.75	2.38	3.50	5.94	4.06	26.13	20.69	19.38	14.5	1.562	3.00	.375x.188	4"NPT	4"NPT	9.69	11.63	3.75	9.50	23.25	21.00	400
711	"	16.75	25.19	"	"	"	7.38	"	"	"	"	8.44	4.31	"	19.50	17.00	"	"	"	"	6"FLG	6"FLG	8.50	"	"	"	"	"	530
718	"	23.75	32.19	"	"	"	10.88	"	"	"	"	11.94	"	"	"	"	"	"	"	"	8"FLG	8"FLG	"	"	"	"	"	"	650

CUSTOMER ORDER NO. 27238
CERTIFIED CORRECT FOR
ROOTS ORDER NO. NES [illegible]

V-BELT DRIVE DATA
BELTS (3) 5VX1230
DRIVE SHEAVE 5V10.9
DRIVEN SHEAVE 5V11.8
CENTER DISTANCE [illegible]

ROOTS DRESSER

DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
CONNERSVILLE, INDIANA 47331

5/3/84

862-753-021

REVISION HISTORY				
No.	DATE	BY	ZONE	COMMENTS
•	•	•	•	•

120426 *

8"-150# ANSI
DRILLED FLANGE:
.88 DIA. - 8 HOLES
EQZO ON 11.75 BC
BOLT HOLES STRADDLE
CENTERLINE (2)

1.00 DIA. - 4 HOLES
ON 22.00 BC

22.00
NOM. DIA.

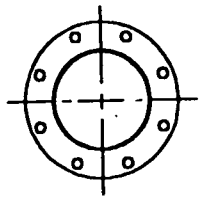
30.00°
(TYP.)

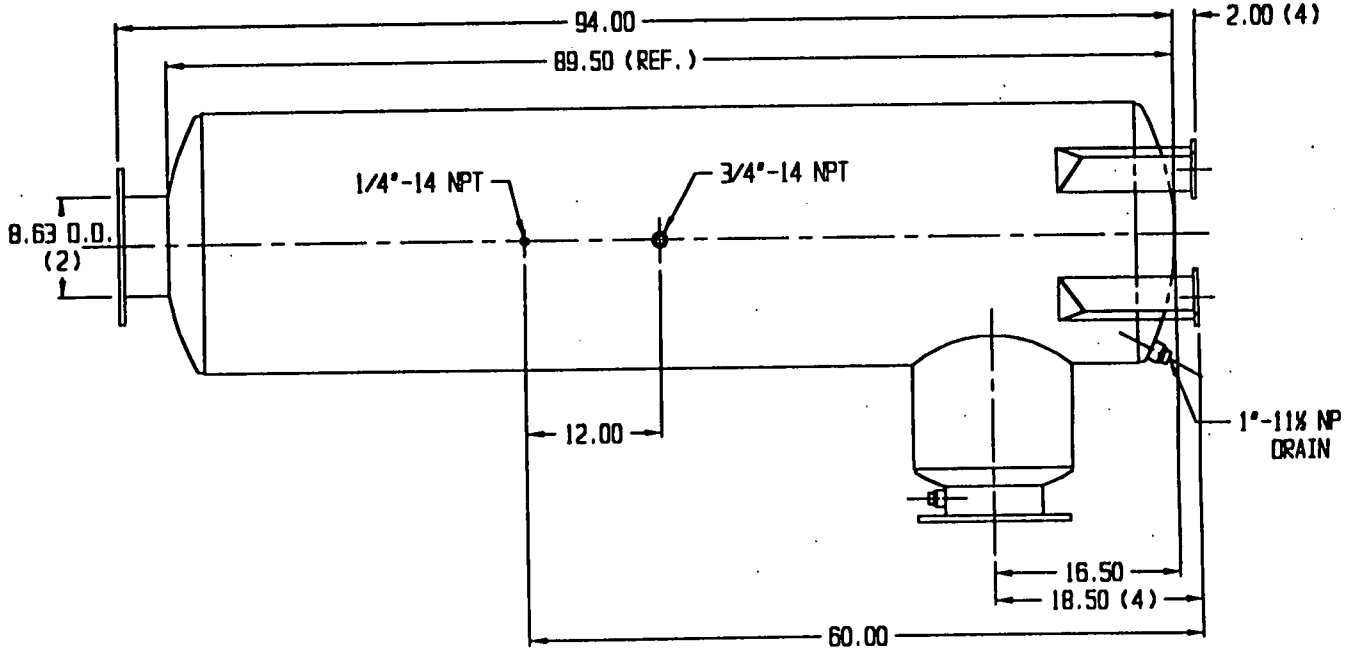
24.50

14.00
NOM. DIA.

3.00

3/4"-14 NPT





BLOWER END

EM PRODUCTS

PHILLIPS & TEMRO *Industries*
A Thyssen Krupp Automotive Company

THIRD ANGLE PROJECTION

DRAWN BY TNV DATE 5/20/99
APPR. BY DATE

DRAWING DIVISION PRIOR LAKE

DESCRIPTION:
PS08-X: 8" FLG S/E CONN.
WITH TYPE "B" LEGS

MFG'R: • MATERIAL: CARBON STEEL SHEET 1

UNLESS SPECIFIED DIMENSION TOLERANCES ARE:		
ANGLES	INCHES	MILLIMETERS
∠± 2°	.00 ± .13 .000 ± •	00. ± • 0.0 ± •

SCALE: 1:12 | QUT. B | PAR. B | DRAWING No. 120426

CUSTOMER TOMLIN EQUIPMENT | WORK ORDER 35141 | FINISH GRAY | WEIGHT 520#

ROOTS SALES/AGENT DIRECTORY

REVISED 10/98 SUPERCEDES ALL PREVIOUS ISSUES

ALABAMA
Roots Division, Dresser
P.O. Box 863
Pelham, AL 35124
Shipping Address
c/o Mechanical Sales
713 Thames Court
Pelham, AL 35124
PH: 205/664-0110
FX:205/664-8633
Milie Avery (174)
Jenella King

CALIFORNIA
Roots Division, Dresser
1260 Broadway, Ste.A
Sonoma, CA 95476
PH: 707/939-8075
FX: 707/939-8135
Rudy Doorman (057)/RM
Marianne Hollman

Roots Division, Dresser
1201 S. Beach Blvd.,
Suite 106
La Habra, CA 90631
PH: 562/947-2599
FX: 562/947-1808
Peggy Hunter

McKenna Engrg. &
Equip. (626)/Agent
340 Maple Avenue
Torrance, CA 90503
PH: 310/328-5520
FX: 310/328-3303
Frank Amason
Gary Ogden
Walt Stoufer
Ed McKenna
Jim Robbins

COLORADO
RO-CAAM, Inc.
(610)/Agent
609 Soda Creek Drive
Evergreen, CO 80439
PH: 303/670-0770
FX: 303/670-8655
Roger Shultz

RO-CAAM, Inc.
(Branch Office)
886 The Eagle Pass
Durango, CO 81301
PH: 970/259-4935

FLORIDA
Barone Equip. Sales
(616)/Agent
4739-41 Transport Dr.,
Bldg. 5
Tampa, FL 33605
PH: 813/247-7574
FX: 813/247-7630
John Barone

GEORGIA
REP, Inc. (601)/Agent
2405 Murphy Blvd.
Gainesville, GA 30504
PH: 770-538-0020
FX: 770/538-0022
Jim Hene
Len Hene
John Mattick

ILLINOIS
Roots Division, Dresser
2174 Gladstone Court,
Suite A
Glendale Heights, IL 60139
PH: 630/582-0111
FX: 630/582-0430
Vince Schuster (027)/RM
Jeff Aversa (056)
Laura Golubski

KANSAS
Aircorp, Inc. (603)/Agent
7763 Quivira Road
Shawnee, KS 66216
PH: 913/962-1000
FX: 913/962-1449
Bob Baty
Bob Baty, Jr.
Rex Hubbard
Ken Hinkson
Marv Fitzpatrick

LOUISIANA
Kirkwook Company, Inc.
(619)/Agent
2705 Independence St.
Metairie, LA 70006
PH: 504/456-6890
FX: 504/455-8240
A. Gerard Kirkwood
(Centrifugal & 10-20° Rotaries Only)

MASSACHUSETTS
Maher Corp. (617)/Agent
(WWT Market Only)
407R Mystic Avenue
Suite 21
Medford, MA 02155-6326
PH: 781/393-0060
FX: 781/396-0239
Dennis Maher
Fred Kibble
Chris Shea
Paul Sussman
Peter Kibble

MINNESOTA
Engineering America, Inc.
(609)/Agent
1851 Buerkle Road
White Bear Lake, MN 55110
PH: 651/777-4041
FX: 651/777-5312
Travis Hackworthy
Chuck Singer
Tony Belden
Tony Tripicchio

MISSOURI
Dresses-Rand
(600)/Agent
406 W. 34th Street
VFW Building-Ste. 716
Kansas City, MO 64111-2780
PH: 816/561-1322
FX: 816/561-1133
Dave Johnson
***Centrifugal Market Specialist**

NEW JERSEY
Roots Division, Dresser
116 Choctaw Ridge Road
Branchburg, NJ 08876
PH: 908/218-0550
FX: 908/218-0314
Howard Shouffler
(139/131)

Roots Division, Dresser
600A Lake Street
Ramsey, NJ 07446
PH: 201/825-0600
FX: 201/825-0022
John Parrish (031)/RM
Dennis Hayes (098/137)
Douglas D. Olenick
Debbie LaBeur-Dodds

OHIO
The Crocker Company
(611)/Agent
3480 Mustafa Drive
Cincinnati, OH 45241
PH: 513/563-6053
FX: 513/563-0329
Bill Worster
Ken Gittinger
Frank Mackell

Tomlin Equipment Co.
(614)/Agent
242 Poplar Street
Toledo, OH 43605
PH: 419/691-3571
FX: 419/691-1928
Steve Rhodes
Wes Jenkins

PENNSYLVANIA
Roots Division, Dresser
425 Stewart Avenue
Jenkintown, PA 19046
PH: 215/884-5340
FX: 215/884-5208
Dale Temple (163)

Roots Division, Dresser
St. Clair Building
Suite 306
1725 Washington Road
Pittsburgh, PA 15241
PH: 412/343-5100
FX: 412/831-3240
Dave Roessler (141)

TEXAS
Roots Division, Dresser
1200 W. Sam Houston Pkwy. N
Houston, TX 77043
PH: 713/935-3496
FX: 713/935-3497
Bob Hazzard
(043, 060, 151)
Kathy Spoonemore (066)
Leslie Aaron

Roots Factory Service &
Repair Center
11611B Tanner Road
Houston, TX 77041
PH: 713/896-4810
FX: 713/896-4927
John Conley (150)
Bob Stamm

WASHINGTON
APSCO (625)/Agent
P.O. Box 2639
Kirkland, WA 98083
Shipping Address
935 Kirkland Avenue
Kirkland, WA 98033
PH: 425/822-3335
FX: 425/827-6171
Joe Anastasi
Roger Perrin
Dale McBain

APSCO (625)/Agent
3173 E. Fox Spit Road
Langley, WA 98260
PH: 360/730-1216
FX: 360/730-1930
Joe Anastasi

CANADA
Beckland Equipment Ltd.
(632)/Agent
3250 Beta Avenue
Burnaby, BC Canada
V5G 4K4
PH: 604/299-8808
FX: 604/299-6162
Harold Bringeland
Tina Klein

PSI Prolew, Inc.
(615)/Agent
163 Labrosse
Point-Claire, Quebec
H9R 1A3 Canada
PH: 514/697-7867
FX: 514/697-0057
Gorden Yapp

MEXICO
Veslo Productos SA de CV
(506)/AGENT
Lamartine No. 160-2o.piso
Colonia Polanco, C.P.
11570, Mexico D.F.
PH: 011-525-545-7942 or
011-525-545-7942
FX: 011-525-531-1682
Roberto Pesqueira Viesca
Director General

PUERTO RICO
Badrena & Preez, Inc.
(628)/Agent
P.O. Box 6368
Loiza Station
San Juan, PR 00914
41 Marginal St. Villamar
Isla Verde, PR 00979
PH: 787/728-7171,
7172,
7173
FX: 787/728-0580
James M. Badrena

ARGENTINA
Orvin S.R.L. (536/Agent)
Cavia 3366
1686 Hurlingham,
BS. AS., Argentina
PH: 011-54-1-452-0171
FX: 011-54-1-452-0171
Raul G. Cartledge

BRAZIL
OMEL - Bombas e
Compressores LTDA
(535/Agent)
Rua Silvio Manfredi -
201 - CEP 07241-000
Guarulhos - Sao Paulo -
Brazil
PH: 011-55-11-6412-3200
FX: 011-55-11-6412-5056
Marzio Vallo
Alan Pickthall

CHILE
Tecnica Hansa Ltda.
(529/Agent)
Marchant Pereira 540
Providencia Santiago-
Chile
PH: 011-562-2045348
011-562-2090957
011-562-2040732
FX: 011-562-2045231
011-562-2045799
Arnold D. Droste

COLOMBIA
Servitool Ltda.
(520/Agent)
Carrera 58 N0. 14-14
Apartado Aereo 90688
Bogota, Colombia
PH: 011-571-4203599
011-571-2616315
FX: 011-571-4137180
Cesar Martinez

PERU
Representaciones
Peruvian Trading S.A.
(526/Agent)
Pasaje Los Jilgueros 108
Urb. Limatambo,
Surquillo Lima 34 Peru
PH: 011-51-14-428209
FX: 011-51-14-428559
Pablo A. Lira

VENEZUELA
Rep. Saver Guinand C.A.
(515/Agent)
Avenida Principal de
Los Ruices
Centro Empresarial
Los Ruices
Oficina #115, Caracas
Venezuela
PH: 011-58-2-2342846
011-58-2-2349968
011-58-2-2395951
FX: 011-58-2-2392742
Enrique Brillembourg

Professional Services
Intl. (PSI) (514/Agent)
Parque, Boyaca
Torre Centro,
PISO 18, No. 183
Av. Sucre, Los Dos
Caminos
Caracas, Venezuela
PH: 011-58-2-284-4990
FX: 011-58-2-286-1977
Jose Zozaya M.

WEST INDIES
H.J. Gransaull & Co. Ltd.
(516/Agent)
P.O. Box 98
San Fernando, Trinidad
West Indies
PH: 809/657-7151
809/657-8015
FX: 809/652-5575
Shawn Spencer

HUDDERSFIELD
Dresser Roots Intl.
Sales Operations (323)
P.O. Box B7
Off St. Andrews Road
Turnbridge, Huddersfield
England HD1 6RB
PH: 011-44-01484-422222
FX: 011-44-01484-422668

HOLLAND
Dresser Roots Intl. Sales
Operations
Kerkstraat 6
5051 LB Goirle
Holland
PH: 011-31-135-300770
FX: 011-31-135-300760

INLET VACUUM AIR FILTERS

Since 1968 Solberg has been manufacturing quality OEM and industrial filters for air compressor, blower and vacuum applications. By pioneering many filter manufacturing techniques and building their own production machinery, Solberg is fulfilling their commitment of continual product improvement and prompt response to customer needs.

The Solberg line includes most all sizes of inlet, inline, and exhaust system filters and elements, filter silencers, oil mist filters, high temperature filters and more. There is a choice of media to suit specific duty requirements. As the filter specialist, Solberg can also provide reliable products for individual needs and unique filter applications. Ask for an engineering evaluation of your requirements.

APPLICATIONS

- Soil Venting
- Soil Remediation
- Vacuum Pumps & Systems
- Intake Suction Filters
- Blowers
- Pneumatic Conveying Systems
- Air Compressors
- Remote Installations

FEATURES

- Use as an elbow in a package without removing for service
- Rugged all steel construction
- Low pressure drop
- Positive sealing - Vacuum tested
- Large dirt holding capacity and easy field cleaning, especially when mounted horizontally or inverted
- 1/4" FPT tap holes on inlet & outlet for differential pressure gauge (3" & larger)

OPTIONS (Inquiries Encouraged)

- Larger sizes available
- Support stands
- Stainless steel housings
- Epoxy coated housings
- Hot dipped galvanized housings
- Unique centrifugal 2-stage filtering system/baffle plates
- Special fittings available for volume orders
- Various elements available - see Element bulletin
- Activated carbon pad or prefilter to reduce odor

Inline filters with optional baffle plates provides centrifugal flow to knock down large particulates.

CSL-235P-400F

- Connection size; 400 = 4"; F at the end of model # denotes flange connection.
- Element part #; Odd #'s = Polyester, Even #'s = Paper, Even #'s + s = Wire Mesh. P = Polyurethane foam pre-filter included.
- CSL denotes Closed System "L" design.

SMI MODEL NUMBERS - CSL Series		EFFECTIVE SURFACE AREA OF ELEMENT IN SQUARE FEET		CONNECTION			Approx. Shipping Wt. Lbs.	DIMENSIONS					
W/Polyester Element	W/Paper Element	Polyester	Paper	Size	Type	Flow CFM		A	B	C	D	E	F
THREADED CONNECTIONS													
CSL-05-025	CSL-04-025	.2	.2	1/4"	MPT	6	.5	2-11/16"	*5/8"	2-1/2"	2-1/4"	*5/8"	—
CSL-05-038	CSL-04-038	.2	.2	3/8"	MPT	6	.5	2-11/16"	*5/8"	2-1/2"	2-1/4"	*5/8"	—
CSL-07-038	CSL-06-038	.58	.58	3/8"	MPT	8	1	3-15/16"	*5/8"	3-1/4"	2-15/16"	*5/8"	—
CSL-07-050	CSL-06-050	.58	.58	1/2"	MPT	10	1	4-1/4"	15/16"	3-1/4"	3-1/4"	15/16"	—
CSL-843-050HC	CSL-842-050HC	.6	1.75	1/2"	FPT	10	3	4-3/8"	3/8"	5-7/8"	2-5/8"	9/16"	5"
CSL-843-075HC	CSL-842-075HC	.6	1.75	3/4"	FPT	20	3	4-3/8"	3/8"	5-7/8"	2-5/8"	9/16"	5"
CSL-843-100HC	CSL-842-100HC	.6	1.75	1"	FPT	25	3	4-3/8"	5/8"	5-7/8"	2-5/8"	3/4"	5"
CSL-849-100HC	CSL-848-100HC	2.0	4.5	1"	FPT	40	5	6-1/2"	3/4"	7-5/16"	4-1/2"	3/4"	6-13/16"
CSL-843-125HC	CSL-842-125HC	.6	1.75	1-1/4"	FPT	45	3	4-3/8"	5/8"	5-7/8"	2-5/8"	3/4"	5"
CSL-849-125HC	CSL-848-125HC	2.0	4.5	1-1/4"	FPT	60	5	6-1/2"	3/4"	7-5/16"	4-1/2"	3/4"	6-13/16"
CSL-849-150HC	CSL-848-150HC	2.0	4.5	1-1/2"	FPT	80	5	6-1/2"	3/4"	7-5/16"	4-1/2"	3/4"	6-13/16"
CSL-851-200HC	CSL-850-200HC	4.5	13.75	2"	FPT	150	15	10-1/4"	3/4"	8-3/4"	5"	3/4"	7-5/8"
CSL-851-250HC	CSL-850-250HC	4.5	13.75	2-1/2"	FPT	195	15	10-1/2"	1"	8-3/4"	5-1/2"	1-1/4"	7-5/8"
CSL-235P-300	CSL-234P-300	8.3	22.8	3"	MPT	300	47	27-1/8"	3"	14"	18-1/2"	3"	13"
CSL-335P-300	CSL-334P-300	12.0	34.0	3"	MPT	300	50	27-1/8"	3"	14"	18-1/2"	3"	13"
CSL-235P-400	CSL-234P-400	8.3	22.8	4"	MPT	520	52	27-1/8"	3"	14"	18-1/2"	3"	13"
CSL-335P-400	CSL-334P-400	12.0	34.0	4"	MPT	520	55	27-1/8"	3"	14"	18-1/2"	3"	13"
CSL-245P-500	CSL-244P-500	14.0	35.5	5"	MPT	800	82	28-1/8"	3"	18-1/2"	19-1/2"	3"	17"
CSL-345P-500	CSL-344P-500	22.1	57.0	5"	MPT	800	88	28-1/2"	3"	18-1/2"	19-1/2"	3"	17"
CSL-275P-600	CSL-274P-600	19.0	45.4	6"	MPT	1100	95	28-1/8"	4"	18-1/2"	20-1/2"	4"	17"
CSL-375P-600	CSL-374P-600	28.0	68.1	6"	MPT	1100	97	28-1/8"	4"	18-1/2"	20-1/2"	4"	17"
FLANGED CONNECTIONS													
CSL-235P-400F	CSL-234P-400F	8.3	22.8	4"	FLG	520	62	27-1/8"	3"	14"	18-1/2"	3"	13"
CSL-335P-400F	CSL-334P-400F	12.0	34.0	4"	FLG	520	64	27-1/8"	3"	14"	18-1/2"	3"	13"
CSL-245P-500F	CSL-244P-500F	14.0	35.5	5"	FLG	800	90	28-1/8"	3"	18-1/2"	19-1/2"	3"	17"
CSL-345P-500F	CSL-344P-500F	22.1	57.0	5"	FLG	800	86	28-1/2"	3"	18-1/2"	19-1/2"	3"	17"
CSL-275P-600F	CSL-274P-600F	19.0	45.4	6"	FLG	1100	110	28-1/8"	4"	18-1/2"	20-1/2"	4"	17"
CSL-375P-600F	CSL-374P-600F	28.0	68.1	6"	FLG	1100	113	28-1/8"	4"	18-1/2"	20-1/2"	4"	17"
CSL-377P-800F	CSL-376P-800F	50.0	125.0	8"	FLG	1800	185	38"	4"	22-1/2"	25-1/2"	4"	21"
CSL-685P-1000F	CSL-384P(2)-1000F	100.0	280.0	10"	FLG	2900	380	57-1/2"	4"	26-13/32"	45"	4"	25"
CSL-685P-1200F	CSL-384P(2)-1200F	100.0	280.0	12"	FLG	3300	390	57-1/2"	4"	26-13/32"	45"	4"	25"
CSL-485P(2)-1200F	CSL-484P(2)-1200F	150.0	400.0	12"	FLG	4950	465	70"	4"	26-13/32"	57"	4"	25"

*Currently 15/16" soon to be 5/8"

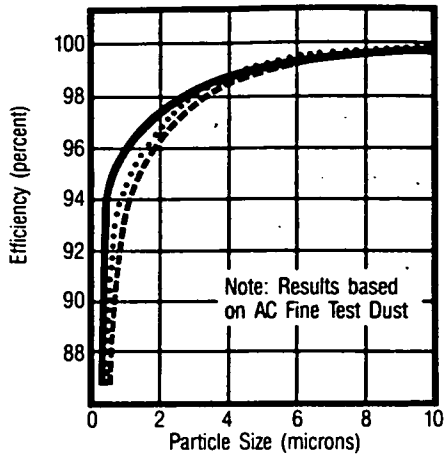
REPLACEMENT ELEMENTS

[illegible] Series
1/2" [illegible] to 12" Flange
Up to 4950 CFM

POLYESTER

Dust Removal efficiency of polyester media at face velocity of:

15 cfm/ft²-media ——————
30 cfm/ft²-media .....
45 cfm/ft²-media - - - - - - -



- Galvanized metal endcaps
- Reinforced with epoxy coated steel wire on both sides of cloth
- Nominally 99+% efficient at 10 microns
- Washable - lukewarm water and mild detergent
- Dust loading capacity 40-50% greater with polyurethane prefilter

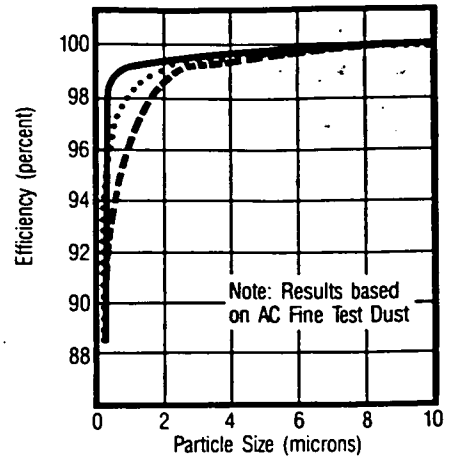
ADVANTAGES

- Less maintenance
- More durable
- Moisture resistant
- Handles hot air and oil mist from unload cycle of reciprocating compressor

PAPER

Dust Removal efficiency of paper media at face velocity of:

10 cfm/ft²-media ——————
15 cfm/ft²-media .....
20 cfm/ft²-media - - - - - - -

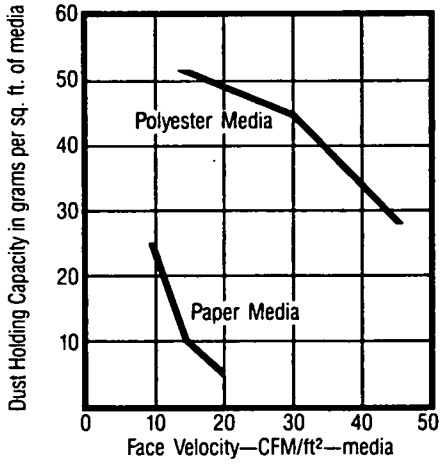


- Galvanized metal endcaps
- Heavy duty industrial strength paper
- Nominally 99+% efficient at 10 microns
- Reinforced with heavy gauge galvanized expanded metal
- Dust loading capacity 40-50% greater with polyurethane prefilter

ADVANTAGES

- Less expensive
- More surface area per given size
- Higher efficiency

Influence of Face Velocity on Dust Holding Capacity



SMI ELEMENT NUMBERS		Flow CFM	EFFECTIVE SURFACE AREA IN SQUARE FEET		DIMENSIONS		
Polyester	Paper		Polyester	Paper	I.D.	O.D.	HT
[illegible]	04	6	.2	.2	—	2-1/4"	1"
[illegible]	06	10	.58	.58	—	3"	1-3/8"
[illegible]	842	40	.6	1.75	2-3/8"	3-7/8"	2-3/4"
[illegible]	848	80	2.0	4.5	2-9/16"	5"	4-3/4"
[illegible]	850	195	4.5	13.75	3-1/2"	5-7/8"	8-3/4"
[illegible]	234P*	520	8.3	22.8	4-3/4"	7-7/8"	9-5/8"
[illegible]	334P*	520	12.0	34.0	4-3/4"	7-7/8"	14-1/2"
[illegible]	244P*	850	14.0	35.5	6"	9-3/4"	9-5/8"
[illegible]	344P	850	22.1	57.0	6"	9-3/4"	14-1/2"
[illegible]	274P	1100	19.0	45.4	8"	11-3/4"	9-5/8"
[illegible]	374P	1500	28.0	68.1	8"	11-3/4"	14-1/2"
[illegible]	376P	1800	50.0	125.0	9"	14-5/8"	14-1/2"
[illegible]	384P	1800	50.0	140.0	14"	19-5/8"	14-1/2"
[illegible]	484P	2880	75.0	200.0	14"	19-5/8"	21-1/2"
[illegible]	—	3500	100.0	—	14"	19-5/8"	28-1/2"

NOTE

Additional interchangeable elements listed in Element Brochure EL-10

* Plastisol Encaps
P = Polyurethane Prefilter

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EM PRODUCTS™
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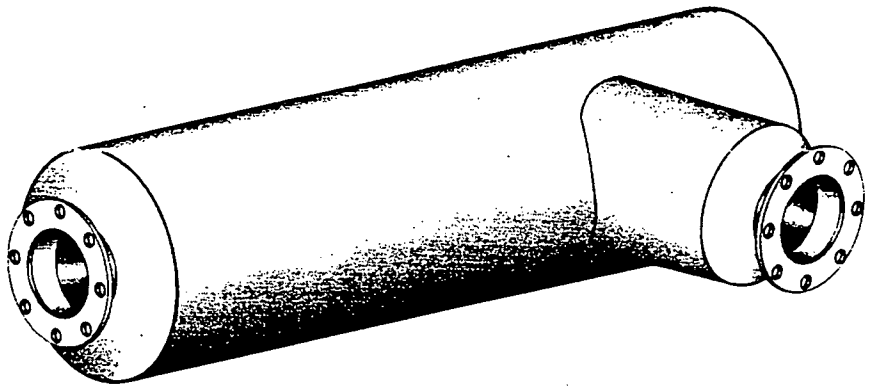
Rotary Positive Blower Silencers

Model PE/PS - Series

Combination Absorptive-Chamber Type Intake/Discharge



The "P" Series intake/discharge silencer is a heavy duty two chambered combination type design. The acoustically packed blower connection, combined with optimally proportioned volume chambers, acoustically balanced by-pass tubes and ported outlet nozzle, provides excellent pulse control, and greater broad band performance for critical pitch-line applications.

Standard Construction Features

- Available in sizes from 2 inch to 30 inch
- Male NPT inlet and discharge connections sizes 2 inch to 4 inch
- 125/150# ANSI drilled plate flanges for 5 inch to 30 inch
- Full welded double shell carbon steel construction
- High density polyester acoustic blanket good to 325° F., wrapped with 304 SS wire mesh cloth and encased in a carbon steel perforated facing
- Gray phenolic resin based fast drying primer suitable for overcoating with urethanes, acrylics, epoxies and industrial enamels. Standard two mil thickness
- Side connection models have two moisture drains located in the bottom chamber of silencer

Optional Construction Features and Accessories

- Stainless steel construction
- Aluminum construction
- Aluminized steel construction
- Vertical mounting legs
- Round mounting bands
- Horizontal mounting saddles
- Horizontal and vertical shell lugs
- Special finish per specification
- Oversized flanges
- Air leak test
- ASME code construction
- Special connections for relief valves and instrumentation
- Special inlet and discharge connection locations
- Special acoustical design
- Acoustical shell lagging
- Inspection openings
- High temperature acoustic pack material
- Contact factory for additional features to meet your requirements

10/98
98BC-4018

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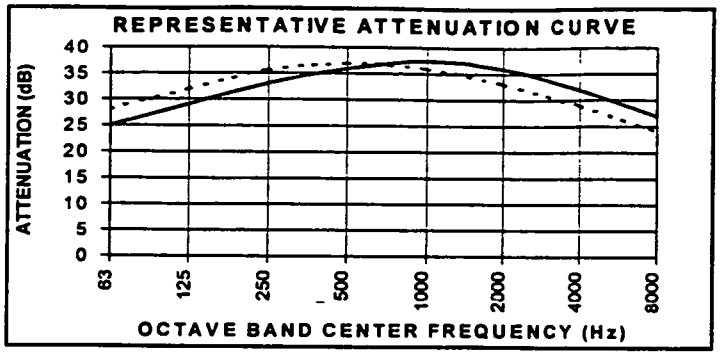
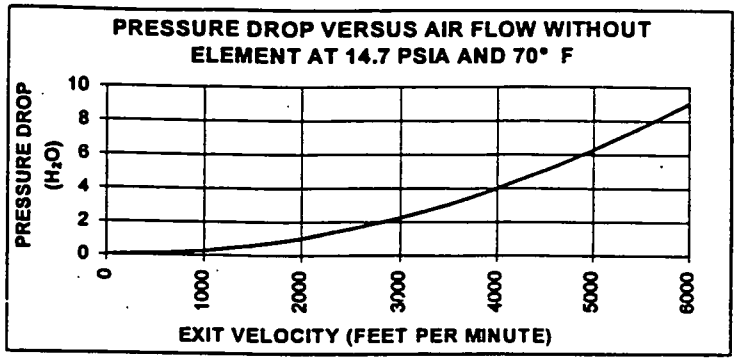
EM PRODUCTS™
PHILLIPS & TEMRO INDUSTRIES

Rotary Positive Blower Silencers

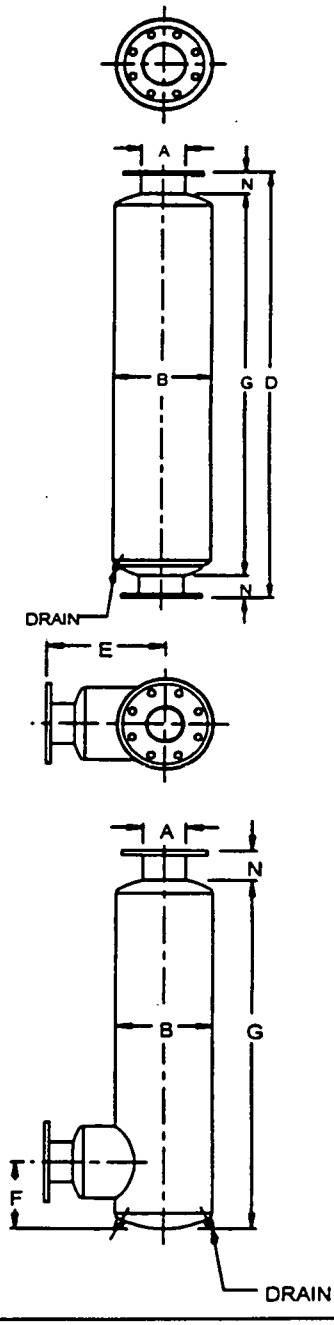
Model PE/PS - Series





—— 12" AND SMALLER ; - - - - 18" AND LARGER

A	B	D	N	G	E	PS MODEL F-MIN	PS MODEL F-MAX	WT
1	SIZES 1" - 1 1/2" USE " U " SERIES OR " BXU " SERIES					---	---	---
1 1/2						---	---	---
2	8	33	3	27	9	FIXED	AT 6	28
2 1/2	10	34	3	28	10	FIXED	AT 7	45
3	10	46	3	40	10	FIXED	AT 7	55
3 1/2	12	52	3	46	11	FIXED	AT 8	75
4	14	53	3	47	14 1/2	8	20	100
5	16	65	3	59	16 1/2	9	26 1/2	175
6	18	72	3	66	20 1/2	10	30	220
8	22	97	3 1/2	90	24 1/2	12	45	440
10	26	122	3 1/2	115	28 1/2	14	60 1/2	660
12	30	135	3 1/2	128	35	15 1/2	66	950
14	36	161	3 1/2	154	40 1/2	17 1/2	78	1600
16	42	181	3 1/2	174	44 1/2	19 1/2	89 1/2	2150
18	48	188	3 1/2	181	47	21 1/2	95	2725
20	48	202	4 1/2	193	53 1/2	22 1/2	100	2960
22	54	204	4 1/2	195	59 1/2	24 1/2	100	3900
24	54	239	4 1/2	230	66	25 1/2	123	4800
26	60	259	4 1/2	250	72	27	130	6000
28	66	279	4 1/2	270	78	31	140	7650
30	72	304	4 1/2	295	78	32	158	8500



- Standard stock silencers have minimum "F" dimension
- 2 inch to 4 inch standard with male NPT connections; 4 inch flange connections available upon request
- 5 inch to 30 inch standard with125/150# ANSI drilled plate flange connections; 5 inch male NPT connections available upon request

Dimensions in inches, weights in pounds. Dimensions and weights are nominal and may vary slightly with production models. Request certified drawings for exact dimensions.

EM Products • 5380 Cottonwood Lane • Prior Lake, MN 55372 • (612) 440-9200 • Fax: (612) 440-3400 • emp@emproducts.com

Is your current piping system causing you problems?. . .

- **Excessive noise and dangerous vibration**
- **Thermal growth-harming valuable equipment**
- **Misalignment among piping elements**

All these problems carry a high price, a very high price: Exorbitant maintenance costs, early metal fatique and a noisy plant. In short, the premature death of your piping system and equipment!

That's why you need answers now.

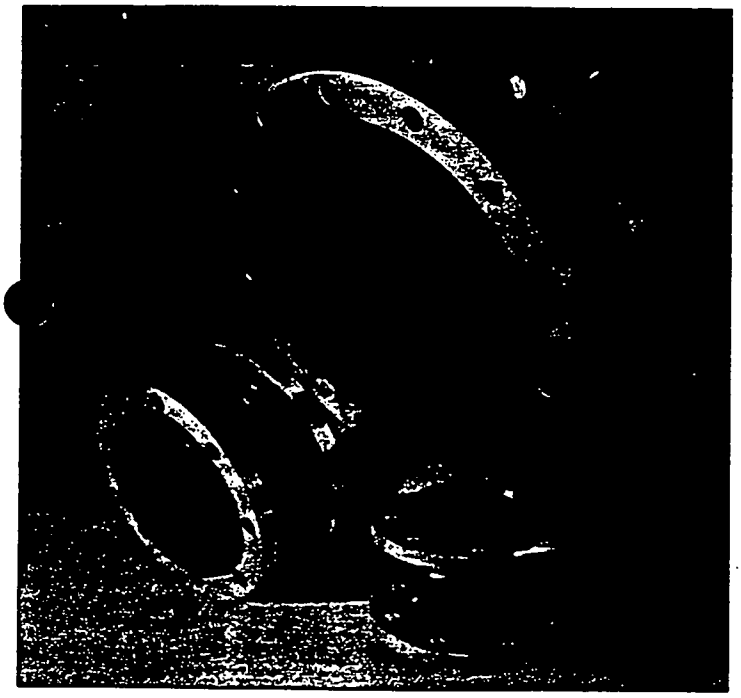
That's why you need help NOW!

How To Solve Your Motion Problems.

Non-metallic expansion joints/flexible connectors are your answer. They'll *neutralize* mechanical vibration in your system by *isolating the vibration at the connection.* They'll *absorb* thermal growth motion and *compensate* for misalignment, protecting the investment you've already made in piping and equipment.

Flexible connectors also minimize stress and early fatigue problems. Remember, less vibration equals less noise. Your plant runs *quieter and safer* with the addition of flexible connectors.

The answer to your motion problems are expansion joints/ flexible connectors. By integrating these shock absorbers with your current piping system, you'll be lengthening your investment's life time and insuring its safety.



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Twin City Hose, Inc. gives you the fast response you need when problems occur. Same day service is available. . . at NO EXTRA CHARGE!

Your exact needs can be met by Twin City Hose, Inc.

You'll get *exactly what your specific job requires.* All Twin City Hose, Inc. products are manufactured from the highest quality materials. In addition to the products shown in this catalog, there are numerous other styles of rubber and teflon expansion joints/flexible connectors available depending on the pressures, temperatures and media. Twin City Hose, Inc. *can solve any problem you have.*

No Order Too Large. . . No Order Too Small.

That is our slogan. That is also our guarantee. Whether you need just one or one thousand, Twin City Hose, Inc. will handle your order.

Call Now. . . We're Ready To Help.

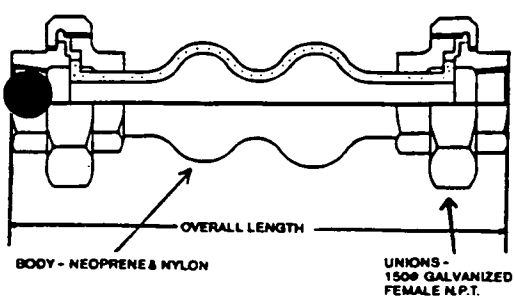
Call Twin City Hose, Inc. with all of your non-metallic expansion joint/flexible connector problems. Whatever the problem, we've got the solution. Call (612) 493-2902 or FAX your problem to us at (612) 493-2907.

We're Twin City Hose, Inc., the problem solvers.

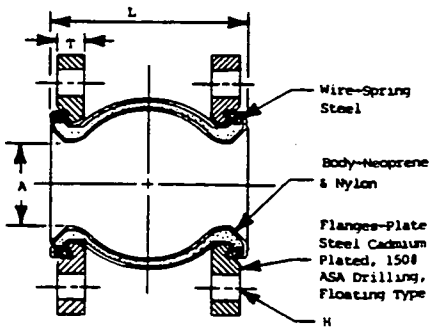
MOLDED RUBBER SPHERE-TYPE EXPANSION JOINTS • SERIES M-S

(Refer to chart #1 on opposite page)

M-FUS-2



M-S-1



M-S-2

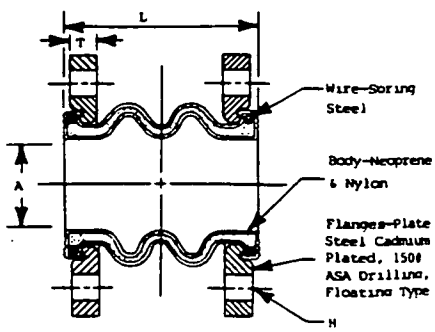


Chart #1

Model Number	A Pipe Size	L Face to Face	Approx. Weight	Holes		Motions			
				No. Holes	Size	Lateral Def.	Ext.	Comp.	Ang. Def.
M-FUS-2	3/4"	8"	2#	NA	NA	±7/8"	1/4"	7/8"	45°
M-FUS-2	1	8	3	NA	NA	7/8	1/4	7/8	45
M-FUS-2	1-1/4	8	4	NA	NA	7/8	1/4	7/8	45
M-S-1	1-1/2	6	6	4	1/2"	1/2	3/8	1/2	15
M-S-2	1-1/2	7	7	4	1/2	1-3/4	1	2	40
M-FUS-2	1-1/2	8	5	NA	NA	7/8	1/4	7/8	45
M-S-1	2	6	9	4	5/8	1/2	3/8	1/2	15
M-S-2	2	7	9	4	5/8	1-3/4	1	2	40
M-FUS-2	2	8	6	NA	NA	7/8	1/4	7/8	45
M-S-1	2-1/2	6	12	4	5/8	1/2	3/8	1/2	15
M-S-2	2-1/2	7	12	4	5/8	1-3/4	1	2	40
M-FUS-2	2-1/2	8	8	NA	NA	7/8	1/4	7/8	45
M-S-1	3	6	14	4	5/8	1/2	3/8	1/2	15
M-S-2	3	7	14	4	5/8	1-3/4	1	2	40
M-S-1	4	6	18	8	5/8	1/2	1/2	3/4	15
M-S-2	4	9	20	8	5/8	1-1/2	1-1/4	2	35
M-S-1	5	6	23	8	3/4	1/2	1/2	3/4	15
M-S-2	5	9	25	8	3/4	1-1/2	1-1/4	2	35
M-S-1	6	6	27	8	3/4	1/2	1/2	3/4	15
M-S-2	6	9	30	8	3/4	1-1/2	1-1/4	2	35
M-S-1	8	6	41	8	3/4	1/2	1/2	3/4	15
M-S-2	8	13	42	8	3/4	1-1/8	1-1/8	2-1/2	35
M-S-1	10	8	57	12	7/8	3/4	5/8	1	15
M-S-2	10	13	57	12	7/8	1-3/8	1-1/8	2-1/2	30
M-S-1	12	8	83	12	7/8	3/4	5/8	1	15
M-S-2	12	13	95	12	7/8	1-3/8	1-1/8	2-1/2	30

OTHER SIZES AND CONFIGURATIONS AVAILABLE UPON REQUEST

DESIGN DATA

1. Maximum Positive Pressure: 225 PSIG
2. Maximum Negative Pressure: 26" HG Vacuum
3. Temperature: 20°F to 240°F
4. Listed Movements Cannot Occur Simultaneously.

Control Rod Unit Applications

Control rod units are designed to absorb static pressure thrust developed at the expansion joint. The control rod units are an additional safety factor, minimizing possible failure of the expansion joint or damage to the equipment when used in this manner. If pressures exceed the stated pressures in chart #2 below, or are unknown, we strongly recommend the installation of Control Rod Units.

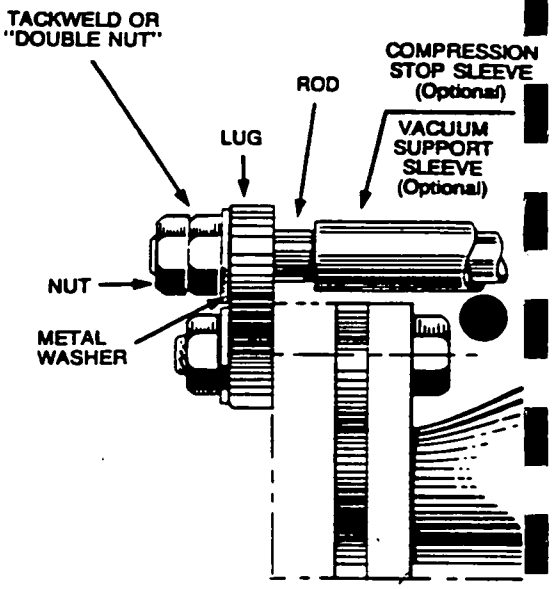
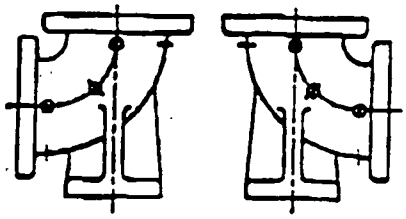


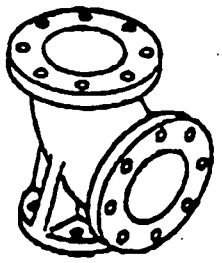
Chart #2

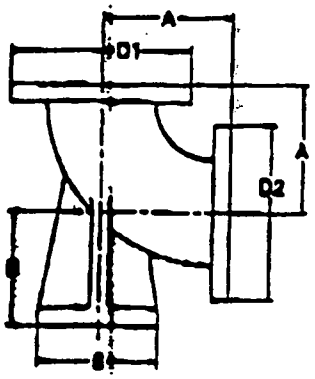
Control units must be installed when pressures (working • test • design • surge) exceed rating below:

Pipe Size	M-S-1	M-S-2
1" thru 4"	180	135
5" thru 10"	135	135
12" thru 14"	90	90
16" thru 24"	45	45
26" thru 30"	35	35

STRAIGHT STANDARD FLANGED BASE 90° EL

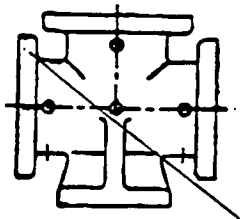


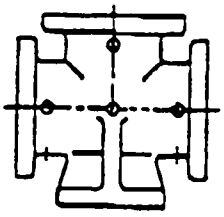


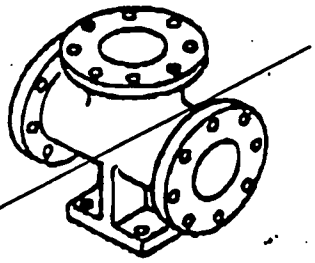


NPS	Dimensions: Center to Face A	Dimensions: Height of Base B	Dimensions: Outside Dia. D(min)	Base Drilling: Round & Square S Base U	Base Drilling: Bolt Circle or Bolt Spacing W(min)
2	4.500	4.125	6.000	4.625	3.500
2 1/2	5.000	4.500	7.000	4.625	3.500
3	5.500	4.125	7.500	5.000	3.875
4	6.500	5.500	9.000	6.000	4.750
5	7.500	6.250	10.000	7.000	5.500
6	8.000	7.000	11.000	7.000	5.500
8	9.000	8.375	13.500	9.000	7.500
10	11.000	9.750	16.000	9.000	7.500
12	12.000	11.250	19.000	11.000	9.500

STRAIGHT STANDARD FLANGED BASE TEES







NPS	Dimensions: Center to Face	Dimensions: Height of Base (min)	Dimensions: Outside Dia. (min)	Base Drilling: Round & Square Base U	Base Drilling: Bolt Circle or Bolt Spacing W(min)
2	4.500	4.125	6.000	4.625	3.500
3	5.500	4.875	7.500	5.000	3.875
4	6.500	5.500	9.000	6.000	4.750
5	7.500	6.250	10.000	7.000	5.500
6	8.000	7.000	11.000	7.000	5.500
8	9.000	8.375	13.500	9.000	7.500

* May not be produced in Blossburg

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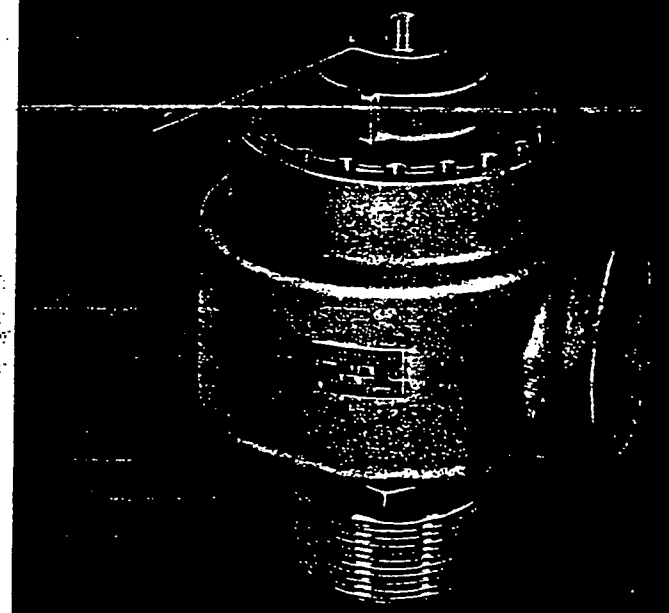
Valve Division

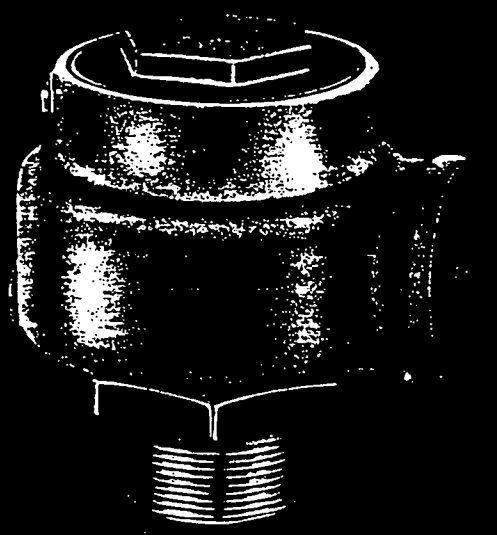
MODELS
215V
337

CAST IRON SAFETY VALVES

FOR AIR AND VACUUM SERVICE

3" 215V @ 13.5" Hg





KUNKLE Valve Division

IRON SAFETY AND VACUUM VALVES

MODELS 215V 337

PRESSURE LIMITS 337 — 60 PSIG-300°F.

VACUUM LIMITS 215V — 22" HG.-300°F.

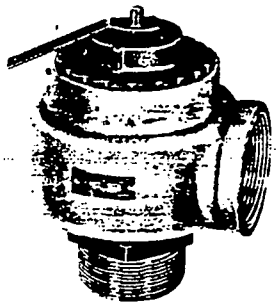
ASME Standard

UV

N.B. Certified

APPLICATIONS

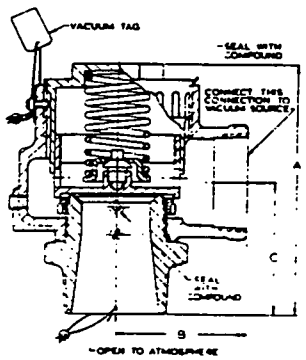
- Protection of low to medium pressure high volume blowers, compressors and pneumatic conveying systems.
- Bulk hauling trailers/equipment.
- Light gauge tanks.
- Protection of high volume vacuum pumps and conveying systems.



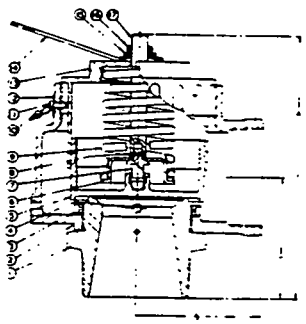
MODEL 337

FEATURES

High capacity full nozzle design. Bronze nozzle, disc and guide with cast iron housing. Flat bronze valve seats are lapped for optimum performance. Warn ring offers easy adjustability for precise opening with minimum preopen or simmer and exact blowdown control. Pivot between disc and spring corrects mis-alignment and compensates for spring side thrust. Model 337 has reversible lift lever for "pull-up" or "pull-down" manual testing. Every valve 100% tested/inspected for pressure setting, blowdown and leakage. All adjustments are factory sealed to prevent tampering or dis-assembly.



MODEL 215V



MODEL 337

SPECIFICATIONS

SIZE IN & OUT	A		B	C	WGHT LBS.
	337	215V			
2"	7¼	6¾	3¼	3¼	8
2½"	8	7½	3¾	3¾	12
3"	9½	9	4¼	4¼	19

CAPACITIES

SCFM Air, 60°F., 10% Accumulation

Set Pressure PSIG	MODEL 337		
	2"	2½"	3"
5	527	799	1157
10	743	1127	1632
15	903	1368	1982
20	1062	1609	2331
25	1221	1850	2680
30	1380	2091	3029
35	1539	2332	3379
40	1698	2573	3728
45	1857	2814	4076
50	2017	3055	4428
60	2335	3537	5125

Set Inches Mercury	MODEL 215V		
	2"	2½"	3"
1	140	213	308
2	217	329	477
3	264	400	579
4	299	453	657
5	331	501	726
6	352	533	772
7	372	564	817
8	391	592	858
9	403	610	884
10	413	625	906
12	424	642	930
12.8+	426	646	935

MODEL NUMBER/ORDER GUIDE

MODEL NO. POSITION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
EXAMPLE	2	1	5	V	—	H	0	1	—	Q	E				
	0	3	3	7											

INLET SIZE
H — 2"
J — 2½"
K — 3"

VARIATION (01 thru 99)
Number Provided Only by Manufacturer to Cover Specific Feature or Option.

DESIGN REVISION
Indicates Non-Interchangeable Revision. Dash (–) If Original Design.

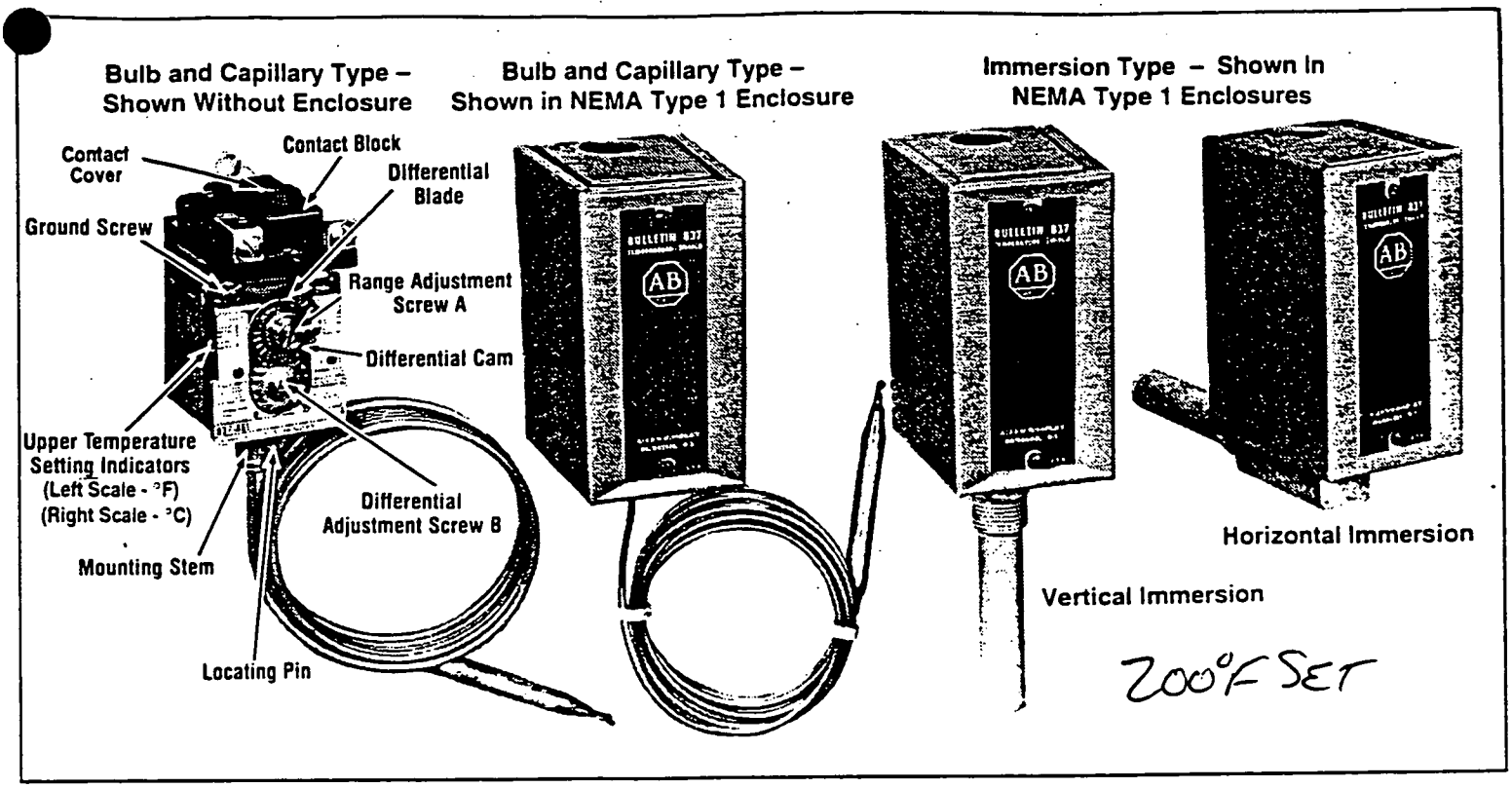
VALVE SERVICE
K-Air ASME Sec VIII (Model 337 Only)
Q-Vacuum (Model 215V Only)

SPRING MATERIAL
E-Stainless (302)

SET PRESSURE
Models 337 2 PSIG (0002) thru 60 PSIG (0060)
Model 215V 1" HG (Inches of Mercury) (0001) thru 22" HG (0022) Vacuum

8222 Bluffton Road
Box 1740
Fort Wayne, Indiana 46801-1740
219-747-1533
FAX 219-747-7958

TEMPERATURE CONTROLS



DESCRIPTION - Bulletin 837 Temperature Controls use a closed, chemically filled bellows system. The temperature sensing bulb is mounted directly on the control or is remotely mounted using a capillary.

Copper capillaries and bulbs are supplied on lower temperature ranges to reduce thermal lag and response time of the controls. Stainless steel is used on temperature ranges above 260°F and is available on lower ranges for the more corrosive applications.

Bronze or stainless steel armor is available for added protection of the capillary. Thermostat wells of brass, carbon steel or stainless steel are used when inserting the sensing bulb into a pressurized system.

Packing gland assemblies are also available to form a seal at any desired position along a standard capillary. Temperature ranges are available from -150°F to +570°F. Controls are available in NEMA Type 1, 4, 4X, 7, 9, and 13 enclosures in addition to the open type.

The standard contact block is single pole, double throw and can be wired to open or close on increasing or decreasing temperature.

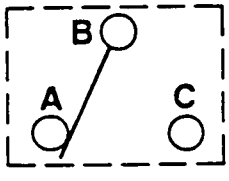
CONTACT RATINGS

Non-Inductive Ratings	Control Circuit Ratings
5 Amperes, 250 Volts	AC-125 VA 24 to 600 Volts
3 Amperes, 600 Volts	DC-57.5 VA 115 to 230 Volts

Manual reset, horsepower rated and other contact block modifications are also available on devices manufactured at the factory.

OPERATION - The bulb and capillary system is filled with a chemical sensitive to temperature change. As the temperature at the bulb or probe rises, vapor pressure increases and decreases on falling temperature. The pressure is transmitted to the bellows through a capillary and operates a low friction, straigh in-line mechanism. A snap action switch will operate at a predetermined temperature setting. On rising temperature the normally closed circuit A-B opens and the normally open circuit B-C closes. This is called the "Trip" temperature. When the temperature returns to a lower predetermined value, circuit A-B will close and circuit B-C will open. This is called the "Reset" temperature. The difference between "Trip" and "Reset" temperature is the differential. Because of the characteristics of vapor pressure operation, the differential will be wider at the minimum range setting and narrows as the control is adjusted to maximum range setting

The vapor pressure method of sensing temperature was selected because it provides extremely long service life. It is not intended to be used on applications requiring instantaneous temperature response.



Standard Contact Arrangement

ADJUSTMENT– Generally, unless otherwise specified, controls shipped from the factory are set at the maximum operating range temperature and minimum differential. The following procedure should be used to set the control to a particular requirement.

OPERATING RANGE ADJUSTMENT– Turn adjustment Screw "A" counterclockwise to lower the upper and lower temperature settings. To increase the upper and lower settings, turn Screw "A" clockwise. The approximate upper temperature setting is shown by indicators on the outer edges of the nameplate.

DIFFERENTIAL ADJUSTMENT– When the differential blade is at the low point of the differential cam the control will function at minimum differential. To increase the differential, turn adjustment Screw "B" counterclockwise. This will decrease the lower temperature setting only. To decrease the differential, turn differential adjustment Screw "B" clockwise. This will raise the lower setting only.

NOTE: As mentioned previously, a particular differential setting will decrease with an increase in temperature operating range.

Condensed instructions are supplied with open style controls and are on the inside of the cover on enclosed devices.

CAUTION: The range adjustment Screw "A" should not be adjusted beyond the temperature indicated on the temperature scale as this may cause the control to malfunction.

It is recommended that periodic inspection of actual temperature be made on an independent instrument and the temperature control be adjusted to compensate for application variables.

MOUNTING– The temperature control should be mounted securely to a firm base using the mounting holes provided. The open type bulb and capillary control is normally mounted in an enclosed panel using the mounting stem lockwasher and nut of the control with the bulb and capillary extending outside the enclosure. A convenient mounting bracket can be provided. Care should be taken to properly locate and support the capillary avoiding strain, vibration, and short bends. The immersion type temperature control without enclosure is provided with a convenient mounting bracket for mounting in an enclosed panel.

CAUTION: Cross-ambient type controls must be mounted with the end of the bulb or immersion tube slanted downward below the horizontal position. If they are mounted horizontally the word "TOP" stamped on the hex fitting or on the bulb must face upward at the 12:00 position.

PILOT LIGHT OPTION– A high intensity neon glow pilot light is available for 120 volt, 60 hertz applications. A 24 volt DC LED pilot light is also available. The pilot light is factory wired across the N.C. contacts, circuit A-B, and can easily be converted to the N.O. contacts, circuit B-C, on the standard contact block.

Unless a third wire is made available, the pilot light is connected across the load contacts which can be either the N.O. or N.C. contacts. The pilot light is on until the load is energized.

Current rating:

120 VAC high intensity neon glow --- 4 mA
24 VDC high intensity LED ---- 22 mA

WARNING: To prevent electrical shock, disconnect from power source before installing or servicing.

CAUTION: For 24 VDC LED pilot lights, polarity must be observed. Red (+) lead of pilot light should always be connected to rear terminal (B).

To order pilot light version add X9 (120VAC) or X15 (24VDC) to catalog number of the selected control.

REPAIRS– Due to the integral construction of the Bulletin 837 Temperature Control, only limited repairs can be made in the field. If returned to the factory for repairs, the condition of the control will be evaluated to determine economic feasibility. When practical, the control will be repaired, factory adjustments made for optimum performance and tested to specifications.

CONTACT BLOCK REPLACEMENT– To order the Bulletin 837 Contact Block Replacement Kit, specify and use Catalog No. 836-N2.

40060-218-01 (C)
Printed in U.S.A.

ALLEN-BRADLEY
A ROCKWELL INTERNATIONAL COMPANY

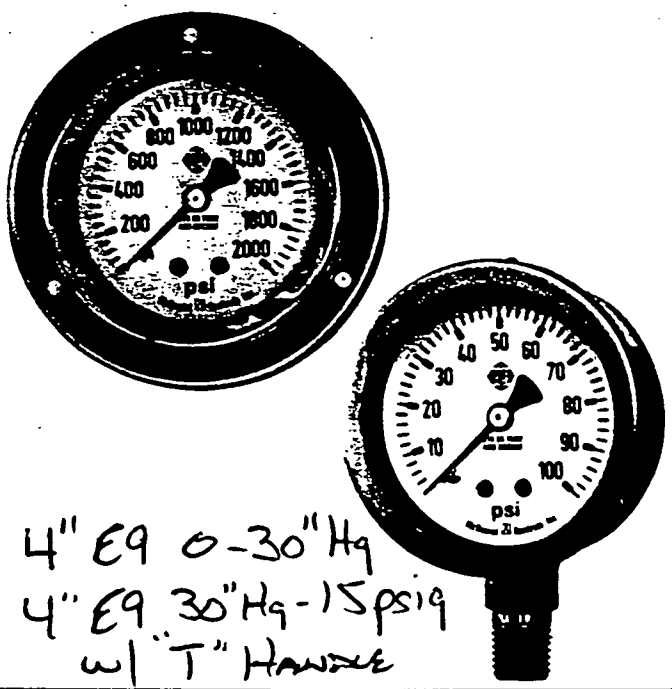
McDANIEL

Liquid Fillable, All Stainless Steel Utility Gauges

The rugged construction of our Series 9 All Stainless Steel gauges provides resistance to corrosive media and harsh environments.

The McDaniel Series 9 gauges feature 316 Stainless Steel wetted parts and a 304 Stainless Steel case with crimped on bezel ring. The case and socket joint is welded. Liquid fillable, in the field, or factory.

This series is ideally suited for O.E.M. and corrosive applications that require an all stainless steel gauge at an economical price.



SPECIFICATIONS

Accuracy:
ASME B40.1 standard - Grade A (2-1-2%)

Dial:
White enameled aluminum. Black figures. Sizes:
2 ½ inches (63mm) - Model **K9**
4 inches (100mm) - Models **E9** and **G9**

Case:
304 Stainless Steel, filled or fillable.

Ring:
304 Stainless Steel crimped on. (Polished on Panel, U-Clamp, and Back connected configurations)

Pointer:
Black enameled aluminum.

Lens:
Polycarbonate.
(Laminated Safety Glass by special order.)

Precision Movement
Stainless Steel

Bourdon Tube:
316 Stainless Steel (C Form 1000 PSI & Below).
(Spiral 1500 PSI & Above).

Pressure Utilization:
300% full scale pressure w/o rupture of the bourdon tube.
130% full scale pressure without loss of accuracy.

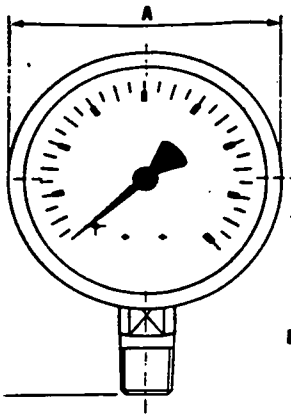
Stem and Socket:
316 Stainless Steel. **E9** ¼" NPT and **G9** ½" NPT
K9 ¼" NPT standard (⅛" NPT by special order)
Removable restrictor screw standard on K9, optional on E9 and G9 models. One piece welded connection.

Ranges Available
Vacuum, Compound, Rec 3-15, up to 10,000 psi

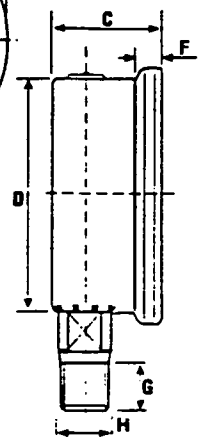
Configurations Available:
Bottom connected standard
(L) = Lower-back connected - K9
(C) = Center-back connected - E9 and G9
(U) = U-Clamp mounted, Lower-back connected on K9, Center-back on E9 and G9
(P) = Front Flange, Lower-back connected on K9, Center-back on E9 and G9
(R) = Rear flange for Back or Bottom connections

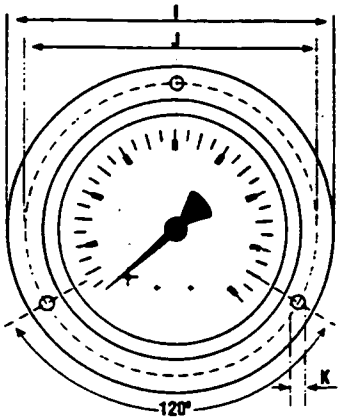
McDaniel Controls, Inc.

P. O. Box 187, Luling, LA 70070 • Highway 90 West, Paradis, LA 70080 U.S.A.
(504) 758-2782 • New Orleans (504) 467-1333 • Fax (504) 758-1688
www.mcdanielcontrols.com



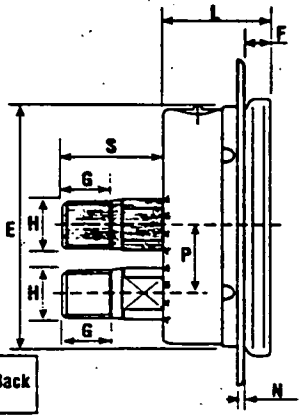
Bottom Connection



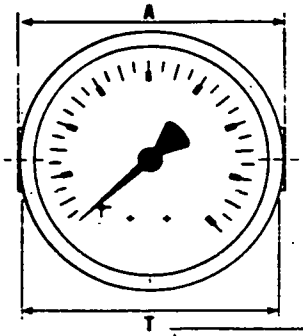


Panel Mount (P)

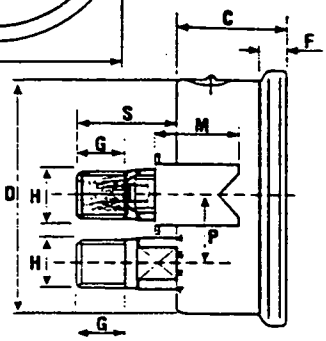
Back Connection:
Lower Back (L) - K9
Center Back (C) - E9 & G9



= Models E9 & G9 are Center Back



U-Clamp (



Model	Nominal Size	Case Diameter	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	S	T
	63	mm	68.5	57.5	31	62	64(4)	7	12	14	85	75	3.5	31	34	2	19	25	70
K9	2.48	inches	2.68	2.24	1.20	2.44	2.51	0.27	0.47	0.55	3.35	2.95	0.14	1.20	1.34	0.07	0.74	0.98	2.76
	100	mm	106	78	33.5(1)	99(6)	100.6(5)	7	12	14	ø132	116(2)	4.8(7)	33.5(3)	32	3.5	–	27	102
E9	3.94	inches	4.17	3.07	1.32	3.89	3.96	0.27	0.47	0.55	5.20	4.57	0.19	1.32	1.26	0.14	–	1.06	4.02
	100	mm	106	88(8)	33.5(1)	99(6)	100.6(5)	7	15	22	ø132	116(2)	4.8(7)	33.5(3)	32	3.5	–	40	102
G9	3.94	inches	4.17	3.48	1.32	3.89	3.96	0.27	0.59	0.87	5.20	4.57	0.19	1.32	1.26	0.14	–	1.57	4.02

(1) = 33.5±1 (mm)
(2) = 116±0.1 (mm)
(3) = 33.5±1 (mm)
(4) = 64±0.5 (mm)
(5) = Ø 100.6 (mm)
(6) = 99±0.2 (mm)
(7) = 3 x 120°
(8) = 88±1 (mm)

Range code	Range psi	Minor increments
A	0 - 15	5
B	0 - 30	1
C	0 - 60	2
D	0 - 100	2
E	0 - 160	5
F	0 - 200	4
G	0 - 300	10
H	0 - 400	10
I	0 - 600	20
J	0 - 800	20
K	0 - 1000	20
L	0 - 1500	50
M	0 - 2000	40
N	0 - 3000	100
4k	0 - 4000	100
O	0 - 5000	100
6k	0 - 6000	200
P	0 - 10000	200
VACUUM	VACUUM	VACUUM
S	VAC 30"Hg - 0	1
RECEIVER	RECEIVER	RECEIVER
T	REC 3 - 15**	2
COMPOUND	COMPOUND	COMPOUND
U	30"Hg + 15	2-0-1
V	30"Hg + 30	2-0-1
W	30"Hg + 60	5-0-2
X	30"Hg + 100	5-0-2
Y	30"Hg + 160	5-0-5
2k	30"Hg + 200	10-0-5
Z	30"Hg + 300	10-0-10

HOW TO ORDER

1 - Select the Model number (K9=2½" dial, ¼" NPT. E9=4" dial, ¼" NPT. G9=4" dial, ½" NPT.)
2 - Specify Range Code from list at left.
3 - Specify Type of Mounting:
(Bottom connection is standard, no code)
"L" = (Lower-back connection - K9)
"C" = (Center-back connected - E9 and G9)
"U" = (U-Clamp, Lower-back connection on - K9, Center-back connected on E9 and G9)
"P" = (Front Flange, Lower-back connected on K9, Center-back on E9 and G9)
"R" = (Rear Flange for Back or Bottom connection - not shown)
4 - Specify any other Special Configuration or options. (special NPT size, dual-scales, Ammonia-NH3, etc.)
5 - Add Type of Filling, if appropriate. (GF=Glycerin Filled)

Example:

Model	Range Code	Type of Mounting	Special Configuration	Type of Filling
K9	D	—	—	GF

Order: **A 2½" all stainless steel utility gauge with ¼" NPT bottom connection standard, range of 100 psi, filled at the factory with glycerin. (K9D–GF)**

Warning Glycerin filled gauges should not be used in applications involving strong oxidizing agents such as chlorine, nitric acid or hydrogen peroxide. (Refer to ASME B40.1)

** Receiver gauge is dual scale. (0 - 100% primary, 0 - 10 square root secondary)

Limited Warranty

McDaniel warrants our utility gauges to be free of defects in material and workmanship: Replacement of any defective gauge will be made at no cost to the purchaser. Gauge failures determined to be caused by over-range and incompatibility with environment/product media or abuse will not be considered under this warranty.

DISTRIBUTED BY:

It is recommended that users of pressure gauges become familiar with American National Standard ASME B40.1, entitled Gauges, Pressure and Vacuum – Indicating Dial Type – Elastic Element. This specification is available from:
American Society of Mechanical Engineers,
United Engineering Center
345 East 47th Street
New York, New York 10077

K9E9G91297

INSTRUCTIONS FOR THE INSTALLATION AND USE OF ASHCROFT® BI-METAL DIAL THERMOMETERS

GENERAL

In removing the thermometer out of the packing box, handle it by the case or case outlet. Avoid handling it by the stem.

INSTALLATION OF THERMOMETERS

The thermometer should be mounted at any convenient location where it will be subjected to the average temperature variations to be indicated.

Avoid bending the stem as this will cause misalignment of the internal parts, resulting in undue frictional errors.

To tighten the thermometer to the apparatus, use a wrench applied to the hexagon head of the threaded connection located just outside of the case.

INSTALLATION

Locate the stem so that at least the last two inches will be subjected to the average temperature to be measured.

Exposing the stem to a temperature in excess of the highest dial reading should be avoided.

The thermometer is normally provided with a threaded connection. To tighten the thermometer to the apparatus or into the well, use an open-end wrench applied to the hexagon head of the threaded connection. Turn until reasonably tight, then tighten still further in the same manner as a pipe elbow or similar pipe fitting until the scale is in the desired position for reading. DO NOT TIGHTEN BY TURNING THE THERMOMETER CASE. *Install the thermometer so that the maximum case temperature is kept below 200°F at all times.*

When a thermometer is equipped with a well, the well should be installed onto the apparatus first. The stem of the thermometer should then be coated with a heat conducting medium (a mixture of glycerine and graphite or vaseline or any other heavy lubricant may be used), after which the thermometer stem is inserted, and tightened into the well.

CAUTION: Thermowells should be used on all pressurized applications, to protect the thermometer stem from corrosion or physical damage, and to facilitate removal of thermometer without disturbing the process.

TESTING

Ashcroft Bi-metal Dial Thermometers are carefully calibrated at the factory and under most operating conditions will retain their accuracy indefinitely. However, as in the case of all instruments, it is well to make periodic checks for accuracy against known standards.

ADJUSTMENT

If it is necessary to make an adjustment to the thermometer, proceed as follows:

On thermometers fitted with an "External Adjustment"—Use a small wrench, small screwdriver or a coin to turn the slotted hexagon head in the back of the case until the pointer indicates the proper temperature on the dial.

MAINTENANCE OF DIAL THERMOMETERS

Aside from occasional testing, little or no maintenance is required.

Be sure that the gasketed glass cover is on the case at all times, as moisture and dirt inside the case will eventually cause the thermometer to lose its accuracy. (See caution note below).

If the thermometer is used for measuring the temperature of a material that may harden and build up an insulating layer on the stem, the thermometer should be removed from the apparatus occasionally, and the stem cleaned. Observe this precaution to insure the sensitivity of the instrument.

CAUTION: Bi-metal Thermometers operating below freezing must have a perfectly tight case to prevent entrance of moisture which eventually will condense and freeze inside the stem. This condition shows up as a failure of the thermometer to read accurately below 32°F or 0°C. For this reason it is important to avoid damage to the glass front, while the stem temperature is at freezing or below.

Thermometers fitted with the non-removable ring are hermetically sealed in a dry atmosphere at the factory and require no further maintenance.

DRESSER INDUSTRIES

INSTRUMENT DIVISION
DRESSER INDUSTRIES INC.
STRATFORD, CONNECTICUT 06497

Form No 250-999-J

Printed in U.S.A.

INSTRUCTIONS FOR THE SELECTION, INSTALLATION AND USE OF THE TYPE 91 SERIES ADAPTER SET

The Type 91 series adapter sets were designed to provide a simple means of installing a Bi-metal Dial Thermometer into an existing Industrial Glass Thermometer well.

The adapter set consists of:

1. A metal liner and spring assembly.
2. An adapter nut.
3. A small supply of heat conducting medium.

METHOD OF SELECTING THE SET

The adapter sets are available in four different sizes. to cover various depths of wells. The "Selection Chart" shows the adapter set number and the Bi-metal Dial Thermometer stem length to use for any well depth from 3⅜" up to 25⅛".

To select the proper adapter set and Bi-metal Dial Thermometer stem length. measure first the well depth by inserting a pencil. or any small diameter rod or stiff wire until it reaches the bottom. (See Figure 1). Be sure the rod does not hang up on any shoulder inside the well. Using your thumb as an index. withdraw the rod and measure the distance from the end of the rod to the index point. (See Figure 2).

Then use the chart to select the adapter set and the Bi-metal Dial Thermometer stem length to fit the well.

Note that one stem length of thermometer covers several different well depths by using the correct adapter set.

For example. a thermometer with a 9" long stem can be used for all well depths between 7⅛" and 10⅛". by choosing the correct adapter set.

The liner is tapped with a 5/16"—18 machine thread so it can be removed from the well if desired.

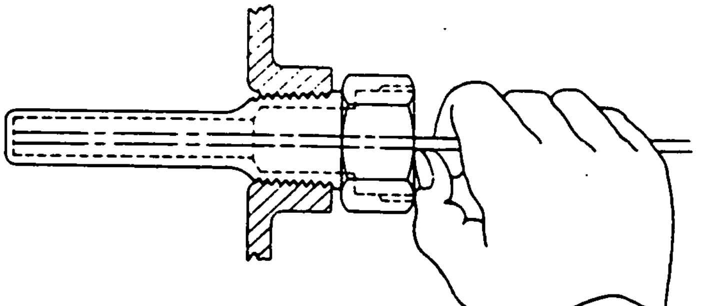


Fig. 1

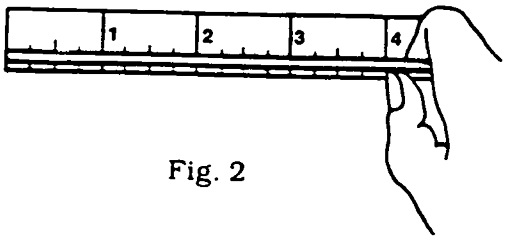


Fig. 2

INSTALLATION

Assemble the adapter nut into the well and tighten securely. (See Figure 3).

Before installing the Bi-metal Dial Thermometer into the adapter and well. coat the lower 3" section of the thermometer stem with a layer of heat conducting medium. This will improve the temperature response of the thermometer.

The metal liner is then slipped over the end of the thermometer stem and a coating of heat conducting medium is applied to the outside wall of the liner.

The thermometer and liner are then inserted into the well and tightened in position. Do not tighten more than is necessary to prevent the thermometer from turning.

Where service temperatures exceed 350°F the heat conducting medium may smoke when first subjected to a high temperature. This is caused by the vehicle. in the heat conducting medium. vaporizing and leaving the dry solids behind. This should not be cause for alarm. The dry solids will act equally well as a heat conducting medium for temperatures up to 1000°F.

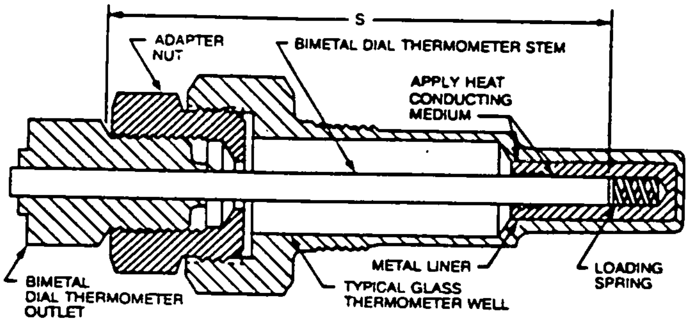
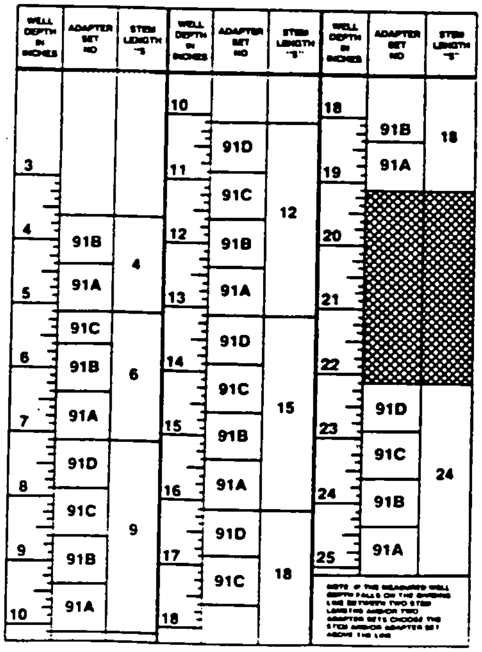


Fig. 3

SELECTION CHART



ITEM 2

U.S. Electric Motors

Ancillaries

Motor Frame
Motor Base

U.S. Electrical Motors
Installation and Maintenance Manual

SAFETY FIRST

High voltage and rotating parts can cause serious or fatal injury. Safe installation, operation, and maintenance must be performed by qualified personnel. Familiarization with and adherence to NEMA MG2, the National Electrical Code (NEC) and local codes is required. It is important to observe safety precautions to protect personnel from possible injury. Personnel should be instructed to:

1. Be familiar with the equipment and read all instructions thoroughly before installing or working on equipment.
2. Avoid contact with energized circuits or rotating parts.
3. Disconnect all power sources before initiating any maintenance or repair.
4. Act with care in accordance with prescribed procedures in handling and lifting this equipment.
5. Be sure unit is electrically grounded in accordance with code requirements.
6. Be sure equipment is properly enclosed or protected to prevent access by children or other unauthorized personnel in order to prevent possible accidents.
7. Be sure shaft key is fully captive before unit is energized.
8. Avoid contact with capacitors until safe discharge procedures have been completed.
9. Provide proper guarding for personnel against rotating parts and applications involving high inertia loads which can cause overspeed.
10. Avoid extended exposure to equipment with high noise levels.

INSPECTION AND HANDLING

Inspect unit to make sure no damage has occurred during shipment. Check nameplate for correct speed, horsepower, voltage, Hertz, and phase for conformance with power supply and equipment. *WARNING*: Units should be lifted using all eyebolts or lugs if provided. These eyebolts or lugs are provided for lifting this unit only and must not be used to lift any additional weight. Lifting angle, from shank of eyebolt, must not exceed 30° for machines with single and 45° for machines with multiple lifting means. Replacement eyebolts must be per ASTM A489 or equivalent. All eyebolts must be securely tightened. Be careful not to touch overhead power lines with lifting equipment. Failure to observe this warning may result in serious personal injury.

STORAGE

Units should be stored indoors, in a clean, dry location & winding should be protected from excessive moisture absorption. NOTE: If motors are to be stored for more than one year, refer to U.S. Electrical Motors. If gear and belt transmission units are to be stored for more than six months, refer to U.S. Electrical Motors.

LOCATION

WARNING: Use only UL Listed Hazardous Location Motors for service in Hazardous Locations as defined in Article 500 of the NEC. Units should be located in a clean, well-ventilated area. *WARNING*: Units should be located in a suitable enclosure to prevent access by children or other unauthorized personnel to prevent possible accidents.

INSTALLATION / MOUNTING

Mount units on a firm, flat surface sufficiently rigid to prevent vibration. Drive belts and chains should be tensioned in accordance with supplier recommendations. Couplings should be properly aligned and balanced. For belt, chain and gear drive selection refer to the drive or equipment manufacturer. For application of drive equipment refer to applicable information in NEMA MG1.

Motors have been dynamically balanced using a half key the same length as the full key shipped with the motor. If pulley keyway length is less than this length, rework long key by removing one-half of excess length between pulley and end of key to maintain balance.

Do not restrict motor ventilation. Unless otherwise specified on nameplate, motor is designed for operation in accordance with NEMA MG1 "Usual Service Conditions" which states an ambient temperature range of -15°C to 40°C (5°F to 104°F). Standard grease lubricated units are suitable for operation within this temperature range, special lubricants may be required for ambient temperatures outside of the range. NOTE: Motors operating under rated load and allowable ambient conditions may feel hot when touched; this is normal and should not be cause for concern. When in doubt, measure frame surface temperature and confer with nearest office. Enclosed motors normally have condensation drain openings. Insure that drain openings are properly located and open (plugs removed) for the motor mounting position. Drain openings should be at the lowest point of end brackets, frame housing and terminal housing when the motor is installed. This may require modification of motor to accomplish. If unit appears wet, and/or has been stored in a damp location, dry out thoroughly and check for adequate insulation resistance to ground before operating.

WARNING: Guards should be provided for all exposed rotating parts to prevent possible personal injury. Keep fingers and foreign objects away from ventilation and other openings. Applications involving *high inertia loads* may damage equipment due to motor overspeed during coast shutdown. Such applications should be referred to U.S. Electrical Motors.

CAUTION: Do not force drive coupling or other equipment onto shaft, as bearing damage may result

POWER SUPPLY AND CONNECTIONS

The power supply must agree with values on nameplate. Terminal voltage should not vary more than ±10% of nameplate voltage at rated frequency. Unbalanced line voltage, greater than one percent, can cause overheating. Do not exceed the continuous rated load amperes on the nameplate. Starting controls and overload protection should be properly sized in accordance with the NEC and the control manufacturer's recommendations.

Motor connections should be made by following instructions on connection diagram. Determine direction of rotation before connecting driven equipment. If direction of rotation label is supplied, operate only in specified direction. Rotation may be reversed on three phase motors by interchanging any two line connections. On single phase motors, interchange leads per connection diagram on motor. Wiring of units, controls and grounding shall be in accordance with local and NEC requirements. *WARNING*: Failure to properly ground unit may cause serious injury to personnel. Where unexpected starting could be hazardous to personnel, do not use automatic reset starting devices.

USE OF VARIABLE FREQUENCY DRIVES

Electric motors can be detrimentally affected when applied with variable frequency drives (VFD's). The non-sinusoidal waveforms of VFD's have harmonic content which causes additional motor heating; and high voltage peaks and short rise times, which result in increased insulation stress, especially when long power cable lengths

are used. Other effects of VFD's on motor performance include reduced efficiency, increased load current, vibration and noise. Standard motors utilized with VFD's must be limited to those application considerations defined in NEMA MG-1 Part 30.

NEMA MG-1 Part 31 defines performance and application considerations for Definite-Purpose Inverter Fed Motors. To insure satisfactory performance and reliability, U.S. Electrical Motors offers and recommends nameplated inverter duty motor products which meet the requirements of NEMA MG-1 Part 31. The use of non-inverter duty motors may result in unsatisfactory performance or premature failure, which may not be warrantable under the Terms and Conditions of Sale. Contact your U.S. Electrical Motors Field Sales Engineer for technical assistance for motor selection, applications and warranty details.

OIL LUBRICATION

Most oil lubricated units are shipped without oil. Refer to instruction manual with unit for specific type and grade of oil to be used, change interval and level. If lubrication instructions specify synthetic oil, do not substitute. *WARNING.* For applications in the food and drug industry (including animal food), consult the petroleum supplier for lubricants that are acceptable to the Food & Drug Administration and other governing bodies.

MAINTENANCE

Inspect units at regular intervals. Keep units clean and ventilation openings clear of dust, dirt or other debris. Lubricate units per this operating instruction sheet and instruction plate on unit. Excessive lubrication may damage the unit. Do not over-grease. *WARNING.* Disconnect all power sources to the unit and discharge all parts which may retain an electrical charge before attempting any maintenance or repair. Screen and covers must be maintained in place when unit is in operation. Failure to observe this warning may result in personal injury.

U.L. Listed Motors For Use in Hazardous Locations: Repair of these motors must be made by the manufacturer or manufacturer's authorized service station approved to repair U.L. Listed motors. The U.L. listing applies to the electric motor only and not to the belt or gear transmissions or other devices that may be connected to the motor.

GREASE LUBRICATION INSTRUCTIONS

Units are prelubricated at the factory and do not require initial lubrication. Relubricating interval depends upon speed, type of bearing and service. Refer to Table 1 for suggested regreasing intervals. Operating conditions may dictate more frequent lubrications. Motor must be at rest and electrical controls should be locked open to prevent energizing while motor is being serviced. (refer to section on Safety). If motor is removed from storage, refer to storage procedures.

To relubricate bearings, remove the drain plug. Inspect grease drain and remove any blockage with a mechanical probe taking care not to damage bearing. *CAUTION.* Under no circumstances should a mechanical probe be used while the motor is in operation. Add new grease at the grease inlet, refer to Table 1 for replenishment quantities. New grease must be compatible with grease in the motor (See Caution Note). Run the motor for 15 to 30 minutes with the drain plug removed to allow purging of any excess grease. Shut off unit and replace the drain plug. Return motor to service. *CAUTION.* Overgreasing can cause excessive bearing temperatures, premature lubricant breakdown and bearing failure. Care should be exercised against overgreasing.

TABLE 1
Recommended Grease Replenishment Quantities & Intervals
(For Lubrication of Units in Service)

Bearing Number		Grease	Lubrication Interval		
62XX	63XX	Fl. Oz.	3600 RPM	1800 RPM	1200 RPM
6203 - 6207	6303 - 6306	0.2	2 years	3 years	3 years
6208 - 6212	6307 - 6309	0.4	1 year	2 years	2 years
6213 - 6215	6310 - 6311	0.6	1 year	2 years	2 years
6216 - 6220	6312 - 6315	1.0	6 months	1 year	2 years
6221 - 6228	6316 - 6320	1.8	6 months	1 year	1 year

For motors mounted vertically or in hostile environments, reduce intervals shown by 50 percent.

Refer to motor nameplate for bearings provided on a specific motor. For bearings not listed in the table above, the amount of grease required may be calculated by the formula:

$$G = 0.11 \times D \times B$$

where: G = Qty of grease in fluid ounces
D = Outside diameter of bearing (inches)
B = Width of bearing (inches)

Table 2
Recommended Greases

THE FOLLOWING GREASES ARE INTERCHANGEABLE WITH THE GREASE AS PROVIDED IN UNITS SUPPLIED FROM FACTORY (unless stated otherwise on a lubrication nameplate provided on motor).

Manufacturer	Grease (NLGI No. 2)
Chevron U.S.A. Inc.	SRI No. 2
Shell Oil Co.	Dolium-R

CAUTION. Greases of different bases (lithium, polyurea, clay, etc.) may not be compatible when mixed. Mixing such greases can result in reduced lubricant life and premature bearing failure. When necessary, prevent such intermixing by disassembling the motor, removing all old grease from bearings and housings (including all grease fill and drain holes). Inspect and replace damaged bearings. Fill bearing housings and bearings approximately 30% full of new grease. Remove any excess grease extending beyond the edges of the bearing races and retainers. Refer to Table 2 for recommended greases.

RENEWAL PARTS & WARRANTY SERVICE

When inquiring for renewal parts, call the U.S. Electrical Motors Parts Department (Memphis, Tennessee) or a Parts Stocking Distributor. For warranty service call the nearest U.S. Motors Authorized Service Station. Give them complete nameplate data including ID number, etc. Request installation & maintenance manuals by product name.

SANTA FE SPRINGS, CA	(562) 906-3945 FAX (562) 941-1858	INTERNATIONAL SALES	(314) 553-2150 FAX (314) 553-2135
ORANGE, CT	(203) 891-1080 FAX (203) 891-1077	MONTREAL, QUEBEC	(514) 332-1880 FAX (514) 332-5912
CHICAGO, IL	(630) 924-5200 FAX (630) 893-0182	MARKHAM, ONTARIO	(905) 475-4670 FAX (905) 475-4672
MEMPHIS, TN	(901) 794-5500 FAX (901) 366-2661	CARACAS, VENEZUELA	(582) 285-2695 FAX (582) 285-4475
DALLAS, TX	(972) 644-0470 FAX (972) 644-0254	BOGOTA, COLOMBIA	(571) 250-2886 FAX (571) 311-9320
		MONTERREY, MEXICO	(528) 389-1300 FAX (528) 389-1320

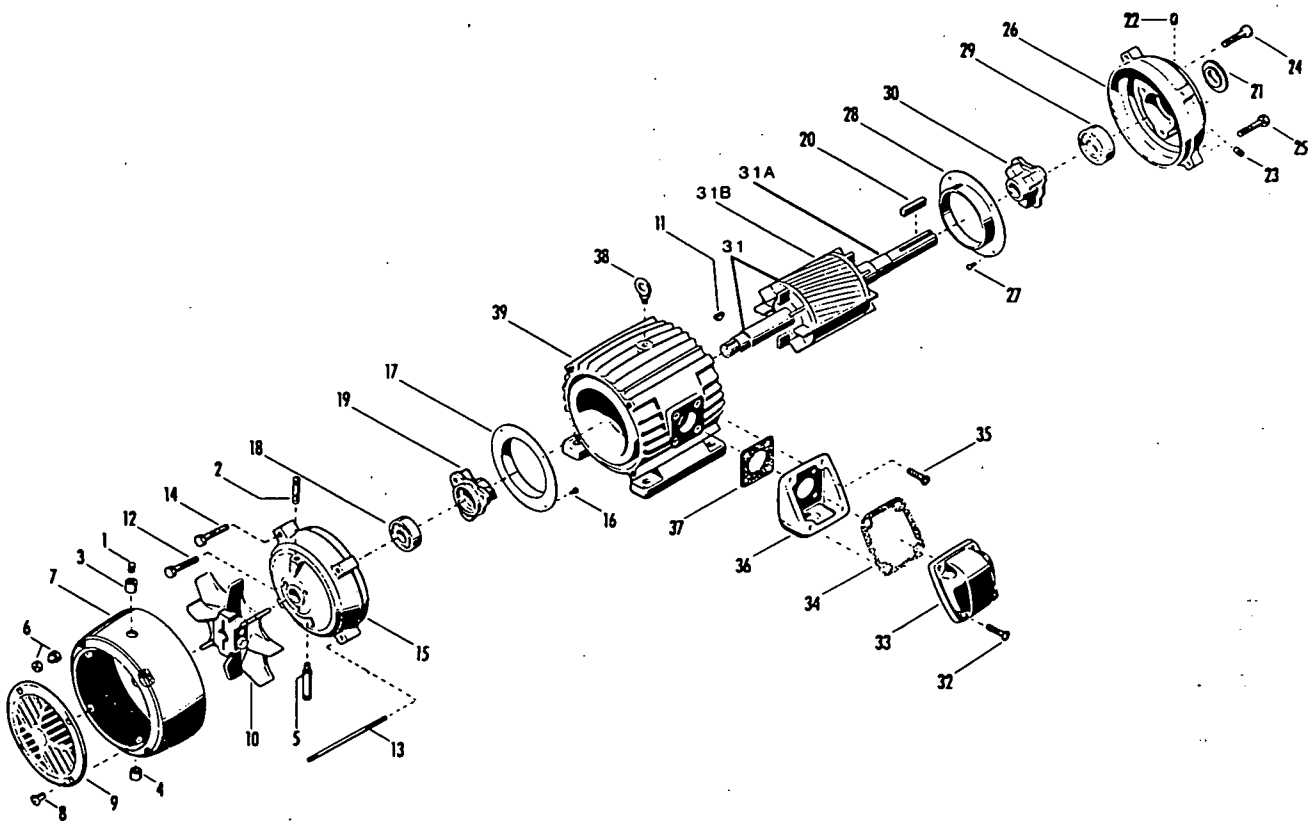
Instr. 109-34J 5/98

Printed in the U.S.A.
http://www.usmotors.com
8100 W. Florissant Ave, Saint Louis, MO 63136

RENEWAL PARTS

PARTS LIST

FRAMES 254T THRU 447T — TYPES T, TC, TCE, CT, TF, TFN, JAD, JDE, L, LF — TOTALLY ENCLOSED



ITEM NO.	QTY	NAME OF PART
1	1	Slotted Headless Pipe Plug
2	1	Pipe Coupling
3	1	Pipe Nipple
4	1	Pipe Cap
5	1	Pipe Nipple
6	2	Cap and Jam Nut
7	1	Fan Cover Guard
8	3	Screw & Lockwasher
9	1	Grill
10	1	Vent Fan Assembly
11	1	Woodruff Key (Not used on frames 254T & 256T)
12	2	Screw
13	2	Stud & Nut
14	2	Screw (Qty 6 on frames 324T & 326T)
15	1	Bracket
16	4	Screw (Used only on frames 286T &326T)
17	1	Air Deflector (Used only on frames 286T & 326T)
18	1	Ball Bearing
19	1	Bearing Cap
20	1	Key
21	1	Water Deflector

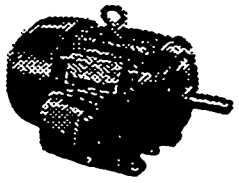
ITEM NO.	QTY	NAME OF PART
22	1	Slotted Headless Pipe Plug
23	1	Pipe Plug
24	2	Screw
25	4	Screw (Qty 8 on frames 324T & 326T)
26	1	Bracket (Not used on types TF)
27	4	Screw (Used only on frames 286T & 326T)
28	1	Air Deflector (Used only on frames 286T & 326T)
29	1	Ball Bearing
30	1	Bearing Cap
31	1	Rotor Assembly (Includes items 31A & 31B)
31A	1	Motor Shaft
31B	1	Rotor Core
32	4	Screw
33	1	Outlet Box Cover
34	1	Gasket
35	4	Screw (Qty 2 on frames 254T & 256T)
36	1	Outlet Box Base
37	1	Gasket (Outlet Box Base)
38	1	Eyebolt
39	1	Wound Stator Assembly

WARNING:

Any disassembly or repair work on explosionproof motors will void the Underwriters' Laboratories, Inc. label unless done by the manufacturer, or a facility approved by the Underwriters' Laboratories, Inc.. Refer to your nearest U.S. Electrical Motors office for assistance.

PRICES:

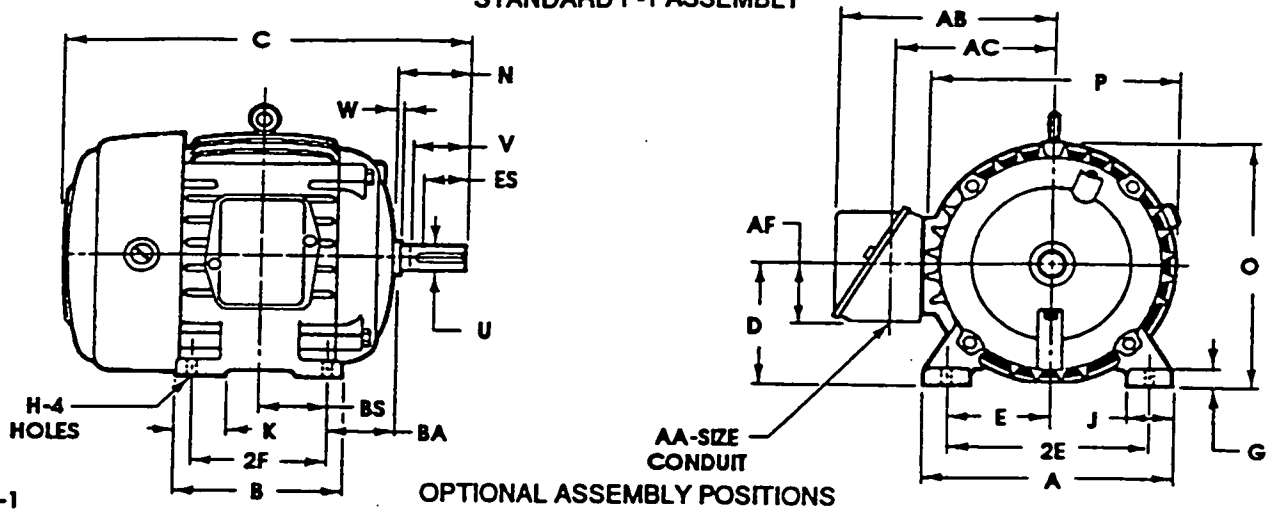
Parts stocking distributors: refer to your USEM renewal parts numerical index.
All others: refer to your nearest USEM parts stocking distributor.



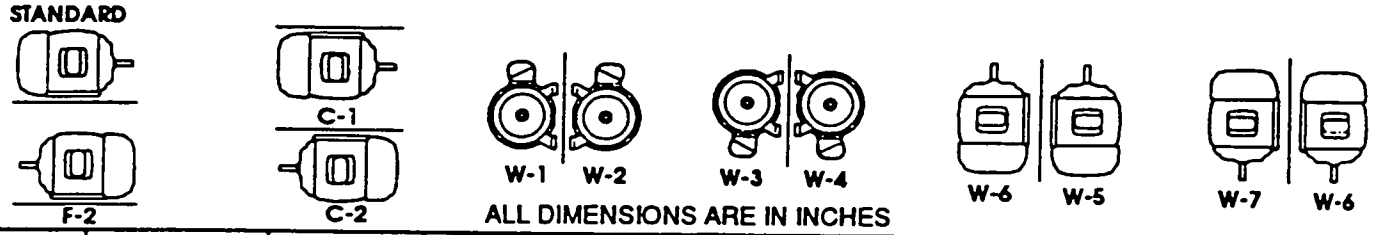
HORIZONTAL MOTORS
HOSTILE DUTY
FRAMES 324T THRU 405TS
TYPE CT

SECTION:	205
PAGE:	20
EFFECTIVE:	01-01-90
SUPERSEDES:	NEW SHEET

STANDARD F-1 ASSEMBLY



OPTIONAL ASSEMBLY POSITIONS



ALL DIMENSIONS ARE IN INCHES

BASIC FRAME	A	D	E	2E	G	H	J	K
320	15-3/4	8	6-1/4	12-1/2	1-1/8	21/32	3-1/4	3-1/8
360	17-3/4	8-31/32	7	14	1-1/4	21/32	3-3/4	3-3/8
400	19-3/4	9-31/32	8	16	1-3/8	13/16	3-3/4	3-1/2

BASIC FRAME	O	P*	W	AA	AB	AC	AF	BA
320	16-3/16	17	3/8	2	13-29/32	10-3/4	3-1/4	5-1/4
360	18-3/32	19-1/32	15/32	3	16-7/16	12-3/16	3-3/8	5-7/8
400	20-15/32	21-13/32	3/8	3	17-11/16	13-7/16	3-3/8	6-5/8

FRAME	B	C	2F	N	U -.001	V MIN.	BS	ES MIN.	SQ. KEY
324T	13-1/2	29-5/32	10-1/2	5-5/8	2-1/8	5	5-1/4	4	1/2
324TS	13-1/2	27-21/32	10-1/2	4-1/8	1-7/8	3-1/2	5-1/4	2-1/4	1/2
326T	15	30-21/32	12	5-5/8	2-1/8	5	6	4	1/2
326TS	15	29-5/32	12	4-1/8	1-7/8	3-1/2	6	2-1/4	1/2
364T	14-1/4	31-1/4	11-1/4	6-11/32	2-3/8	5-5/8	5-5/8	4-3/8	5/8
364TS	14-1/4	29-1/4	11-1/4	4-5/16	1-7/8	3-1/2	5-5/8	2-1/8	1/2
365T	15-1/4	32-1/4	12-1/4	6-11/32	2-3/8	5-5/8	6-1/8	4-3/8	5/8
365TS	15-1/4	30-1/4	12-1/4	4-5/16	1-7/8	3-1/2	6-1/8	2-1/8	1/2
404T	15-1/4	36-1/8	12-1/4	7-5/8	2-7/8	7	6-1/8	5-3/4	3/4
405T	16-3/4	37-5/8	13-3/4	7-5/8	2-7/8	7	6-7/8	5-3/4	3/4
405TS	16-3/4	34-19-32	13-3/4	4-5/8	2-1/8	4	6-7/8	2-25/32	1/2

*Largest motor width.

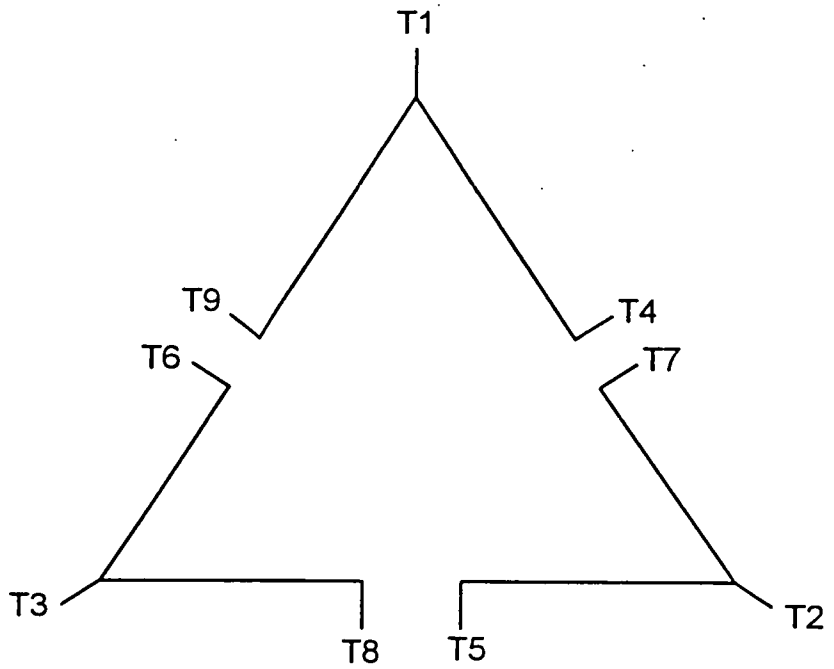
Dimension "D" will never be exceeded, but may be less then value shown. When exact dimensions are required, shims up to 1/16" may be necessary.

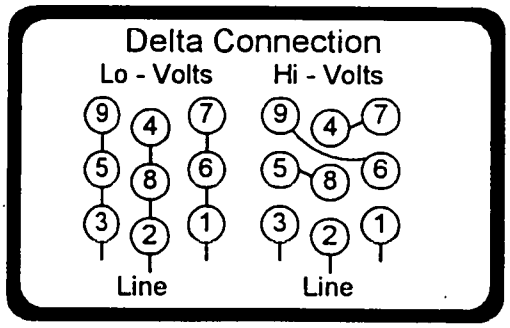
All rough casting dimensions may vary by 1/4" due to casting variations.

Conduit box can be located on either side and opening may be located in steps of 90°, regardless of location. Standard as shown with conduit opening down.

Motor Wiring Diagram

9 Lead, Dual Voltage (DELTA Conn.)





To reverse direction of rotation interchange connections L1 and L2.

Each lead may have one or more cables comprising that lead.
In such case each cable will be marked with the appropriate lead number.

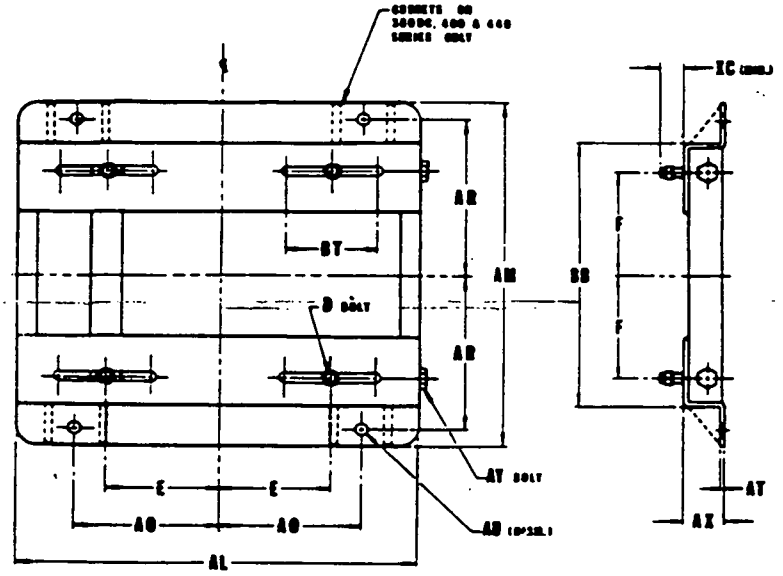
Connection Plate: A109145
Connection Decal: 344122

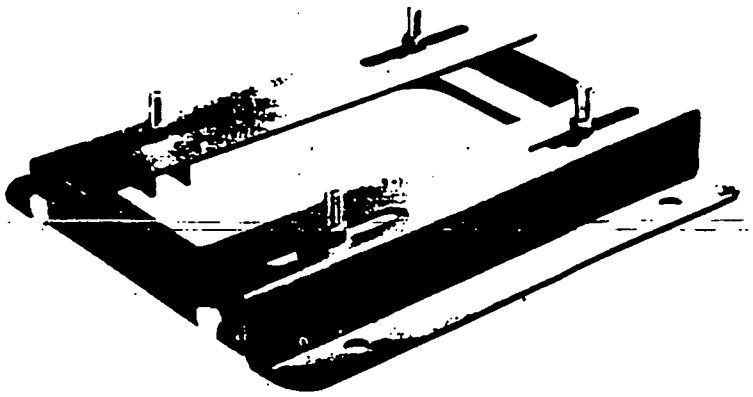
OVERLY HAUTZ MOTOR BASE COMPANY
215 SOUTH WEST STREET • LEBANON, OHIO 45036
(513) 932-0025

NEMA

STEEL ADJUSTABLE MOTOR BASES

DOUBLE ADJUSTING BOLT





STYLE B2

STOCK BASES

FRAME & PART NO.	AL	AM	AX	BB	E	F	AO	AR	AU	BT	AT	XC	D BOLT	AY BOLT	APPROX. WT. (LBS.)
254-B2	17-3/4	15-1/8	2	10-3/4	5	4-1/8	6-1/4	6-5/8	5/8	4	3/16	1-3/8	1/2 x 1-3/4	5/8 x 9	17
256-B2	17-3/4	16-7/8	2	12-1/2	5	5	6-1/4	7-1/2	5/8	4	3/16	1-3/8	1/2 x 1-3/4	5/8 x 9	18
284-B2	19-3/4	16-7/8	2	12-1/2	5-1/2	4-3/4	7	7-1/2	5/8	4-1/2	3/16	1-5/8	1/2 x 2	5/8 x 9	21
286-B2	19-3/4	18-3/8	2	14	5-1/2	5-1/2	7	8-1/4	5/8	4-1/2	3/16	1-5/8	1/2 x 2	5/8 x 9	22
* 324-B2	22-3/4	19-1/4	2-1/2	14	6-1/4	5-1/4	8	8-1/2	3/4	5-1/4	3/16	2-1/8	5/8 x 2-1/2	3/4 x 9	30
* 326-B2	22-3/4	20-3/4	2-1/2	15-1/2	6-1/4	6	8	9-1/4	3/4	5-1/4	3/16	2-1/8	5/8 x 2-1/2	3/4 x 9	31
* 364-B2	25-1/2	20-1/2	2-1/2	15-1/2	7	5-5/8	9	9-1/8	3/4	6	1/4	2	5/8 x 2-1/2	3/4 x 11	45
* 365-B2	25-1/2	21-1/2	2-1/2	16-1/2	7	6-1/8	9	9-5/8	3/4	6	1/4	2	5/8 x 2-1/2	3/4 x 11	46
404-B2	28-3/4	22-3/8	3	16-1/2	8	6-1/8	10	9-7/8	7/8	7	1/4	2-9/16	3/4 x 3	3/4 x 14	55
405-B2	28-3/4	23-7/8	3	18	8	6-7/8	10	10-5/8	7/8	7	1/4	2-9/16	3/4 x 3	3/4 x 14	56
444-B2	31-1/4	24-5/8	3	19-1/4	9	7-1/4	11	11	7/8	7-1/2	5/16	2-1/2	3/4 x 3	3/4 x 14	74
445-B2	31-1/4	26-5/8	3	21-1/4	9	8-1/4	11	12	7/8	7-1/2	5/16	2-1/2	3/4 x 3	3/4 x 14	75
447-B2	31-1/4	30-1/8	3	24-3/4	9	10	11	13-3/4	7/8	7-1/2	5/16	2-1/2	3/4 x 3	3/4 x 14	89
449-B2	31-1/4	35-1/8	3	29-3/4	9	12-1/2	11	16-1/4	7/8	7-1/2	5/16	2-1/2	3/4 x 3	3/4 x 14	95

Bases noted (*) also available with gussets for additional strength: add the letter "G" after the part number. Example: 326-B2-G

NON STOCK BASES

FRAME & PART NO	AL	AM	AX	BB	E	F	AO	AR	AU	BT	AT	XC	D BOLT	AY BOLT	APPROX. WT. (LBS.)
364DC-B2	25-1/2	20-1/2	2-1/2	15-1/2	7	5-5/8	9	9-1/8	7/8	6	1/4	2-9/16	3/4 x 3	3/4 x 11	47
365DC-B2	25-1/2	21-1/2	2-1/2	16-1/2	7	6-1/8	9	9-5/8	7/8	6	1/4	2-9/16	3/4 x 3	3/4 x 11	48
366DC-B2	25-1/2	23-1/4	2-1/2	18-1/4	7	7	9	10-1/2	7/8	6	1/4	2-9/16	3/4 x 3	3/4 x 11	49
404DC-B2	28-3/4	22-3/8	3	16-1/2	8	6-1/8	10	9-7/8	1	7	1/4	3-1/16	7/8 x 3-1/2	3/4 x 14	56
405DC-B2	28-3/4	23-7/8	3	18	8	6-7/8	10	10-5/8	1	7	1/4	3-1/16	7/8 x 3-1/2	3/4 x 14	57

AC & DC Bases Are Identical For Frames 254 Thru 326

DIMENSIONS ARE IN INCHES: Bases are furnished with one coat of corrosion-resistant gray primer and zinc plated nuts and bolts.

Bases listed may also be used if the motor frame is succeeded by S, T, TS, U, US or any letter combination as long as the motor complies with N.E.M.A.

The liability of the Overly-Hautz Company to the purchaser is limited to replacement of defective materials supplied. One year from the date of our shipment all liability shall terminate. There are no warranties which extend beyond the description on the face hereof.

DIMENSION SHEET
MB-200-B2
1-1-71

CERTIFIED FOR: _____

60 HERTZ PERFORMANCE DATA
HOSTILE DUTY PREMIUM EFFICIENT / CTE - 460 VOLT

HP	RPM		FRAME	TYPE	FLA	LRA	TYPICAL EFFICIENCY				TYPICAL POWER FACTOR			FLT	LRT	BDT	NEMA CODE
	SYNC.	FL					FL										
							NOM.	100%	75%	50%	100%	75%	50%	lb-ft	%FL	%FL	LETTER
1	1800	1755	143	CTE	1.5	13.7	86.5	84.0	84.9	81.6	72.2	64.0	50.9	3.0	410	520	M
	1200	1155	145	CTE	1.8	10.7	82.5	80.0	81.6	78.1	63.1	52.6	40.0	4.5	300	380	K
1 1/2	3600	3505	143	CTE	1.9	18.6	84.0	81.5	83.5	80.4	86.7	81.7	71.8	2.2	320	420	L
	1800	1740	145	CTE	2.1	17.6	86.5	84.0	86.2	84.0	77.3	69.5	56.5	4.5	360	440	L
	1200	1175	182	CTE	2.4	15.4	86.5	84.0	85.8	83.3	67.8	59.0	45.8	6.7	191	337	K
2	3600	3500	145	CTE	2.5	24.0	84.0	81.5	85.3	83.2	89.3	85.4	77.1	3.0	320	419	L
	1800	1735	145	CTE	2.8	25.0	86.5	86.5	86.4	84.7	77.3	70.6	57.3	6.1	363	442	L
	1200	1170	184	CTE	3.1	21.7	87.5	85.5	87.5	85.3	68.0	59.4	46.3	8.9	210	363	K
3	3600	3540	182	CTE	3.8	31.6	88.5	86.5	88.0	85.8	82.8	77.4	67.1	4.4	250	334	K
	1800	1765	182	CTE	4.0	31.0	89.5	87.5	89.7	88.2	79.1	72.6	60.4	8.9	250	380	K
	1200	1175	213	CTE	4.4	30.1	89.5	87.5	89.7	87.9	71.6	64.3	51.9	13.4	270	340	J
5	3600	3520	184	CTE	6.0	45.8	89.5	87.5	90.1	89.3	87.0	83.6	75.6	7.5	231	292	J
	1800	1755	184	CTE	6.3	46.0	90.2	88.5	90.9	90.4	82.4	78.5	68.3	15.0	230	0	J
	1200	1170	215	CTE	7.0	46.0	90.2	88.5	90.7	89.8	74.3	68.1	56.7	22.4	260	310	J
7 1/2	3600	3535	213	CTE	8.9	67.0	91.7	90.2	91.6	90.3	86.0	83.5	76.3	11.1	189	319	J
	1800	1765	213	CTE	9.2	63.4	91.7	91.7	92.1	91.5	83.2	79.9	71.1	22.3	232	304	H
	1200	1185	254	CTE	10.1	75.2	91.7	90.2	91.7	90.1	75.7	68.6	56.0	33.2	264	366	K
10	3600	3520	215	CTE	11.8	79.3	91.7	90.2	92.1	91.5	86.5	85.7	79.9	14.9	168	286	H
	1800	1760	215	CTE	11.9	77.0	91.7	90.2	92.6	92.4	85.7	82.8	75.7	29.8	220	280	G
	1200	1185	256	CTE	12.5	100.3	91.7	90.2	92.6	91.8	81.7	76.8	66.7	44.4	233	317	J
	3600	3550	254	CTE	17.7	138.0	91.7	90.2	91.5	90.1	86.5	84.9	78.4	22.2	199	304	J
	1800	1775	254	CTE	18.4	115.8	93.0	93.0	93.4	93.0	82.1	79.4	70.7	44.4	233	248	G
	1200	1180	284	CTE	19.0	123.9	92.4	91.0	92.6	91.9	80.0	75.2	64.8	66.6	220	280	H
20	3600	3550	256	CTE	23.0	189.5	92.4	91.0	92.5	91.5	88.1	86.7	81.1	29.6	220	315	J
	1800	1770	256	CTE	23.7	140.3	93.6	93.6	94.2	94.2	84.4	83.2	77.0	59.3	231	233	F
	1200	1180	286	CTE	25.1	163.8	92.4	91.0	92.8	92.3	80.7	76.3	66.0	89.0	220	280	H
25	3600	3565	284	CTE	29.8	198.0	92.4	91.0	91.8	90.4	85.0	83.0	76.2	36.8	190	252	H
	1800	1775	284	CTE	29.3	182.3	93.6	92.4	94.1	93.8	85.4	83.5	76.7	74.0	180	250	G
	1200	1185	324	CTE	29.8	196.9	93.0	91.7	93.8	93.8	84.5	82.0	74.1	111.0	187	250	G
30	3600	3560	286	CTE	34.0	217.3	92.4	92.4	92.8	92.1	89.4	89.0	86.3	44.3	195	229	G
	1800	1775	286	CTE	34.4	209.4	94.1	93.0	94.6	94.4	86.9	85.0	79.1	88.8	194	256	F
	1200	1180	326	CTE	35.0	210.5	93.6	92.4	94.3	94.4	85.7	83.8	77.1	133.3	198	250	F
40	3600	3570	324	CTE	46.0	361.0	93.6	92.4	92.9	91.4	87.0	85.1	78.7	58.8	218	348	J
	1800	1780	324	CTE	46.0	299.0	94.1	93.0	94.6	94.3	86.5	83.6	76.1	118.1	190	256	G
	1200	1190	364	CTE	46.0	289.7	94.5	93.6	95.0	94.8	86.2	85.0	80.0	176.7	154	218	G
50	3600	3545	326	CTE	56.0	364.0	93.0	91.7	93.3	92.7	89.9	90.0	87.5	74.1	195	276	G
	1800	1775	326	CTE	56.0	341.0	94.1	93.0	95.0	95.1	88.3	87.2	82.5	147.9	190	237	F
	1200	1190	365	CTE	58.0	362.1	94.5	93.6	95.1	95.0	85.4	85.2	80.4	221.0	154	218	G
60	3600	3570	364	CTE	68.0	434.0	93.6	92.4	93.5	92.5	88.3	87.4	82.4	88.3	136	300	G
	1800	1785	364	CTE	69.0	533.9	95.0	94.1	95.3	95.0	85.7	84.9	79.3	176.7	157	204	H
	1200	1190	404	CTE	70.0	453.2	94.5	93.6	94.9	94.5	85.0	82.9	76.2	265.0	165	237	G
75	3600	3565	365	CTE	84.0	667.4	94.1	93.0	94.1	93.4	88.8	88.5	83.8	110.4	147	300	H
	1800	1785	365	CTE	84.0	514.1	95.4	94.5	95.8	95.7	87.6	87.0	82.9	220.9	168	213	F
	1200	1190	405	CTE	87.0	551.1	95.0	94.1	95.4	95.1	85.0	83.5	77.2	331.1	165	228	G
100	3600	3570	405	CTE	110.0	749.0	93.6	92.4	93.8	92.5	91.1	90.6	87.5	147.1	104	278	G
	1800	1780	405	CTE	113.0	709.7	95.4	94.5	95.5	95.0	86.9	84.6	78.0	294.8	165	238	G
	1200	1185	444	CTE	124.0	701.6	95.4	94.5	95.6	95.2	79.1	76.0	66.8	442.6	130	225	F
125	3600	3575	444	CTE	148.0	948.0	94.5	93.6	94.0	92.8	83.7	80.3	72.0	183.7	130	256	G
	1800	1785	444	CTE	147.0	877.0	95.4	94.5	95.6	95.2	83.5	81.0	73.5	368.1	110	256	F
	1200	1185	445	CTE	154.0	955.9	95.8	95.0	95.9	95.6	79.3	75.4	65.7	552.9	140	243	G

ITEM 3

Liquid Separator Silencer

Ancillaries

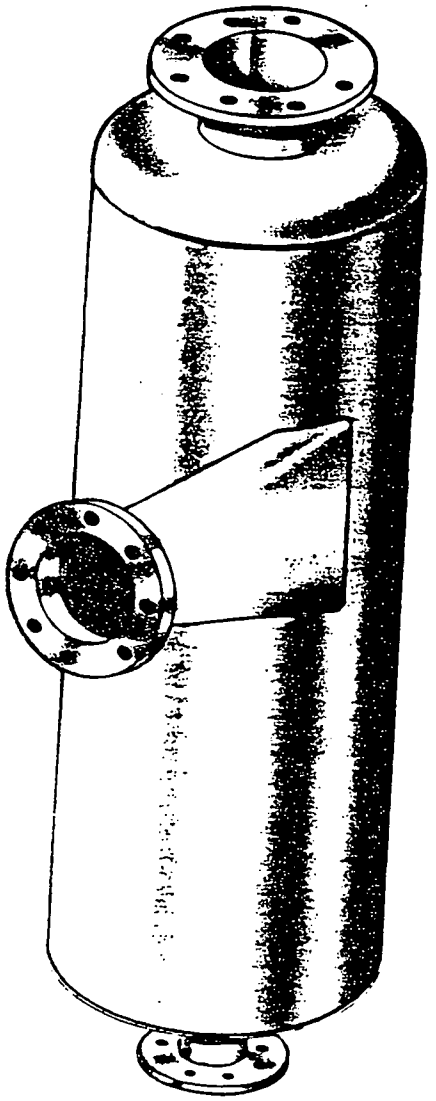
Point Level Sensors
Crane Demming Pumps
Gauges

EM PRODUCTS™
PHILLIPS & TEMRO INDUSTRIES

Liquid Separator Silencers

Model LIS - Series

The "LIS" series is a two chambered vessel designed to remove entrained liquid from air/gas stream on the inlet of a vacuum system. The tangential inlet creates cyclonic flow as air/gas and liquid enter the vessel. The cyclonic flow certrifugally extracts 99% of the entrained liquids from the air/gas stream. Gravity draws the separated liquid into the bottom chamber of the vessel while air/gas flows upward and out the vessel discharge nozzle. Vacuum pumps or a barometric leg complete with a liquid seal are commonly used for the extraction of liquid.



Standard Construction Features

- Available in sizes from 4 inch to 24 inch
- 125/150# ANSI drilled plate flanges for sizes 4 inch to 24 inch
- Full welded heavy duty steel construction
- Gray phenolic resin based fast drying primer suitable for overcoating with urethanes, acrylics, epoxies and industrial enamels. Standard two mil thickness

Optional Construction Features and Accessories

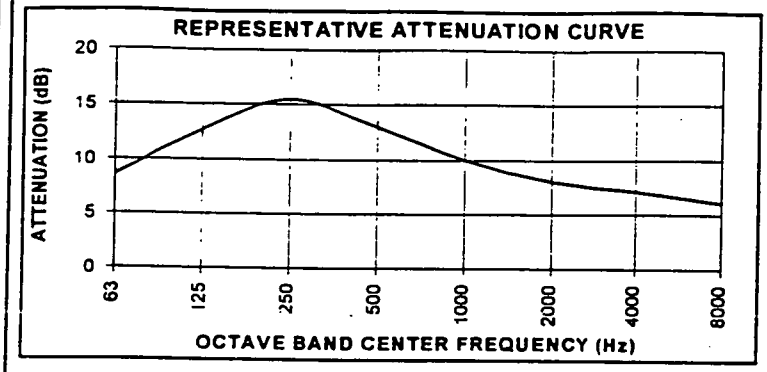
- Stainless steel construction
- Aluminized steel construction
- Special mounting brackets
- Special gauge fittings
- Special connections
- Special tank capacities
- Clean out and inspection ports
- Air leak tests
- Special acoustic designs
- ASME code construction
- Special finish per specification
- Contact factory for additional features to meet your requirements

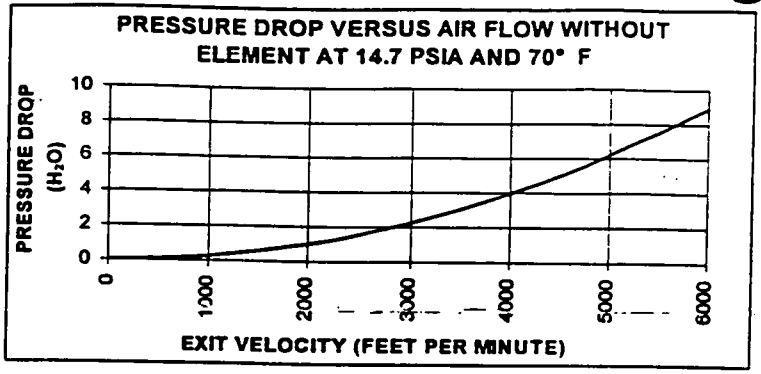
10/98
98BC-5002

EM Products • 5380 Cottonwood Lane • Prior Lake, MN 55372 • (612) 440-9200 • Fax: (612) 440-3400 • emp@emproducts.com

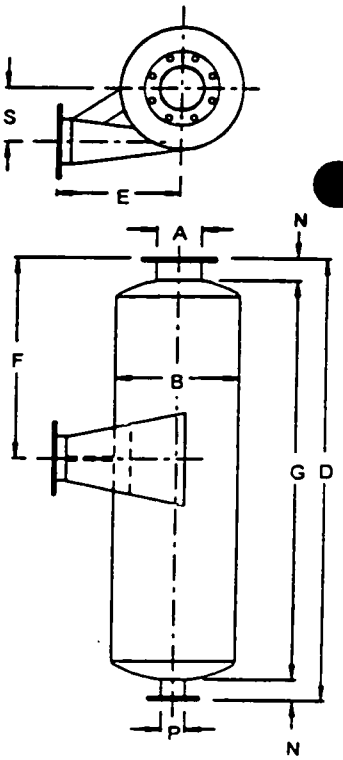
EM PRODUCTS™
PHILLIPS & TEMRO INDUSTRIES

Liquid Separator Silencers
Model LIS - Series





Model No.	A	B	D	G	E	S	F	N	P*	Weight	GPM
LIS-4	4	12	52	46	13	5	19	3	2	155	35
LIS-5	5	16	58	52	14	7	23	3	2 1/2	210	55
LIS-6	6	18	66	60	18	8	30	3	3	270	80
LIS-8	8	22	78	71	21	10	36	3 1/2	3 1/2	445	150
LIS-10	10	24	85	78	26	10	37	3 1/2	4	585	200
LIS-12	12	30	97	90	31	13	45	3 1/2	5	790	300
LIS-14	14	36	105	98	36	15	47	3 1/2	6	1225	400
LIS-16	16	42	114	107	41	18	50	3 1/2	6	1880	500
LIS-18	18	42	135	128	45	18	68	3 1/2	8	2250	600
LIS-20	20	48	138	129	50	20	66	4 1/2	8	3125	800
LIS-22	22	54	149	140	55	23	70	4 1/2	10	3930	1000
LIS-24	24	60	158	149	60	26	74	4 1/2	10	4755	1200



* Standard 'P' connection = 2 inch to 4 inch male NPT; 5 inch and larger standard 125/150# ANSI drilled plate flange

- 4 inch to 24 inch standard 125/150# ANSI drilled plate flange connection; 4 inch and 5 inch male NPT connections available upon request

Dimensions in inches, weights in pounds. Dimensions and weights are nominal and may vary slightly with production models. Request certified drawings for exact dimensions.

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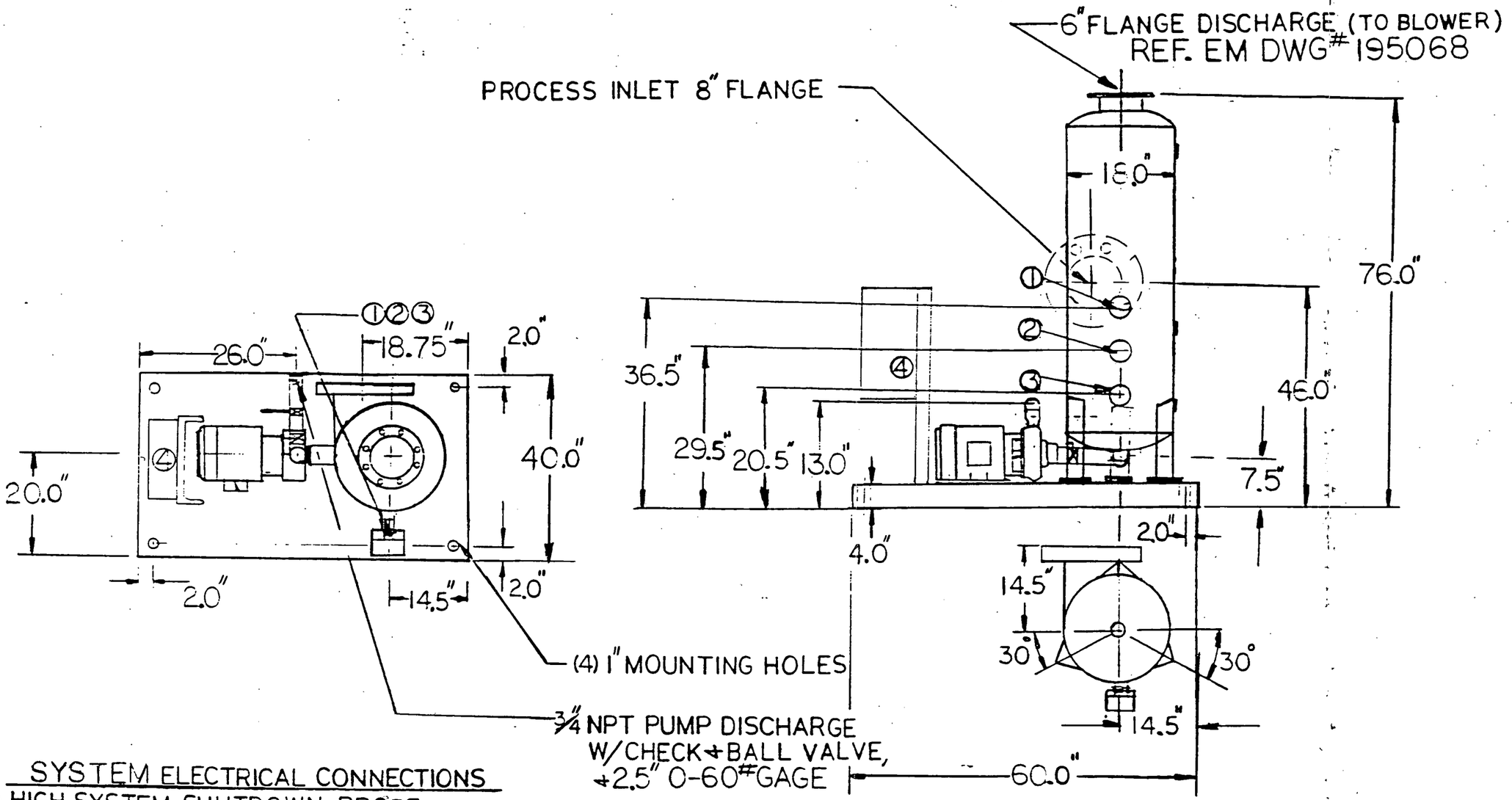


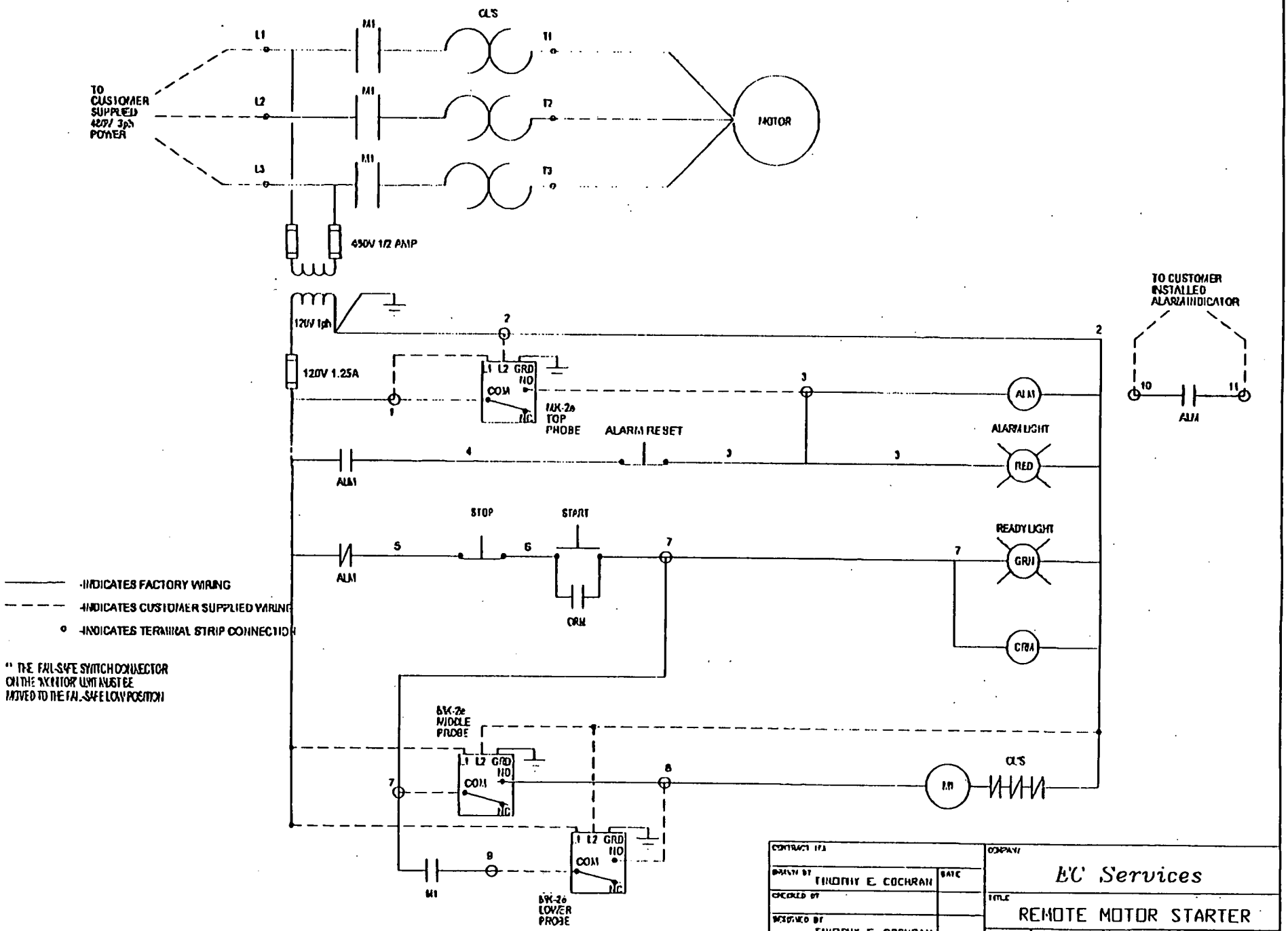
SYSTEM ELECTRICAL CONNECTIONS

① HIGH SYSTEM SHUTDOWN PROBE
② PUMP START PROBE
③ PUMP OFF PROBE
④ PUMP MAIN POWER CONTROL PANEL

APPROX. WEIGHT: 650#

T-15-1000-SEP SEPARATOR

SCALE: NONE	APPROVED BY: TOMLIN EQUIP	DRAWN BY SSR
DATE: 10-7-95		REVISED 6-21-99
SCIENTECH NES, INC.		
PO# 27238		DRAWING NUMBER TOMNES 2

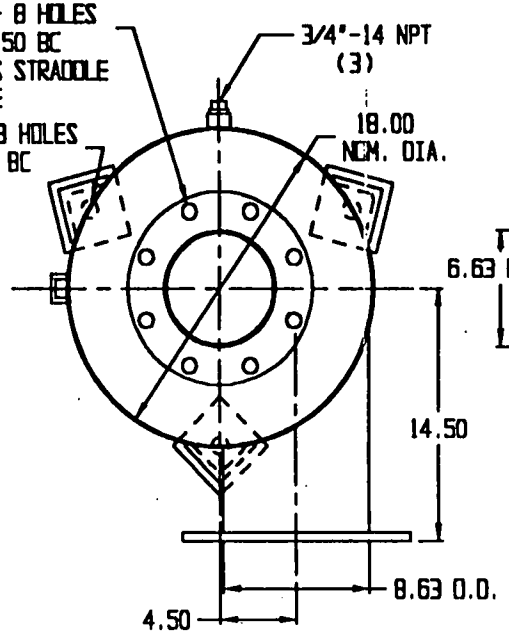


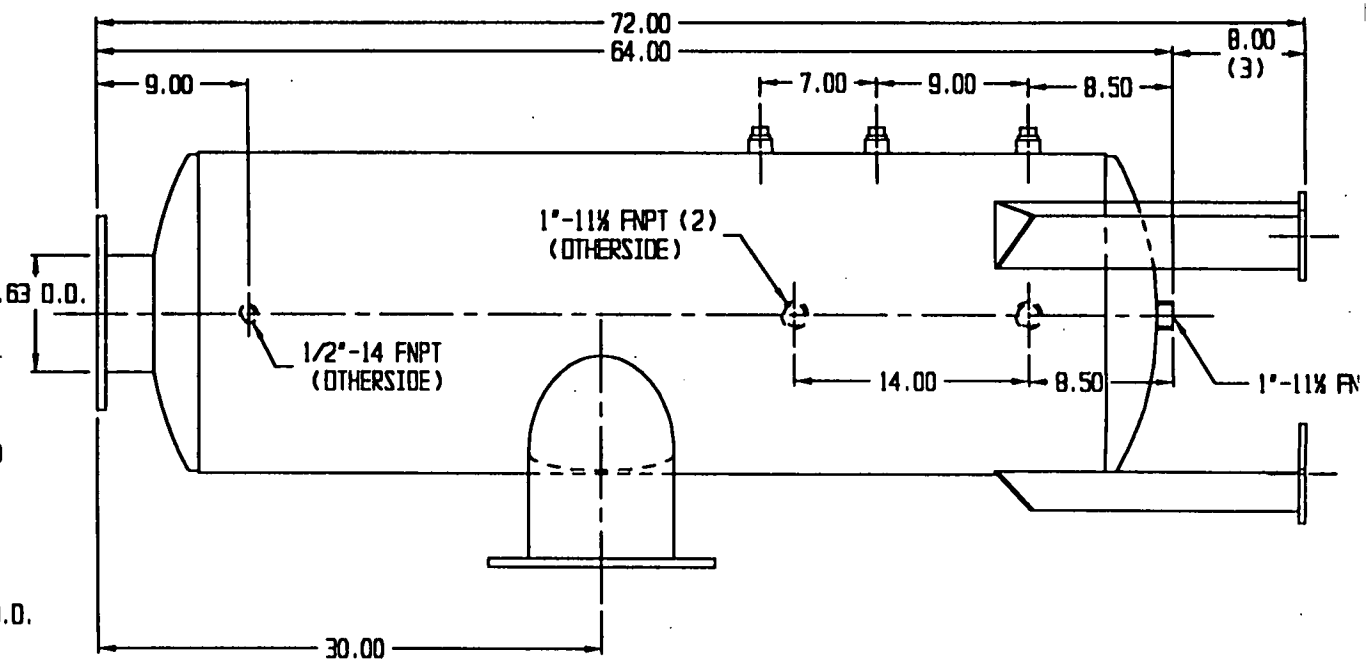
CONTRACT NO.	COMPANY: EC Services
DRAWN BY: TIMOTHY E. COCHRAN	DATE
CHECKED BY	TITLE: REMOTE MOTOR STARTER
MODIFIED BY: TIMOTHY E. COCHRAN	SIZE: A; FORM NO.; DWG NO. / FILE NAME: 599/1
COMPLETED BY	SCALE: NTS; DATE: 5-20-99; SHEET: 1 of 1
CUSTOMER: TOHLIN EQUIPMENT CO	

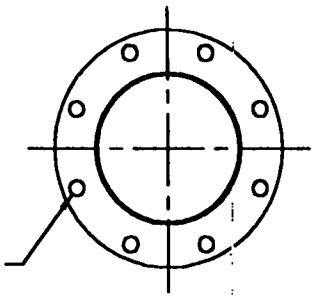
REVISION HISTORY				
No.	DATE	BY	ZONE	COMMENTS
*	*	*	*	*

195068 *

6"-150# ANSI
DRILLED FLANGE:
.88 DIA. - 8 HOLES
EQZD ON 9.50 BC
BOLT HOLES STRADDLE
CENTERLINE
1.00 DIA. - 3 HOLES
ON 18.00 BC







8"-150# ANSI
DRILLED FLANGE:
.88 DIA. - 8 HOLES
EQZD ON 11.75 BC
BOLT HOLES STRADDLE
CENTERLINE

GAS FLOW

NOTE:
LEAK TEST AT 7 PSIG

EM PRODUCTS	PHILLIPS & TEMRO Industries — A Thyssen Krupp Automotive Company		
THIRD ANGLE PROJECTION	DRAWN BY TNV	DATE 5/20/98	DESCRIPTION: LIS08-X : 8" FLG SIDE AND 6" FLG END CONN. WITH "3" LI
DIMENSIONS ARE IN: X [ ] , [ ] , [ ]	APPR. BY	DATE	
UNLESS SPECIFIED DIMENSION TOLERANCES ARE: ANGLES ±1°	DRAWING ORIGIN PRIOR LAKE		REF: * MATERIAL: CARBON STEEL SHEET 1
INCHES .00 ± .13 .000 ± *	MILLIMETERS 00. ± * 0.0 ± *		SCALE: 1:8 CUT. B FAB. * DRAWING No. 195068

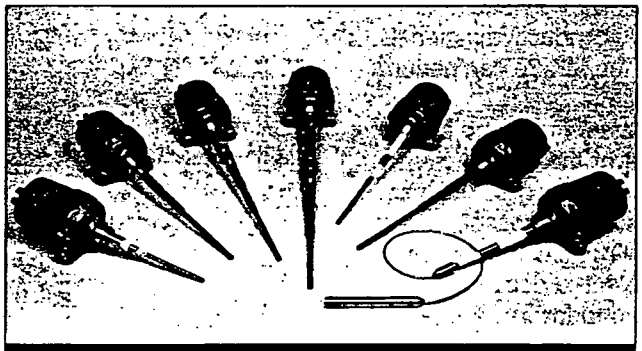
CUSTOMER TOMLIN EQUIPMENT | WORK ORDER 35141 | FINISH GRAY | WEIGHT 120#

BULLETIN

464

INSTALLATION & OPERATION

MK-2e RF Capacitance Point Level Sensor



Model MK-2e

- Designed for OEMs and End Users
- Extremely Versatile and Economical
- Dry Bulk, Liquid and Slurry Applications
- Immune to Material Build-up
- Several Probe Variations and Options
- Complete Hazardous Location Protection Available

The MK-2e RF Capacitance Sensor is a highly versatile point level measurement device specifically designed for OEMs as well as end users. Its sensing capability permits reliable indication in a wide range of dry bulk and liquid materials. The driven shield feature of the MK-2e provides a means to ignore product build-up on the probe that would otherwise cause false signaling. The MK-2e is available in over 100 different configurations each suited to optimize sensing performance in various applications.

Stub Probe: Usually used in tight spaces, or in applications with heavy material, the stub probe is a shorter version of the standard probe.

Kynar® Coated Probe: Some probe variations can be provided with a Kynar coating for highly conductive or corrosive materials.

Pipe Extension/Lagged Housing Version: The pipe extension probe extends the sensing point and build-up immunity up to 12 feet. The lagged housing version "Lags" the housing up to 24 inches away from the mounting point for high temperature applications and/or vessels with external insulation.

Food Grade Probe: Most probes variations are available with nylon insulators for food grade applications, enhancing the use of the MK-2e in food stuff materials.

Standard Probe: The most commonly used probe variation, the standard probe performs reliably in many different applications.

Cable Extension Probe: The cable extension probe can extend the sensing point up to 50 feet beneath the mounting point. It should be noted that the build-up immunity, however, is not extended with the cable version.

PRINCIPLE OF OPERATION

The operation of the MK-2e is based on RF capacitance technology. A radio frequency is applied to the probe and is continually analyzed to determine the influence caused by the surrounding environment. Since all materials have dielectric constants and conductance values different from air, the resultant impedance as seen by the radio frequency shift changes when material contacts the probe. Capacitance variances create a change in impedance. The active probe of the MK-2e and the vessel's wall make up the two plates of a capacitor. The probe's insulator and surrounding air provide the dielectric material. As the air (having a dielectric constant of 1.0) is displaced with any other material (dielectric constant > 1.0), the capacitance effect is enhanced, thereby changing the application's impedance. This influence is measured within the circuitry and compared to a reference established by the sensitivity setting. The sensitivity setting determines how much influence must be present before the sensor's output changes.

The driven shield section of the MK-2e probe enables the circuitry to ignore product build up on the probe that would otherwise cause false sensing. The driven shield is activated with the same radio frequency potential that is sent to the sensing probe. Since electrical current can not flow between identical potentials, the driven shield blocks current which would normally flow from the active probe to the vessel wall through the material build-up. This forces measurement of the material surrounding the active probe, rather than the material build-up.

MONITOR MANUFACTURING, INC.

"SETTING THE STANDARD FOR SUPPLIER EXCELLENCE"

Pipe Extension Probe Mounting: (see Figure 7)

1.) Select a mounting location in accordance with the Pre-Installation Recommendations.

2.) If using a welded fitting, cut a 1-1/2" hole into the top of the vessel corresponding to the 1-1/4" mounting connection used. If using a Monitor mounting plate, cut a 2-1/2" center hole and six 11/32" mounting holes (for 5/16" bolts) on a 7" bolt circle. Use mounting plate as a template.

3.) Weld fitting or attach mounting plate to vessel wall.

4.) Insert probe through fitting, grease threads with anti-seize, then, thread unit tightly into place by gripping and rotating housing. Teflon tape may be used to achieve pressure sealing capability if desired. Continuity between sensor mounting point and vessel wall must be maintained to assure proper probe operation. If continuity is impaired, connect a wire between the housing's external ground screw and the vessel wall.

5.) Mechanical reinforcement of the pipe extension should be considered whenever the overall probe length (from mounting point to probe tip) exceeds 60". Mechanical clamping, such as "U" or "C" channel with "U" bolts should be used. DO NOT USE HEAT to connect brace to pipe extensions as wiring inside pipe could be damaged.

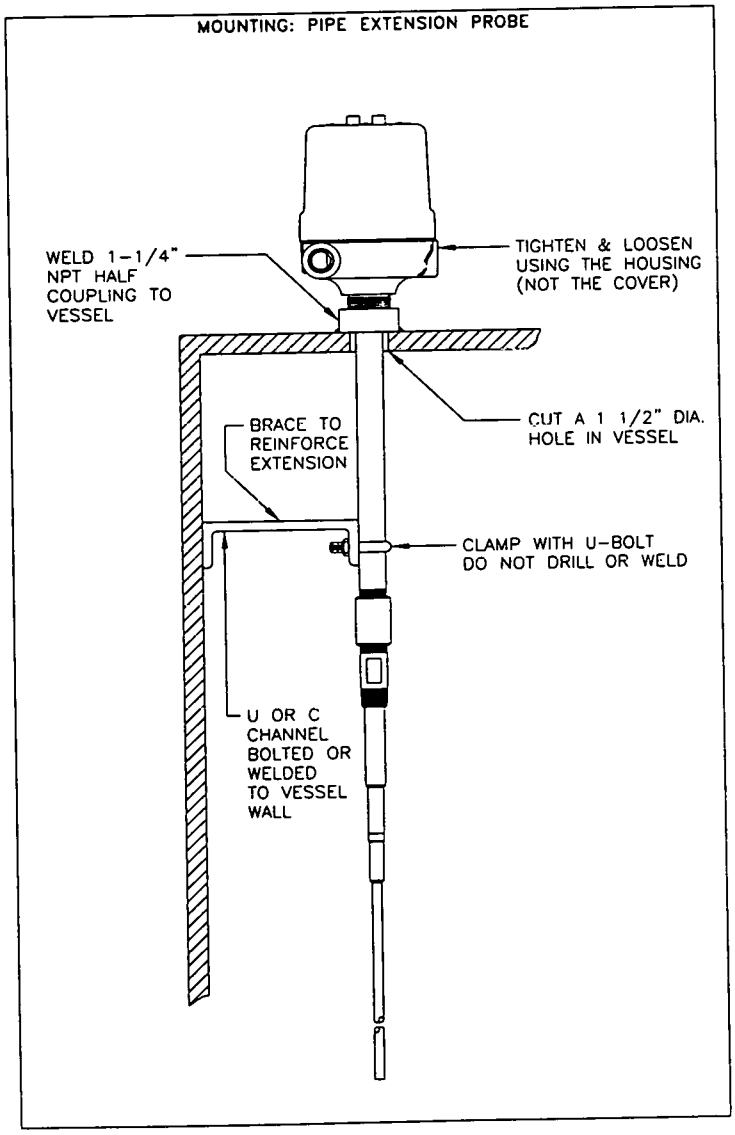


Figure 7

ELECTRICAL INSTALLATION

The electronics module of the MK-2e is positioned inside the housing such that all wiring can easily be pulled into the unit through the two 3/4" NPT conduit connections on the housing.

Power Input: (see Figure 8)

The MK-2e sensors are designed to accept either 115VAC or 230VAC line voltage (factory set). Verify the intended voltage supply is compatible with the voltage configuration of the electronics (Note indicated voltage on PCB next to terminal block). Improper wiring will prevent proper operation of the unit and may result in electrical damage to the circuit. An earth ground screw is provided at the conduit connection area for protective ground.

Output Relay Contacts:

The MK-2e is equipped with two full sets of isolated contacts (DPDT). These can be connected to any type of control device, provided ratings are observed (see specifications). When available use an independent voltage source to operate the load. Insure all electrical codes are followed and proper wiring gauge size is used to support the load current.

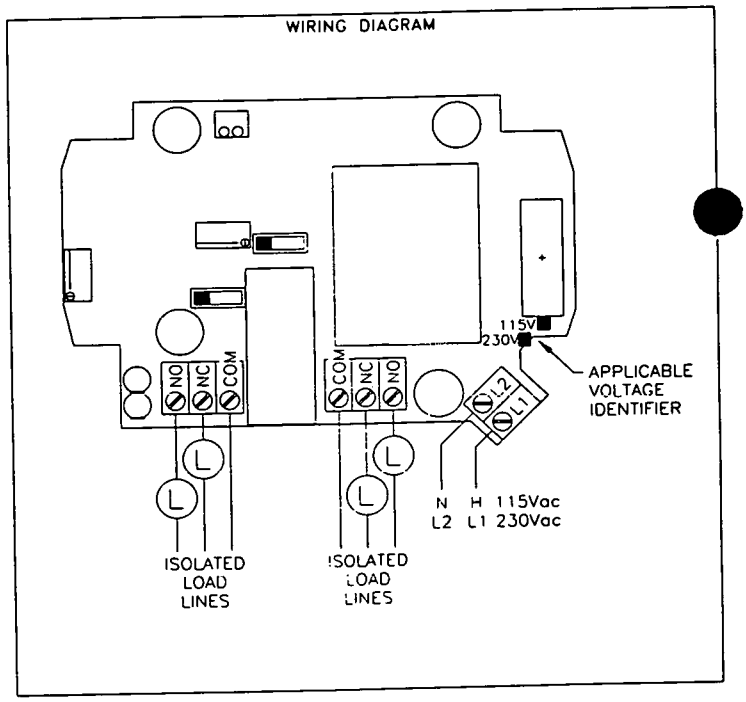


Figure 8

CALIBRATION

Sensitivity: (see Figure 9)
Sensitivity is set in the field via a "Sense Select" switch and a "Sense Adjust" 25-turn potentiometer. The switch selects the range of capacitance expected to be seen at the probe.

High: When selected, this position permits calibration when the capacitance detected on the probe is 0-75pf. This factory setting will satisfy most applications.

Low: When selected, this position permits calibration when the capacitance detected on the probe is 70-150pf. This setting may be required for conductive applications or long cable extension configurations where initial capacitance is great. Setting can be selected in the field.

The "Sense Adjust" tunes the sensitivity of the MK-2e to the material being sensed. Rotating the adjustment in a clockwise direction will increase the sensitivity making the material easier to "see". There are two different procedures which can be used in the calibration process. Both utilize the simple "2-Step Calibration" procedure. One procedure sets the sensitivity with the probe being exposed to the material, while the second procedure exposes the probe to free air only. Since the capacitance being measured is directly related to the material being sensed, the best results will be achieved by setting the calibration while the probe is exposed to the application material.

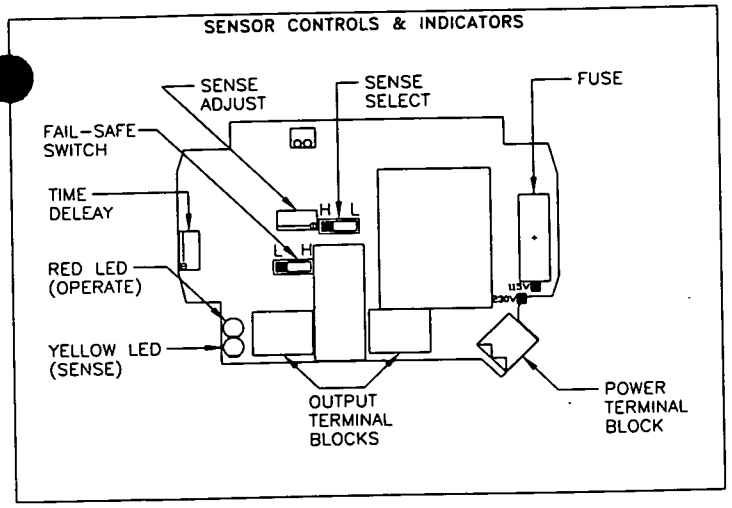


Figure 9

2-Step Calibration- probe exposed to material

1.) While the probe is not covered with material, rotate "Sense Adjust" clockwise just until the "Sense" (yellow) LED turns on.

2.) Permit the application material to cover the probe. While counting the number of revolutions, rotate "Sense Adjust" counter-clockwise until the "Sense" (yellow) LED turns off. Reposition "Sense Adjust" at the half way point between the LED on and LED off settings. (e.g. After inserting the probe into the material, if it takes 2 counter-clockwise turns of "Sense Adjust" for the "Sense" (yellow) LED to turn off, then "Sense Adjust" should be repositioned 1 clockwise turn.)

2-Step Calibration- probe exposed to free air only

1.) Rotate "Sense Adjust" clockwise just until the "Sense" (yellow) LED turns on.

2.) Reposition "Sense Adjust" a number of turns counter-clockwise with respect to the three described sensitivities below (see Figure 10). It is desirable to reposition "Sense Adjust" in accordance to "2-Step Calibration - probe exposed to material" procedure once material can cover the probe. Materials with high dielectric constants or conductivity, require the sensitivity adjustment further counter-clockwise than those applications with low dielectric constants.

SENSITIVITY SETTING OF THE MK-2e			
SENSITIVITY DESCRIPTION	NO. OF ADJ TURNS	MATERIAL DIELECTRICS	TYPICAL APPLICATIONS
HIGH	0-1	1.5-3.0	PLASTICS, SOAP, OILS, RUBBER, CEMENT
MED	1-3	3.0-9.0	GRAINS, FERTILIZERS, FEED, SALT
LOW	> 3	> 9.0	WASTEWATER, SLURRIES, ANY WATER BASED SOLUTIONS

Figure 10

Delay:
A 25-turn potentiometer is provided for setting the time delay between the time material is sensed (yellow LED on) and the time the relay contact output changes (red LED on). A clockwise rotation will increase the delay from .25 to 15 seconds. This adjustment minimizes false signals associated with temporary material shifts. The delay between the time material is "not sensed" (yellow LED off) and the time the relay contact output changes (red LED off) is fixed at .25 seconds.

Fail-safe: (see Figure 11)
The term fail-safe refers to the output signal condition which occurs with a loss of power to the probe. A switch permits selection of either low or high fail-safe.

High Fail-Safe: The relay will de-energize when material is sensed at high level or with power loss.

Low Fail-Safe: The relay will de-energize when material is below low level or with power loss.

Note the designations on the electronics label refer to the relay contact status when no material is sensed and low fail-safe is selected (Relay is de-energized). The designations are reversed when no material is sensed and high fail-safe is selected (Relay is energized).

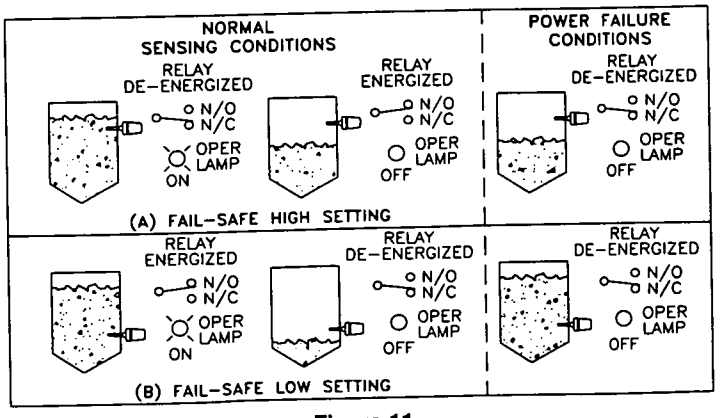


Figure 11

PCB Indicators:

1.) Yellow LED - Its status describes the "sensing" condition of the MK-2e. Illumination indicates that the amount of capacitance established by "Sense Adjust" has been detected. Its status is not affected by the time delay setting.

2.) Red LED - Its status describes the "operate/output" condition of the MK-2e. Illumination indicates the relay output is in the "operate/material sensed" condition. Its state is influenced by the time delay setting but not by the fail-safe setting.

External Indicators: (see Figure 12)

Some models include an externally viewable bi-color LED to display the MK-2e status without the need to remove the cover. The following interpretations can be made from its status.

Power Status:

No power/circuit failure - Green OFF, Red OFF

Power/circuit operational - Either Green or Red ON

Output Status:

"Operate" condition - Green OFF, Red ON

"Not in Operate" condition - Green ON, Red OFF

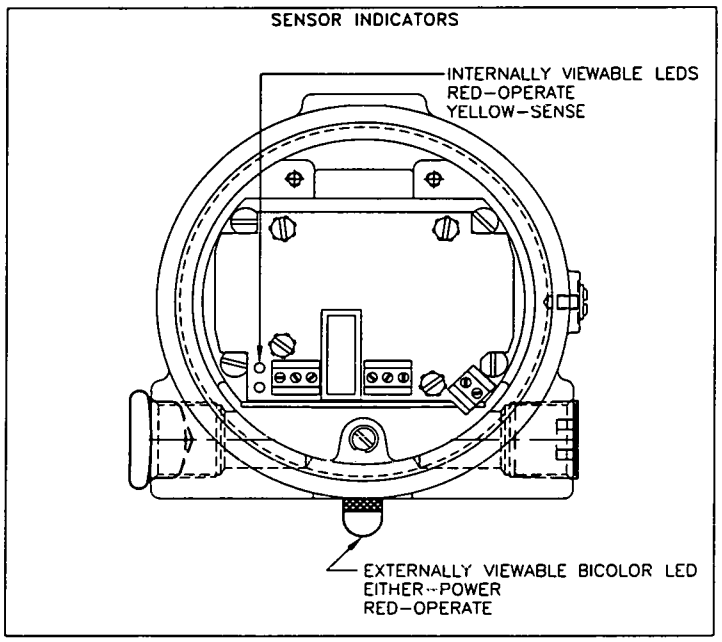


Figure 12

TROUBLESHOOTING

PROBLEM: Sensor will not sense material.

CAUSE/SOLUTION:

1.) Verify power is applied to sensor.

2.) Verify "Sense Adjust". Reposition adjustment clockwise therefore making the probe more sensitive to "difficult to sense" materials.

3.) Verify "Sense Select" setting. If full clockwise rotation of "Sense Adjust" never permits sensing, reposition "Sense Select" to "HIGH" setting and recalibrate "Sense Adjust" setting.

4.) Verify probe coverage when sensing is expected. The sensor is not designed to be "tip sensitive". Permit significant probe coverage before expecting material sensing.

5.) Verify continuity between probe mount and vessel wall. If no continuity, connect a ground wire between the housing and vessel wall.

6.) Verify connection of the electronic module to the probe.

PROBLEM: Sensor remains in "SENSE" mode even when material is absent.

CAUSE/SOLUTION:

1.) Verify the active probe is not in direct contact with any internal vessel structure. If so reposition sensor.

2.) Verify "Sense Adjust" setting. Reposition adjustment counter-clockwise therefore making the probe less sensitive to "easy to sense" materials.

3.) Verify "Sense Select" setting. If full counter-clockwise rotation of "Sense Adjust" keeps sensor in "SENSE" mode, reposition "Sense Select" to "LOW" setting and recalibrate "Sense Adjust" setting.

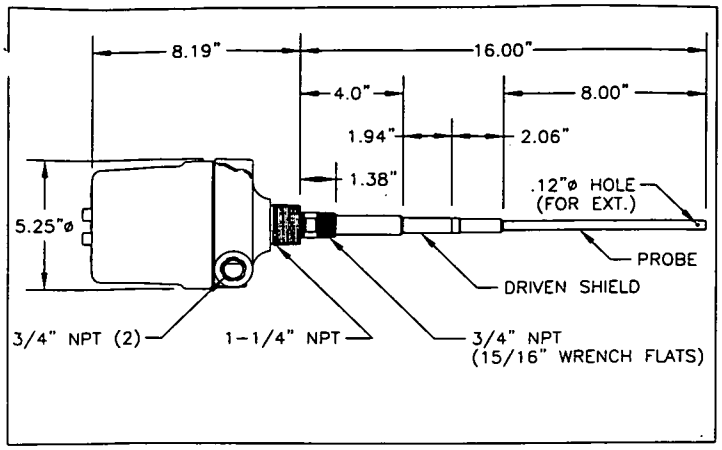
PROBLEM: Output contacts perform opposite of designations (N/O, N/C).

CAUSE/SOLUTION:

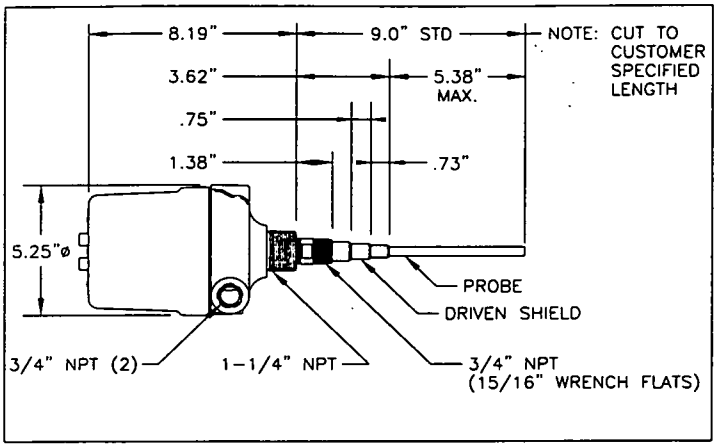
1.) Designations on PCB relate to relay status when in "Fail-safe Low" mode and when no material is sensed. If "Fail-safe High" mode is used, the designations are reversed. Swap wire terminations of N/O and N/C if necessary. Changing the fail-safe selection is not recommended unless fail-safe feature is not a concern to the application.

MAINTENANCE

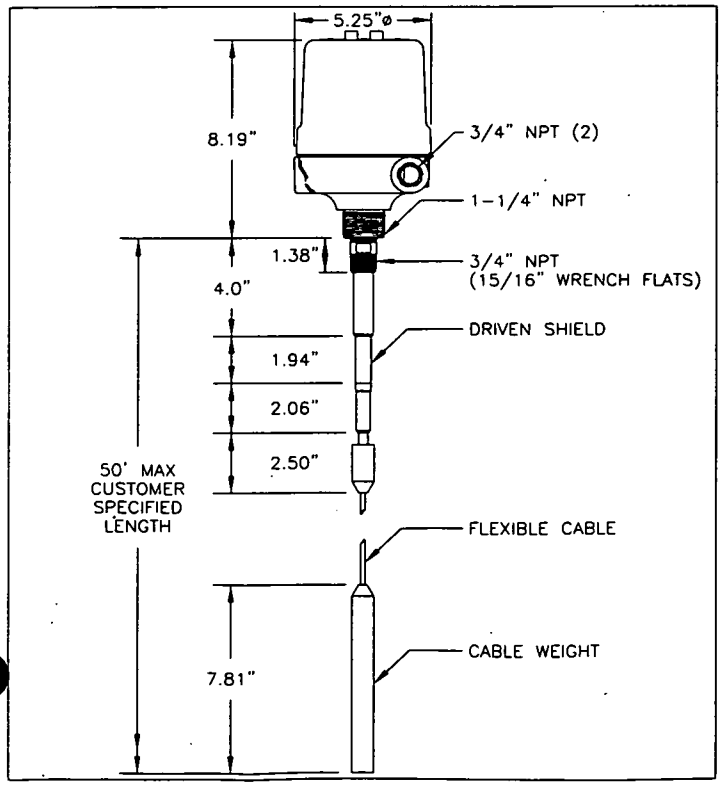
The MK-2e is a maintenance free product and should be serviced by Monitor Manufacturing only. If operation appears inappropriate, refer to troubleshooting section of this bulletin. If proper operation is not achievable, consult the factory.



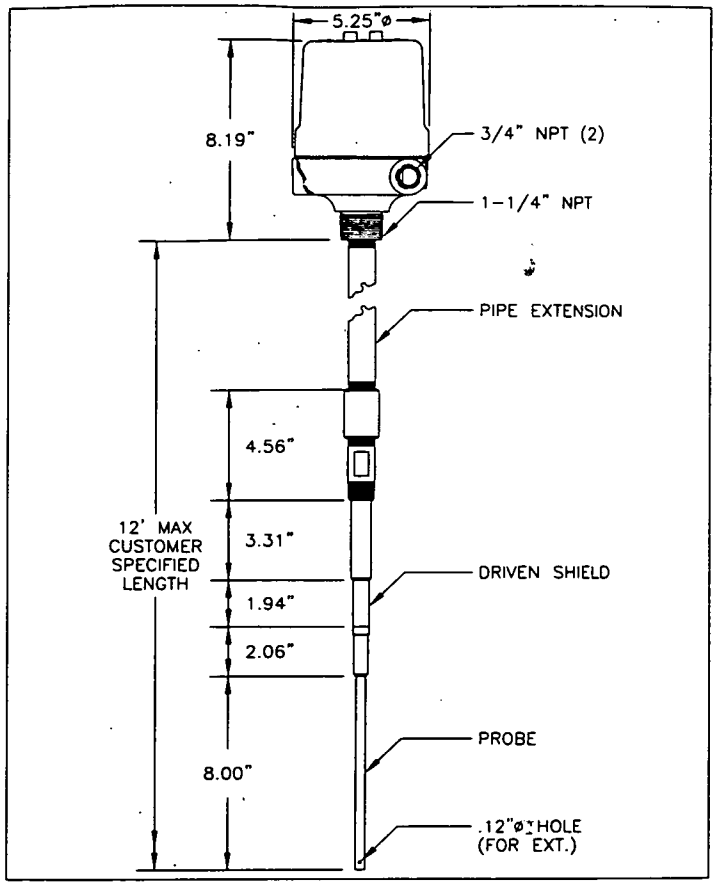
STANDARD, FOOD GRADE, KYNAR COATED PROBE



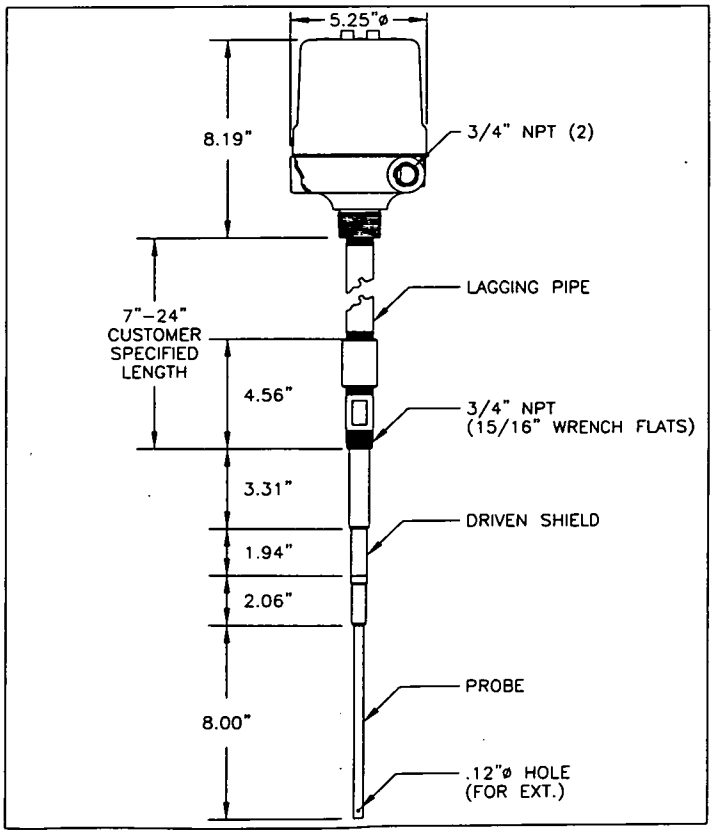
STUB PROBE



CABLE EXTENSION PROBE



PIPE EXTENSION PROBE



LAGGED HOUSING VERSION

464

MODEL MK-2e

SAFETY

Electrical Shock Caution:
The MK-2e is powered with HIGH VOLTAGE. Extreme care shall be taken if the unit's cover is removed and live electrical terminations are exposed. To avoid electrical shock, do not contact any exposed electrical connections. Each unit is provided with a "protective ground" connection which shall be terminated to earth ground potential This terminal shall be used to eliminate shock hazard in the unlikely event of internal insulation breakdown.

Hazardous Location Caution:
Some MK-2e models are "approved" for use in certain Hazardous Locations (see specifications). These models shall only be used in applications covered by these ratings or those considered non-hazardous. Failure to comply could result in catastrophic damage to personnel and property. The following must be maintained to assure safe operation.

1.) **Mechanical integrity:** The dimensions of the housing, cover or probe shall not be altered.
2.) **Electrical integrity:** Substitution of electrical components may impair intrinsic safety and therefore is prohibited.
3.) **Maintenance:** Removal of the sensor cover to conduct maintenance while power is yet supplied does not meet hazardous location requirements. If done, it is at the risk of the customer only.

WARRANTY

Monitor Manufacturing warrants each MK-2e to be free from defects in material and workmanship under normal use and service within two (2) years from the date of purchase within North America, and within one (1) year from date of purchase outside of North America. The purchaser must give notice of an defect to Monitor within the warranty period, return the product intact and prepay transportation charges. The obligation of Monitor Manufacturing under this warranty is limited to repair or replacement at its factory. This warranty shall not apply to any product which is repaired or altered outside of the Monitor Manufacturing factory, or which has been subject to misuse, negligence, accident, incorrect wiring by others or improper installation.

Monitor reserves the right to change the design and/or specifications without prior notice.

SPECIFICATIONS

Power:	115V or 230 Vac (+ 15%) factory set
Temperature:	-40 to 160 F operating
Output Relay:	DPDT, 5A @ 240Vac or 24Vdc, 1/8HP @ 120/240Vac
Indicators:	"Sense" yellow LED illuminates when material is sensed "Operate" red LED illuminates to indicate output switching after selected time delay period
External lights:	Bi-color LED indicating power and operate mode
Sensitivity:	Coarse- switch selectable 0.5pf to 75pf, 70pf to 150pf Fine- multi-turn adjustment within coarse range
Stability:	+/- .015pf per degree F @ 0.5pf setting
Time delay:	.25 -15 sec delay to activate (hold-off), multi-turn adjustment
Fail-safe:	Switch selectable - HI/LO
Immunity:	Protected via driven shield to 150 ohm load
Enclosure:	Cast aluminum, screw-on cover, polyester coated orange
Conduit:	(2) 3/4" NPT
Approvals:	FM: Class I, Groups C,D; Class II, Groups E,F,G; Ordinary loc.
(Most Models)	$CSA_{NRTL/C}$: Class I, Groups C,D; Class II, Group G; Ordinary loc. NEMA 4/Type 4 enclosure. Consult factory for exact ratings on specific configurations

Standard/Food Grade Probe

Mounting:	1-1/4" NPT alum, or combo 3/4" NPT 316ss and 1-1/4" NPT alum
Insulator material:	Ryton® (standard); Nylon (food grade)
Probe material:	3/8" diameter, 316ss, with 316ss guard
Probe length:	16" from alum mounting
Temp. (probe only):	+450 F max (Ryton®); +300 F max (Nylon)
Pressure:	50 psi max (1 1/4 NPT alum), 150 psi max (3/4 NPTss)

Stub Probe

Mounting:	1-1/4" NPT, or combo 3/4" NPT 316ss and 1-1/4" NPT alum
Insulator material:	Ryton® and Nylon versions
Probe material:	3/8" diameter, 316ss, with 316ss guard
Probe length:	Cut to customer specification; application dependent
Temp. (probe only):	Ryton® - +450 F max, Nylon- +300 F max
Pressure:	50 psi max (1-1/4" NPT alum), 150 psi max (3/4" NPT ss)

Cable Extension Probe

Mounting:	1-1/4" NPT alum, or combo 3/4" NPT 316ss and 1-1/4" NPT alum
Insulator material:	Nylon
Probe material:	1/8" diameter 316ss Teflon® jkt'd cable, with 316ss guard
Cable length;	Customer specified up to 50' overall insertion from alum mtg
Temp. (probe only):	+300 F max
Pressure:	50 psi max (1-1/4" NPT alum), 150 psi max (3/4" NPT ss)

Pipe Extension Probe

Mounting:	1-1/4" NPT alum
Lag material:	galvanized or 316ss
Pipe ext length:	Customer specified up to 144" overall insertion
Interface to:	Std., Food Grade or Kynar® Coated only (see applicable specs)

Kynar® Coated Option

Mounting:	combo 3/4" NPT 316ss and 1-1/4" NPT alum
Insulator material:	Kynar® over Ryton® insulators and 316ss probe
Probe material:	3/8" diameter, 316ss, with 316ss guard
Probe length:	16" from alum mounting
Temp. (probe only):	+200 F max
Pressure:	50 psi max (1 1/4 NPT alum), 150 psi max (3/4 NPT ss)

Lagged Housing Version

Mounting:	3/4" NPT 316ss
Lag material:	galvanized or 316ss
Lag length:	Customer specified from 7" to 24"
Interface to:	Standard Probe only (see applicable specs)

Ryton® - Trademark of Phillips Chemical Co. Kynar® - Trademark of Elf Atochem.
Teflon® - Trademark of Dupont Chemical Co.

464A.2.0397.2.5M

MONITOR MANUFACTURING, INC.

44W320 Keslinger Rd. ▼ P.O. Box 8048 ▼ Elburn, IL 60119-8048 ▼ 800-766-6486 ▼ 630-365-9403 ▼ Fax: 630-365-5646
E-mail: monitor@monitormfg.com ▼ http://www.monitormfg.com

McDANIEL

Liquid Filled, Stainless Steel Case Utility Gauges

"For the price-conscious buyer . . .

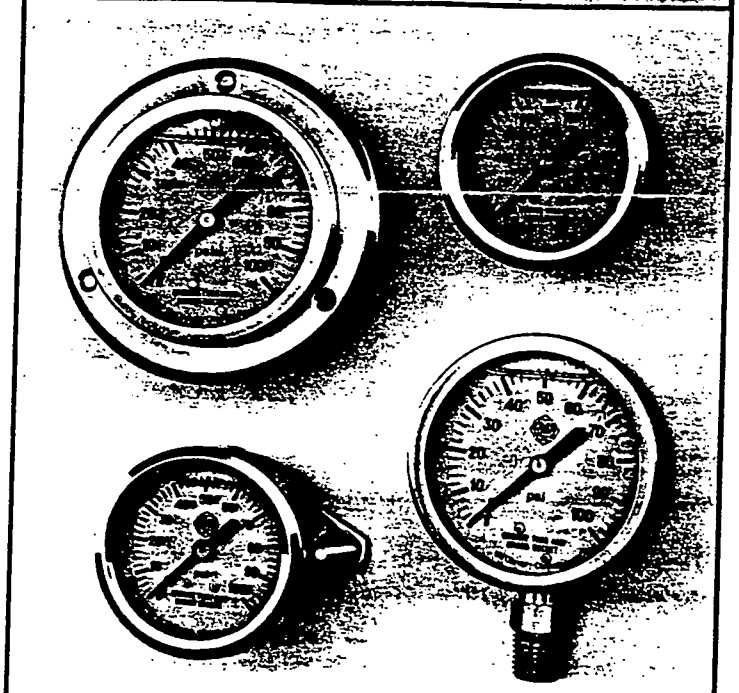
McDaniel utility gauges are designed for the price-conscious buyer and user who have an emphasis on maintaining quality and accuracy in a general purpose gauge.

Our utility line offers trusted McDaniel quality in an economical package. Special consideration given to rigorous McDaniel standards for durability, accuracy, and quality of construction.

Our Series 6: Glycerin filled, stainless steel case utility gauges with brass internals. Designed for applications with a corrosive atmosphere and where pulsation and/or vibration are present.

Standard features include a restrictor screw (removable) in the inlet port for pulsation dampening.

. . . and quality user."



SPECIFICATIONS

Accuracy:
ASME B40.1 standard Grade B (3 – 2 – 3%)

Dial:
White enameled aluminum. Black figures.

Case:
304 Stainless steel

2½" J6
0-60psig
Pump Discharge
Gage

Pointer:
Black enameled aluminum.

Lens:
Polycarbonate.

Precision Movement
Brass.

Bourdon Tube:
Copper alloy (C Form 600 PSI & Below).
Phosphorous bronze (Spiral 800 PSI & Above).

Temperature Utilization:
-4 + 176 degrees Farenheit.
-20 + 80 degrees Celsius.

Pressure Utilization:
Static: 75% maximum scale.
Dynamic: 66% maximum scale.

Stem and Socket:
Brass. Restrictor screw standard.
J6 = 1/4" NPT (1/8" special order avaliable)
T6 = 1/4" or 1/8" NPT avaliable

Dial Sizes / Ranges Available
2" - (T6) / Vac. Comp. Rec 3-15, up to 15,000 psi
2 1/2" - (J6) / Vac. Comp. Rec 3-15, up to 15,000 psi

Configurations Available:
Bottom connected standard
(L) = Center-back connected
(U) = U-Clamp mounted. Center-back connected
(P) = Front Flange. Center-back connected

McDaniel Controls, Inc.

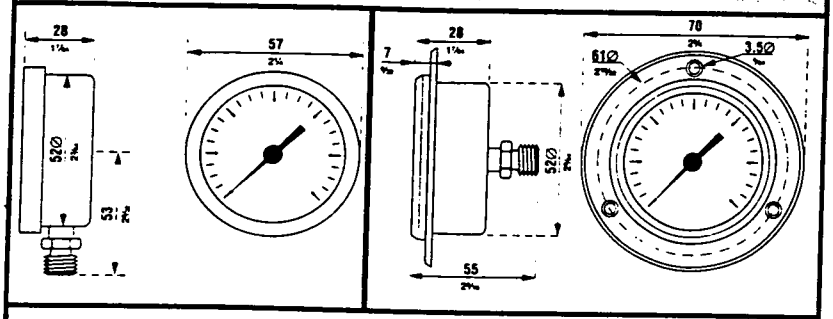
P. O. Box 187, Luling, LA 70070 • Highway 90 West, Paradis, LA 70080 U.S.A.
(504) 758-2782 • New Orleans (504) 467-1333 • Fax (504) 758-1688

DIMENSIONAL DATA

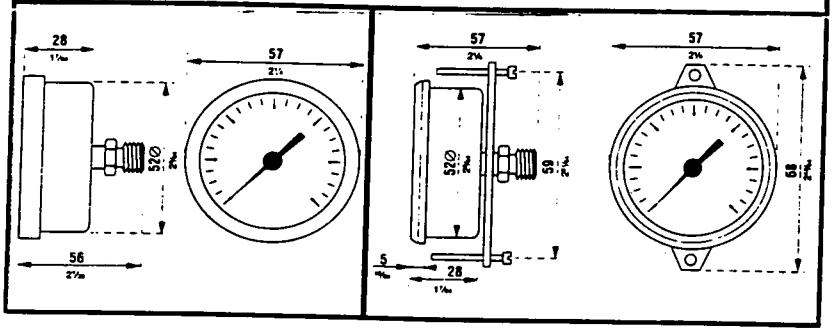
In millimeters (mm) and inches (in.)

T 6

BOTTOM CONNECT — PANEL MOUNT

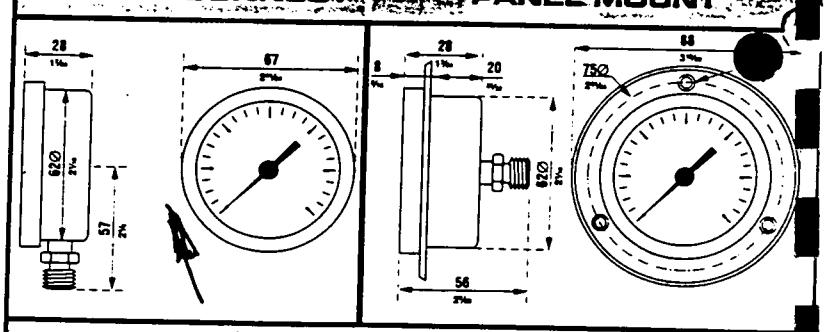


CENTER BACK — U — CLAMP

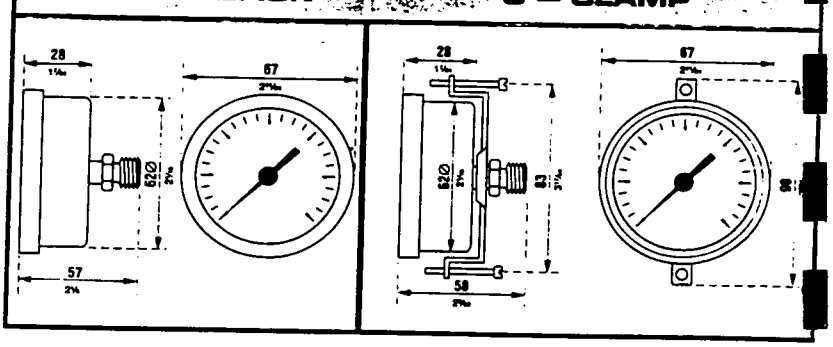


J 6

BOTTOM CONNECT — PANEL MOUNT



CENTER BACK — U — CLAMP



McDaniel also makes gauges in other materials; in sizes and ranges to fit a wide variety of applications, and in many special configurations.

Ask your representative about McDaniel gauges with stainless steel or Monel® internals, all brass or all stainless steel gauges, test gauges, or other requirements.

® Monel is a registered trademark of INCO family of companies

Range code	Range psi	Minor Increments
A	0 - 15	.5
B	0 - 30	1
C	0 - 60	1
D	0 - 100	2
E	0 - 160	5
F	0 - 200	5
G	0 - 300	10
H	0 - 400	10
I	0 - 600	20
J	0 - 800	20
1K*	0 - 1000	20
L	0 - 1500	50
M	0 - 2000	50
N	0 - 3000	100
4k	0 - 4000	100
O	0 - 5000	100
6k	0 - 6000	200
P	0 - 10000	200
Q	0 - 15000	500
VACUUM	**VACUUM**	**VACUUM**
S	VAC 30"Hg - 0	1
RECEIVER	**RECEIVER**	**RECEIVER**
T	REC 3 - 15**	2
COMPOUND	**COMPOUND**	**COMPOUND**
U	30"Hg + 15	1-0-2
V	30"Hg + 30	1-0-2
W	30"Hg + 60	2-0-5
X	30"Hg + 100	2-0-5
Y	30"Hg + 160	2-0-10
2k	30"Hg + 200	5-0-15
Z	30"Hg + 300	10-0-30

HOW TO ORDER

1 - Select the model number **(T6, J6)**
2 - Specify range code from list at left.
3 - Specify mounting code:
(Bottom connection is standard, no code)
"L" = (Center-back connection)
"U" = (U-Clamp, Center-back connection)
"P" = (Panel mount w/front flange, Center-back connection)
4 - Specify any other special configurations or options. (special NPT size, dual-scales, etc.)

Model #

(Example: **T6E:** **"T6"** = 2" (50mm) Dial - **"E"** = (0 - 160 psi range)
J61kP: **"J6"** = 2 1/2" (63mm) Dial - **"1k"** = (1000 psi range) - **"P"** = (Panel mount)

* Use 1K on **T6** and **J6** for 0 - 1000 psi range.
** Receiver gauge is dual scale. (0 - 100% primary, 0 - 10 square root secondary)

Limited Warranty

McDaniel warrants our utility gauges to be free of defects in material and workmanship: Replacement of any defective gauge will be made at no cost to the purchaser. Gauge failures determined to be caused by over-range and incompatibility with environment/product media or abuse will not be considered under this warranty.

DISTRIBUTED BY:

It is recommended that users of pressure gauges become familiar with American National Standard ASME B40.1, entitled Gauges, Pressure and Vacuum – Indicating Dial Type – Elastic Element. This specification is available from:

American Society of Mechanical Engineers,
United Engineering Center
345 East 47th Street
New York, New York 10077

ITEM 4

Rotary Vane Air Compressor

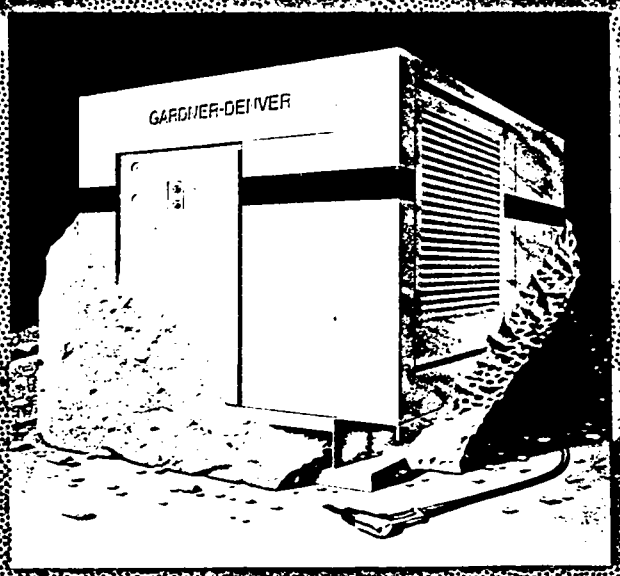
Ancillaries

Operation and Service Manual
Auto Sentry Controls Manual
Parts List

GARDNER DENVER

ROTARY SCREW AIR COMPRESSORS

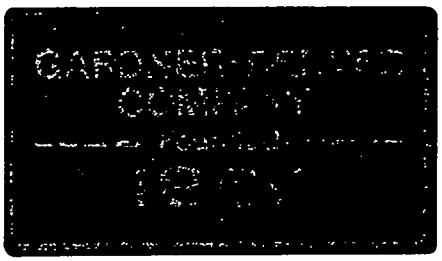
40 TO 500 HP - 60 Hz
30 TO 375 KW - 50 Hz



Durability Measured In Decades

When you choose from the full line of rotary screw air compressors by Gardner-Denver, you have three important factors in your favor.

First, you can choose from a broad selection of models to find the one that best fits your application. You will find a Gardner-Denver compressor to do your job most effectively and at the lowest cost over the long haul.



Second, you benefit today and for decades to come from the proud tradition of Gardner-Denver durability. For over 100 years, factories, mines and oil fields have chosen our compressors and pumps for their dependability. Today we continue to build products for maximum efficiency and durability so our customers receive the best value delivered.

Third, you get the dedicated support of an international team of Gardner-Denver professionals to help you keep your compressor running at peak efficiency, backed by readily-available genuine parts, a substantial warranty, and Gardner-Denver's world wide reputation for standing behind everything we make and sell.

Why Best Value Always Costs Less

When you select a new compressor, you need to remember that its initial cost is **only part** of determining the true value. Think of its **total cost (the total cost to buy, to own and to operate the compressor) over a specific period of time, whether it's 5 years or 20 years.**

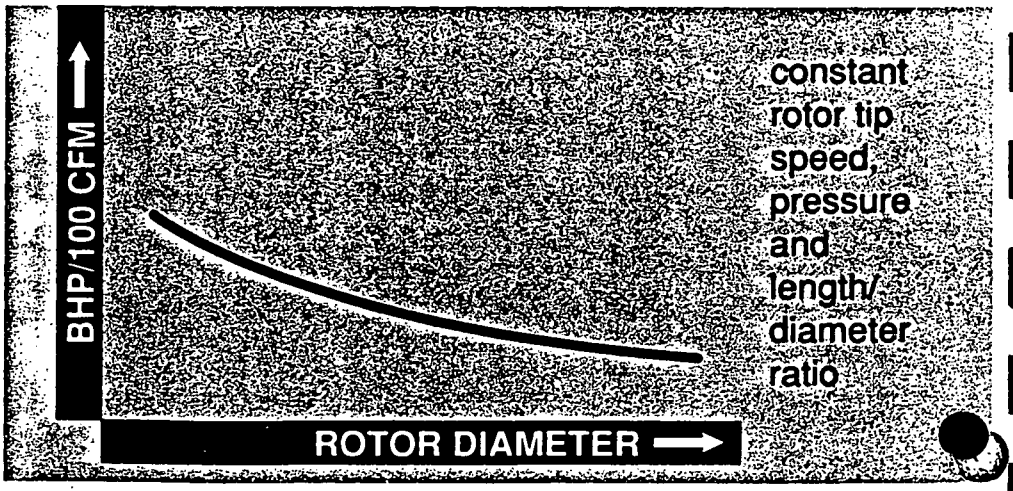
A compressor with a lower purchase price *may* be more expensive in the long run. For instance, one large screw-type air compressor can cost you as much as $404,000 a year in energy costs alone. Yet, replacing that unit with a same-size Gardner-Denver Electra-Saver® Rotary Screw Air Compressor could **immediately** cut operating costs to $340,000—**a $64,000 savings.** (This assumes a 500 HP (375 KW) compressor operating 24 hours a day with power costs at $.08 per KWH.)

Rotary screw compressors from Gardner-Denver cost less to own and operate over the years because of the quality and technology we build in. Our patented, simplified design uses fewer wearing parts.

We use special molecular iron, machined to 0.005 mm precision; special tapered roller bearings with a calculated L-10 life in excess of 90,000 hours (15-20 years); corrosion-resistant, rigid control lines; the industry's most advanced microprocessor-based control system to operate your compressor for maximum efficiency; and patented Turn-Valve or Intensive Injection Lubrication Systems to **cut operating costs by as much as 16%.**

Another important advantage of a Gardner-Denver compressor is the large, direct-drive air end. With **rotors up to 41% larger** in diameter than other compressor brands, its operating speeds are among the lowest in the industry. Low speeds translate to less wear and contribute to long compressor life, as well as low operating cost.

So when you take a good look at your **total** compressor cost—**initial price, operating or energy costs, plus service costs** (including regular maintenance items and replacement parts)—you will conclude that best value always costs less.



Brake HP requirements per 100 CFM decline as rotor diameter increases. Efficiency also increases because air output per revolution rises faster than air leakage.

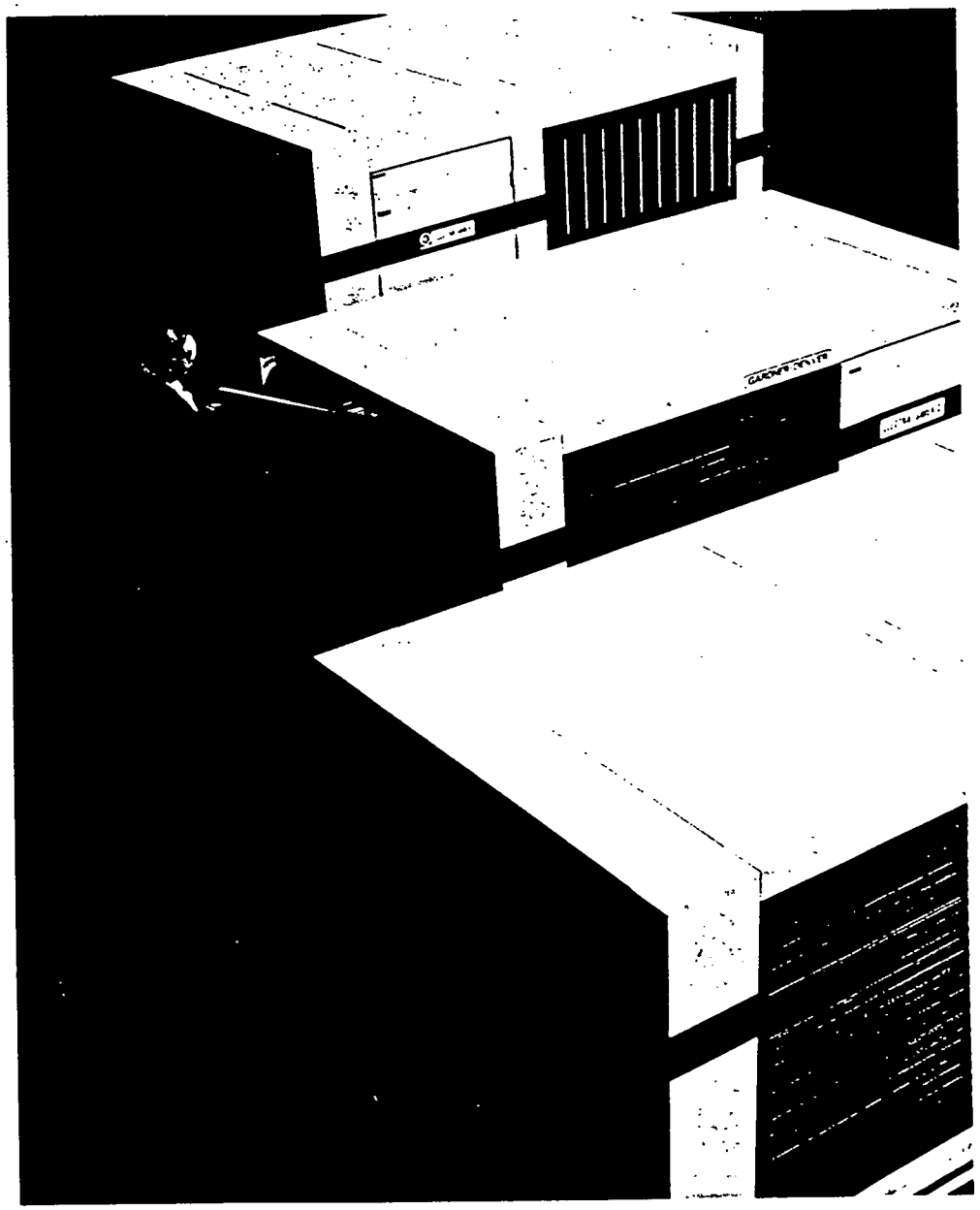
Three Strong Performers That Meet Any Production Air Job

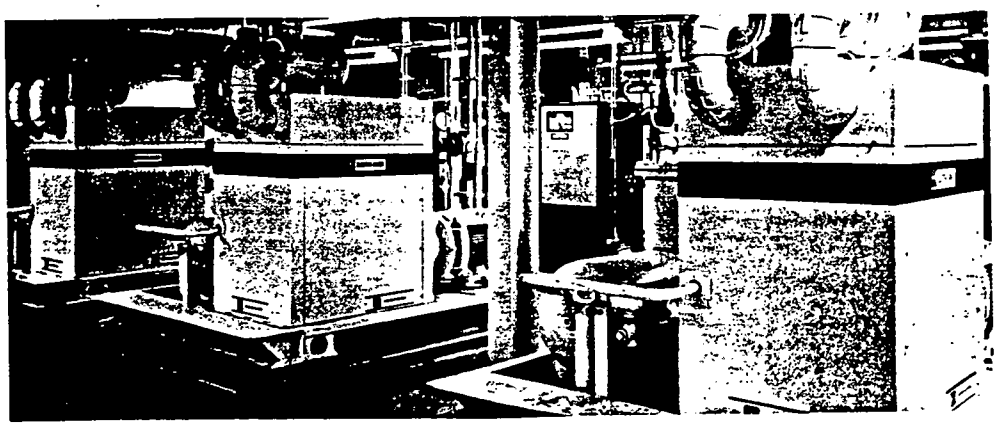
Electra-Screw® Rotary Screw Compressors have the lowest initial cost. They're ideal for applications requiring 40 to 200 HP (30 to 149 KW) and up to 950 CFM (27 m³min.). Electra-Screw Compressors are designed around the Gardner-Denver patented Intensive Injection® Lubrication System, which improves compressor efficiency **6 to 8%** over conventional lubricant injection, providing the highest CFM per brake horsepower in the industry.

Electra-Saver II® Rotary Screw Compressors are the best medium-size compressors you can find because of their larger, slower turning ends, long life bearing systems and low operating cost. Like the Electra-Screw line, they are designed around the patented Intensive Injection Lubrication System. The Electra-Saver II is ideal for applications requiring 40 to 150 HP (30 to 112 KW) and up to 760 CFM (52 m³/min.).

Electra-Saver® Turn Valve Screw Compressors are the top of the Gardner-Denver line and are the most overall-efficient compressors available today. Their unique Turn Valve® technology matches energy input to system demand, reducing the energy requirements under lessened load conditions—subsequently **reducing energy costs as much as 16%.** Electra-Saver compressors are for applications requiring 100 to 500 HP (75 to 375 KW) and up to 2580 CFM m³/min.).

At Gardner-Denver we simply add the best value to our compressors. A closer look at our compressor features and their benefits will prove that to you.





Three Gardner-Denver Electra Saver compressors cut operating costs as much as 16% for this large industrial manufacturer.

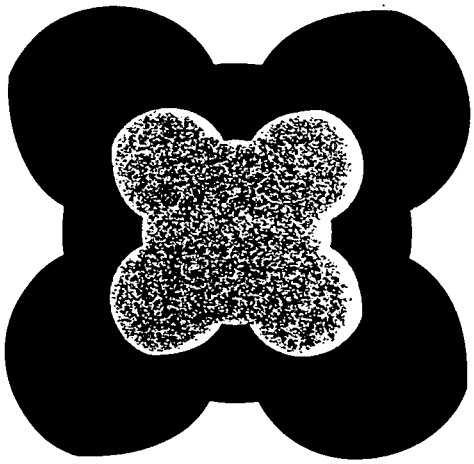
Meet Your Match In Premium Features

Gardner-Denver offers **more** features per horsepower, **more** features per price, **more** options to match your job—and **more** efficiency to save power costs. The cost savings of owning and operating a Gardner-Denver compressor begin to build the first minute you turn it on—and keep building throughout its long, productive life.

Exclusive Gardner-Denver features. All Gardner-Denver rotary screw compressors contain a unique combination of outstanding features:

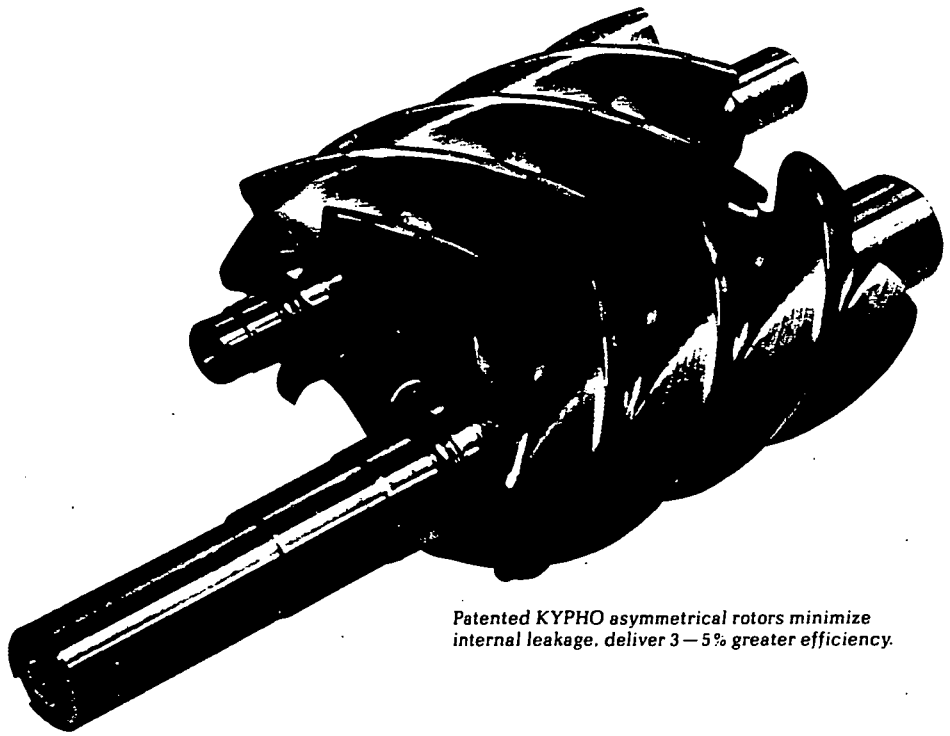
- **Exclusive KYPHO Rotor Profile** returns greater efficiency over its operating range and delivers a **3% to 5% operating efficiency advantage** over standard rotor designs. Its asymmetrical rotor shape inherently provides a tighter seal between the grooves of the rotors to reduce slippage, eliminate vibration and increase efficiency.
- **Rotors Up To 41% Larger** in diameter than other compressor brands deliver operating speeds among the lowest in the industry. Low speeds extend air end life, reduce compression heat and contribute to overall lower operating cost.

Comparison of Rotor Sizes; Gardner-Denver in dark blue.



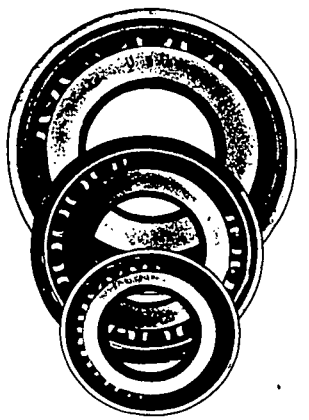
Up to 41% larger than competitive rotors. Gardner-Denver rotors add measurably to longer life.

- **Direct-driven, Unitized Air Ends** with lower operating speeds for longer life and lower operating costs.



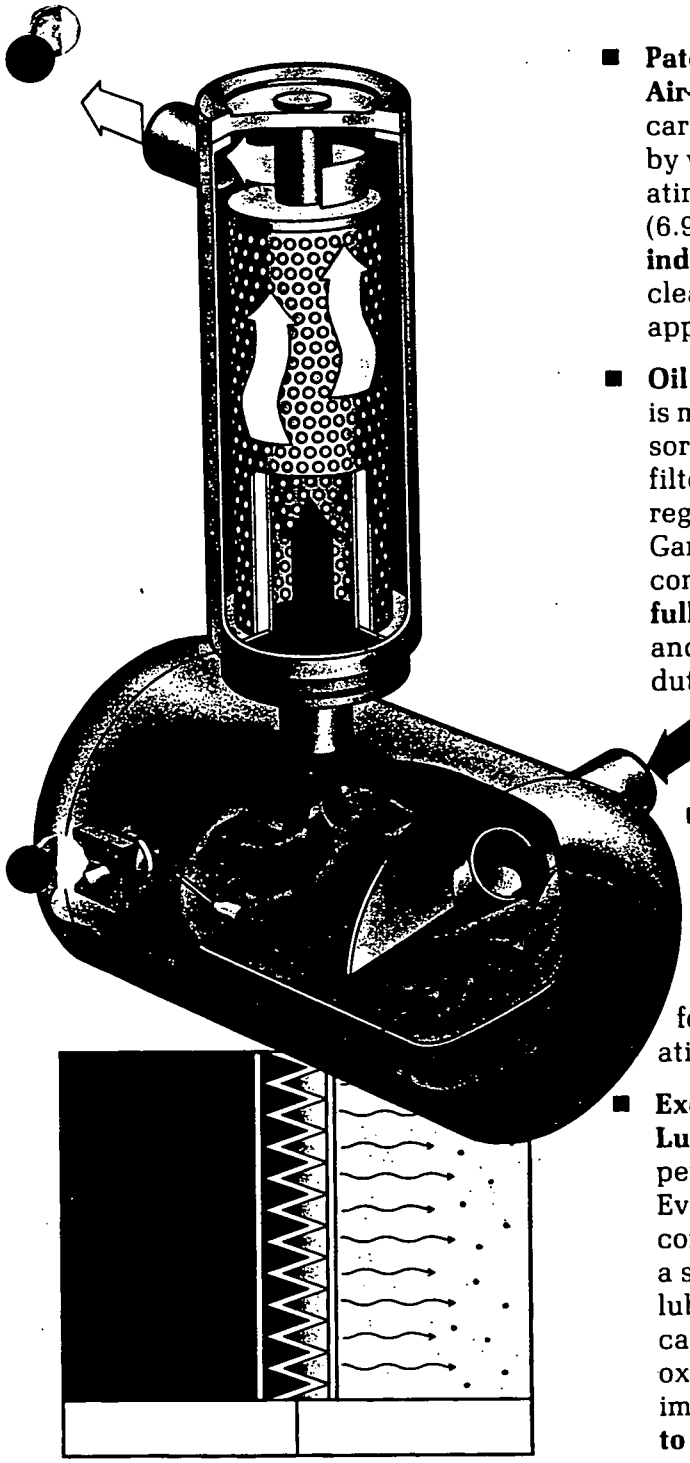
Patented KYPHO asymmetrical rotors minimize internal leakage, deliver 3—5% greater efficiency.

- **Only Corrosion Resistant Control Lines** are used throughout. You will never find plastic tubing on a Gardner-Denver Air Compressor.
- **Vibration Isolators** reduce operating noise and vibration.
- **Long-Life Bearings** mean longer service. All Gardner-Denver compressors are designed with large, cylindrical roller bearings at the inlet and time-proven tapered roller bearings at the discharge. These bearings have a calculated L-10 life expectancy in excess of 90,000 hours—or 15 to 20 years of normal operation.



Bearings as much as 170% larger than others use offer over 90,000 hour L-10 life expectancy.

- **Heavy-Duty Canister Air Filter** standard on most models. This standard Gardner-Denver feature is only an option with other compressor manufacturers. The high-efficiency replaceable element removes airborne particulate of **5 microns and larger** from compressor inlet air to **extend the interval between lubricant changes by up to 20%.**

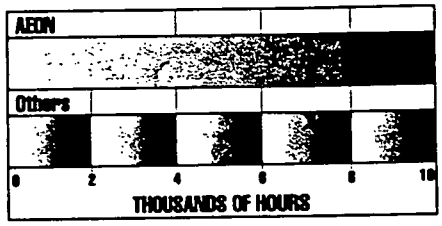


Dirt particles smaller than the diameter of a hair are stopped by the exclusive Gardner-Denver air filter.

- **Patented ELIMINATOR™ Air-Oil Separator** limits oil carryover to less than 2 PPM by weight at full load operating pressure of 100 PSIG (6.9 Bar)—**the lowest in the industry.** The result is the cleanest air possible for all applications.
- **Oil Cooler And Filter.** Nothing is more important to compressor life than proper lubricant filtering and temperature regulation. That's why Gardner-Denver compressors come equipped with **spin-on, full-flow, 10-micron oil filters** and factory-mounted, heavy-duty oil coolers.

Exclusive Eliminator air oil separator limits oil carryover to 2 ppm to deliver the industry's cleanest air.

- **Thermostatic Oil Mixing Valve For Temperature Control** warms the oil for better circulation throughout the unit and ensures optimum oil temperature for the most efficient operation under all conditions.
- **Exclusive AEON™ Long-Life Lubricant** outlasts standard petroleum-based lubricant. Every Gardner-Denver rotary compressor is shipped with a standard charge of AEON lubricant—a long-life lubricant with a patented anti-oxidant package, which improves service levels **up to four times longer** over petroleum-based lubricants. That means you get up to a full year of operation on a single fill.
- **Heavy-Duty Aftercoolers** reduce the load on air-drying equipment. The factory-mounted, air-cooled aftercooler and moisture separator effectively reduces the discharge air temperature **to within 15°F of ambient**—5°F cooler than other compressors.



Exclusive with Gardner-Denver. AEON lubricant extends change period up to a year, at least three times over ordinary lubricant.

- **Maintenance Reducing Design Features,** like simplified access to air/oil separator and filters, as well as spin-on filters, **cut maintenance time by up to 90%.**
- **A Broad Selection Of Job-Related Options** match Gardner Denver compressors to your application. Although options vary with individual models, you can tailor your compressor to exactly meet your needs. Options include **Sound Attenuating Enclosures** and selection of **Motor Types** (WYE-Delta, TEFC or ODP).

AutoSentry® Control Technology Simple, Efficient, Reliable

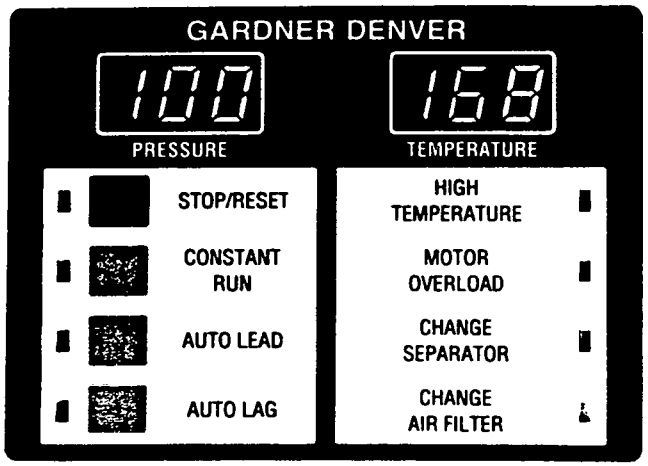
At the heart of every compressed air system is the compressor controller, serving a two-fold function of maintaining intelligent, efficient system operation and monitoring compressor safeguards and maintenance advisories. Auto Sentry control technology responds with simple, easy to understand and operate controls that utilize state-of-the-art microprocessor technology to assure maximum energy efficiency, all with the guarantee of Gardner Denver reliability. Like an around-the-clock serviceman, the Auto Sentry controller faithfully watches over your compressed air system, **so you don't have to.**

Simplicity - Ease of Operation
As maintenance staffs are challenged to be more time efficient, the ease of operation and time saving features of the Auto Sentry controller are a sure fit into your maintenance regimen. Standard operating displays of system pressure and compressor discharge temperature in large, one-half inch text provide the operator with immediate access to critical information needed. Current status of system operation mode and advisories allows the operator to quickly assess compressor run conditions.

In addition, setting or changing required operating conditions is a snap. Just scroll through the full text explanations with a simple touch to the microprocessor pad. User friendly software directs the operator quickly and easily through the compressor maintenance and set point prompts.

Consistent with the Gardner Denver compressor package design philosophy, simplilicity has been designed into the Auto Sentry controller because time is money.

Efficiency - Energy Conservation Saves Money
The cost of electricity is the major expense in the production of compressed air. Electrical expense for a two-shift operation of a new compressor will likely exceed the initial purchase price of a compressor in the first year, alone. Auto Sentry controllers are designed with energy efficiency in mind. A major energy saving feature is that these controllers maintain a lower maximum pressure while still providing required plant pressure. For example, in many systems, Auto Sentry controllers can hold system pressure at 100 psig without compressing

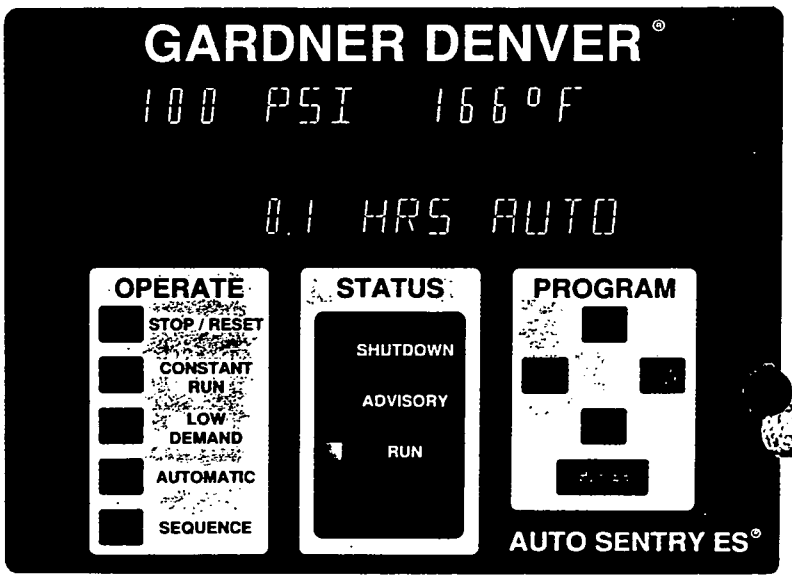


AutoSentry® S Controller

- Standard on Electra-Screw 7.5-100 HP
- Constant run or automatic start/timed stop with blowdown at unload with Auto Lead/Lag compressor capability
- LED displays for compressor and separator temperature/pressure
- LED maintenance display and protective shutdowns for: oil/inlet air filter, compressor and separator high temperature and main/fan motor overload

AutoSentry® ES Controller

- Standard on Electra-Saver II 40-150 HP and Electra-Screw 125-200 HP
- Mode Selections include: constant run, low demand, automatic with timed stop, sequence (up to 8 units) stop/reset and emergency stop
- VFD displays for: hourmeter, discharge air temperature, system pressure, reservoir temperature/pressure, and separator pressure differential
- VFD advisory display includes: service air filter, change separator, oil filter, oil; low ambient/high temperature conditions
- Protective shutdowns for: high temperature, low oil pressure, main/fan motor overload, high pressure change separator and power interruption
- Standard electronic modulation control, thermal controlled air-cooled fan motor start and motor rotation jog.



more than 2-4 psi above this level. An inefficient controller must compress up to 10 psi above the system requirement just to maintain the same 100 psig.

For every 2 psi increase in pressure that your compressor must maintain, an additional 1% in BHP is required. A 10 psi increase means an extra 5% BHP is consumed. This will equate to hundreds, if not thousands of dollars a year. The ability of Auto Sentry controllers to maintain a narrow pressure band through rapid response is worth money in your pocket.

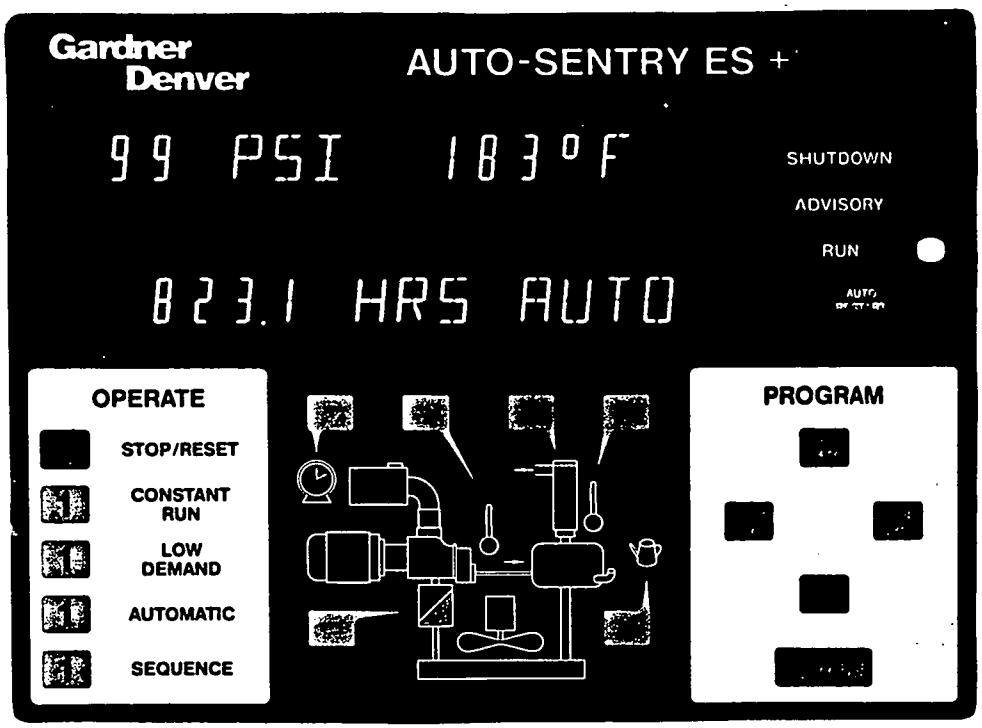
Maintaining constant volume with minimum pressure fluctuation to the air system is achieved through rate of change monitoring. Simply put, rate of change is a function of time and pressure. By continually monitoring your air system, the microprocessor controller can diagnose what is happening relative to your manufacturing air flow requirements and quickly match compressor delivery with system demand. If there is a sudden, rapid decrease or increase in pressure, the Gardner Denver controller will sense it and respond by making an immediate adjustment. Overpressuring your compressor system increases energy consumption and costs, underpressuring can affect quality of manufacturing processes and goods resulting in scrap, as well as the efficiency of down-line air treatment equipment like air dryers.

Reliability - Compressor Safeguarding and Troubleshooting

The best way to avoid a non-productive compressor shutdown is to safeguard against those conditions which place the compressor longevity at risk. Offering the most extensive package of compressor advisories and protective shutdowns in the industry, the Auto Sentry controller continuously monitors and displays system inputs that warn the operator of potential dangers. Full text displays easily identify the source of system failures in the event of a protective shutdown. Advisories warn the operator in advance of conditions which need to be corrected to avoid interrupted compressor operation. By constantly monitoring itself of potential dangers and providing simple, easy-to-understand trouble-shooting prompts, the Auto Sentry controller turns hours of down time into hours of productive output.

AutoSentry® ES+

- Standard on SAV 200-300, optional upgrade to ES controller
- Complete system diagnostics with interactive compressor diagram
- Mode selection, each with modulating inlet valve or load/no load control including: constant run, low demand with reservoir blowdown, automatic with timed blowdown and stop, stop/reset and emergency stop
- VFD display for hourmeter, loaded hours and total running time, system/reservoir pressure, separator differential pressure and motor amps
- VFD advisory lamps include: service air filter, change separator, oil and oil filter; low/high temperature, sequencing communications error and high motor amps
- VFD protective shutdown lamps for high temperature, low oil pressure, main/fan motor overload, high pressure and change separator
- Choice of one field selectable message: high vibration, phase relay, motor protector or low voltage

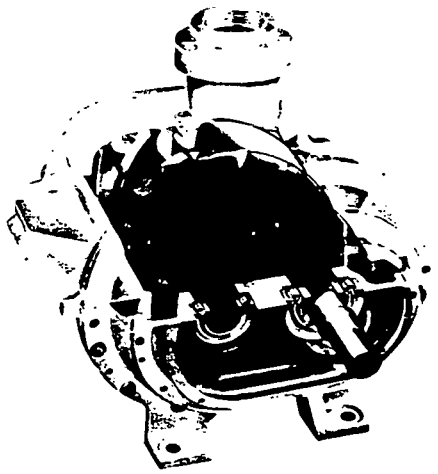


- Standard power interruption protection, high speed electronic modulation control, thermal controlled air-cooled fan motor start and contacts for remote start/stop operation plus remote monitoring

Electra-Screw 40 to 200 HP (30 to 149 KW)

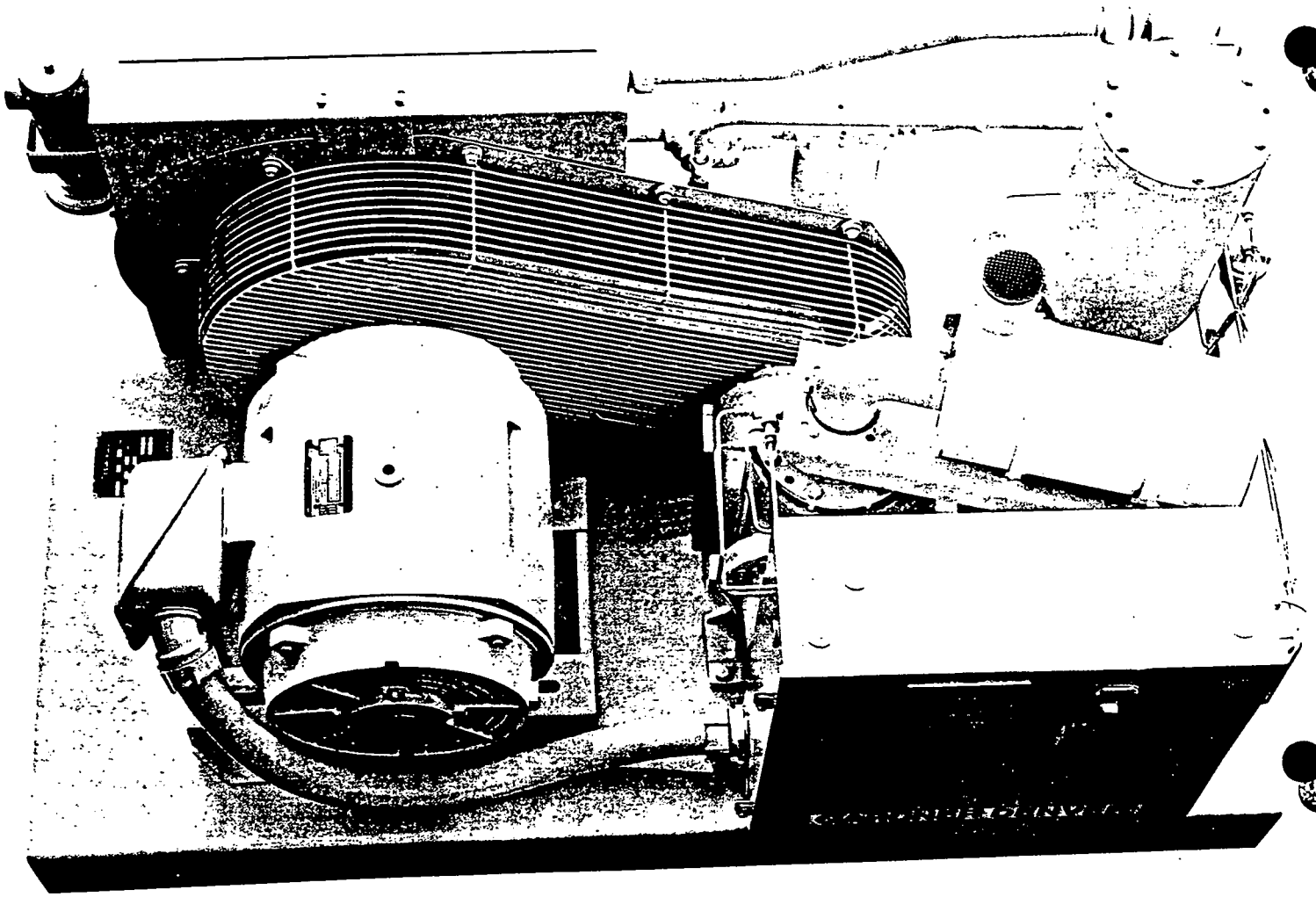
Meet Your Match In Affordability

Careful attention to detail has allowed Gardner-Denver to offer the cost-conscious customer a compact, field-proven package with the quality and performance for which we have become famous. Gardner-Denver Electra-Screw compressors are the industry's most affordable series, and one of the most economical-to-operate compressors you can buy. From the patented KYPHO air end to the state-of-the-art Auto Sentry electronic controller, Electra-Screw sets itself apart from the competition.

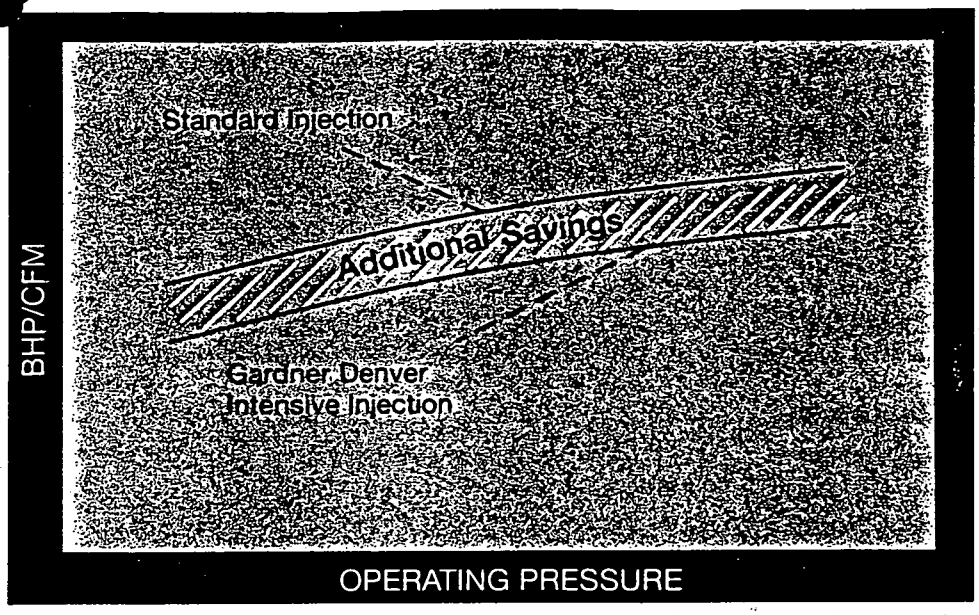


Electra-Screw air end with KYPHO rotor and Intensive Injection.

Intensive Injection pays an immediate dividend through lower energy costs. This ingenious design improves efficiency 6 to 8% over conventional lubricant injection. Lubricant injection into the compression chamber of a rotary screw compressor has three major functions: cooling the heat of compression, lubrication of the rotors, and sealing the internal running clearances.



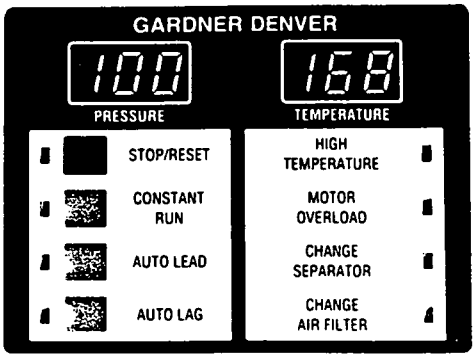
Clean, uncluttered Electra-Screw compressor incorporates exclusive Gardner-Denver features making it easier to maintain and operate.



Patented Intensive Injection provides increased efficiency through more effective sealing and heat removal.

Of these, cooling the compression cycle is the key factor in controlling power consumption. Intensive Injection feeds the coolant into the compression chamber as a dense mist through four injection ports. The dense mist accelerates the rate of heat exchange between the air/oil mixture, with most of the injection and heat transfer occurring when the air has reached its highest pressure and greatest temperature. Hot spots are eliminated. The discharge air is pulsation-free and ready to use immediately, due to the steady continuous intermeshing of the rotors and the cooler discharge air temperatures.

In its class, only Electra-Screw offers the advantage of Intensive Injection and its cost-saving operation.



Only Electra-Screw in its class offers the pushbutton simplicity and efficiency of Auto Sentry control.

Like all Gardner-Denver rotary screw compressors, the Electra-Screw line incorporates rugged components, like a rigid steel sub-base and corrosion-resistant control lines.

And Electra-Screw is the only compressor line in its class that offers the exclusive Gardner-Denver Auto Sentry one touch, solid-state electronic controller with more diagnostic and shut down capability than any comparable compressor.

Electra-Screw compressors come standard with a factory-fill of AEON long-life compressor coolant/lubricant with a useful service life of up to **4000 hours between changeouts**. This long-life lubricant, in conjunction with the state-of-the-art air/oil separation system, means as much as 67% less cost for the user when it comes time to change coolant. This is in addition to cost savings of up to 88% less make-up coolant–which means more money in the user's pocket.

Electra-Screw Compressors–the affordable answer to today's constantly rising costs.

Money-Saving Features of Electra-Screw Compressors:

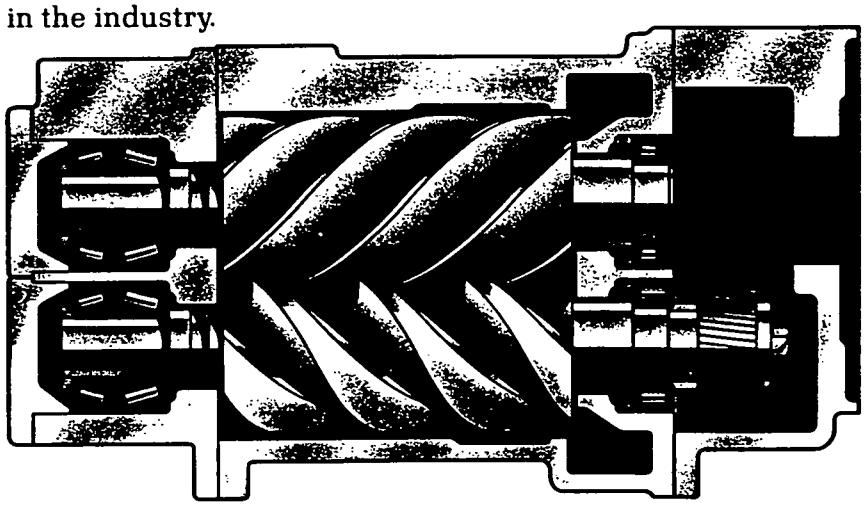
1. Exclusive KYPHO rotor profiles,
2. Intensive Injection,
3. Auto Sentry Electronic Controller,
4. ELIMINATOR Air/Oil Separator,
5. Corrosion-resistant rigid control lines,
6. Non-geared air end,
7. Large, long-life antifriction bearings,
8. Cost-saving AEON coolant/lubricant,
9. Unitized air end mounted to rigid steel base with all-angle elastomer vibration isolators (except 40 - 50 HP).

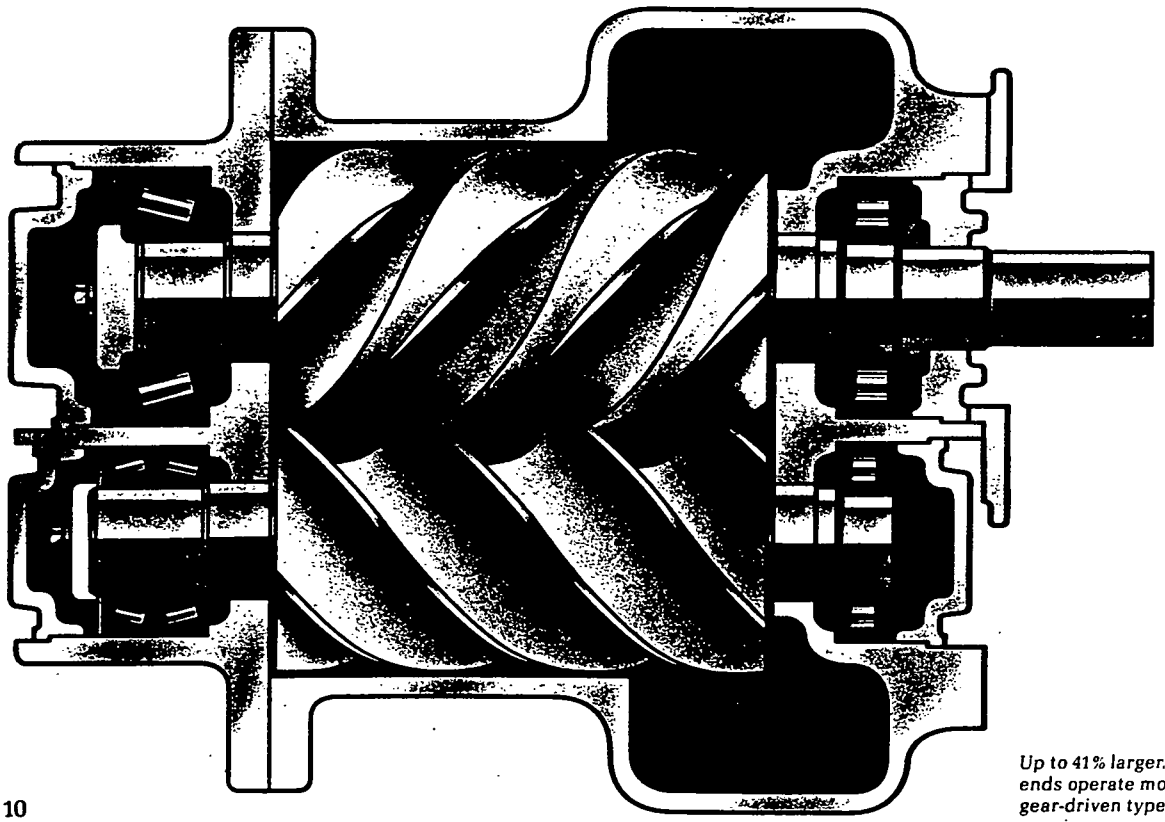
Electra-Saver II 40 to 150 HP (30 to 112 KW)

Meet Your Match In Reliability

When full load efficiency and added durability are the deciding factors, Gardner-Denver's Electra-Saver II is the premier product in the industry.

Starting with the same basic design as the Electra-Screw, Electra-Saver II takes durability to a new level. Through the use of **Intensive Injection,** Gardner-Denver's unique **KYPHO rotor profile,** and **larger, slower-turning air ends,** Electra-Saver II not only offers as much as **6% to 8% efficiency gain** over ordinary compressors—but adds a **life expectancy exceeding 100,000 hours.**

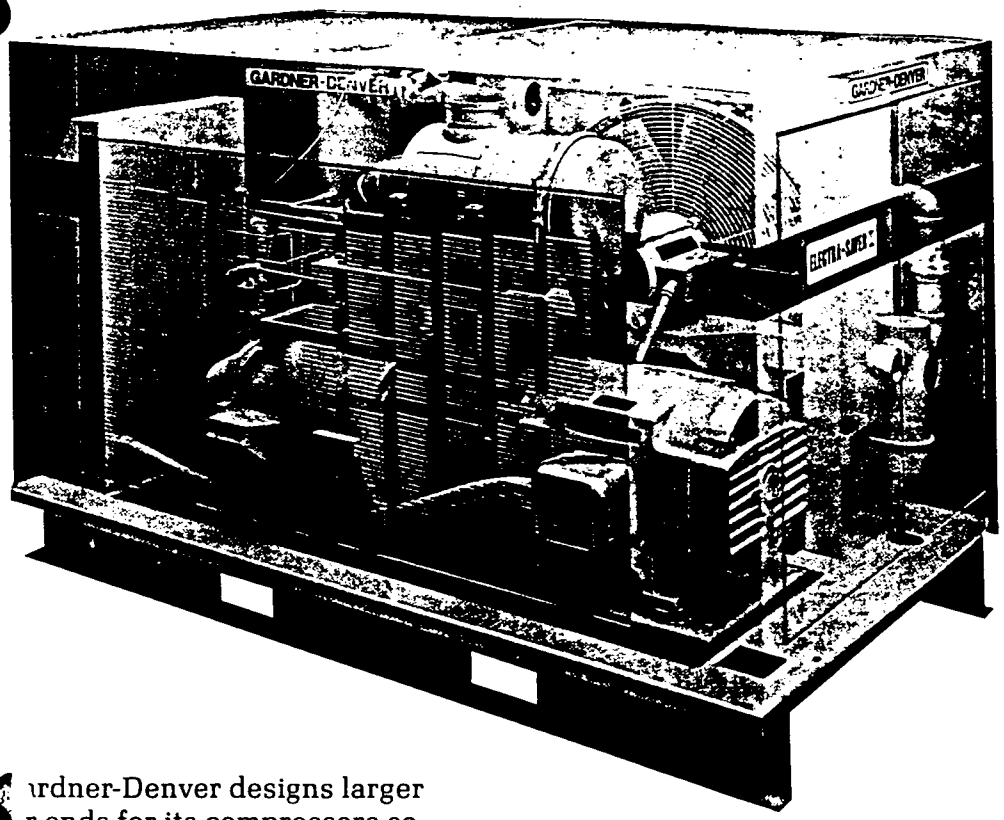




Air ends—the prime reason Gardner-Denver compressors save you money. The durability and efficiency of a compressor package are largely a function of the size of the air end. The most important compressor efficiency measure to consider is the **volume of compressed air delivered each minute** and the corresponding brake horsepower required to produce that volume.

Although smaller air ends can be manufactured at a lower cost, their operating efficiency, life expectancy and maintenance periods can be proportionally shorter. For a smaller air end to deliver the same volume, the rotor has to turn faster, usually through the use of gears. Eventually, these gears wear out and require replacement, not only shortening the compressor's useful life, but increasing its **total cost.**

Up to 41% larger, direct drive Gardner-Denver air ends operate more slowly, efficiently than smaller, gear-driven types.



ırdner-Denver designs larger ir ends for its compressors so they can be **direct driven** at the motor's own speed. Not only does the greater operating efficiency of a larger air end **extend operating life,** it also **reduces energy costs year after year.**

In addition to greater durability, larger air ends also **deliver compressed air more efficiently.** In an air end, the clearances between the rotors are potential leakage areas. A smaller rotor set has a higher leakage area per unit displacement (measured in cubic feet of air per revolution). And, the oil used to lubricate the rotors creates "drag," that increases as the rotor speeds increase. Finally, gear driven units suffer further efficiency losses due to gear friction. **As a result, the inefficiencies of smaller air ds show up in increased power sage that nullify the savings in their initial lower price.**

The use of larger, slower-turning, direct drive air ends is a major contributing factor to the outstanding durability of Gardner-Denver Electra-Saver II rotary screw compressors.

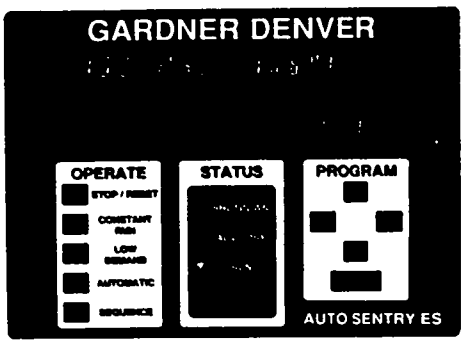
Like all Gardner-Denver rotary screw compressors, Electra-Saver II incorporates rugged components like a rigid steel subbase and corrosion-resistant control lines.

Electra-Saver II, alone in its class, offers the exclusive Gardner-Denver Auto Sentry ES one touch, solid-state electronic controller with more diagnostic and shut down capability than any comparable compressor.

If you want **efficiency combined with dollar-saving durability,** Electra-Saver II should be your first choice.

Features of Electra-Saver II Compressors:

1. Exclusive KYPHO rotor profiles,
2. Patented Intensive Injection,
3. Auto Sentry ES Electronic Controller,
4. ELIMINATOR Air/Oil Separator,
5. Long-life AEON 9000 SP (8000-hour) coolant/lubricant,
6. Direct driven, non-geared air end,
7. Large, long-life antifriction bearings,
8. Heavy-duty canister-type inlet air filter.



With the most sophisticated solid-state controller in its class, the one touch Auto Sentry ES design is easy to understand and operate.

Electra-Saver 100 to 500 HP (75 to 375 KW)

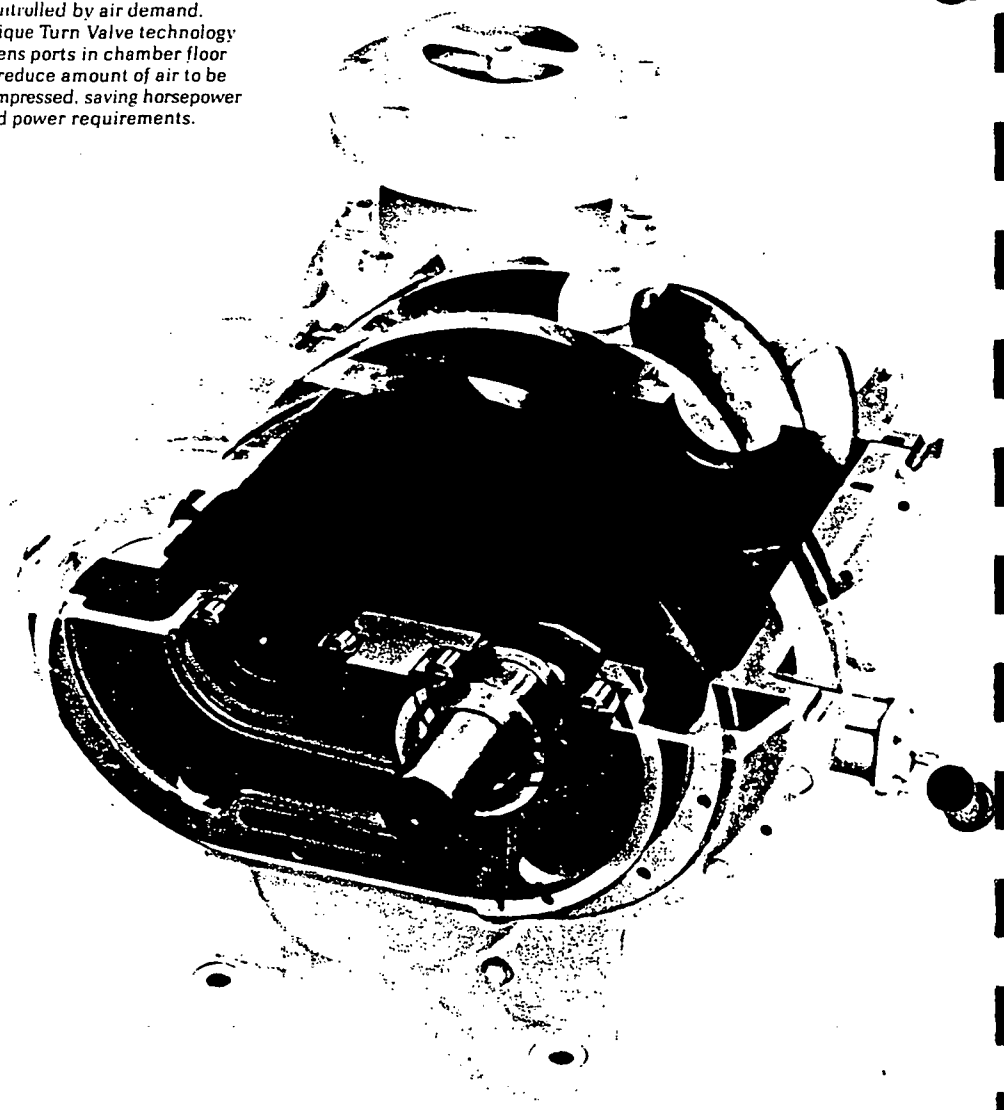
Meet Your Match In Energy Efficiency

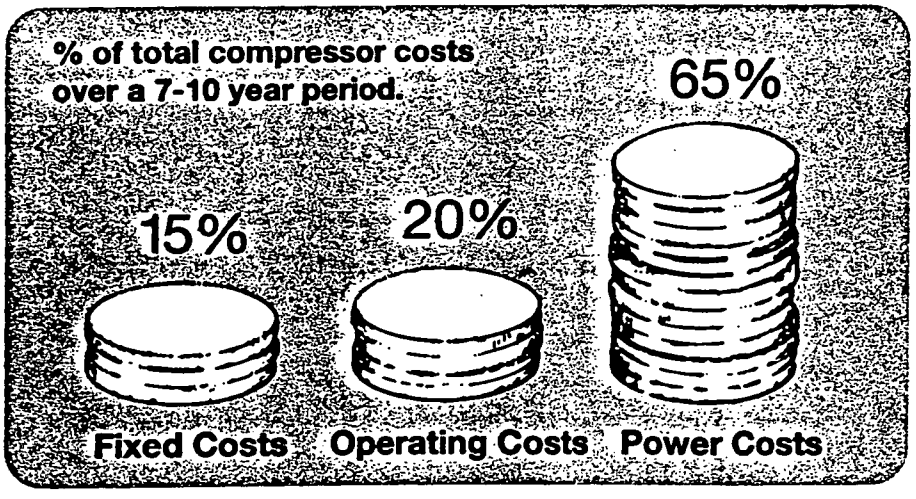
Dollar for dollar, nothing matches the Gardner-Denver Electra-Saver for maximizing your dollar. Electra-Saver set new efficiency records before competition even considered energy conservation. The unique **Turn Valve** technology matches energy input to system demand, slashing energy costs as much as **16%.**

With this type of efficiency, an Electra-Saver compressor will more than **pay for itself in savings within six years!**

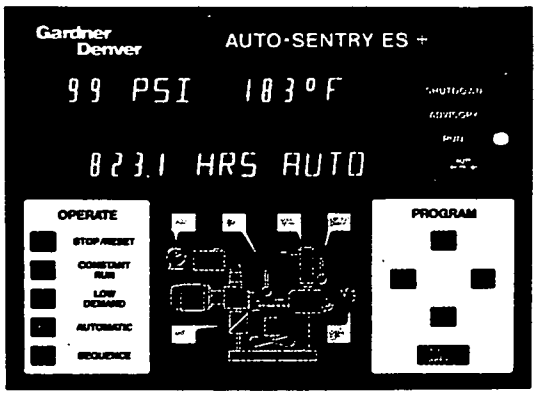
As the single largest expense in the production of compressed air, energy cost far exceeds the initial purchase price, maintenance cost and all other operational expenses. Rarely does a plant compressor operate at full load,

Controlled by air demand, unique Turn Valve technology opens ports in chamber floor to reduce amount of air to be compressed, saving horsepower and power requirements.

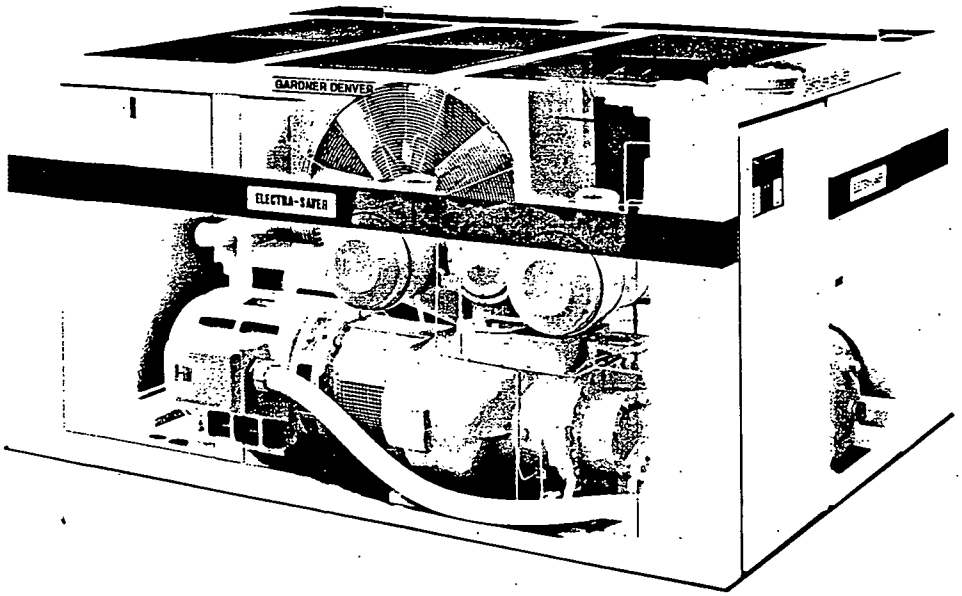




As the single largest expense, energy costs far exceed initial purchase cost—and can actually exceed the original purchase price in the first year of operation, based on the kilowatt hour cost for a two-shift operation of a new compressor.



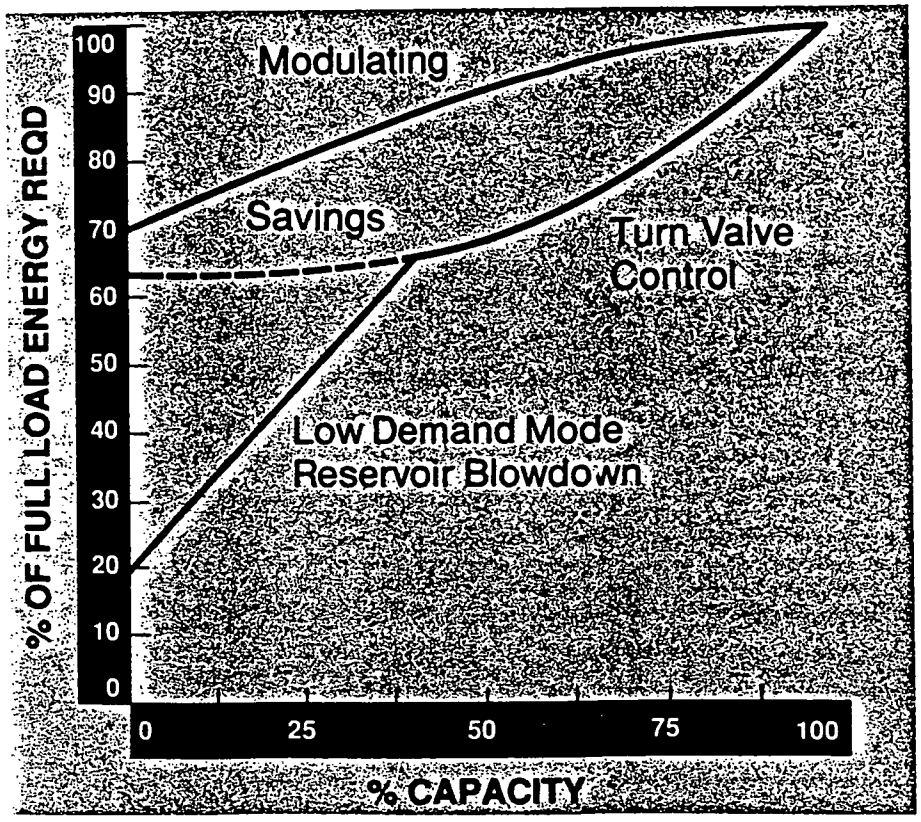
With the most advanced, yet simple to operate control design in the industry, the Auto Sentry ES+ offers complete diagnostic capability with the operation mode to fit your application.



because loads vary. Surveys pinpoint a 60%-70% of capacity average as more realistic, with full loading only occurring during peak demand periods.

But, a typical throttled inlet compressor operating at 65% of capacity **still requires 91% of full load horsepower.**

By compressing air in direct proportion to system demand, the Electra-Saver Turn Valve control system dramatically reduces part-load horsepower—at 65% of capacity, **Electra-Saver requires only 75% of full load horsepower**—a 17.6% reduction. And that builds up the savings **beyond** the excellent inherent efficiencies of Gardner-Denver compressors.



Features of Electra-Saver Compressors

1. Exclusive KYPHO rotor profiles,
2. Exclusive patented Turn Valve technology,
3. Auto Sentry ES+ Electronic Controller (200-300 HP),
4. ELIMINATOR Air/Oil Separator,
5. Long-life AEON coolant/lubricant,
6. Direct connected air end with large, slower-turning rotors,
7. Large, long-life anti-friction bearings with L-10 life expectancy of over 100,000 hours,
8. Corrosion-resistant control lines,
9. Rugged, heavy-duty base and components used throughout.

Exclusive Gardner-Denver Turn Valve Capacity Control System is more efficient than Modulating Control, especially at less than 80' capacity. At 40% capacity, additional savings are realized through exclusive Low Demand Mode (18% unloaded HP).

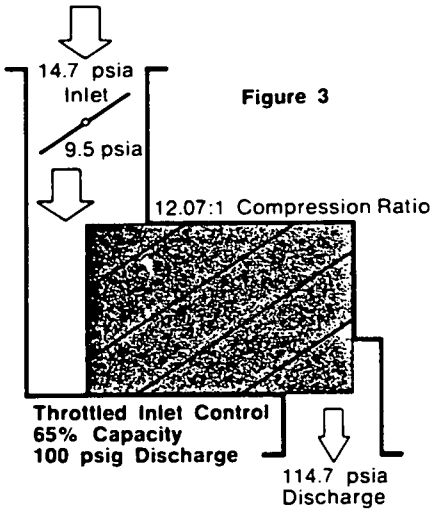


Figure 3

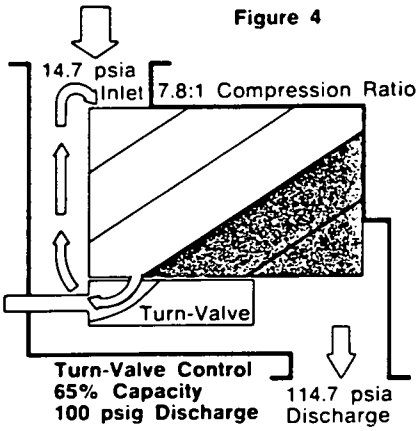


Figure 4

At 65% capacity, throttled inlet compressor still needs 91% of full load HP, while Turn Valve system uses only 75% of full load HP.

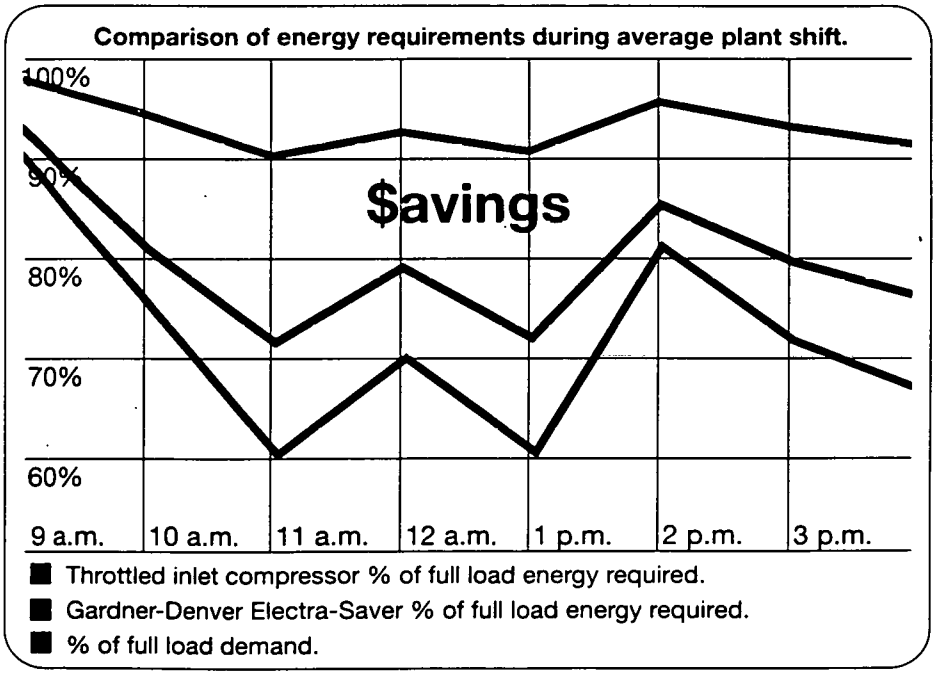
Electra-Saver (Continued)

Here's how it works. The beauty of Turn Valve design is its very simplicity. A pressure-actuated cylinder rotates the contoured Turn Valve to open or close a series of ports cast in the cylinder wall. With the ports closed, air is compressed to meet 100% of system demand. As demand is satisfied, the Turn Valve rotates to expose one or more ports, returning unneeded air to the suction inlet **before compression begins.** This effectively reduces the amount of air to be compressed, thereby reducing overall power consumption. With the Electra-Saver design, you don't compress air you don't need.

As you would imagine from the top of the line compressor, Electra-Saver incorporates **all** the Gardner-Denver efficiency-building standard features—**ELIMINATOR** Air/Oil Separator, **Aftercooler,** direct-connected **air ends,** long-life **bearings,** and friction-reducing **AEON lubricant.** They are built with rugged components, like a rigid steel sub-base and corrosion-resistant control lines.

Electra-Saver, alone in its class, offers the exclusive Gardner-Denver **Auto Sentry ES** one touch, solid-state electronic controller with more diagnostic and shut down capability than any other compressor.

When you add up all the advantages, all the efficiencies, and compare total cost to buy, own, operate and maintain, Electra-Saver is the most economical compressor.



With exclusive Turn Valve system, the Electra-Saver responds precisely to system air demands, using less HP and operating efficiently even under part load.

Option / Family Horsepower	Electra-Screw 7.5-15	Electra-Screw 25-30	Electra-Screw 40-50	Electra-Saver II 40-50	Electra-Screw 60-100	Electra-Saver II 60-100	Electra-Saver 100	Electra-Screw 125-200	Electra-Saver II 125-150	Electra-Saver 125-150	Electra-Saver 200-300	Electra-Saver 350-500
Auto-Sentry S	S	S	S		S							
Auto Sentry ES				S		S	S	S	S	S		O
Auto Sentry ES+				O		O	O	O	O	O	S	O
Standard												S
Intensive Injection		S	S	S	S	S		S	S			
Turn Valve							S			S	S	S
Air Cooled	S	S	S	S	S	S	S	S	S	S	S	S
Water Cooled				O	O	O	O	O	O	O	O	O
1800 RPM	S, 7.5	S	S	S		S	S		S	S	S	S
3600 RPM	S, 10-15				S			S				
Main Motor:												
Full Voltage	S	S	S	S	S	S		S	S			S
Wye-Delta				O		O	S		O	S	S	O
Premium Efficiency		O	O	O	O	O	O	O	O	O	O	O
TEFC		O	O	O	O	O	O	O	O	O	O	O
Severe Duty		O	O	O	O	O	O	O	O	O	O	O
Enclosure:												
Factory Mounted Full	S	O	O	O	O	O	O	O	O	O	O	
Factory Mounted Part												S
Field Kit		O	O	O	O	O	O	O	O	O	O	
Low Sound	O, 7.5-10	O	O									

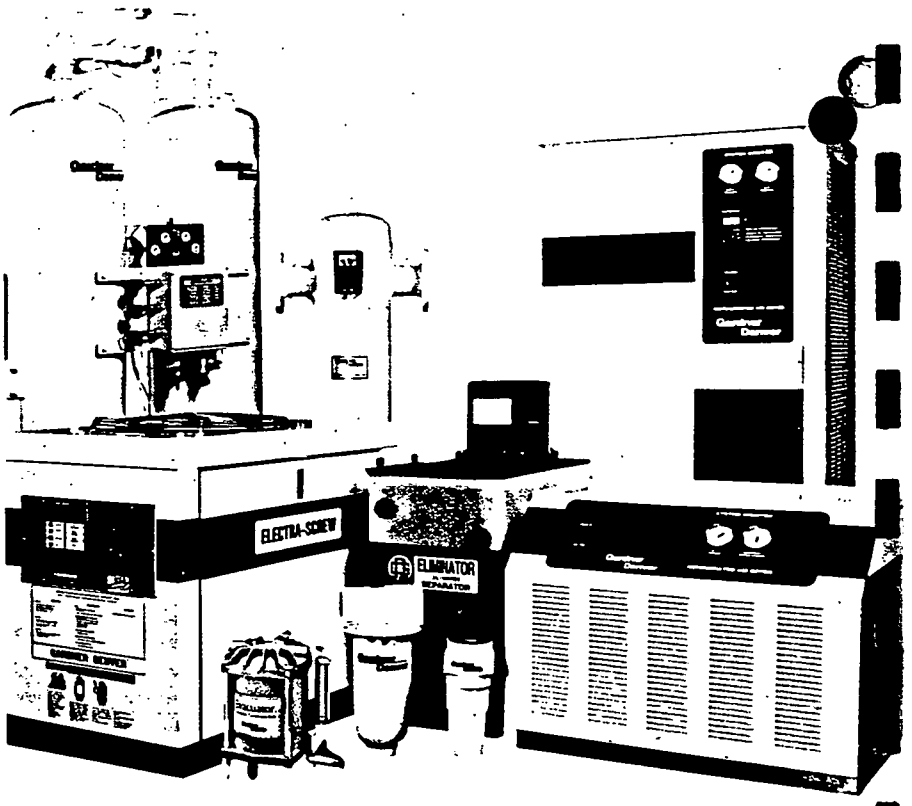
S - Standard
O - Optional

Total System Reliability

All compressed air systems require dry, clean air and environmentally sound disposal of by-products. That is why Gardner Denver's support does not stop at the blower or compressor stage of your air system.

Rust, oil vapors, wear particles, air pollution, industrial gases and humidity all can foul pressurized air flows. Proper removal of these contaminates is essential in preventing costly damage to air tools, machine centers, gauges and other critical components.

To ensure total system reliability, Gardner Denver provides a broad range of dryers, coalescing filters, oil/water separators, mechanical-electrical or pneumatic drains, compressor lubricants, cleaning fluids, particulate filters and aftercoolers. ONE-STOP shopping from Gardner Denver assures that all components of the system are designed to work together and are backed by customer support today and for years to come.



A complete family of compressors and ancillary products offered by Gardner Denver.

	Ancillary Products	Capacities
Dryers	Refrigerated Dryers	10 to 2,000 SCFM
	Twin Tower Regenerative Dryers	50 to 2,070 SCFM
Filters	Particulate Filters (5 micron)	up to 4,143 SCFM
	Coalescing Filters (.01 - 1 micron)	up to 3,200 SCFM
Condensate Drains	Automatic Mechanical Drain	up to 200 PSIG
	Automatic Electrical Drain Valve	up to 300 PSIG
	Evacuator Pneumatic Condensate Drain	52 oz & up to 450 PSIG
Separators	Eliminator Oil/Water Separator	20 to 90 Gallon Reservoirs
	Liquid Separators	25 to 1,700 SCFM
Compressor & Blower Lubricants	Food Grade, Biodegradable, Petroleum & Synthetic Bases Free Oil Analysis Program	2,000 to 8,000 Hours Service Life

MEMBER COMPRESSED AIR AND GAS INSTITUTE® CAGI

Gardner Denver

For additional information contact your local representative or Gardner Denver Compressor and Pump Division,
1800 Gardner Expressway, Quincy, Illinois 62301
Customer Service Department Telephone:
(800) 682-9868 FAX: (217) 228-8243

Sales and Service in all major cities.

For parts information, contact Gardner Denver
Master Distribution Center, Memphis, TN
Telephone: (800) 245-4946 FAX: (901) 542-6159

GARDNER DENVER ISO 9001 CERTIFIED QUALITY SYSTEM

Bulletin 13-9-202. 2nd Edition
10M 10/97

http://www.gardnerdenver.com mktg@gardnerdenver.com

GARDNER DENVER®

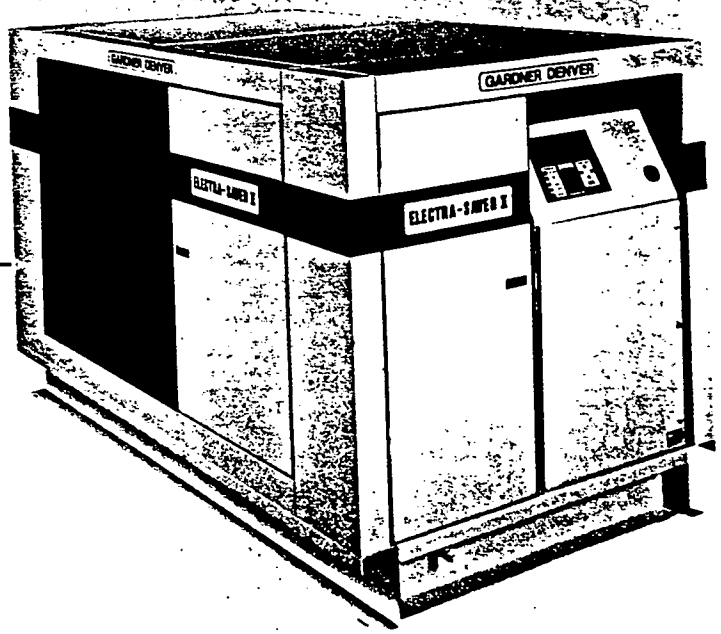
ELECTRA-SAVER II®

Rotary Screw Air Compressors

60-75-100 HP

45-55-75 KW

50/60 HZ



INTENSIVE INJECTION

- 6-8% improved full load operating efficiency provided by patented Intensive Injection lubrication system.
- Immediate payback through energy savings.
- Provides highest CFM per brake horsepower in the industry.

ACOUSTIC ENCLOSURE

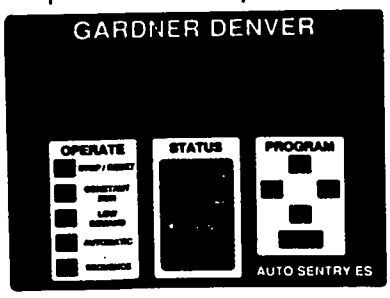
- Significant overall noise reduction with optional full sound attenuating enclosure (standard on international units).
- Unrestricted access to all service points through three hinged access doors, two bolted roof panels and one full length lift off rear door.

DIRECT DRIVEN NON-GEARED AIR END

- Increased bearing life (L-10 life in excess of 100,000 hours) due to large tapered roller bearings.
- Permanent alignment of the flexible coupling between air end and motor is assured by rigid C-flange mounting.

AUTO SENTRY™ ES SERIES SOLID STATE ELECTRONIC CONTROLLER

- Every control option available in the industry is standard on the Gardner Denver Auto Sentry™ ES controller.
- More self-diagnostic capability than any other rotary screw compressor.
- Built-in ability to sequence two compressors.
- User friendly readout. No codes to decipher. Digital and full text Vacuum Fluorescent Display (VFD).



MAINTENANCE REDUCING DESIGN FEATURES

- Simplified access to air/oil separator, requiring removal of only 6 bolts and no piping to change separator elements. Cuts maintenance time by 90%.
- Easy access to spin-on 10 micron full-flow oil filter and air filter (mounted directly to the inlet valve).

HEAVY DUTY INLET AIR FILTER

- Removes 99% of airborne particulate 5 microns and larger.
- Special option for most competitive models.
- Extends lubricant life by almost 20%.
- Extends air end life while reducing inlet air noise.

ELIMINATOR™ AIR/OIL SEPARATOR

- Better separation and longer life ensured due to having TWICE the surface area of conventional separators.
- Lowest oil carry-over in the industry—less than 2 PPM (by weight) at 100 PSIG (6.9 bar), full load operation.
- Reduces pressure loss common with competitive separation designs.

STANDARD EQUIPMENT

- Direct Drive, non-geared, C-flange mounted air end
- Modulating, vertical inlet valve
- Heavy duty, 5 micron, dry, canister type inlet air filter
- 460 volt, 3 phase, 60 HZ, 1800 RPM, or 380/415 volt, 3 phase, 50 HZ, 1500/3000 RPM, 1.15 SF, ODP, C-Flange drive motor
- Air end and motor shaft are coupled through a permanently aligned, resilient cushion-type flexible coupling
- Unitized air end/motor assembly mounted to the compressor base with all angle elastomer vibration isolators
- ASME coded air/oil reservoir with ELIMINATOR™ separator element
- Oil cooler/aftercooler:
  - — Air cooled models - heavy duty radiator-type with thermally controlled, totally enclosed fan motor
  - — Water cooled models - shell and tube heat exchanger
- Thermostatic oil mixing valve
- Package mounted moisture separator and trap
- 10 micron, full flow oil filter
- Rigid steel base with forklift slots
- Pressure relief valve and discharge check valve
- Automatic blowdown valve with muffler
- Minimum discharge pressure valve
- Galvanized steel piping lubricant system
- Factory fill with AEON™ 9000 SP synthetic lubricant for 8,000 hour change interval
- Auto Sentry™ ES Series, solid state, touch pad, microprocessor based controller includes:
  - — Full programmability
  - — Full text/digital display
  - — Full electrical system diagnostics
  - — Mode selection
    - Constant run - Low demand - Auto start/timed stop
    - Sequence up to 8 units (with identical controllers)
  - — Emergency stop button
  - — Full text/digital display including: hourmeter, discharge air temp, system pressure, reservoir temp and pressure and separator differential pressure.
  - — Advisory points including: service air filter, change separator, change oil filler and change oil.
  - — Protective shutdowns including: high temperature, low oil pressure, fan motor overload, main motor overload, high pressure and change separator.
  - — Power interruption protection
  - — Electronic modulation control
  - — Thermally controlled air cooled fan motor starting
  - — Motor rotation jog function
- NEMA 12/IP-65 control/electrical enclosure includes:
  - — Rugged full voltage main motor starters

  OR
  - — *Rugged Star Delta Starters on international units*
  - — Separate fan motor starter
  - — Control voltage transformer
  - — Auto Sentry™ ES microprocessor based controller

OPTIONAL EQUIPMENT

- Wye-Delta main motor and starter (IEC rated)
- NEMA 4/IP-66 control enclosure
- TEFC or high efficiency, main compressor motor
- Full sound attenuating enclosure *(standard on international units)*
- Magnetic water control valve (water cooled units)
- Automatic water temperature regulator (water cooled units)
- Seacoast corrosion resistant air cooled oil cooler/aftercooler.
- Remote mounted air cooled, oil cooler/aftercooler
- Factory fill AEON™ 6000 FG Food Grade synthetic lubricant

PERFORMANCE DATA

60 HZ

Motor HP	Style	Model	cfm[1]	m3/min	Standard Rating psig	Standard Rating bar
60	ST-60	EBM*K	270	7.64	100	6.9
			236	6.68	125	8.6
			208	5.89	150	10.3
75	ST-75	EBM*L	361	10.22	100	6.9
			320	9.06	125	8.6
			267	7.56	150	10.3
100	ST-100	EBP*M	490	13.88	100	6.9
			440	12.46	125	8.6
			360	10.19	150	10.3

50 HZ

Motor HP	Style	Model	cfm[1]	m3/min	Standard Rating psig	Standard Rating bar
45	ST-60	EBM*K	260	7.36	100	6.9
			193	5.47	125	8.6
			190	5.38	150	10.3
55	ST-75	EBM*L	361	10.22	100	6.9
			320	9.06	125	8.6
			255	7.22	150	10.3
75	ST-100	EBM*M	475	13.45	100	6.9
			410	11.61	125	8.6
			390	11.04	150	10.3

HP		Approximate Dimensions (2) Length	Width	Height		Approximate Shipping Weight (3) With Enclosure	Less Enclosure
60/75	in.	90	55	60	lbs.	3415	2960
	mm	2286	1397	1524	kg	1578	1342
100	in.	90	55	60	lbs.	4275	3820
	mm	2286	1397	1524	kg	1938	1732

1. Full Package Performance with CFM (M^3/Min) measured at the terminal discharge of the package in accordance with CAGI/Pneurop acceptance test code PN2CPT2.
2. Dimensions shown are nominal and apply to both air and water cooled units. Dimensions for installation will be furnished upon request.
3. Weights shown are for air cooled models with standard equipment. Water cooled models weigh slightly less.

Member CAGI

Gardner Denver

For additional information contact your local representative or Gardner Denver Machinery Inc., Customer Service Department, 1800 Gardner Expressway, Quincy, Illinois 62301
Telephone: (800) 682-9868 FAX: (217) 224-7814

Sales and Service in all major cities.

For parts information, contact Gardner Denver, Master Distribution Center, Memphis, TN
Telephone: (800) 245-4946 FAX: (901) 542-6159

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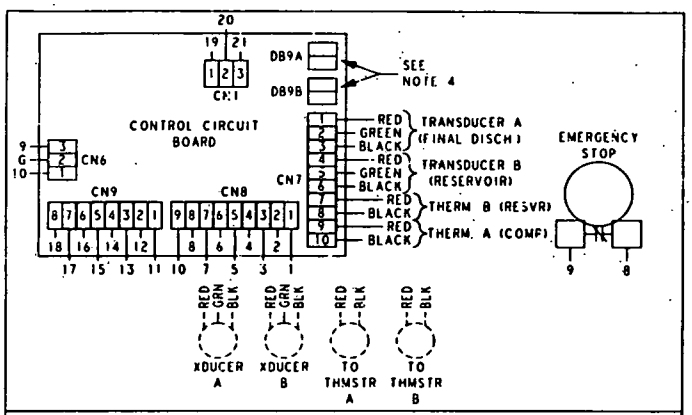
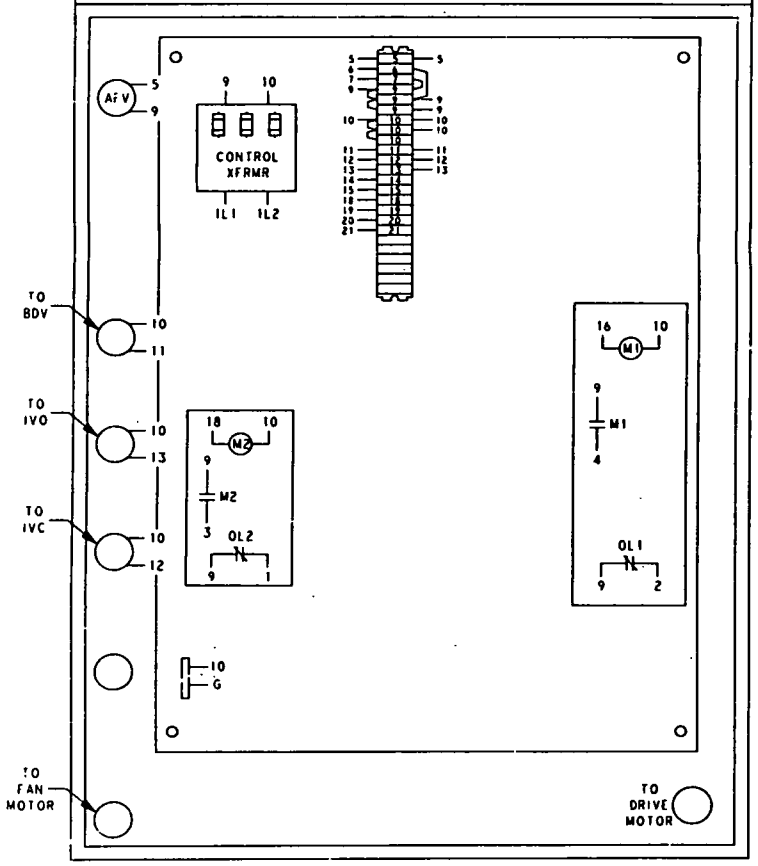




NOTE 1: FORM C CONTACT FOR USE BY
CONTACT OPERASTES FOLLOWING CO
RATING: 120VAC, 2 AMP
NOTE 2: FOR USE WITH OPTIONAL VIBRA
REMOVE JUMPER BETWEEN TERMINALS
NECT N.C. VIBRATION SWITCH CONTA
INALS 7 & 9
NOTE 3: FOR CONTROL BY REMOTE CONT
JUMPER BETWEEN TERMINALS 6 & 9 (
TACT TO TERMINALS 6 & 9
NOTE 4: DB9A & DB9B ARE FOR USE OF (
COMMUNICATIONS CABLE
NOTE 5: WHEN A WATER CONTROL SOLEN
IS USED, WIRE TO TERMINALS 18 & 1

□ = CONNECTION TO CONTROL BOA
⬡ = PANEL TERMINAL BLOCKS

LEGEND:
AFV - AIR FILTER VACUUM SWITCH
BDV - BLOWDOWN SOLENOID VALVE
IVC - INLET VALVE CLOSE SOLENOID
IVO - INLET VALVE OPEN SOLENOID

TAP DRILL DEPTHS ARE MAXIMUM FULL THD DEPTHS ARE MINIMUM

LET	REVISIONS	DATE	BY	CK	LET
	RELEASED ECN E900819				C
A	DELETED WIRE NO'S 21 - 24 BET-				A
	WEEN FAN FUSES & XFMR ADDED				
	WIRE NO'S 1L1,2,3 & 1T1,2,3				
	ADDED TERMINAL 18 & 6 SPARES				
	CN6 TERMINALS WERE H-N-G				
	AFV WAS MTD ABOVE XDCRS				
	ADDED NOTE 5 ECN E901004	10-5-90			
B	REVISED TO AGREE WITH NEW				
	BOX ARRANGEMENT				
	ECN E920903	9-2-92			

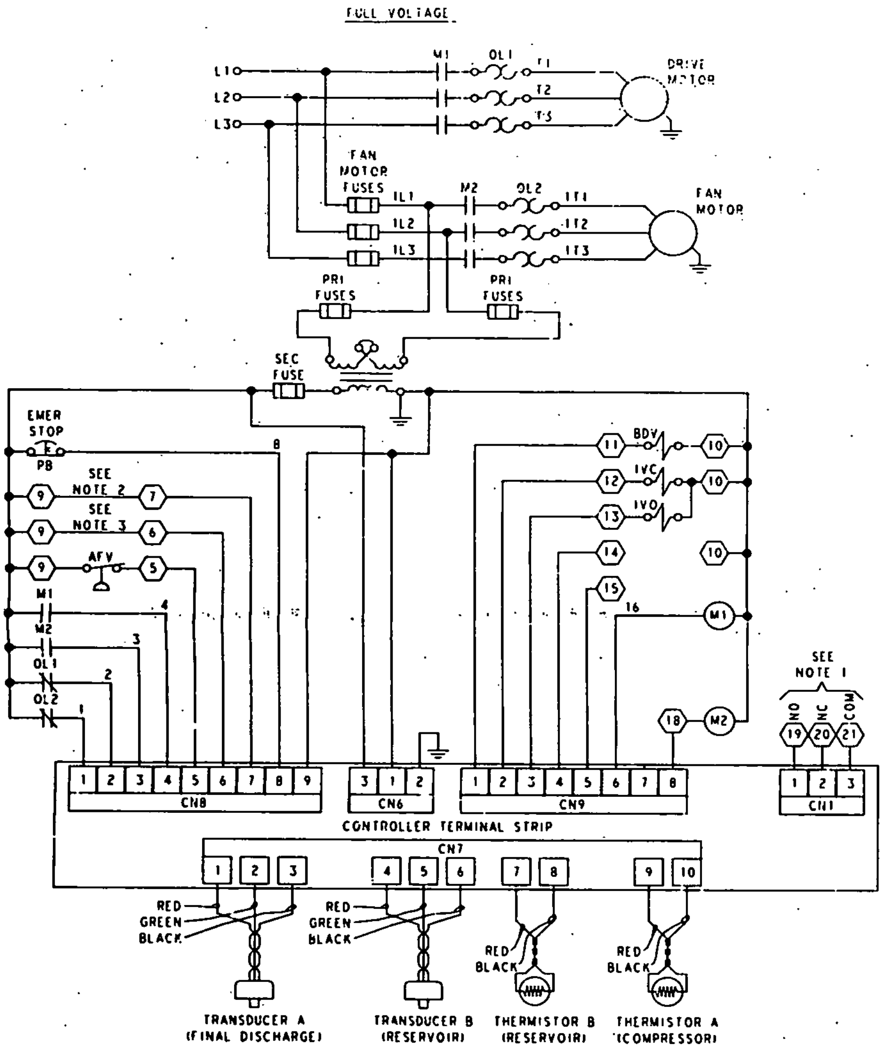
:OP SHUTDOWN.

:WITCH.
CON-
TERM-

REMOVE
:T CON-

:AL

ALVE



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REVISION	DATE	BY	CK	LET
WAS B THERM B WAS NO,NC & COM TO TB's				
ECN E9312C7	1-9-94			

Gardner Denver
Gardner Denver Machinery Inc
Quincy, Illinois

FOR ALL CURRENT SPECIFICATIONS REFER TO BILL OF MATERIAL

DIAGRAM-WRG (DUAL) CONTROL/STARTER

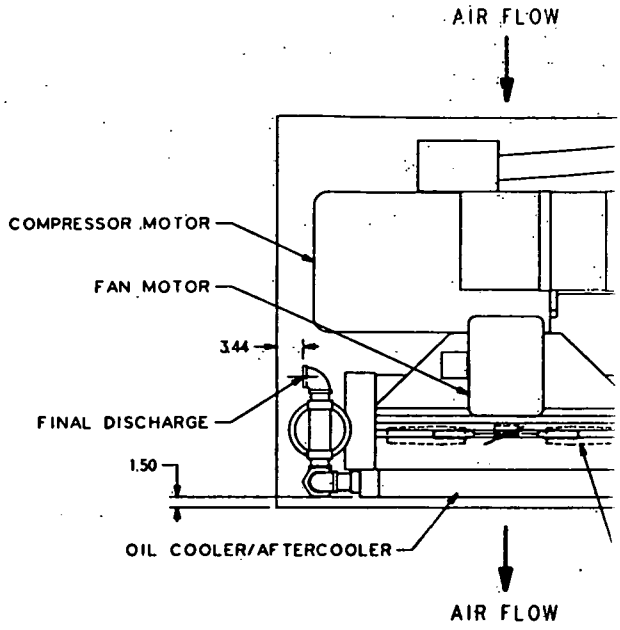
DR RFW 8-28-90
CK JEK 8-28-90
SCALE NTS

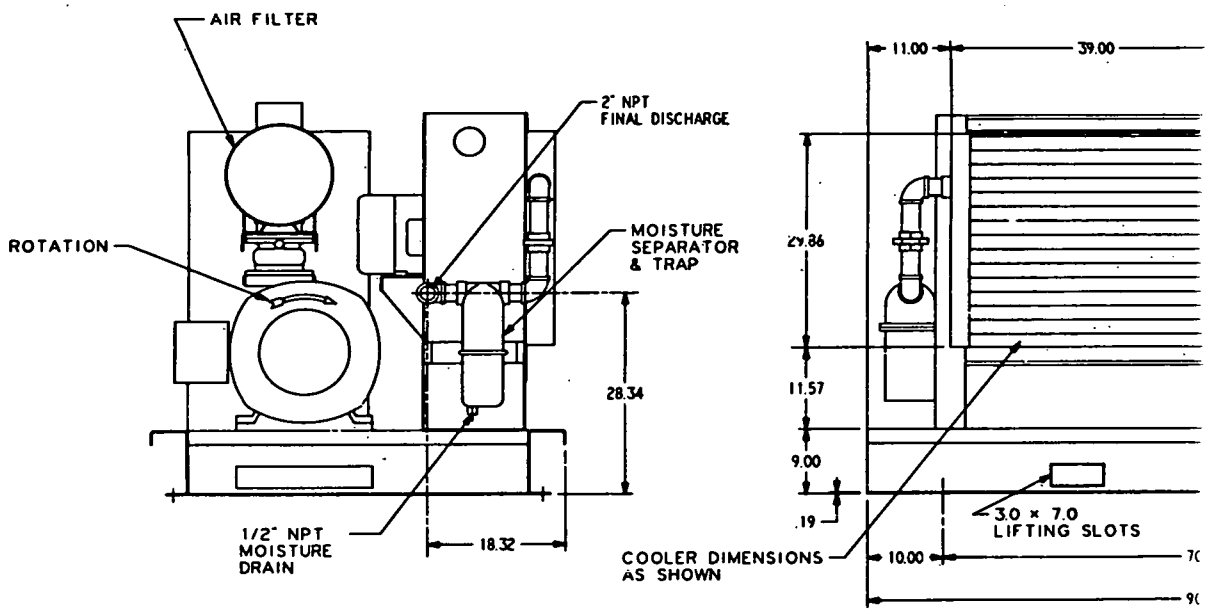
209ECP546

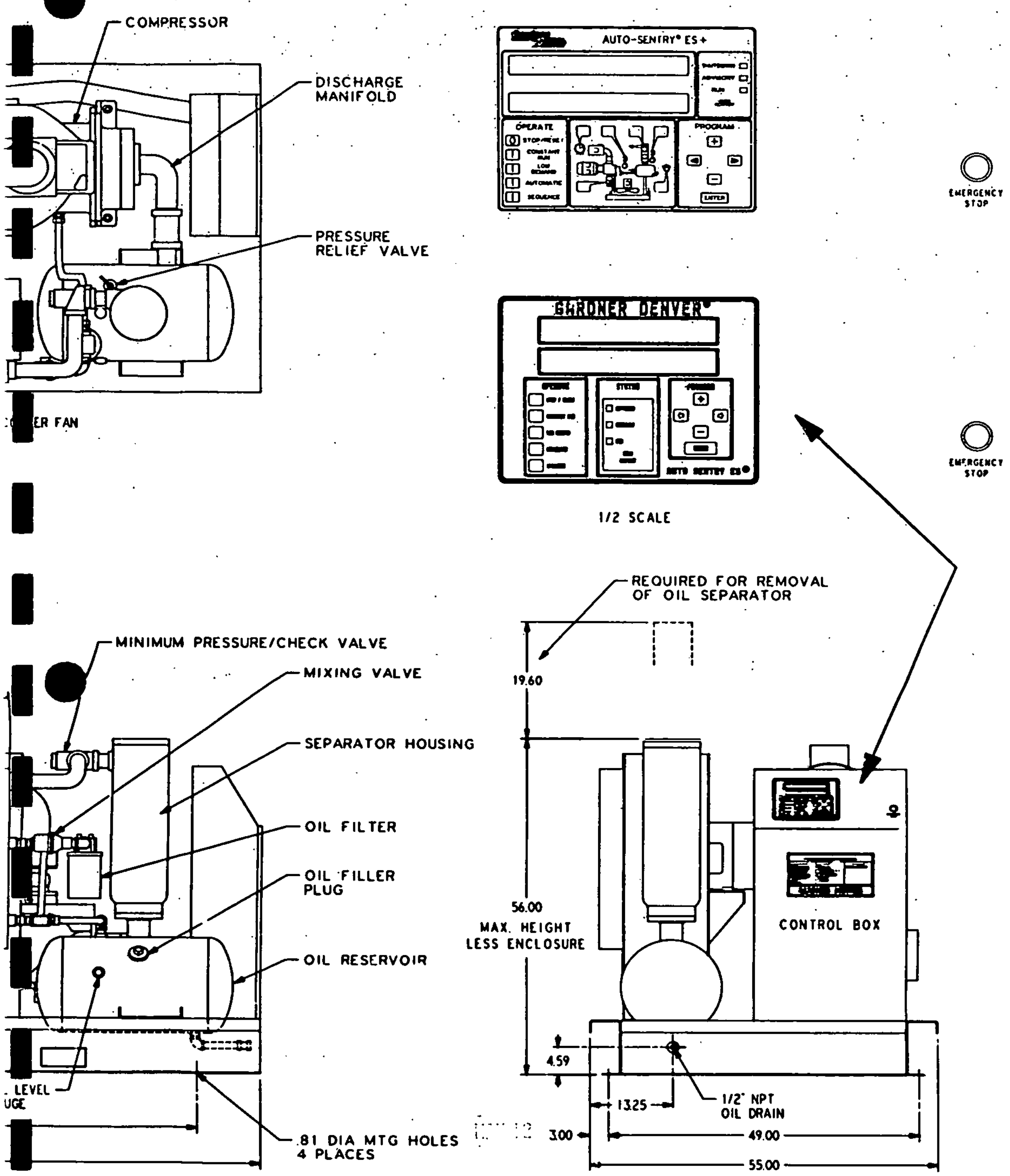
FILE NO B CAD/CAM

THIS PRINT CERTIFIED ONLY FOR:
CUSTOMER NAME _____
ORDER NO. _____
MACHINE SERIAL NO. _____
GARDNER DENVER MACHINERY INC.
QUINCY, ILLINOIS
CERTIFIED BY _____
DATE _____

NOTE:
THIS OUTLINE APPLIES TO THE FOLLOWING MODELS:
EBMOK ---------- 60HP
EBMOL ---------- 75HP
EBPOM ---------- 100HP
EAPOM ---------- 100HP







W.P.

…ASED PER ECN 3951010З

Gardner Denver
Gardner Denver Machinery Inc.
Quincy, Illinois

FOR ALL CURRENT SPECIFICATIONS REFER TO BILL OF MATERIAL

OUTLINE-UNIT/PKG
60,75&100 HP AIR COOLED

RRA

1/8

393EBM894

FILE NO. 8 CAD/CAM

GARDNER DENVER®

13–910–641
9th Edition
January, 1999

ELECTRA–SAVER®

ELECTRA–SAVER II®

STATIONARY BASE–MOUNTED COMPRESSOR

AUTO SENTRY®–ES+ CONTROLS

AUTO SENTRY®–ES CONTROLS

DOMESTIC MODELS
40 – 100 HP
EBH, EBM, EBP & EAP

INTERNATIONAL MODELS
EBM – 45 – 75 KW (60 – 100 HP)

OPERATING AND SERVICE MANUAL

Gardner Denver

MAINTAIN COMPRESSOR RELIABILITY AND PERFORMANCE WITH GENUINE GARDNER DENVER® COMPRESSOR PARTS AND SUPPORT SERVICES

Gardner Denver® Compressor genuine parts, manufactured to design tolerances, are developed for optimum dependability — specifically for Gardner Denver compressor systems. Design and material innovations are the result of years of experience with hundreds of different compressor applications. Reliability in materials and quality assurance are incorporated in our genuine replacement parts.

Your authorized Gardner Denver® Compressor distributor offers all the backup you'll need. A worldwide network of authorized distributors provides the finest product support in the air compressor industry. Your local authorized distributor maintains a large inventory of genuine parts and he is backed up for emergency parts by direct access to the Gardner Denver Master Distribution Center (MDC) in Memphis, Tennessee.

Your authorized distributor can support your Gardner Denver® air compressor with these services:

1. Trained parts specialists to assist you in selecting the correct replacement parts.
2. Factory warranted new and remanufactured rotary screw air ends. Most popular model remanufactured air ends are maintained in stock at MDC for purchase on an exchange basis with liberal core credit available for the replacement unit.
3. A full line of factory tested AEON™ compressor lubricants specifically formulated for use in Gardner Denver compressors.
4. Repair and maintenance kits designed with the necessary parts to simplify servicing your compressor.

Authorized distributor service technicians are factory–trained and skilled in compressor maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair services.

For the location of your local authorized Gardner Denver Air Compressor distributor refer to the yellow pages of your phone directory or contact:

Distribution Center:
Gardner Denver
Master Distribution Center
5585 East Shelby Drive
Memphis, TN 38141
Phone: (901) 542–6100
(800) 245–4946
Fax: (901) 542–6159

Factory:
Gardner Denver
1800 Gardner Expressway
Quincy, IL 62301
Phone: (217) 222–5400
Fax: (217) 224–7814

REMANUFACTURED AIR ENDS

Whenever an air end requires replacement or repair, Gardner Denver offers an industry unique, factory remanufactured air end exchange program. From its modern Remanufacturing Center in Indianapolis, IN, Gardner Denver is committed to supplying you with the highest quality, factory remanufactured air ends that are guaranteed to save you time, aggravation and money.

Immediately Available

Repair downtime costs you money, which is why there are over 200 remanufactured units in inventory at all times, ready for immediate delivery.

Skilled Craftsmen

Our Remanufacturing assembly technicians average over 20 years experience with air compression products.

Precision Remanufacturing

All potentially usable parts are thoroughly cleaned, inspected and analyzed. Only those parts that can be brought back to original factory specifications are remanufactured. Every remanufactured air end receives a new overhaul kit: bearings, gears, seals, sleeves and gaskets.

Extensive Testing

Gardner Denver performs testing that repair houses just don't do. Magnaflux and ultrasonic inspection spot cracked or stressed castings, monochromatic light analysis exposes oil leaks, and coordinate measurement machine inspects to +/– .0001", insuring that all remanufactured air ends meet factory performance specifications.

Warranty

Gardner Denver backs up every remanufactured air end with a new warranty . . . 18 months from purchase, 12 months from service.

Gardner Denver remanufactured air ends deliver *quality without question . . . year in and year out.*

Call Gardner Denver for information on the air end exchange program and the name of your authorized distributor.

Phone Number: 800–245–4946 or
FAX: 901–542–6159

FOREWORD

Gardner Denver Rotary Screw compressors are the result of advanced engineering and skilled manufacturing. To be assured of receiving maximum service from this machine the owner must exercise care in its operation and maintenance. This book is written to give the operator and maintenance department essential information for day–to–day operation, maintenance and adjustment. Careful adherence to these instructions will result in economical operation and minimum downtime.

⚠ DANGER

Danger is used to indicate the presence of a hazard which will cause severe personal injury, death, or substantial property damage if the warning is ignored.

⚠ WARNING

Warning is used to indicate the presence of a hazard which can cause severe personal injury, death, or substantial property damage if the warning is ignored.

⚠ CAUTION

Caution is used to indicate the presence of a hazard which will or can cause minor personal injury or property damage if the warning is ignored.

NOTICE

Notice is used to notify people of installation, operation or maintenance information which is important but not hazard–related.

This book covers the following models:

DOMESTIC MODELS:

HP	PSIG	Model	Parts List	Controller Manual
40, 50	100, 125	EBH99D	13–9–555	13–910–647
	100, 125, 150	EBH99E	13–9–561	13–910–647
60, 75	100, 125, 150	EBM99F	13–9–560	13–910–647
		EBM99H	13–9–562	13–910–647
100	100, 125, 150	EBP99D	13–9–560	13–910–647
		EBP99E	13–9–562	13–910–647
		EBP99F	13–9–566	13–910–647
		EAP99E	13–9–560	13–910–647
		EAP99F	13–9–566	13–910–647

INTERNATIONAL MODELS:

HP (KW)	PSIG (BARS)	Model	Parts List	Controller Manual
60, 75, 100 (45, 55, 75)	100, 125, 150 (6.9, 8.6, 10.3)	EBM99G	13–9–557X	13–910–647

INSTRUCTIONS FOR ORDERING REPAIR PARTS

When ordering parts, specify Compressor MODEL, Method of Cooling, HORSEPOWER and SERIAL NUMBER (see nameplate on unit). The Serial Number is also stamped on top of the cylinder flange to the right of the inlet housing.

All orders for Parts should be placed with the nearest authorized distributor.

Where NOT specified, quantity of parts required per compressor or unit is one (1); where more than one is required per unit, quantity is indicated in parenthesis. SPECIFY EXACTLY THE NUMBER OF PARTS REQUIRED.

DO NOT ORDER BY SETS OR GROUPS.

To determine the Right Hand and Left Hand side of a compressor, stand at the motor end and look toward the compressor. Right Hand and Left Hand are indicated in parenthesis following the part name, i.e. (RH) & (LH), when appropriate.

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SECTION 1
GENERAL INFORMATION

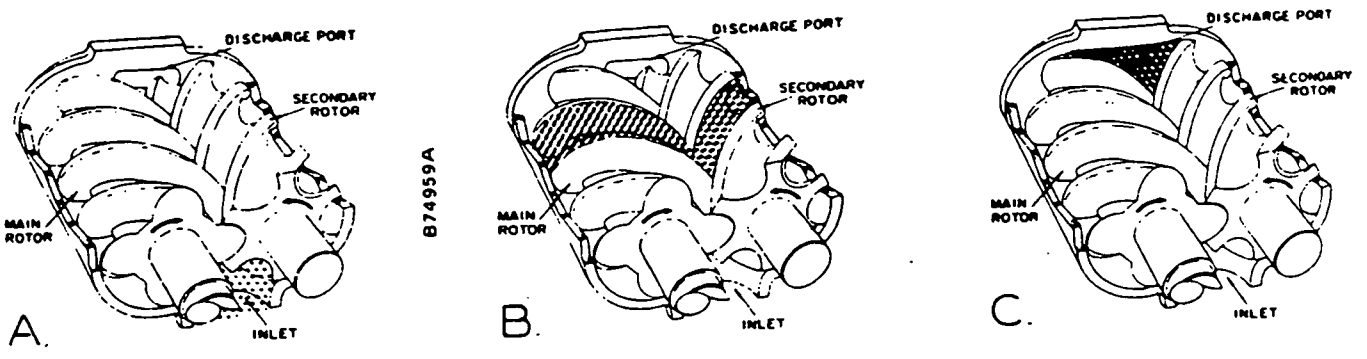


FIGURE 1–1 – COMPRESSION CYCLE

COMPRESSOR – The Gardner Denver Rotary Screw compressor is a single stage, positive displacement rotary machine using meshing helical rotors to effect compression. Both rotors are supported between high capacity roller bearings located outside the compression chamber. Single width cylindrical roller bearings are used at the inlet end of the rotors to carry part of the radial loads. Tapered roller bearings at the discharge end locate each rotor axially and carry all thrust loads and the remainder of the radial loads.

COMPRESSION PRINCIPLE (FIGURE 1–1) – Compression is accomplished by the main and secondary rotors synchronously meshing in a one–piece cylinder. The main rotor has four (4) helical lobes 90° apart. The secondary rotor has six (6) matching helical grooves 60° apart to allow meshing with main rotor lobes.

The air inlet port is located on top of the compressor cylinder near the drive shaft end. The discharge port is near the bottom at the opposite end of the compressor cylinder. *Figure 1–1 is an inverted view to show inlet and discharge ports.* The compression cycle begins as rotors unmesh at the inlet port and air is drawn into the cavity between the main rotor lobes and secondary rotor grooves (A). When the rotors pass the inlet port cutoff, air is trapped in the interlobe cavity and flows axially with the meshing rotors (B). As meshing continues, more of the main rotor lobe enters the secondary rotor groove, normal volume is reduced and pressure increases.

Oil is injected into the cylinder to remove the heat of compression and seal internal clearances. Volume reduction and pressure increase continues until the air/oil mixture trapped in the interlobe cavity by the rotors passes the discharge port and is released to the oil reservoir (C). Each rotor cavity follows the same "fill–compress–discharge" cycle in rapid succession to produce a discharge air flow that is continuous, smooth and shock free.

AIR FLOW IN THE COMPRESSOR SYSTEM (FIGURE 5–1, page 34) – Air enters the air filter and passes through the inlet unloader valve to the compressor. After compression, the air/oil mixture passes into the oil reservoir where most of the entrained oil is removed by velocity change and impingement and drops back into the reservoir. The air and remaining oil passes into the separator and separator housing where the oil is separated and passes through tubing connecting the separator housing and compressor. The air passes through the minimum pressure valve, discharge check valve and cooler, then to the plant air lines.

LUBRICATION, COOLING AND SEALING – Oil is forced by air pressure from the oil reservoir through the oil cooler, thermostatic mixing valve, and oil filter and discharges into the compressor main oil gallery. A portion of the oil is directed through internal passages to the bearings, gears and shaft oil seal. The balance of the oil is injected directly into the compression chamber to remove heat of compression, seal internal clearances and lubricate the rotors.

TURN VALVE (EAP UNITS ONLY) – The turn valve is a rotary helical valve located on the discharge side of the cylinder toward the inlet end. The valve opens and closes ports in the cylinder which communicates with the inlet passage. This varies the compressor rotor volume to match the demand for air, thus reducing the part–load power requirement.

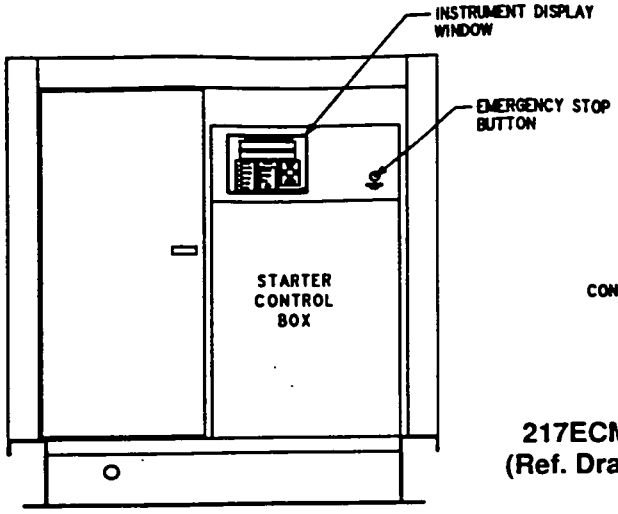


FIGURE 1–2 – STARTER BOX

217ECM797
(Ref. Drawing)

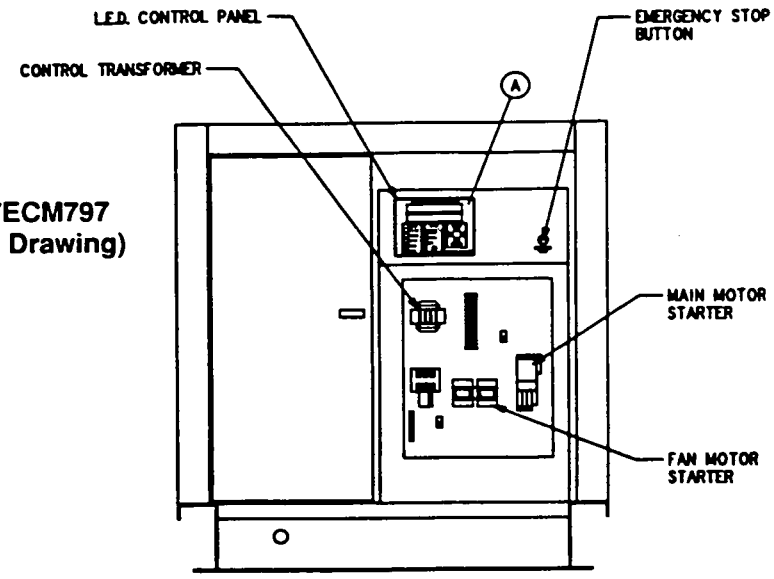
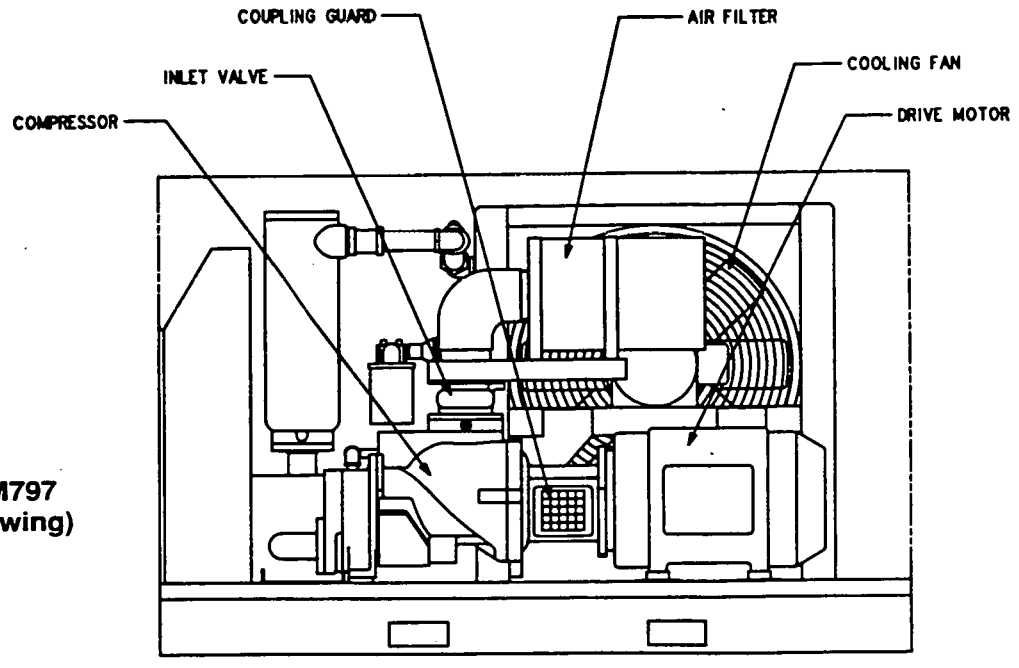


FIGURE 1–3 – PACKAGE – CONTROLLER & STARTERS



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(Ref. Drawing)

FIGURE 1–4 – PACKAGE – DRIVE MOTOR & AIR FILTER

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(Ref. Drawing)

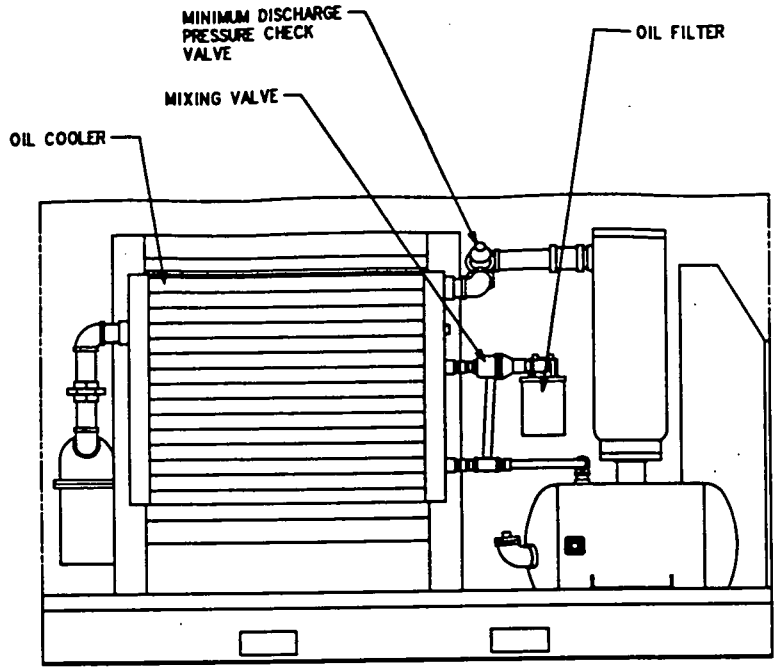


FIGURE 1–5 – PACKAGE – OIL FILTER, OIL LEVEL GAUGE, MIXING VALVE, MINIMUM PRESSURE VALVE & CHECK VALVE

219ECM797–A
(Ref. Drawing)

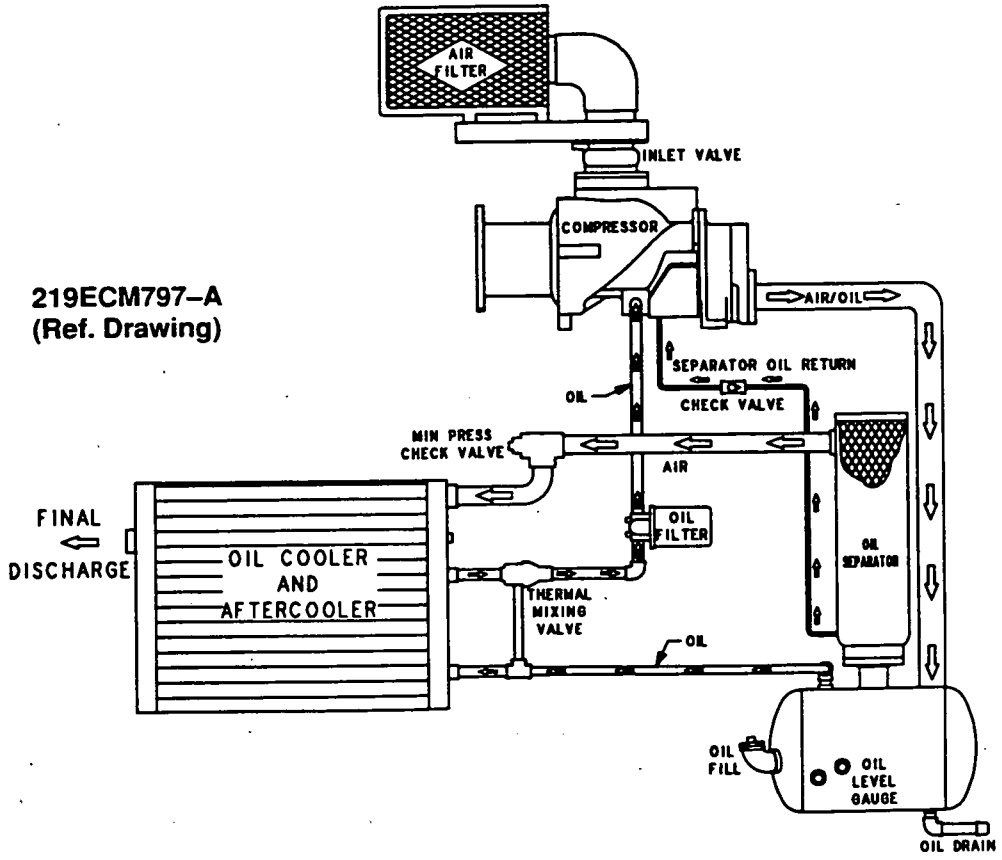


FIGURE 1–6 – PACKAGE – AIR/OIL FLOW DIAGRAM

SAFETY PRECAUTIONS

Safety is everybody's business and is based on your use of good common sense. All situations or circumstances cannot always be predicted and covered by established rules. Therefore, use your past experience, watch out for safety hazards and be cautious.

Some general safety precautions are given below:

⚠ DANGER

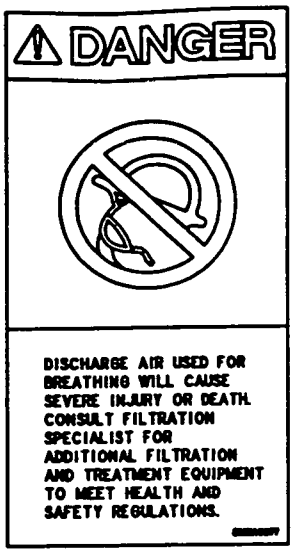
Failure to observe these notices could result in injury to or death of personnel.

- **Keep fingers and clothing away from revolving fan, drive coupling, etc.**
- **Do not use the air discharge from this unit for breathing – not suitable for human consumption.**
- **Do not loosen or remove the oil filler plug, drain plugs, covers, the thermostatic mixing valve or break any connections, etc., in the compressor air or oil system until the unit is shut down and the air pressure has been relieved.**
- **Electrical shock can and may be fatal.**
- **Compressor unit must be grounded in accordance with the National Electrical Code. A ground jumper equal to the size of the equipment ground conductor must be used to connect the compressor motor base to the unit base.**
- **Fan motors must remain grounded to the main base through the starter mounting panel in accordance with the National Electrical Code.**
- **Open main disconnect switch, tag and lockout before working on the control.**
- **Disconnect the compressor unit from its power source, tag and lockout before working on the unit – this machine is automatically controlled and may start at any time.**

⚠ WARNING

Failure to observe these notices could result in damage to equipment.

- Stop the unit if any repairs or adjustments on or around the compressor are required.
- Disconnect the compressor unit from its power source, tag and lockout before working on the unit – this machine is automatically controlled and may start at any time.
- An Excess Flow Valve should be on all compressed air supply hoses exceeding 1/2 inch inside diameter. (OSHA Regulation, Section 1926.302)
- Do not exceed the rated maximum pressure values shown on the nameplate.
- Do not operate unit if safety devices are not operating properly. Check periodically. Never bypass safety devices.



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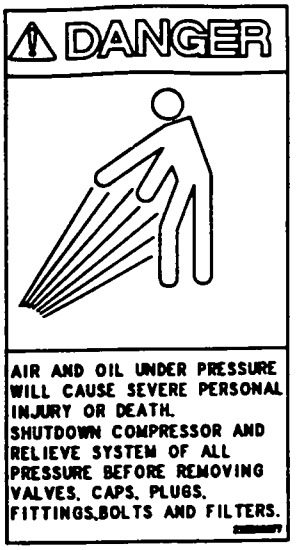

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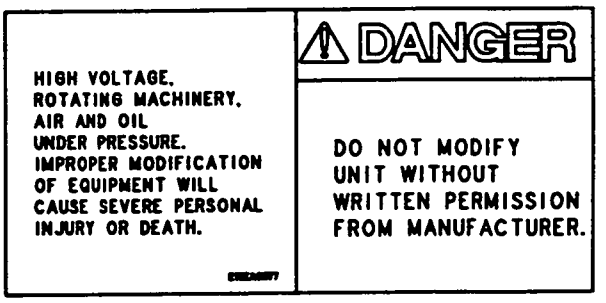

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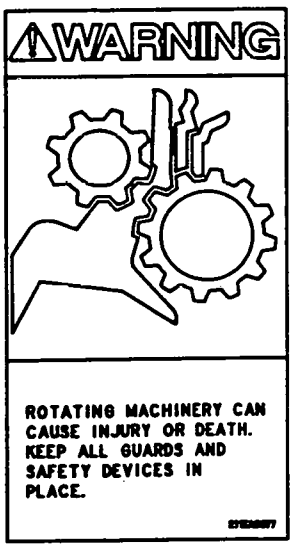

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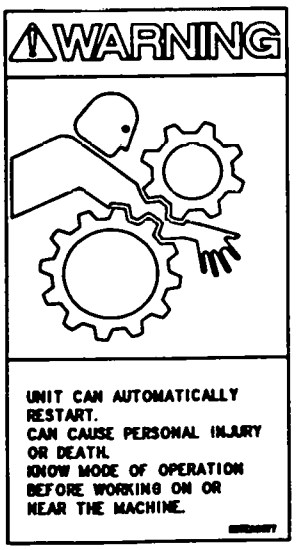

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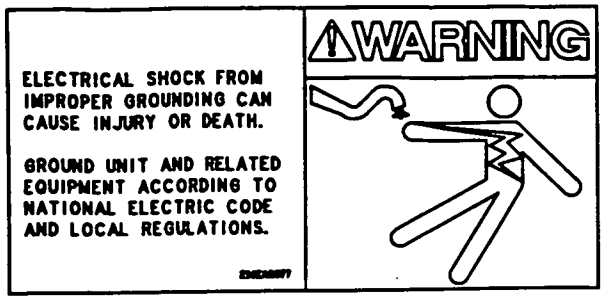

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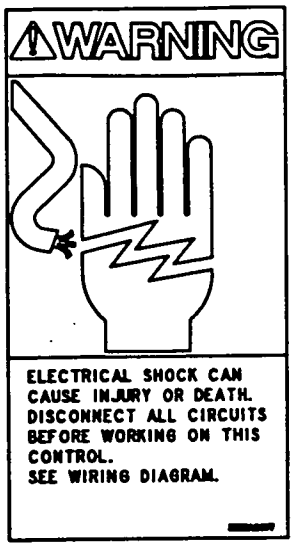

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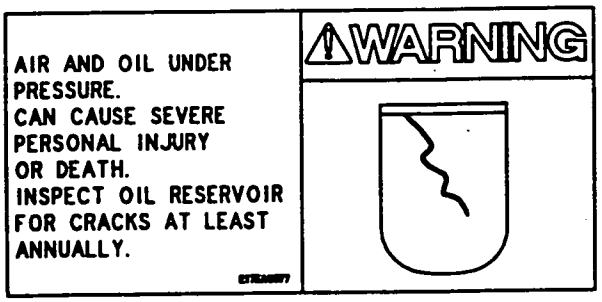

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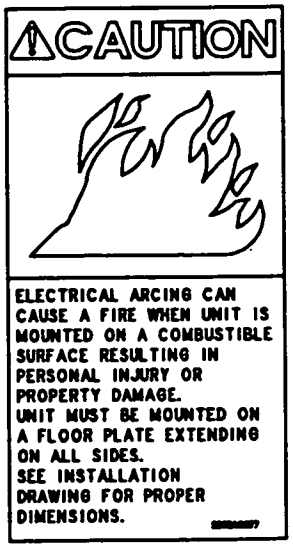

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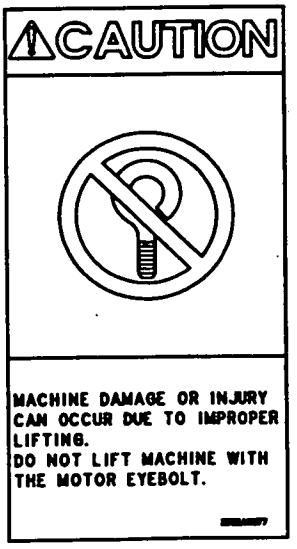

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SECTION 2
INSTALLATION

GENERAL – On receipt of the unit, check for any damage that may have been incurred during transit. Report any damage or missing parts as soon as possible.

> **⚠ CAUTION**
>
> **Do not electric weld on the compressor or base; bearings can be damaged by passage of current.**

LIFTING UNIT – Proper lifting and/or transporting methods must be used to prevent damage. Lifting slots are provided in the base for towmotor use. The unit may also be moved into location by rolling on bars.

> **⚠ CAUTION**
>
> **Lift compressor unit by base only. Do not use other places such as motor, compressor or discharge manifold piping as lifting points.**

> **⚠ DANGER**
>
> **The eyebolts or lugs provided on the motor are for lifting the motor only and should not be used to lift any additional weight. All eyebolts must be securely tightened. When lifting the motor the lifting angle must not exceed 15 degrees. Failure to observe this warning may result in damage to equipment or personal injury.**

> **⚠ DANGER**
>
> **Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.**

LOCATION – The compressor should be installed, whenever possible, in a clean, well–lighted, well–ventilated area with ample space all around for maintenance. Select a location that provides a cool, clean, dry source of air. In some cases it may be necessary to install the air filter at some distance from the compressor to obtain proper air supply.

Both the air–cooled and water–cooled units require cooling air as well as air to the compressor inlet. Proper ventilation MUST be provided; hot air must be exhausted from the compressor operating area. A typical inlet–outlet air flow arrangement is shown in FIGURE 2–1.

Air–Cooled Units – A combination oil/aftercooler is supplied as standard equipment on all air–cooled units. The air–cooled unit with the standard enclosure requires sufficient flow, FIGURE 2–2, page 9, for the compressor oil/aftercooling system and for electric motor cooling. Air is drawn into the unit at the motor side of the enclosure and is exhausted at the oil cooler side. Do not block the air flow to and from the unit. Allow three and one–half (3–1/2) feet (1.1 M) to the nearest obstruction on the starter end and control box end of the unit. Allow three (3) feet (.9 M) to the nearest obstruction above and on other sides of unit. For continuous efficiency, oil cooler cores must be periodically cleaned with either vacuum or compressed air. If wet cleaning is required, shield motor and spray on a mild soap solution and flush with clean water.

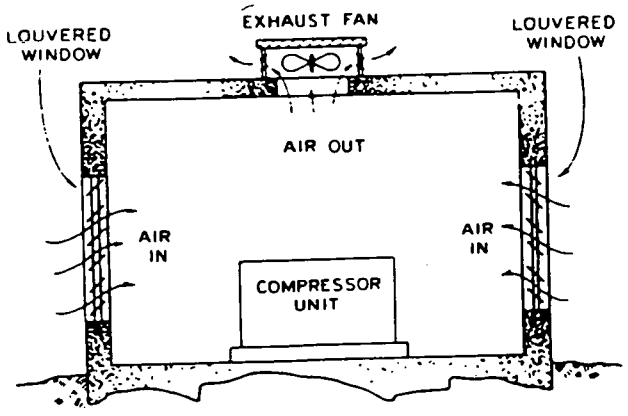


FIGURE 2–1 – TYPICAL COMPRESSOR ROOM

Minimum Air Flow * For Compression And Cooling – Cubic Feet/Minute (Cubic Meters/Minute)		
HP (KW)	Air Cooled	Water Cooled
40 & 50 HP	6,500	1,400
60–100 HP	12,500	1,700
(45–75 KW)	(354)	(48)

* 80° F (27° C) Inlet Air

FIGURE 2–2 – AIR FLOW CHART

⚠ WARNING

For aluminum oil coolers, do not use any cleaning solution that is not compatible with aluminum. Use of improper solution may result in damage to the cooler.

Water–Cooled Units – The water–cooled unit with the standard enclosure requires sufficient air flow, FIGURE 2–2, for electric motor cooling. Air is drawn into the unit at the top of the enclosure and is exhausted at the motor side. Do not block air flow to and from unit. Allow three and one–half (3–1/2) feet (1.1 M) to the nearest obstruction on the starter end and control box side of the unit. Allow three (3) feet (.9 M) to the nearest obstruction above and on other sides of the unit.

FOUNDATION – The G–D Rotary Screw compressor requires no special foundation, but should be mounted on a smooth, solid surface. Whenever possible install the unit near level. Temporary installation may be made at a maximum 10° angle lengthwise or 10° sidewise.

Mounting bolts are not normally required. However, installation conditions such as piping rigidity, angle of tilt, or danger of shifting from outside vibration or moving vehicles may require the use of mounting bolts and shims to provide uniform support for the base.

OIL RESERVOIR DRAIN – The oil drain is piped from the bottom of the reservoir to the side of the frame. This drain is approximately 4.50 inches (115 mm) above the floor level. If this is not sufficient to conveniently drain the oil some other methods of providing drain are:

1. Elevate the compressor unit on a suitable structure to obtain the desired drain height.

⚠ CAUTION

If the compressor unit base is raised above floor level, the space between the floor and the base bottom must be closed with solid material all around to prevent recirculation of hot air from the oil cooler end and over temperature operation.

2. Construct an oil sump or trough below the floor level and pump or bail the drained oil.
3. Pump oil from the reservoir filler opening or drain to a container.

ENCLOSURE – The compressor, electric motor, oil cooler and aftercooler are mounted inside the enclosure. Service doors are provided for maintenance access. Be sure to allow enough space around the unit for the doors to open completely. Any of the enclosure doors may be removed by opening the door and lifting it up slightly to disengage the hinges.

⚠ DANGER

Do not operate the compressor with the fan and coupling guard removed. Exposed fan and belts may cause injury to personnel.

The motor inspection/air filter service panel is held by two latches and lifts away from the enclosure. The air outlet panel is attached by screws to the enclosure and is not readily removeable.

INSTALLATION FOR COLD WEATHER OPERATION (FIGURE 2–3, page 10) – It is recommended that the unit be installed inside a shelter that will be heated to temperatures above freezing (32°F, 0°C). This will eliminate many of the problems associated with operating units in cold climates where freezing rain, drifting snow, freezing condensate and bitter cold temperatures are encountered.

Refer to Engineering Data Sheet 13–9–411 for the advantages of using the heat recovered from rotary compressors. This heat recovery could easily pay for an adequate shelter for the unit.

When an outside installation must be made, the precautions required will depend on the severity of the environment. The following are general guidelines for outside installations:

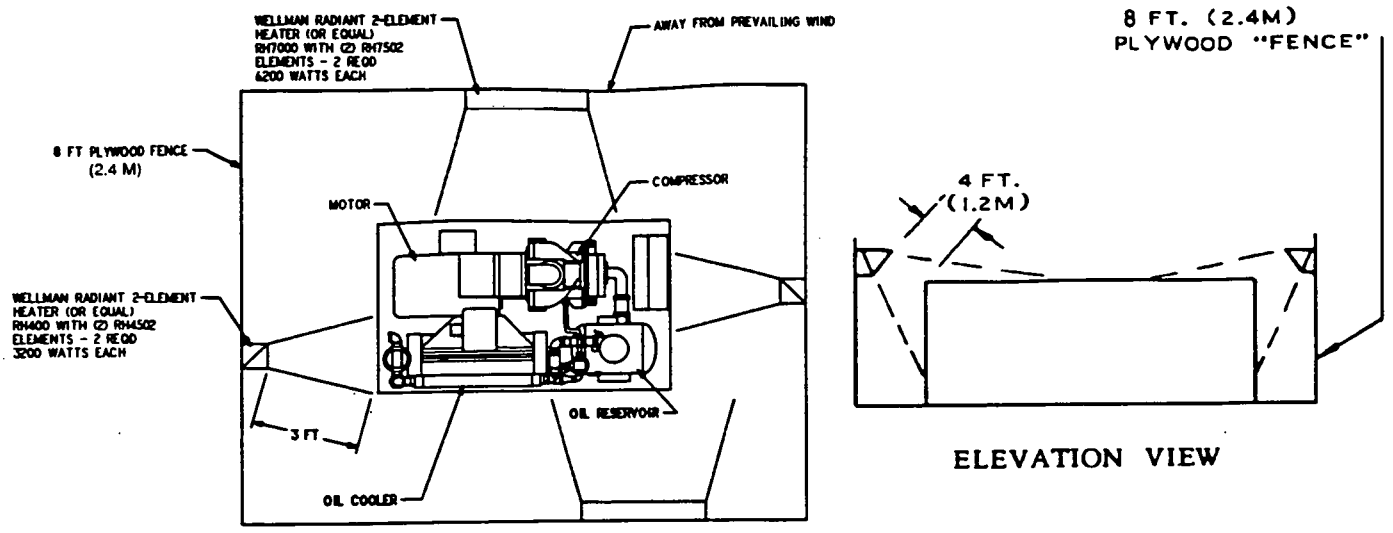


FIGURE 2–3 – COLD WEATHER INSTALLATION

Cold Weather (Down To +10°F, –12°C)

1. Be sure all drains, traps, and control lines, including pressure transducer lines are heated to avoid freezing of condensate. Heat tape with thermostat control is generally satisfactory for this purpose and can be obtained at various local plumbing or hardware outlets at nominal cost.

2. If an air–cooled aftercooler is to be used, provisions to bypass the aftercooler must be made. Since cold air contains very little moisture, successful operation can be achieved without the aftercooler.

3. Provide at least some simple shelter such as a plywood windbreak to protect against drifting snow.

4. Use only Gardner Denver® AEON™ 9000 SP lubricant.

5. Monitor the unit carefully during start–up and operation to be sure it is functioning normally.

6. Specify NEMA 4 enclosure for electrical devices.

Extreme Cold Weather Operation (Down To –40°F, –40°C)

In addition to the above, the following should be provided:

1. It will be necessary to provide shutters or to block off part of the cooler in some manner since the cooler is greatly oversized for operation in these low temperatures. Since shutters are not provided as a factory option, blocking off a portion of the cooler with plywood should be satisfactory.

2. Auto operation should not be used in extreme environments.

3. Some means of providing heat during shutdown should be provided. There are various methods to accomplish this, but since openings are not provided for sump heaters, the use of radiant heaters is recommended. The heaters should be sized to provide at least a +10°F (–12°C) environment for coolers, motor and sump. FIGURE 2–3, page 10, shows how these might be located in a typical installation and sizes required.

Remember unsheltered (outside) installations should be avoided where possible. Installation next to a heated building where enough heat can be used to keep the compressor room above freezing will save many complications in the operation and installation of the unit.

Refer to Engineering Data Sheet 13–9–411, available from an authorized Gardner Denver distributor, for the advantages of using the heat recovered from rotary compressors. This heat recovery could easily pay for an adequate shelter for the unit.

AUXILIARY AIR RECEIVER – An auxiliary air receiver is not required if the piping system is large and provides sufficient storage capacity to prevent rapid cycling. When used, an air receiver should be of adequate size, provided with a relief valve of proper setting, a pressure gauge and a means of draining condensate. A means of draining condensate will need to be provided for.

MOISTURE SEPARATOR/TRAP – Since the unit is equipped with a built–in aftercooler, a combination moisture separator and trap is furnished with the unit.

Length of Inlet Line	Diameter of Pipe Size
0 to 10 Feet (0 to 3 Meters)	Same as Compressor Inlet Opening
10 to 17 Feet (3 to 5 Meters)	One Size Larger Than Inlet Opening
17 to 38 Feet (5 to 11.5 Meters)	Two Sizes Larger Than Inlet Opening

FIGURE 2–4 – INLET LINE LENGTHS

CONTROL PIPING – Control piping is not necessary since the Electra–Screw® unit is factory wired and piped for the control system specified.

INLET LINE – Where an inlet line is used between the air filter and the compressor, it must be thoroughly cleaned on the inside to prevent dirt or scale from entering the compressor. **If welded construction is used, the line must be shot blasted and cleaned to remove welding scale.** In either case, the inlet line must be coated internally by galvanizing or painting with a moisture and oil–proof sealing lacquer. Up to ten (10) feet (3 meters) in length, the inlet line should be the full size of the inlet opening on the compressor. If an extra–long line is necessary, the pipe size should be increased according to Inlet Line Length Chart, FIGURE 2–4.

HEAT EXCHANGER (DOMESTIC)							
HP	Model	Water Temperature to Heat Exchanger Gallons/minute				Maximum Water Flow GPM*	Approx. Water Pressure Drop @ 90° F Water Temp. PSI
		60° F.	70° F.	80° F.	90° F.		
40 HP	EBHSH_	3.4	4.3	5.7	8.6	30.0	1.0
50 HP	EBHSJ_	4.1	5.1	6.8	10.2	30.0	1.5
60 HP	EBMSK_	5.0	6.2	8.3	12.5	40.8	2.0
75 HP	EBMSL_	6.0	7.6	10.1	15.1	40.8	1.5
100 HP 100 HP	EBPSM_ EAPSM_	8.4 8.4	10.5 10.5	14.1 14.1	21.1 21.1	40.8 40.8	5.0 5.0

HEAT EXCHANGER (INTERNATIONAL)							
KW	Model	Water Temperature to Heat Exchanger Liters/Second				Maximum Water Flow L/S *	Approx. Water Press. Drop @ 32° C. Water Temp. Bar
		16° C.	21° C.	27° C.	32° C.		
45 KW	EBMSK_	.32	.39	.52	.79	2.57	.14 Bar
55 KW	EBMSL_	.44	.54	.73	1.09	2.57	.10 Bar
75 KW	EBMSM_	.58	.73	.97	1.44	2.57	.35 Bar

* Flows exceeding "Maximum Water Flow" will cause severe erosion and will void unit warranty.

FIGURE 2–5 – HEAT EXCHANGER (OIL COOLER) APPROXIMATE WATER FLOW

AFTERCOOLER (DOMESTIC)							
HP	Model	Water Temperature to Heat Exchanger Gallons/minute				Maximum Water Flow GPM*	Approx. Water Pressure Drop @ 90° F Water Temp. PSI
		60° F.	70° F.	80° F.	90° F.		
40 HP	EBHSH_	.5	.7	.9	1.3	26.0	Less than 1 PSI for any flow rate shown in the table.
50 HP	EBHSJ_	.7	.9	1.2	1.8	26.0	
60 HP	EBMSK_	.8	1.0	1.4	2.1	26.0	
75 HP	EBMSL_	1.2	1.5	2.0	3.0	26.0	
100 HP 100 HP	EBPSM_ EAPSM_	1.7 1.7	2.1 2.1	2.8 2.8	4.1 4.1	26.0 26.0	

AFTERCOOLER (INTERNATIONAL)							
KW	Model	Water Temperature to Heat Exchanger Liters/Second				Maximum Water Flow L/S *	Approx. Water Press. Drop @ 32° C. Water Temp. Bar
		16° C.	21° C.	27° C.	32° C.		
45 KW	EBMSK_	.05	.06	.09	.13	1.64	Less than .1 Bar for any flow rate shown in the table.
55 KW	EBMSL_	.08	.09	.13	.19	1.64	
75 KW	EBMSM_	.11	.13	.18	.26	1.64	

* Flows exceeding "Maximum Water Flow" will cause severe erosion and will void unit warranty.

FIGURE 2–6 – AFTERCOOLER APPROXIMATE WATER FLOW

Accessibility for inlet air filter servicing must be considered when relocating the filters from the unit to a remote location.

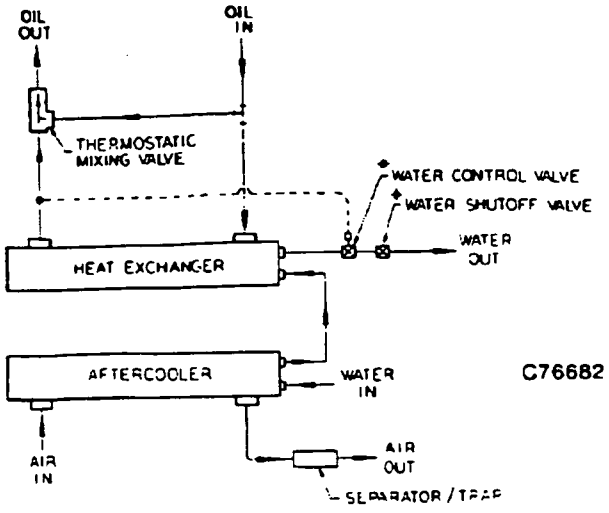
DISCHARGE SERVICE LINE – The discharge service line connection on both water–cooled and air–cooled units is made at the right hand corner of the unit, viewed from the opposite end from control panel side. When manifolding two or more rotary screw units on the same line, each unit is isolated by the check valve in the unit discharge line. If a rotary screw unit is manifolded to another compressor, be sure the other compressor has a check valve in the line between the machine and the manifold. If a rotary screw and a reciprocating compressor are manifolded together, an air receiver must be located between the two units.

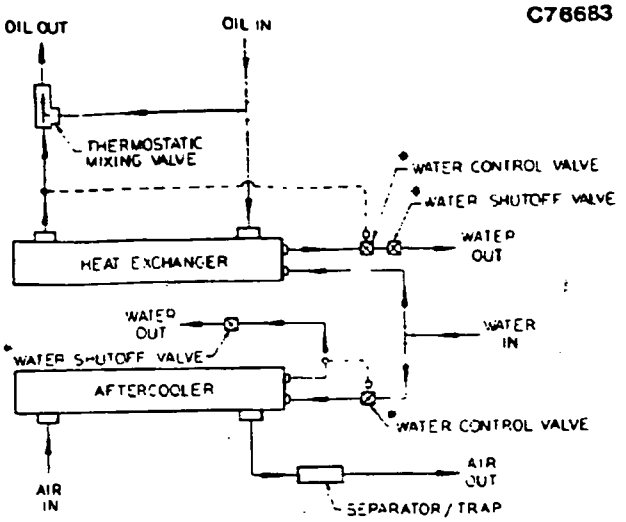
⚠ DANGER

Discharge air used for breathing will cause severe injury or death.

Consult filtration specialists for additional filtration and treatment equipment to meet health and safety standards.

BLOWDOWN VALVE PIPING – The blowdown valve is fitted with a muffler for operation indoors. If the installation requires, the muffler may be removed and the





* (OPTIONAL) WATER CONTROL VALVE AND WATER SHUTOFF VALVE MUST BE ORDERED SEPARATELY.

FIGURE 2–7 – SERIES PIPING

FIGURE 2–8 – PARALLEL PIPING

blowdown valve piped to the outside with a pipe size the same as the blowdown valve outlet connection.

WATER PIPING (Water–Cooled Heat Exchanger Models Only) – On machines equipped with water–cooled heat exchangers, the water inlet and outlet connections are located in the unit base flange on the left side of the unit.

⚠ WARNING

It is mandatory that any water cooled unit be installed in a shelter heated to temperatures above freezing (32° F., 0° C).

The water source should be capable of supplying up to the maximum flow shown in FIGURE 2–5, page 11, and FIGURE 2–6, page 12, at a minimum pressure of 40 psig (2.8 Bars); maximum allowable water pressure is 150 psig (10.3 Bars). The water flow rates shown are approximate and a guide to sizing piping, cooling tower and other water system equipment.

The heat exchanger system is designed to operate with water inlet temperatures from 60° to 90° F (16° to 32° C) and a water outlet temperature not to exceed 110°F (43° C). If water cooler than 60° F is used, high water outlet temperatures (over 110° F, 43° C) will be experienced along with shortened heat exchanger life caused by tube fouling and corrosion. If water warmer than 90° F (32° C) is used, higher compressor oil inlet temperatures and high water usage will result.

Most water systems will require control of impurities: filtration, softening or other treatment. See "Compressor Oil Cooler – Water–Cooled Heat Exchanger" for more information on the water system.

SERIES PIPING (FIGURE 2–7) – Water flow must be through aftercooler first for effective cooling of discharge air and is so piped on the standard water–cooled unit.

PARALLEL PIPING (FIGURE 2–8) – A separate water control valve is required to control the discharge air temperature. If a remote (externally mounted) water–cooled aftercooler is piped in parallel with the heat exchanger, provide a separate water control valve for the aftercooler and pipe separate inlet water lines to both the aftercooler and heat exchanger.

The water control valve is to be adjusted to maintain oil out of the heat exchanger within the 140° to 150° F (60° to 66° C) range regardless of inlet water flow or temperature as long as a minimum flow for a given temperature is met (FIGURE 2–5, page 11, and FIGURE 2–6, page 12. See Section 5, page 33, for ad-

justment instructions and maximum allowable lubricant temperature.

ELECTRICAL WIRING – Standard Units – The Electra–Saver® compressor is factory wired for all starter to motor and control connections for the voltage specified on the order. It is necessary only to connect the unit starter to the correct power supply. The standard unit is supplied with an open drip–proof motor, a NEMA 12 starter and control enclosure. See "Location" paragraph, page 8, for distance to the nearest obstruction on starter and control box sides of the unit.

Lower operating voltages (200/208) require that the unit starter be remote mounted since the starter is too large to be mounted within the control enclosure. If not supplied with the compressor unit, the starter is to be a size 6 full voltage non–reversing type in NEMA (CEMA) enclosure suitable for the environment, with two (2) rejection type control circuit fuses (size according to motor starter manufacturer's standard), a 200 (208) volt coil, and three (3) overload heaters for 200 (208) volt 100 HP (75 KW), 1.15 service factor motor.

The overload heaters are to be selected according to starter manufacturer's tables based on motor nameplate full load amperage.

⚠ WARNING

Electrical shock can cause injury or death. Open main disconnect switch, tag and lockout before working on starter/control box.

GROUNDING – Equipment must be grounded in accordance with Table 250–95 of the National Electrical Code.

⚠ WARNING

Failure to properly ground the compressor package could result in controller malfunction.

MOTOR LUBRICATION – Long time satisfactory operation of an electric motor depends in large measure on proper lubrication of the bearings. The following charts show recommended grease qualities and regreasing intervals for ball bearing motors. For additional information refer to the motor manufacturer's instructions. The following procedure should be used in regreasing:

1. Stop the unit.
2. Disconnect, tag and lockout the unit from the power supply.
3. Remove the relief plug and free hole of hardened grease.
4. Wipe lubrication fitting clean and add grease with a hand–operated grease gun. Only enough grease should be added to replace the grease used by the bearing. Too much grease can be as harmfull as insufficient grease. The grease cavity should be about 1/2 full.
5. Leave the relief plug temporarily off. Reconnect the unit and run for about 20 minutes to expell the excess grease.
6. Stop the unit. Replace the relief plug.
7. Restart the unit.

⚠ WARNING

Rotating machinery can cause injury or death. Open main disconnect, tag and lockout power supply to the starter before working on the electric motor.

ELECTRIC MOTOR GREASE RECOMMENDATIONS (–30° to 50° C)

MANUFACTURER	TRADE NAME
CHEVRON	SRI #2
SHELL	DOLIUM R
EXXON	UNIREX #2
EXXON	POLYREX

ELECTRIC MOTOR REGREASING INTERVAL

Type of Service	Typical Examples	Rating	Relubrication Interval
Standard	One– or Two–Shift Operation	Up to 150 HP (112 KW)	18 Months
		Above 150 HP (112 KW)	12 Months
Severe	Continuous Operation	Up to 150 HP (112 KW)	9 Months
		Above 150 HP (112 KW)	6 Months
Very Severe	Dirty Locations, High Ambient Temperature	Up to 150 HP (112 KW)	4 Months
		Above 150 HP (112 KW)	2 Months

SECTION 3
STARTING & OPERATING PROCEDURES

PRESTART–UP INSTRUCTIONS – A new unit as received from the factory has been tested and then prepared for shipping only. Do not attempt to operate the unit until checked and serviced as follows:

1. **Compressor Oil** – Check the oil level in the reservoir. Add oil only if the oil level gauge reads in the red "ADD OIL" range. Do not mix different type oils. The unit is shipped filled with Gardner Denver AEON™ 9000 SP Lubricating Coolant which is suitable for the first 8000 hours under normal operating conditions.

   REPLACE OIL FILTER EVERY 1000 HOURS.

   Initial fill, or filling after a complete draining of the system, may show the oil level in the yellow "EXCESS OIL" range. After start–up, the oil will fall into the green operating range as system components are filled. If necessary, add oil to bring the level to the top of the green range as read when the unit is operating at full load and normal pressure. See FIGURE 5–5, page 38.

NOTICE

Regular maintenance and replacement at required intervals of the oil filter, air filter and air–oil separator is necessary to achieve maximum service and extended drain intervals of AEON™ 9000 SP synthetic lubricant. Use only genuine Gardner Denver filters designed and specified for this compressor.

⚠ DANGER

Before removing the oil filler plug, always stop the unit and release air pressure, tag and lockout the power supply to the starter. Failure to release pressure or properly disconnect the power may result in personal injury or death.

During unloaded operation and after shutdown, the system will partially drain back into the oil reservoir and the oil level may read higher than when operating on load. DO NOT DRAIN OIL TO CORRECT; on the next loaded cycle or start, oil will again fill the system and the gauge will indicate the operating level.

2. **Air Filter** – Inspect the air filter to be sure it is clean and tightly assembled. Refer to Section 6, "Air Filter," page 45, for complete servicing instructions. Be sure the inlet line, if used, is tight and clean.
3. **Coupling** – Check all bolts and cap screws for tightness. See Section 7, page 47.
4. **Piping** – Refer to Section 2, "Installation," page 8, and make sure piping meets all recommendations.
5. **Electrical** – Check the wiring diagrams furnished with the unit to be sure it is properly wired. See FIGURE 4–13 thru FIGURE 4–15, pages 30 thru 32, for general wiring diagrams and Section 2, page 8 for installation instructions.
6. **Grounding** – Equipment must be properly grounded according to Table 250–95 of the National Electrical Code.

⚠ WARNING

Failure to properly ground the compressor package could result in controller malfunction.

7. **Rotation** – Check for correct motor rotation using "JOG MODE." Compressor drive shaft rotation must be clockwise standing facing the compressor coupling.

⚠ WARNING

Operation with incorrect motor rotation can damage equipment and cause oil eruption from the compressor inlet. When checking motor rotation, induce minimum rotation (less than one revolution if possible). Never allow motor to reach full speed.

8. **System Pressure** – Set the controls to the desired load pressure. DO NOT EXCEED THE MAXIMUM OPERATING PRESSURE ON THE COMPRESSOR NAMEPLATE. See Controller Manual 13–9/10–647.

⚠ WARNING

Operation at excessive discharge air pressure can cause personal injury or damage to equipment. Do not adjust the full discharge air pressure above the maximum stamped on the unit nameplate.

9. **Operating Mode** – Refer to Section 4 for detailed information on the control system.

10. **Enclosure** – Check for damaged panels or doors. Check all screws and latches for tightness. Be sure doors are closed and latched.

STARTING THE UNIT – Observe the following starting procedures.

Unit Cold – If the unit is a water–cooled heat exchanger model, open any manual water inlet valves wide open. Start the unit by pushing either the "CONSTANT RUN" button or one of the "AUTO" buttons. Since the unit is equipped with a minimum (65 psig, 4.5 Bars) pressure discharge valve, no special procedure to maintain unit reservoir pressure is required.

Unit Hot – No warm–up period is required. If the unit is a water–cooled heat exchanger model, open any manual water inlet valves wide open. Start the unit by pushing either the "CONSTANT RUN" button or one of the "AUTO" buttons.

DAILY CHECK – Refer to Section 8, "Maintenance Schedule," page 48.

STOPPING THE UNIT – Press "STOP–RESET" button. The oil reservoir will automatically blow down as the motor stops. If the unit is a water–cooled heat exchanger type, close any manual water inlet valves.

SECTION 4
CONTROLS & INSTRUMENTATION

GENERAL DESCRIPTION – The Gardner Denver rotary screw compressor is prewired with all controls, motor, and starter for the voltage and horsepower at the time of ordering. It is necessary only to connect the compressor unit to the correct power supply and to the shop air line (and to the appropriate water supply if water cooled). A standard compressor unit consists of the compressor, oil reservoir, oil cooling system and filter, motor type as specified, NEMA 12 starter / control box, and control components as described below.

AUTO SENTRY® OPERATION

Operation of the "Auto Sentry®" is dependent on selection of an operating mode from the controller keypad. Prior to starting, the [STOP/RESET] key must be pressed to place the controller into its READY state (as indicated on the display). Compressor operation may then be started by pressing an operating mode key.

AUTOMATIC is the most commonly selected mode of operation, as it will operate the compressor unit automatically in the most efficient manner for the demand of the air system.

Once operating, the mode may be changed at any time by pressing a key, and the selected mode will be displayed in the lower right corner of the message window. Press the [STOP/RESET] key at any time to stop the compressor under normal conditions.

Detailed instructions for the controller are found in the manual 13–9/10–647.

⚠ WARNING

Automatic restarting or electrical shock can cause injury or death. Open, tag and lockout main disconnect and any other circuits before servicing the unit.

CONTROL DEVICES

Controller – This compressor unit features the "AUTO SENTRY®" controller, which integrates all the control functions under microprocessor control. Its functions include safety and shutdown, compressor regulation, operator control, and advisory/maintenance indicators. The keypad and display provide the operator with a logical and easily operated control of the compressor and indication of its condition. The controller is factory adjusted for the compressor package, but allows tuning for specific applications.

Relief Valve – A pressure relief valve(s) is (are) installed in the final discharge line and set to approximately 120–125% of the unit's full load operating pressure for protection against over pressure. Periodic checks should be made to ensure its (their) operation.

The relief valve should be tested for proper operation at least once every year. To test the relief valve, raise the system operating pressure to 75% of the relief valve set pressure and manually open the valve with the hand lever. Hold the valve open for a few seconds and allow it to snap shut.

⚠ WARNING

When the relief valve opens, a stream of high velocity air is released, resulting in a high noise level and possible discharge of accumulated dirt or other debris. Always wear eye and ear protection and stand clear of the discharge port when testing the relief valve to prevent injury.

⚠ CAUTION

Never paint, lubricate or alter a relief valve. Do not plug vent or restrict discharge.

⚠ WARNING

Operation of unit with improper relief valve setting can result in severe personal injury or machine damage.

Insure properly set valves are installed and maintained.

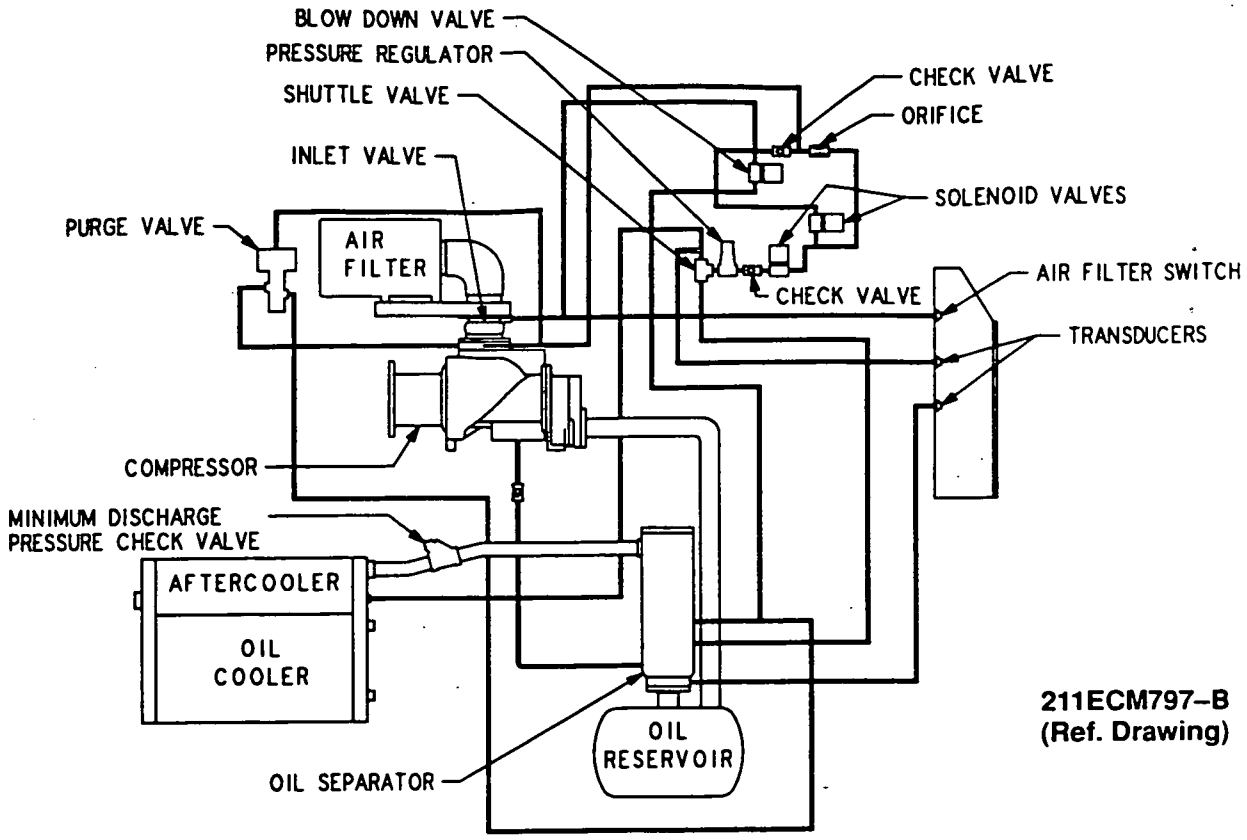


FIGURE 4–1 – SCHEMATIC TUBING DIAGRAM

Blowdown Valve (FIGURE 4–2) – This valve normally is used for control functions, but also serves to relieve reservoir pressure following a shutdown. The blowdown valve is a two–way solenoid valve which is piped into the oil reservoir outlet ahead of the minimum pressure valve. When the solenoid is de–energized, the valve opens and the coolant system is blown down. When the solenoid is energized, the valve closes to allow the coolant system to pressurize. A control air check valve is provided to ensure that the inlet valve is closed during blowdown.

Oil Level Gauge (FIGURE 1–6, Section 1, page 3) – This gauge is located on the oil reservoir and indicates the oil level. See section 5 for information on how to correctly read the gauge and proper lubrication.

Minimum Discharge Pressure/Check Valve (FIGURE 4–3, page 20) – An internal spring–loaded minimum pressure valve is used in the final discharge line to provide a positive pressure on the coolant system of the compressor even if the air service valve is fully open to atmospheric pressure. This valve also functions as a check valve to prevent back flow of air from the shop air line when the unit stops, unloads, or is shut down.

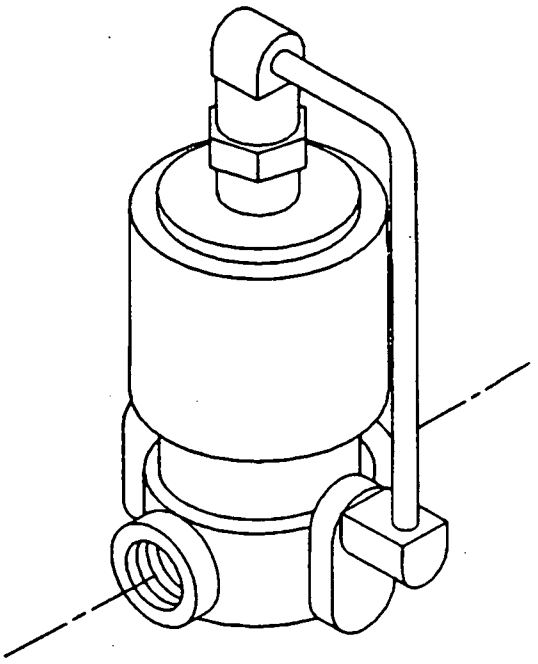


FIGURE 4–2 – BLOWDOWN VALVE

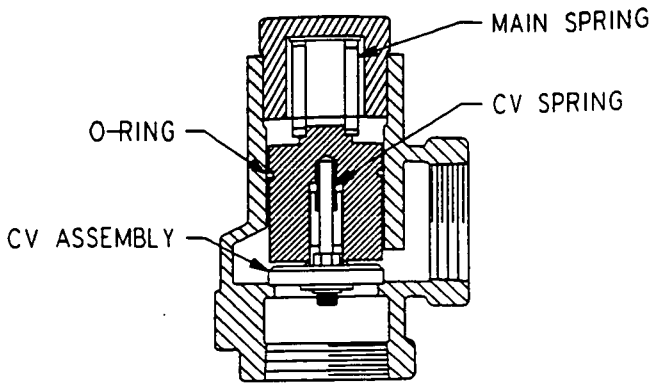


FIGURE 4–3 – MINIMUM DISCHARGE PRESSURE / CHECK VALVE

The valve incorporates a spring–loaded piston which maintains approximately 65 psig in the oil reservoir. When the air pressure on the upstream (reservoir) side of the valve rises above 65 psig, the spring is overridden and the valve opens to full porting.

The valve does not require maintenance or adjustment. If the valve fails to function, check the valve stem O–ring for sealing, valve orifices for restriction, or valve and valve seat for burrs and dirt.

The valve is adjustable within a small range. It is adjusted by a screw on the side of the valve. By turning the screw, the minimum pressure to open the valve increases. Conversely, backing it out decreases the minimum pressure required to open the valve.

To service the valve, unscrew the valve cap from the body. The internal parts will come out after the cap has been removed. Repair kits are available from your local authorized Gardner Denver Machinery distributor.

Inlet Valve (FIGURE 1–4, page 2, and FIGURE 4–4) – The Inlet valve restricts the inlet to control delivery and closes to unload the compressor. At shutdown, the inlet valve closes to prevent the back flow of air.

The inlet valve position is controlled by air pressure in its piston cylinder, which is controlled by the "Auto Sentry®" Controller through solenoid valves IVC and IVO. As Pressure to the piston is increased, the valve closes to restrict air flow and compressor delivery.

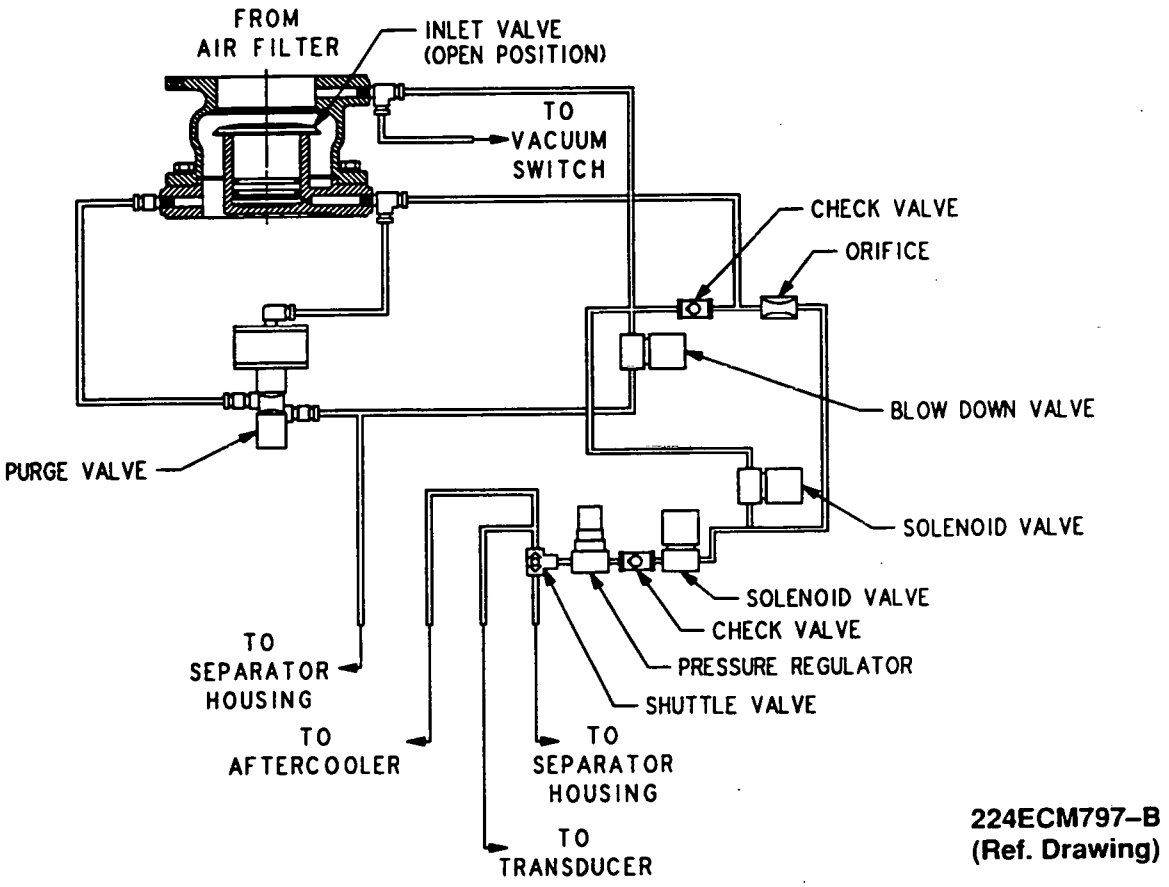


FIGURE 4–4 – INLET VALVE

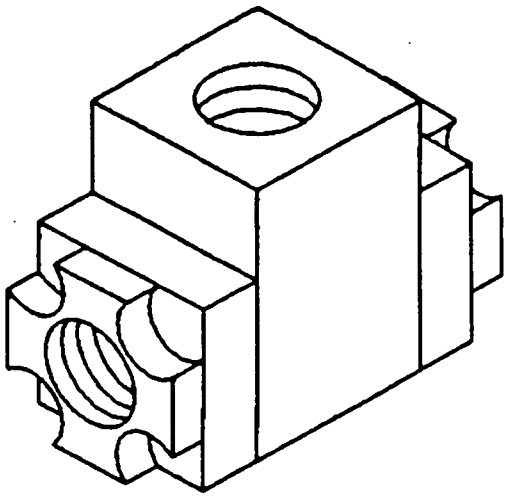


FIGURE 4–5 – SHUTTLE VALVE

Solenoid Valves IVC and IVO – These valves control position of the inlet valve in response to signals from the "Auto Sentry®" Controller. With both valves de–energized, the normally open IVC valve allows control pressure to the inlet piston to close the valve. If IVC only is energized, the inlet valve is held in its current position. If both valves are energized, control pressure is relieved from the inlet piston to allow the valve to open.

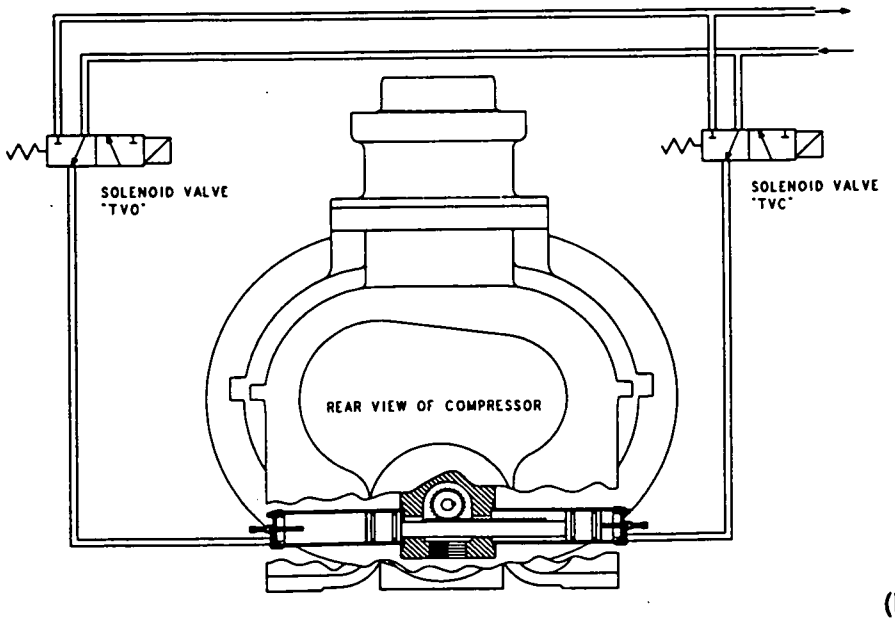
Pressure Regulator – The pressure regulator is used to supply a constant and low control pressure to prevent damage to the inlet valve from "slamming." The regulator should be set for 25–30 psig.

Shuttle Valve (FIGURE 4–5) – Also known as a double check valve, the shuttle valve is a device which will take two (2) supply signals and allow the one with the highest pressure to pass through. The shuttle valve is used to provide control air pressure from either the reservoir or plant air system, as required during different operating conditions.

Purge Air Valve – The purge valve is a normally closed two–way air actuated valve that admits purge air from the final discharge manifold to the compressor to counteract the oil knock that occurs in oil–flooded rotary screw compressors when they are completely unloaded with pressure in the oil reservoir. This valve is controlled by the same control pressure which controls the inlet valve.

Turn Valve (Electra–Saver only) (FIGURE 4–6)– The turn valve is a helical valve which, when rotated, opens and closes a series of ports cast into the compressor cylinder. When these ports are open, they direct some of the air which would otherwise be compressed back to the inlet, reducing both capacity and power consumption.

Turn Valve Actuator (Electra–Saver only) – The turn valve actuator is a rotary rack and pinion device which positions the turn valve according to system demand. Filtered oil from the compressor sump is directed to the outboard end of the two actuating cylinders to move the



213ECM797
(Ref. Drawing)

FIGURE 4–6 – TURN VALVE – ELECTRA–SAVER ONLY

rack and rotate the valve. Located on the ends of the cylinders are adjusting screws which limit the travel of the actuator. When looking at the rear of the compressor, the adjusting screw on the right on the compressor adjusts the fully closed (full–load) position of the valve. The full load position of the actuator may be checked by removing the adjusting screw at the unloaded end of the actuator (left side of the compressor) and using a rod to push the pistons to the full load position. The rod must be clean and free of burrs and scale. Take care not to scrape the cylinder walls when moving the pistons.

Solenoid Valves TVC and TVO (Electra–Saver only) – These valves control the position of the turn valve in response to signals from the "AUTO SENTRY" controller. With both valves de–energized, equal pressure is applied to both ends of the actuator to hold it in its present position. If TVC only is energized, the right side of the turn valve actuator is exhausted to the compressor inlet cavity, causing the turn valve to move towards the full load position. If TVO only is energized, the left end of the turn valve actuator is exhausted to the compressor inlet cavity, causing the turn valve to move towards the unload position. See "Auto Sentry Operation" in Controller Manual 13–9/10–647, for a description of how the turn valve position is controlled during normal operation.

System Pressure Transducer – This transducer is connected after the minimum pressure valve. It converts the pressure in the plant air system into an electrical signal for use by the "Auto Sentry" controller for modulation and control.

Reservoir Pressure Transducer – This transducer is connected to the coolant system. Its signal is used to prevent loaded starts, monitor reservoir pressure, and monitor the condition of the air/oil separator.

Air Filter Vacuum Switch – This switch is used to monitor air filter condition and alert the user if the filter requires service or replacement.

Discharge Thermistor – This sensor is located directly in the compressor discharge. Its signal is used to monitor compressor temperature and shut down the compressor if a coolant problem is detected.

Reservoir Thermistor – This sensor is located near the separator and is used to monitor temperature and shut down the compressor if high temperatures are detected.

Emergency Stop Push–Button – This is a maintained push–button, and removes power from the controller outputs regardless of controller status. It is located on the upper section of the panel, next to the keypad. This should be used for emergency purposes only – use the keypad [STOP/RESET] for normal controlled stopping.

⚠ WARNING

Automatic restarting or electrical shock can cause injury or death. Open, tag and lockout main disconnect and any other circuits before servicing the unit.

Vibration Switch – The "Auto Sentry" controller has one additional input available for dealer or user installed optional shutdown switches. The switch is simply wired in place of the jumper between terminals 7 and 9 of the terminal strip. If the contact is opened, the compressor will be shut down, and will display "SHUTDOWN – HIGH VIBRATION".

The vibration shutdown switch is to be mounted on the compressor coupling cover, and detects an increase in vibration that could be an indication of impending damage to the unit. The switch actuates when the selected level of vibration is exceeded.

The switch must be adjusted when the unit is first installed. Refer to the switch manufacturer's instruction manual for complete details.

Control Transformer – This control device changes the incoming power voltage to 110–120 volts for use by all unit control devices. The transformers employed are usually connectable for several input voltages, refer to the transformer label for connection prior to energizing. Two primary and one secondary fuse are provided. Refer to adjacent labeling for replacement information.

Terminal Strip – This provides connections for all 110–120 volt devices not contained within the enclosure.

Fan Starter – The starter is used to provide control and overload protection for the cooling fan or the ventilation fan of water–cooled units with enclosure. Overload heaters should be selected and adjusted based on the motor nameplate amps and the instructions located inside the cover of the electrical enclosure. Three fuses are provided. Refer to adjacent labeling for replacement information.

Main Starter – This starter is used to provide control and overload protection for the main drive motor. Full voltage starters employ a single contactor, overload heaters should be selected and adjusted based on the motor nameplate amps and the instructions located in-

side the cover of the enclosure. Wye–delta starters employ three contactors which are controlled sequentially to provide low current starting. For wye–delta starters, the motor nameplate amps must be first multiplied by 0.577 before using the heater table.

Optional Switches – The "Auto Sentry" controller has one additional input available for dealer or user installed optional shutdown switches. If the contact is opened, the compressor will be shut down, and will display "HIGH VIBRATION."

COMPRESSOR CAPACITY CONTROL – TURN VALVE UNITS ONLY

The capacity of the compressor is controlled by the action of the Turn Valve and the Compressor Inlet Valve.

The turn valve controls compressor delivery to match demands of 40% to 100% of the compressor's maximum capacity. The inlet valve throttles to control compressor delivery to match demands of 0% to 40% of the compressors maximum capacity.

Example with normal setting of 100 PSIG:

Compressor Delivery	Inlet Valve	Turn Valve	Discharge Manifold Pressure
Full Capacity	Open	Closed	100
70% Capacity	Open	50% Open	100
40% Capacity	Open	Full Open	100
30% Capacity	Closing	Full Open	103
20% Capacity	Closing	Full Open	103
0% Capacity	Closed	Full Open	103

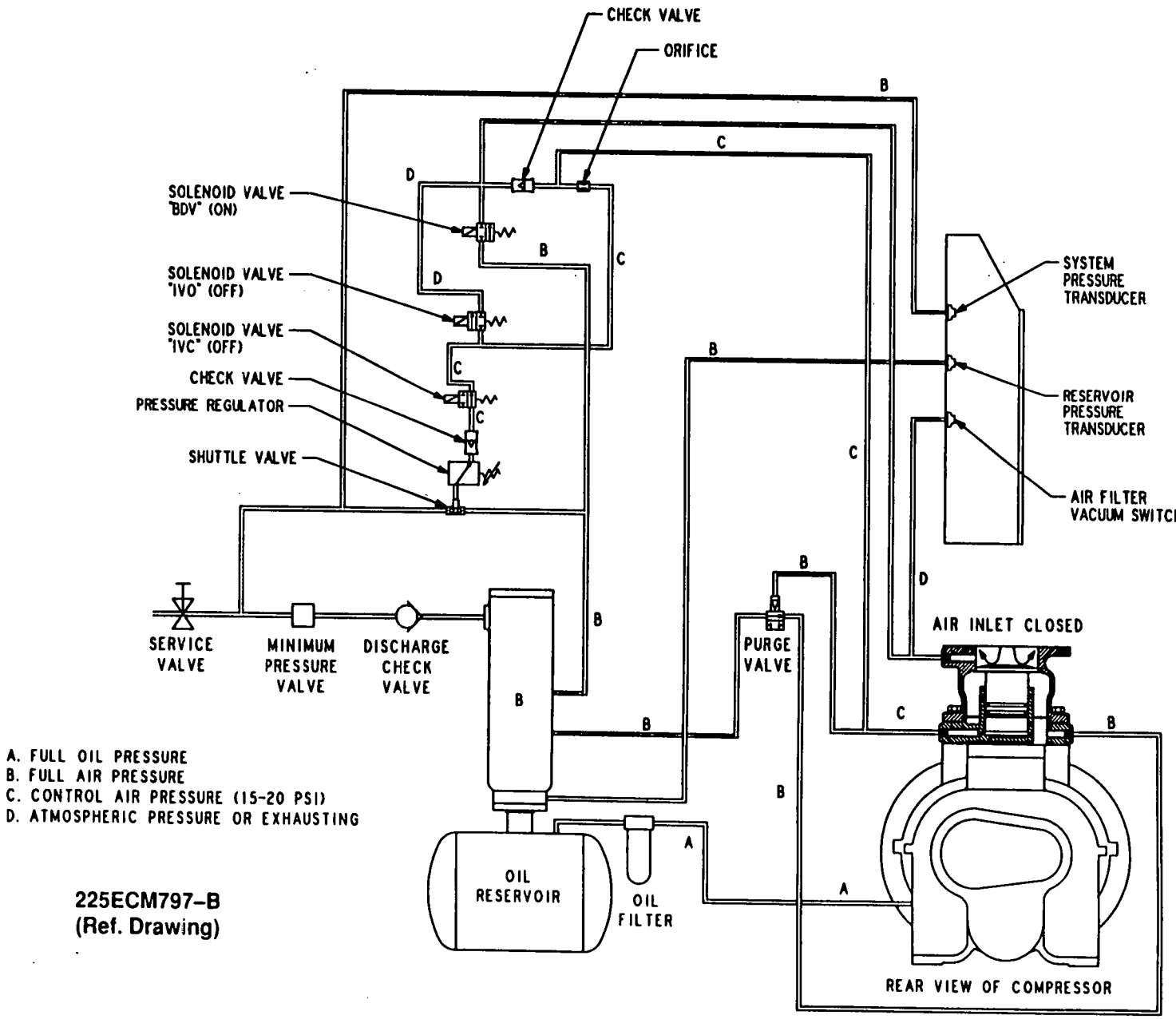


FIGURE 4-7 – CONTROL SCHEMATIC – COMPRESSOR UNLOADED – CONSTANT SPEED MODE
EBH & EBM UNITS ONLY

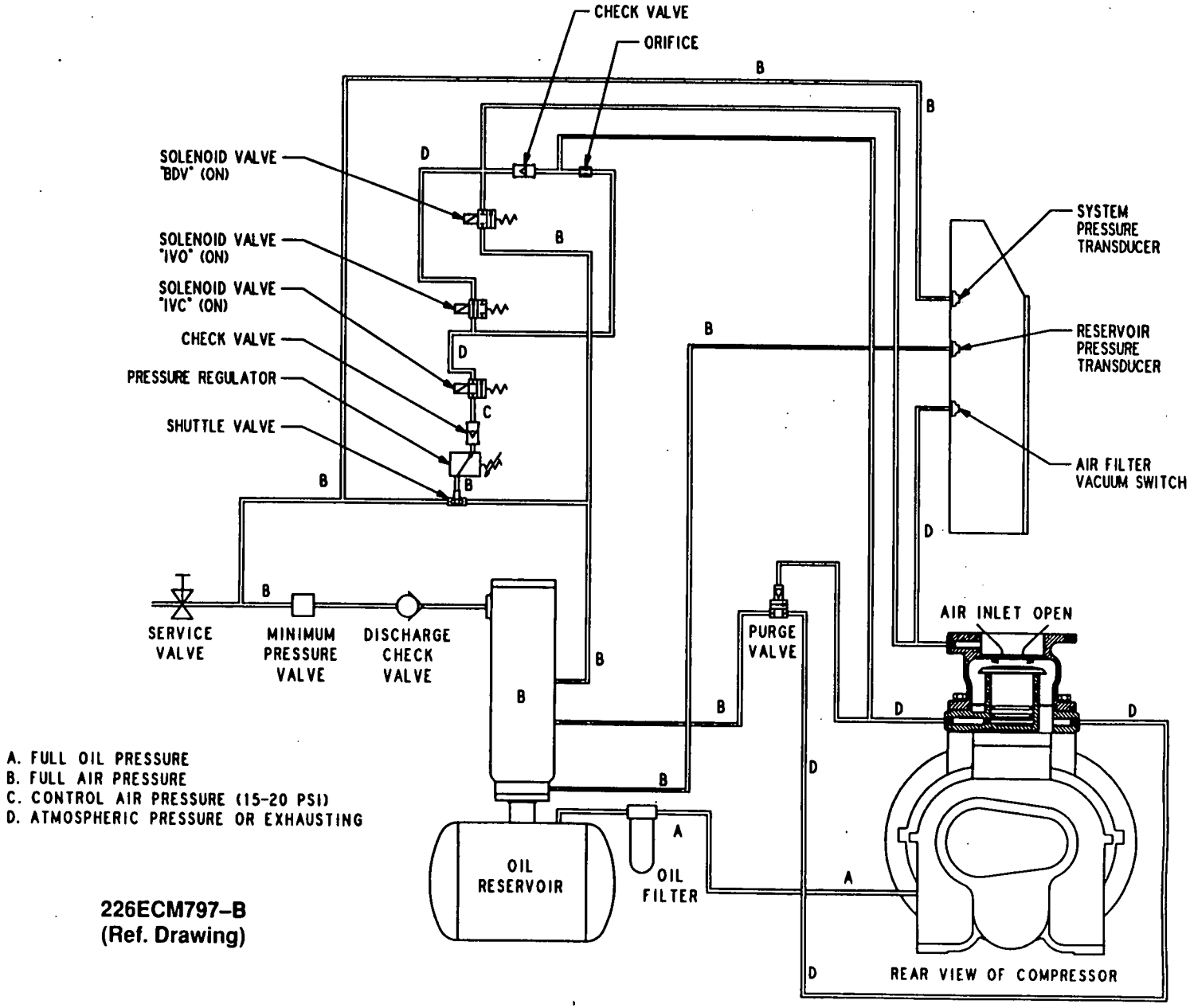


FIGURE 4-8 – CONTROL SCHEMATIC – COMPRESSOR AT FULL LOAD – CONSTANT SPEED MODE
EBH & EBM UNITS ONLY

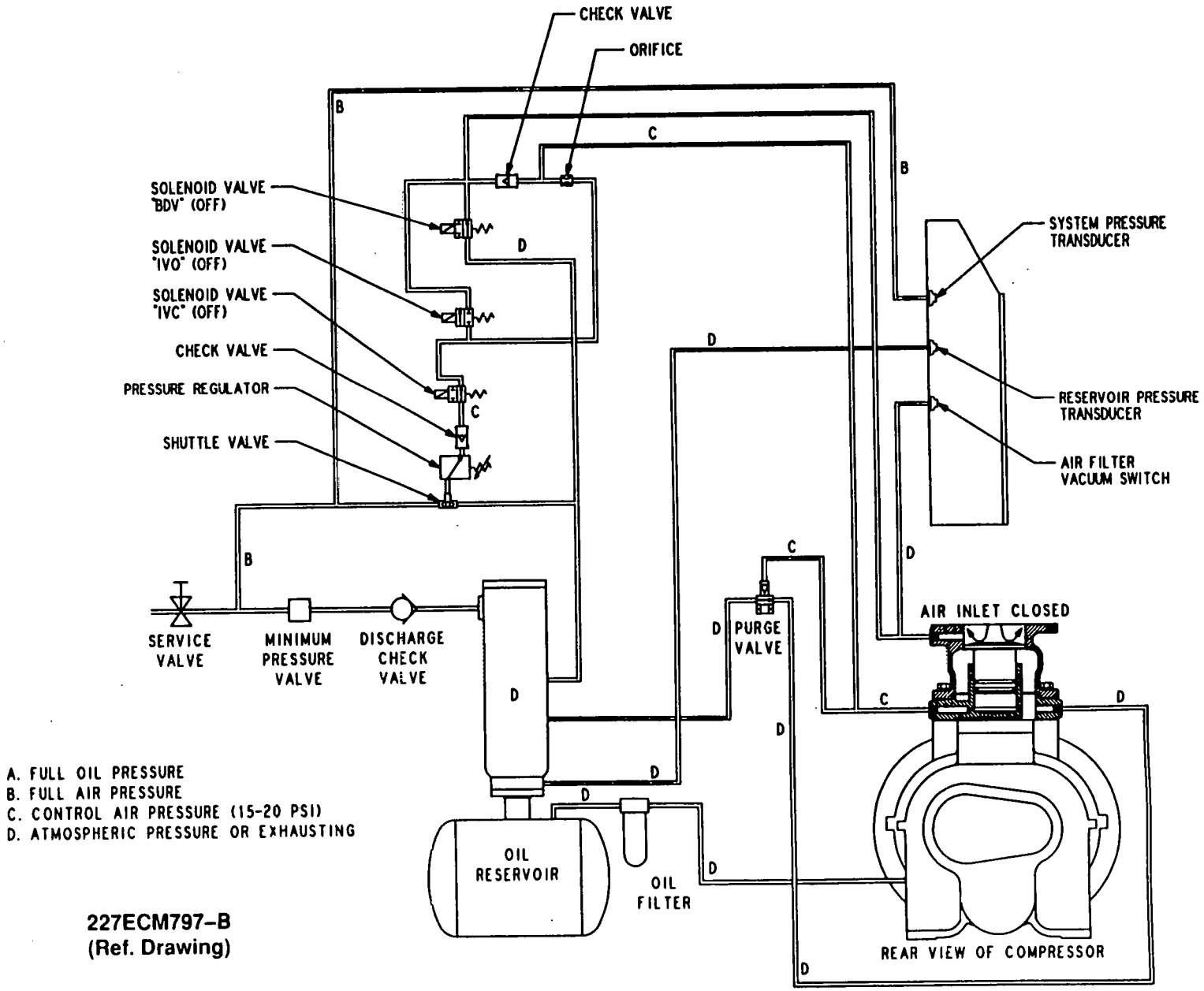


FIGURE 4-9 – CONTROL SCHEMATIC – COMPRESSOR UNLOADED – LOW DEMAND MODE OR AUTO MODE
EBH & EBM UNITS ONLY

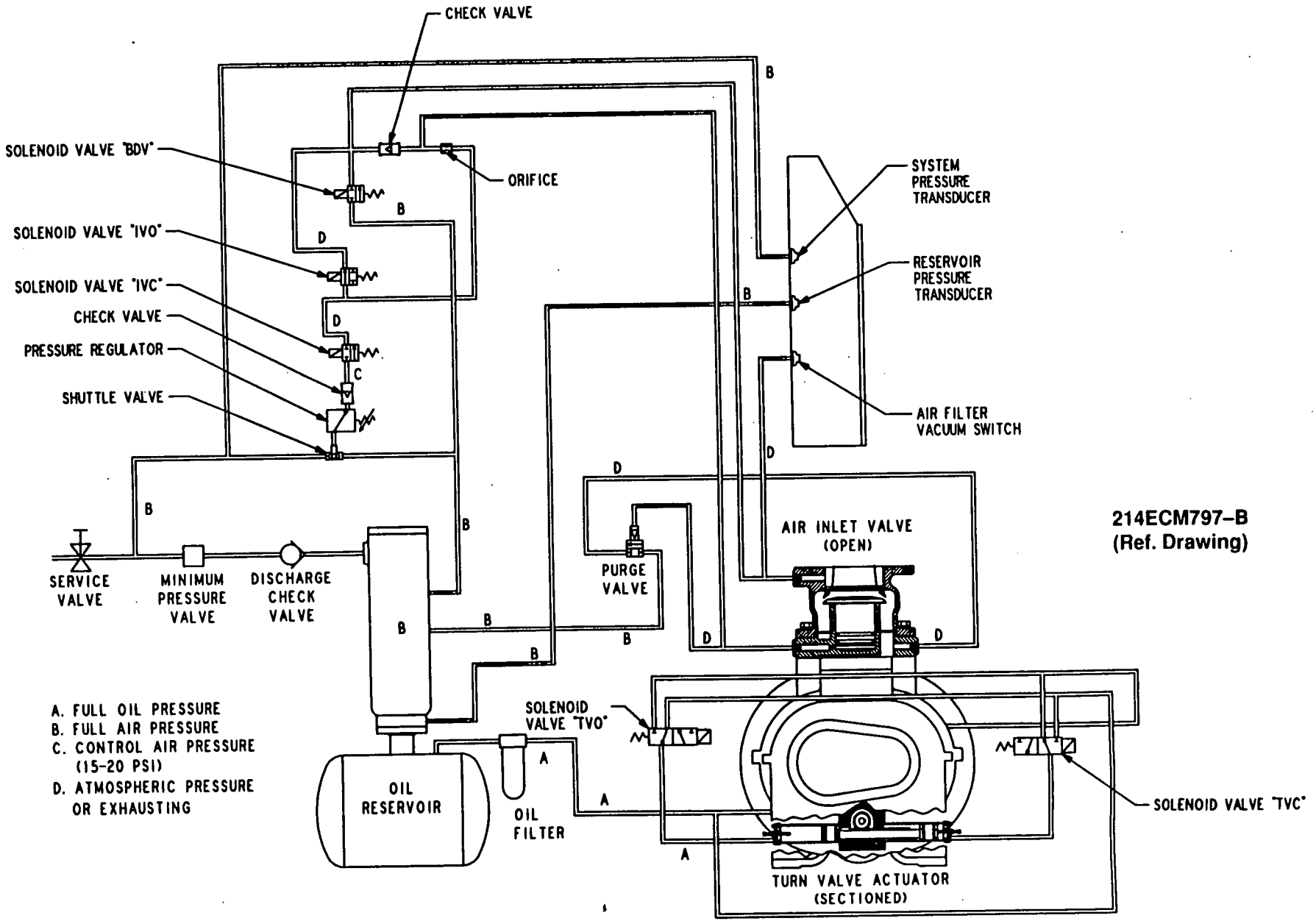


FIGURE 4-10 – CONTROL SCHEMATIC – COMPRESSOR AT FULL LOAD
EAP UNITS ONLY

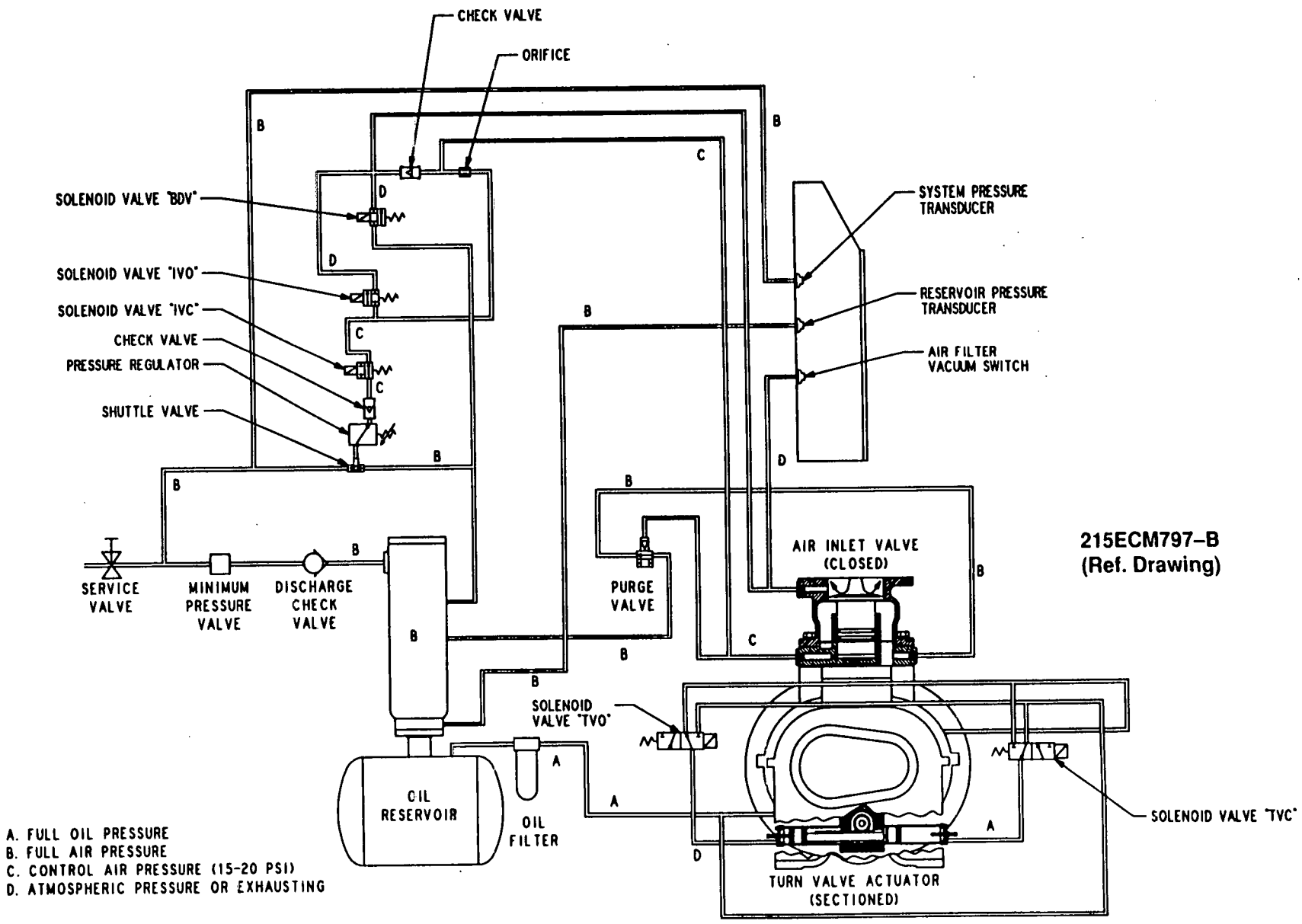


FIGURE 4-11 – CONTROL SCHEMATIC – COMPRESSOR FULLY UNLOADED – LOW DEMAND MODE SWITCH OFF
EAP UNITS ONLY

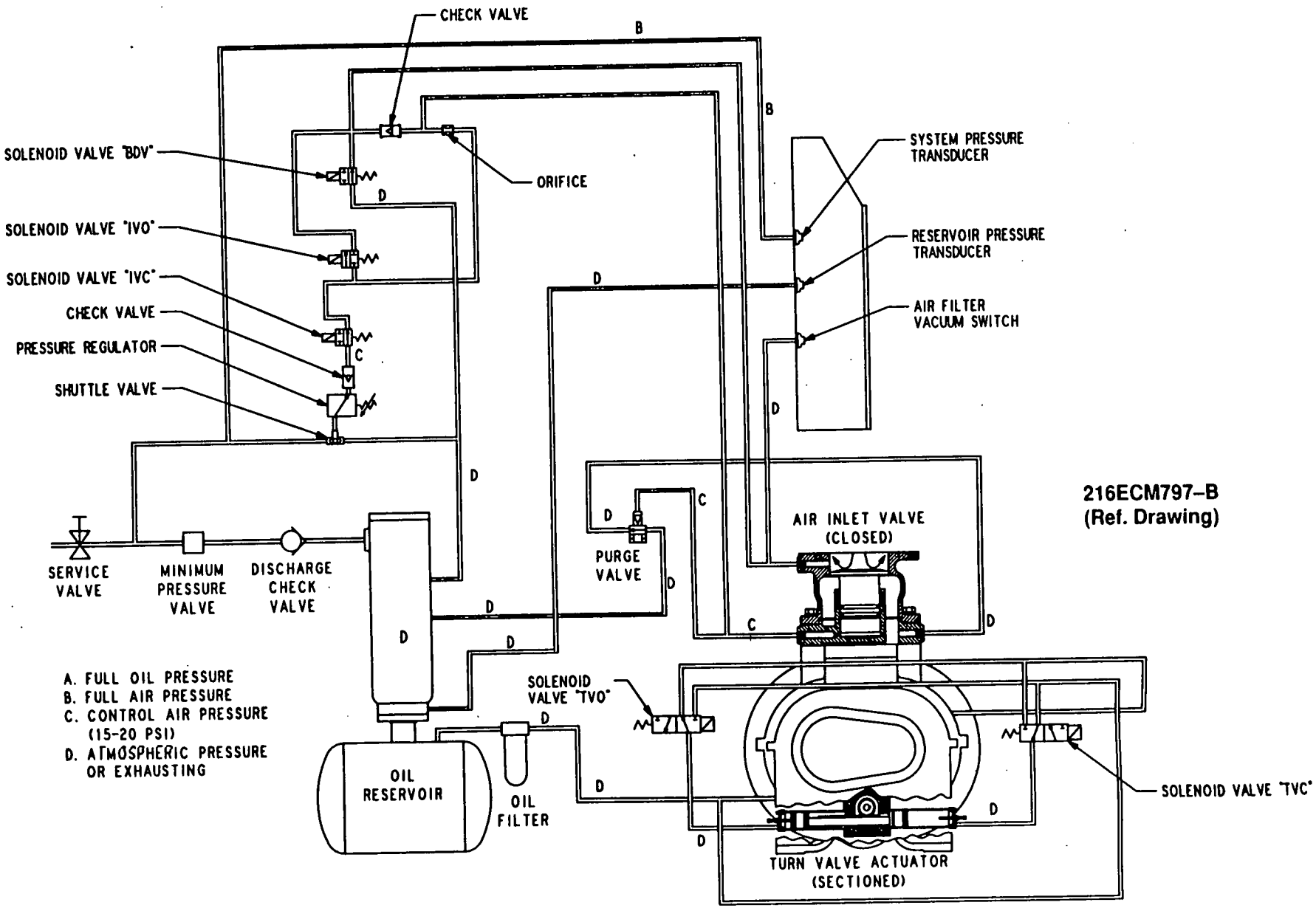
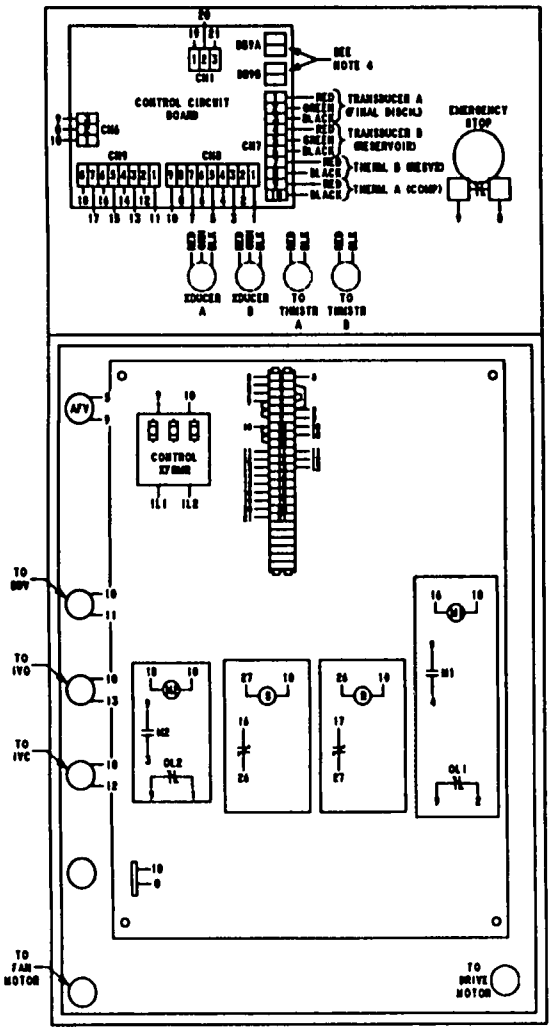


FIGURE 4-12 – CONTROL SCHEMATIC – COMPRESSOR FULLY LOADED – LOW DEMAND MODE SWITCH ON EAP UNITS ONLY



NOTE 1- FORM C CONTACT FOR USE BY OTHERS. CONTACT OPERATES FOLLOWING COMPRESSOR SHUTDOWN. RATING: 120VAC, 2 AMP.
NOTE 2- FOR USE WITH OPTIONAL VIBRATION SWITCH. REMOVE JUMPER BETWEEN TERMINALS 7 & 9. CONNECT N.C. VIBRATION SWITCH CONTACT TO TERMINALS 7 & 9.
NOTE 3- FOR CONTROL BY REMOTE CONTACT. REMOVE JUMPER BETWEEN TERMINALS 6 & 9. CONNECT CONTACT TO TERMINALS 6 & 9.
NOTE 4- DBPA & DBPB ARE FOR USE OF OPTIONAL COMMUNICATIONS CABLE.
NOTE 5- WHEN A WATER CONTROL SOLENOID VALVE IS USED, WIRE TO TERMINALS 10 & 10.

□ - CONNECTION TO CONTROL BOARD.
○ - PANEL TERMINAL BLOCKS

LEGEND
AFV - AIR FILTER VACUUM SWITCH
DBV - BLOWDOWN SOLENOID VALVE
IVC - INLET VALVE CLOSE SOLENOID VALVE
IVO - INLET VALVE OPEN SOLENOID VALVE

LEAD CONNECTION FOR TWELVE-LEAD MOTORS	
LOW VOLTAGE CONNECTIONS	HIGH VOLTAGE CONNECTIONS
T1 T4 T2 T5 T3 T6	T1 T4 T2 T5 T3 T6

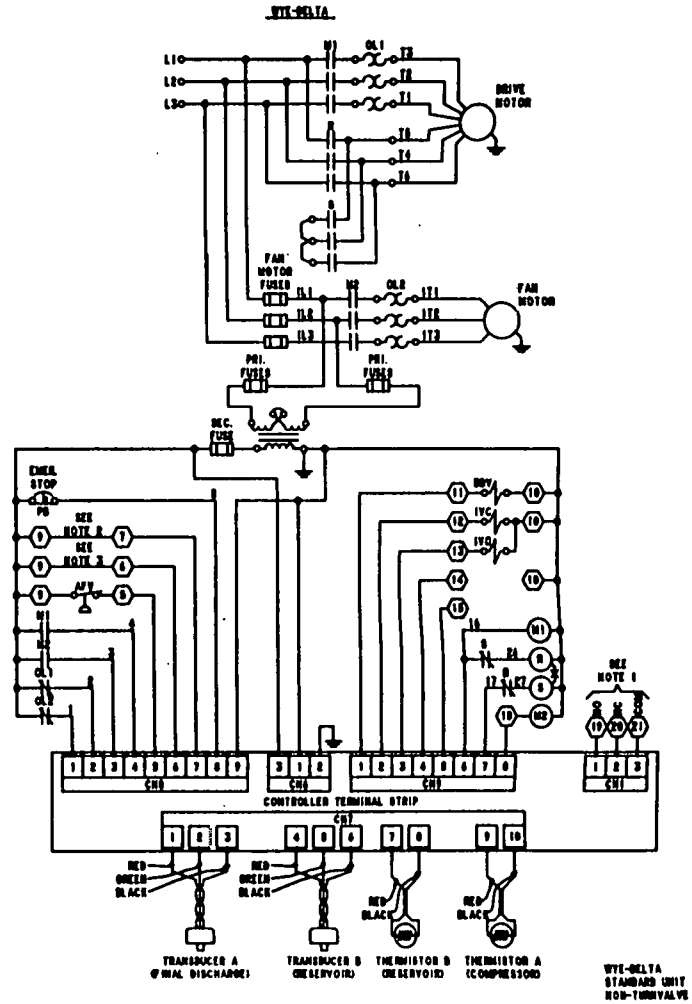
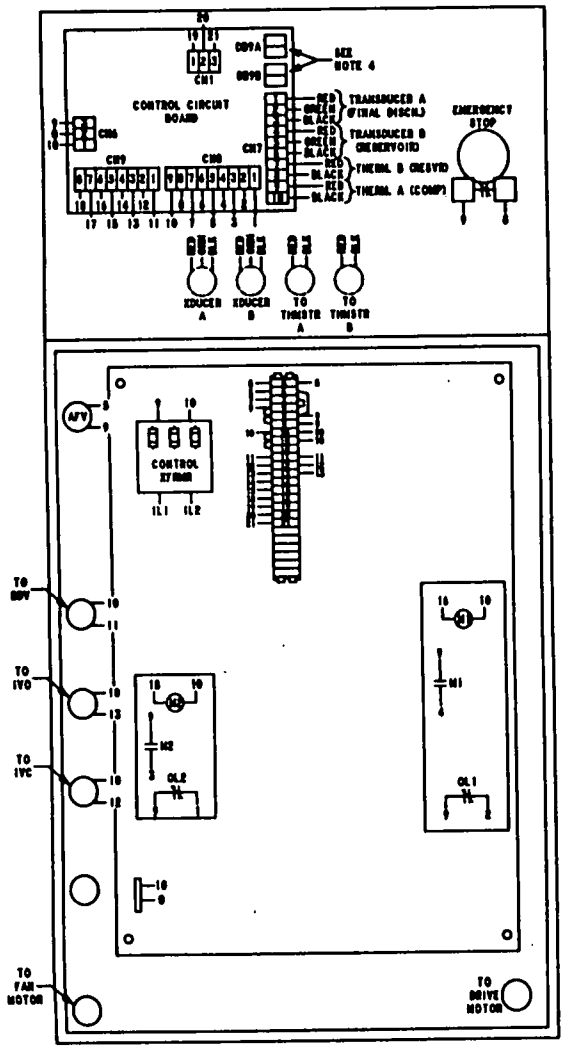


FIGURE 4-13 - WIRING DIAGRAM - 207ECP546
(WYE-DELTA - EBH, EBM & EBP UNITS WITH ES CONTROLS)



NOTE 1: FORM C CONTACT FOR USE BY OTHERS. CONTACT OPERATES FOLLOWING COMPRESSOR SHUTDOWN. RATING: 120VAC, 2 AMP.
NOTE 2: FOR USE WITH OPTIONAL VIBRATION SWITCH. REMOVE JUMPER BETWEEN TERMINALS 7 & 9. CONNECT N.C. VIBRATION SWITCH CONTACT TO TERMINALS 7 & 9.
NOTE 3: FOR CONTROL BY REMOTE CONTACT, REMOVE JUMPER BETWEEN TERMINALS 6 & 9. CONNECT CONTACT TO TERMINALS 6 & 9.
NOTE 4: 209A & 209B ARE FOR USE OF OPTIONAL COMMUNICATIONS CABLE.
NOTE 5: WHEN A WATER CONTROL SOLENOID VALVE IS USED, WIRE TO TERMINALS 10 & 18.

□ = CONNECTION TO CONTROL BOARD.
⬡ = PANEL TERMINAL BLOCKS

LEGEND:
AFV - AIR FILTER VACUUM SWITCH
BDV - BLOWDOWN SOLENOID VALVE
IVC - INLET VALVE CLOSE SOLENOID VALVE
IVO - INLET VALVE OPEN SOLENOID VALVE

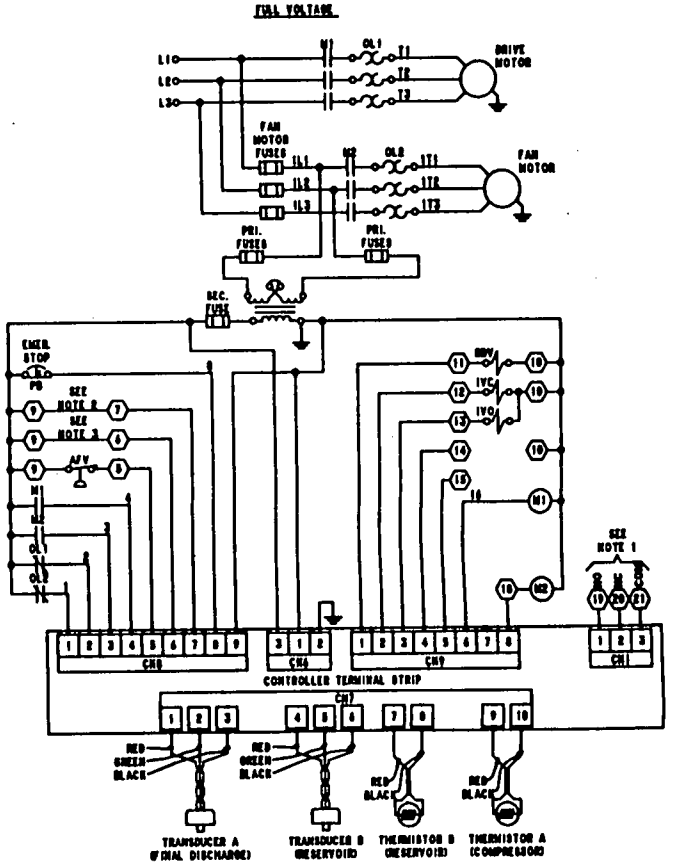
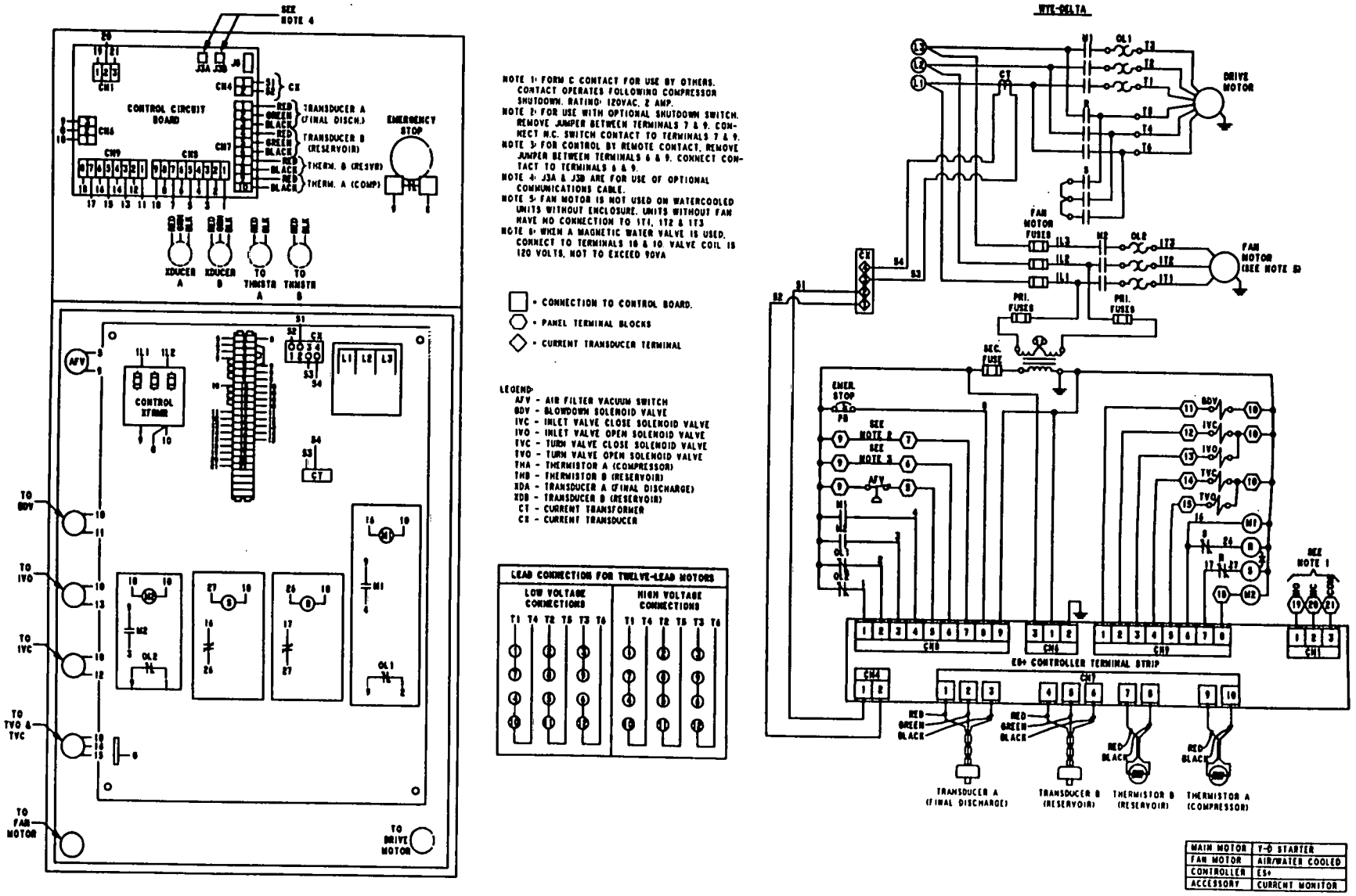


FIGURE 4–14 – WIRING DIAGRAM – 209ECP546
(FULL VOLTAGE – EBH, EBM & EBP UNITS WITH ES CONTROLS)



NOTE 1: FORM C CONTACT FOR USE BY OTHERS. CONTACT OPERATES FOLLOWING COMPRESSOR SHUTDOWN. RATING: 120VAC, 2 AMP.
NOTE 2: FOR USE WITH OPTIONAL SHUTDOWN SWITCH. REMOVE JUMPER BETWEEN TERMINALS 7 & 9. CONNECT N.C. SWITCH CONTACT TO TERMINALS 7 & 9.
NOTE 3: FOR CONTROL BY REMOTE CONTACT, REMOVE JUMPER BETWEEN TERMINALS 6 & 9. CONNECT CONTACT TO TERMINALS 6 & 9.
NOTE 4: J3A & J3B ARE FOR USE OF OPTIONAL COMMUNICATIONS CABLE.
NOTE 5: FAN MOTOR IS NOT USED ON WATERCOOLED UNITS WITHOUT ENCLOSURE. UNITS WITHOUT FAN HAVE NO CONNECTION TO 1T1, 1T2 & 1T3
NOTE 6: WHEN A MAGNETIC WATER VALVE IS USED, CONNECT TO TERMINALS 10 & 10. VALVE COIL IS 120 VOLTS, NOT TO EXCEED 90VA

- ▭ - CONNECTION TO CONTROL BOARD.
- ⬡ - PANEL TERMINAL BLOCKS
- ◇ - CURRENT TRANSDUCER TERMINAL

LEGEND:
AFV - AIR FILTER VACUUM SWITCH
BDV - BLOWDOWN SOLENOID VALVE
IVC - INLET VALVE CLOSE SOLENOID VALVE
IVO - INLET VALVE OPEN SOLENOID VALVE
TVC - TURN VALVE CLOSE SOLENOID VALVE
TVO - TURN VALVE OPEN SOLENOID VALVE
THA - THERMISTOR A (COMPRESSOR)
THB - THERMISTOR B (RESERVOIR)
XDA - TRANSDUCER A (FINAL DISCHARGE)
XDB - TRANSDUCER B (RESERVOIR)
CT - CURRENT TRANSFORMER
CX - CURRENT TRANSDUCER

LEAD CONNECTION FOR TWELVE-LEAD MOTORS

LOW VOLTAGE CONNECTIONS						HIGH VOLTAGE CONNECTIONS					
T1	T4	T2	T5	T3	T6	T1	T4	T2	T5	T3	T6
●		●		●			●		●		●
	●		●		●			●		●	
●		●		●			●		●		●
	●		●		●			●		●	

MAIN MOTOR	Y-Δ STARTER
FAN MOTOR	AIR/WATER COOLED
CONTROLLER	ES+
ACCESSORY	CURRENT MONITOR

FIGURE 4–15 – WIRING DIAGRAM – 216EAP546
(WYE–DELTA – EAP UNITS WITH ES+ CONTROLS AND CURRENT MONITOR)

SECTION 5
LUBRICATION
OIL COOLER, OIL FILTER & SEPARATOR

COMPRESSOR OIL SYSTEM (FIGURE 5–1, page 34) cools the compressor, lubricates moving parts and seals internal clearances in the compression chamber.

The oil inlet line is connected at the bottom of the oil reservoir. Air pressure in the oil reservoir forces oil through the oil cooler, thermostatic mixing valve, oil filter and into the compressor main oil gallery.

The oil passes through internal passages for lubrication, cooling and sealing. The air–oil mixture is then discharged to the oil reservoir where a large part of the entrained oil drops out of the air stream; the air then passes through the final oil separator where most of the remaining oil is removed. The separated oil is returned to the compressor and the air passes to the final discharge line.

RECOMMENDED LUBRICANT – Gardner Denver compressors are factory filled with AEON lubricants. These lubricants are formulated to the highest quality standards and are factory authorized, tested and approved for use in rotary screw compressors. AEON lubricants are available through your authorized Gardner Denver compressor distributor.

OIL SPECIFICATIONS (Domestic and International) – The factory fill compressor lubricant is Gardner Denver AEON™ 9000 SP lubricating coolant which can be used for year–round operation. AEON™ 9000 SP is a synthetic, extended life lubricant which can extend lubricant change intervals up to 4 times that of a petroleum based lubricant.

A lubricant analysis program for a periodic check of lubricant quality and remaining life can maximize the change interval.

⚠ CAUTION

Use of improper lubricants will cause damage to equipment. Do not mix different types of lubricants or use inferior lubricants.

⚠ CAUTION

Improper equipment maintenance with use of synthetic lubricants will damage equipment. Oil filter and oil separator change intervals remain the same as for AEON™ 4000 — See Maintenance Schedule, page 48.

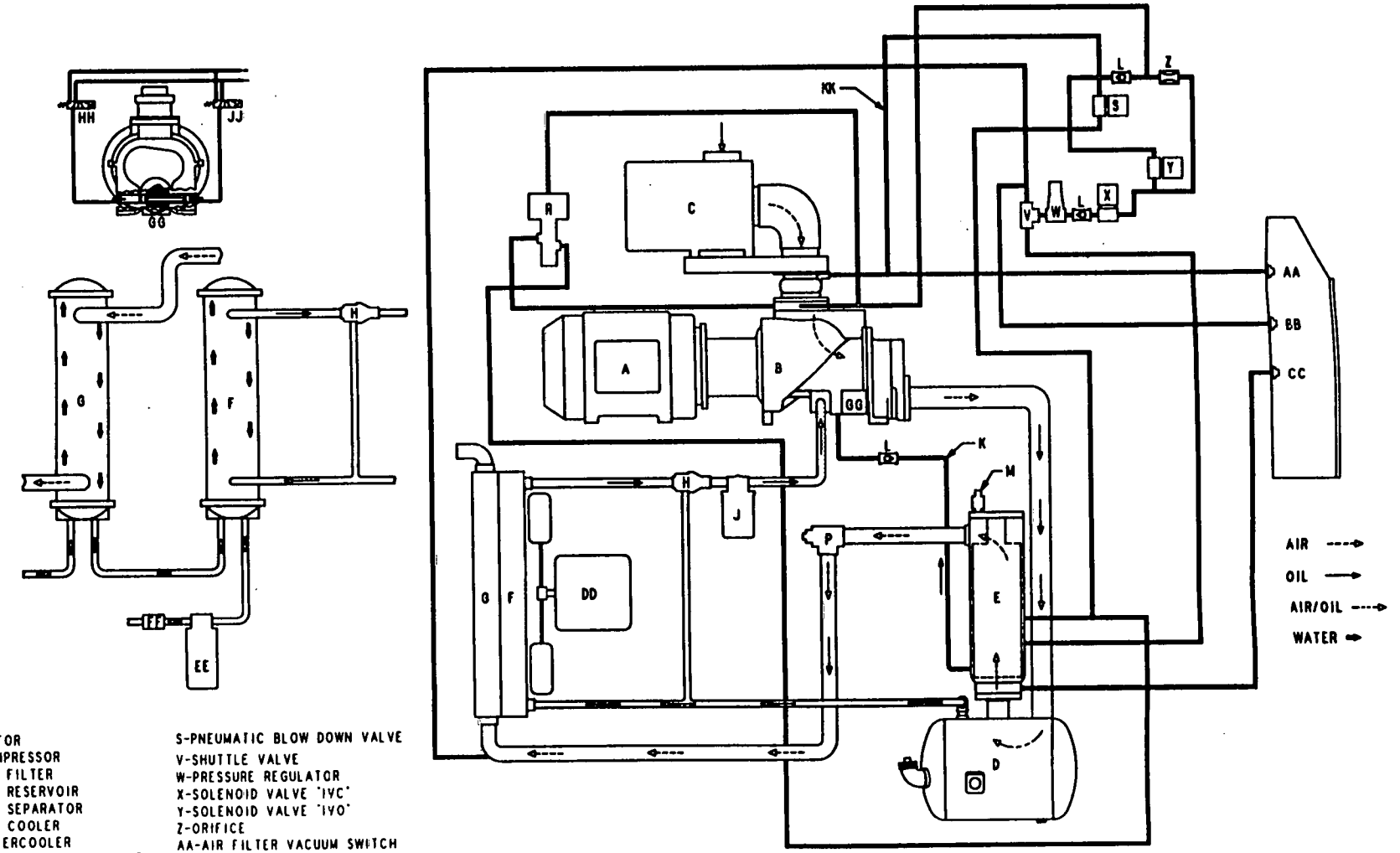
HIGH TEMPERATURE OPERATION – Gardner Denver AEON 9000 SP lubricating coolant will operate at a sustained discharge temperature up to 210°F (99°C) when unusually high ambient air temperature is encountered.

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

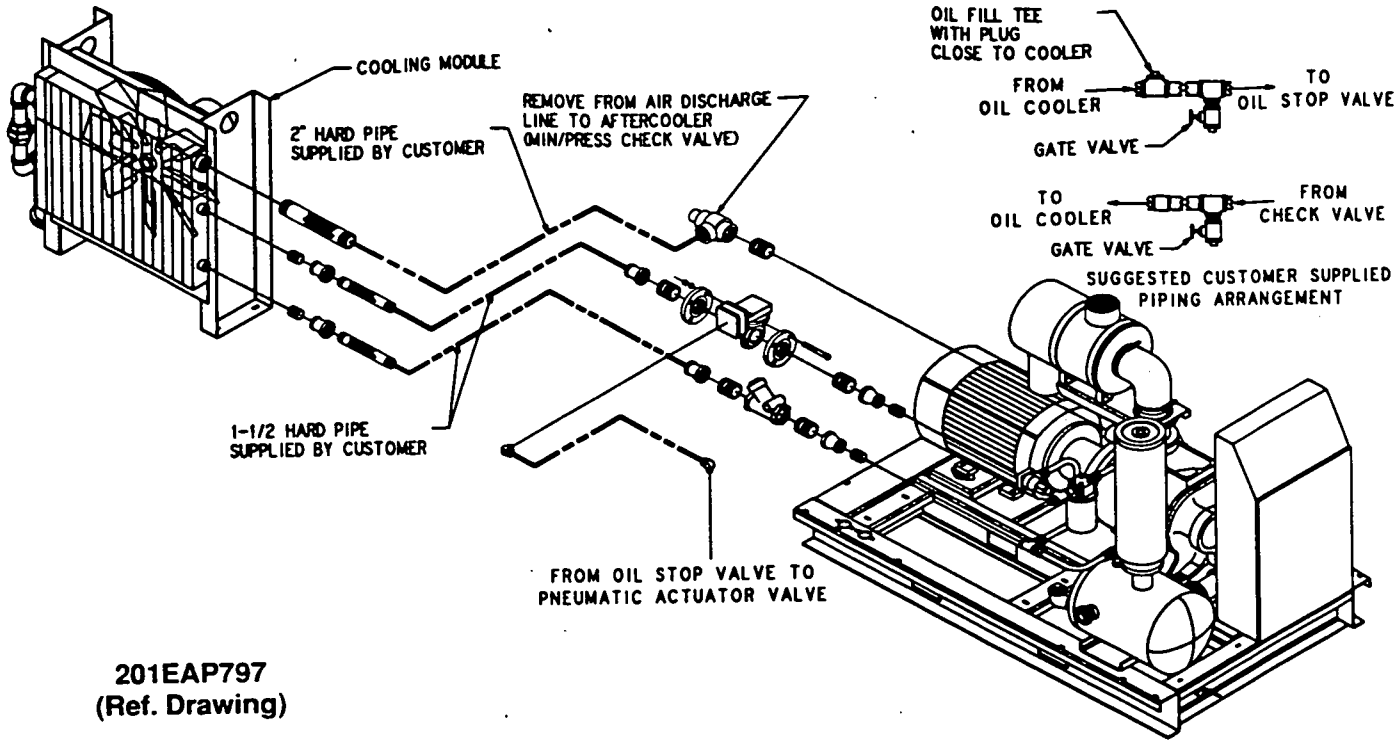
⚠ WARNING

High temperature operation can cause damage to equipment or personal injury. Do not repeatedly restart the unit after high temperature stops operation. Find and correct the malfunction before resuming operation.

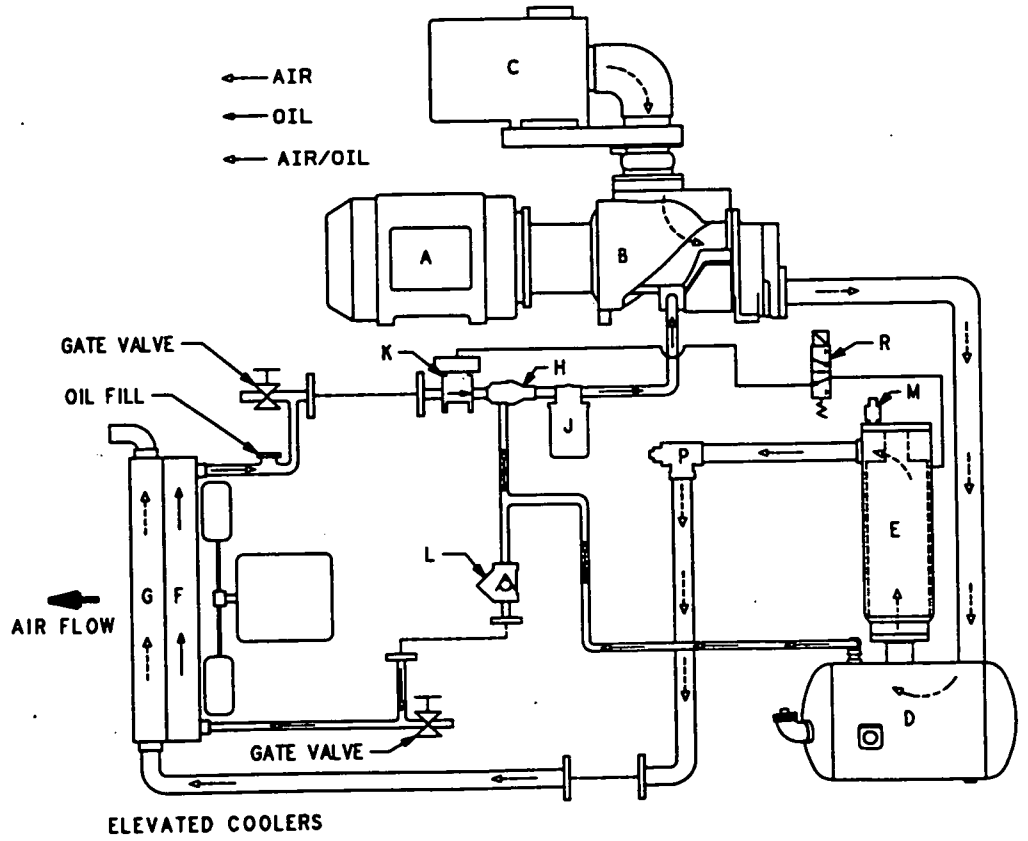


A-MOTOR
B-COMPRESSOR
C-AIR FILTER
D-OIL RESERVOIR
E-OIL SEPARATOR
F-OIL COOLER
G-AFTERCOOLER
H-THERMAL MIXING VALVE
J-OIL FILTER
K-SEPARATOR TO CYLINDER OIL RETURN LINE
L-CHECK VALVE
M-PRESSURE RELIEF VALVE
P-MINIMUM DISCHARGE PRESSURE CHECK VALVE
R-PURGE AIR VALVE
S-PNEUMATIC BLOW DOWN VALVE
V-SHUTTLE VALVE
W-PRESSURE REGULATOR
X-SOLENOID VALVE "IVC"
Y-SOLENOID VALVE "IVO"
Z-ORIFICE
AA-AIR FILTER VACUUM SWITCH
BB-SYSTEM PRESSURE TRANSDUCER
CC-DISCHARGE PRESSURE TRANSDUCEF
DD-FAN AND MOTOR
EE-WATER FLOW CONTROL VALVE
FF-MAGNETIC WATER SHUTOFF VALVE
GG-TURN VALVE ACTUATOR
HH-SOLENOID VALVE "TVO"
JJ-SOLENOID VALVE "TVC"
KK-BLOWDOWN LINE

FIGURE 5-1 – FLOW DIAGRAM – AIR/OIL SYSTEM – TURN VALVE UNITS



201EAP797
(Ref. Drawing)



A - MAIN MOTOR
B - COMPRESSOR
C - INLET FILTER
D - OIL RESERVOIR
E - OIL SEPARATOR
F - OIL COOLER
G - AFTERCOOLER
H - MIXING VALVE BODY
J - OIL FILTER
K - OIL STOP VALVE
L - CHECK VALVE
M - RELIEF VALVE
P - MIN PRESS/CHECK VALVE
R - PNEUMATIC 3 WAY VALVE

218ECM797-A
(Ref. Drawing)

FIGURE 5-2 - OIL FLOW DIAGRAM - REMOTE OVERHEAD MOUNTED COOLER

⚠ WARNING

All materials used in Gardner Denver® compressor units are compatible with AEON™ 9000 SP Lubricating Coolant. Use caution when selecting downstream components such as air line lubricating bowls, gaskets and valve trim.

AEON™ 9000 SP Synthetic Lubricant is not compatible with low nitrile Buna N or acrylic paints. AEON™ 9000 SP is compatible with most air system downstream components.

Material Safety Data Sheets (MSDS) are available for all AEON lubricants from your authorized Gardner Denver distributor or by calling 217–222–5400.

REMOTE MOUNTED ELEVATED COOLER ASSEMBLY PROCEDURE – The Compressor package will be built and tested with the coolers mounted on the package. On enclosed units, the fan motor will be disconnected after test and the vent fan motor connected in its place. The vent fan will be mounted in the enclosure. A contactor (starter) will be shipped loose and remote mounted with the cooler by others upon start–up at the job site. The control box will be wired for remote elevated coolers at the factory.

NOTICE

All requirements of local codes should be followed.

When connecting pipe fittings to the cooler, support the threaded coupling with a pipe wrench when tightening the connection. Use silicone sealant on all steel to aluminum threaded connections. All piping should be firmly supported to avoid strain on the cooler manifold and connections. Flexible connections should be installed in all interconnecting piping, adjacent to the cooler, to avoid transmitting piping weight or vibrations to the cooler elements. Before beginning installations, check to be sure that no debris or foreign matter remains in the couplings or cooler bodies. Be certain interconnecting piping is clean to avoid clogging the cooler passages.

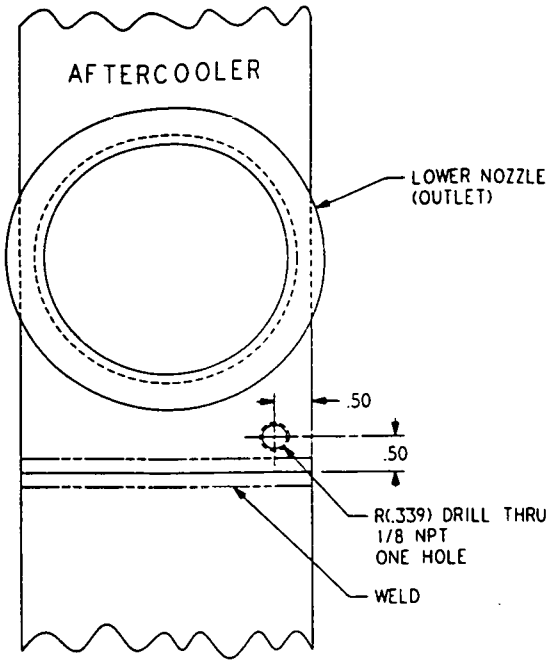


FIGURE 5–3 – COOLER DRAIN DETAIL

AFTERCOOLER PIPING – At shutdown of the system, all units should be drained completely of condensate if there is any possibility of freezing or corrosion damage. To help remove the condensate, the cooler may be tapped per FIGURE 5–3 and a drain cock installed. After opening the drain cock, blow air into the cooler from a connection on the opposite side of the cooler. At the same time the connection on the drain side of the cooler should be plugged. The drain cock should be left open until the machines are ready for start–up.

⚠ WARNING

Failure to remove condensate from an idle cooler in freezing temperatures will cause permanent cooler damage. Drain condensate after system shutdown. It is the owner/operator's responsibility to ensure that condensate has been drained and cooler dried out to prevent cooler damage.

HEAT EXCHANGER (OIL) PIPING – All remote elevated cooler applications must be sent through Engineering for approval and for recommending pipe size. When the cooling module is removed from the pack-

age, the thermal mixing valve (H) remains on the package. Control group part number 200ECM4002 will be mounted on package at the factory. This group controls the oil stop valve as well as not allowing machine to run blown down. See FIGURE 5–2, page 35.

NOTICE

Remote mounted elevated coolers have a maximum pipe length of 30 feet (9 M) (each way) and a maximum height of 20 feet (6 M) with a minimum of fittings. Engineering will review all remote elevated cooler applications and recommend pipe size on an individual basis. Customer Service should include the engineering recommendation in the special order sent to Engineering.

Kit number EAQ68330 includes the oil stop valve, check valve and flanges and must be installed on all remote elevated coolers per See FIGURE 5–2, page 35, and the following instructions.

1. Mount the check valve (90J113) as shown.
2. Mount the drain valves in the lowest section of the pipe on each side of the cooler connections.
3. Mount the oil stop valve (90AR243) in the line after the thermal mixing valve as shown.

Modifications to the control lines will be made at the factory per 288ECM810 schematic. Air to the oil stop valve must come from the upper fitting in the separator housing, then pass through the 3–way pneumatic valve. Control air to the valve must be from the line between the tee and the orifice in the blowdown muffler line per FIGURE 5–2, page 35. When the machine blows down, it will activate the pneumatic valve and it will shut off the air and vent the line between the pneumatic control valve and the oil stop valve to atmosphere. This will shut the oil stop valve and prevent excessive oil from running into the reservoir.

Failure to install these parts could result in high oil carryover and cause the machine to shutdown on high discharge temperature.

COLD AMBIENT OPERATION – See "Installation for Cold Weather Operation," page 9.

ADDITION OF OIL BETWEEN CHANGES must be made when the oil level is in the red range on the gauge as read while the unit is on. To add oil, follow these steps:

1. Be sure the unit is completely off and that no air pressure is in the oil reservoir.
2. Disconnect, tag and lockout the power supply to the starter.
3. Wipe away all dirt around the oil filler plug.
4. Remove the oil filler plug and add oil as required to return the oil level to the center of the green range on the gauge.
5. Install the oil filler plug, restore power, run and check for leaks.

DO NOT OVERFILL. The quantity required to raise the oil level from the red range center of the green range is shown in FIGURE 5–4, page 38. Repeated addition of oil between oil changes may indicate excessive oil carry–over and should be investigated.

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

⚠ CAUTION

Excessive oil carry–over can damage equipment. Never fill oil reservoir above the "FULL" marker.

LUBRICANT CHANGE PROCEDURE – Upgrading to a longer life lubricant is essentially a very worthwhile practice. Following are the primary steps to be com-

pleted when upgrading or changing the type of lubricant.

1. Thoroughly drain system:
   - Drain oil from air end and cooler while hot.
   - Break low point connections and drain oil from pipe runs.
   - Dump oil from the filter and reinstall used filter.
2. Fill the system with a 50 percent charge of the new lubricant:
   - Start the machine and stay there to observe.
   - Allow the machine to run about five minutes at temperature, or until temperature stabilizes, then shut down.
3. Thoroughly drain the machine.
4. Change to a new filter and separator.
5. Fill the system with a full charge of the new lubricant, then reinstall drain plug.
6. Machine should then be run normally, however, total run time after the initial changeout should be 50 percent of normal anticipated service life of the new lubricant.
   - Drain all lubricant from the system, change the filter and separator, and replace with a full charge of the new lubricant.
7. Subsequent lubricant changeouts should be at normal intervals. (See "Oil Change Interval" and chart below.)

OIL LEVEL GAUGE (FIGURE 1–6, page 3, and FIGURE 5–4) indicates the amount of oil in the oil reservoir. Read oil level only when unit is on. In operation the oil level will fluctuate as the compressor loads and unloads. Add oil only when the oil is at the bottom of the red range on the gauge as read when the compressor is on. Drain oil only when the oil level is above the center of the green range on the gauge as read when the compressor is on.

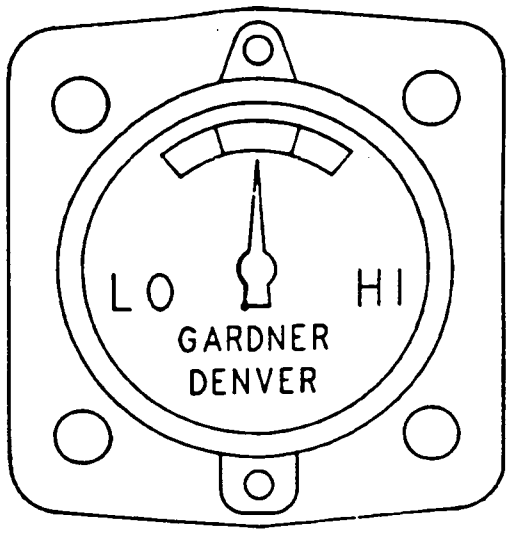


FIGURE 5–4 – OIL LEVEL GAUGE

MOISTURE IN THE OIL SYSTEM – In normal humidity and with normal operating temperatures and pressures, the thermal mixing valve controls the oil temperature and prevents moisture contamination of the oil. Unusual cooling of the oil reservoir, short loaded cycl in high humidity or malfunctions of the thermal valve may result in moisture in the oil system which is detrimental to compressor lubrication and could cause oil carryover. If moisture is observed in the oil reservoir, drain the moisture and correct the condition causing the accumulation. See "Compressor Oil System Check," page 44 and "Thermal Control (Thermostatic Mixing) Valve," page 40.

OIL CHANGE INTERVAL – Recommended oil change intervals are based on oil temperature. FIGURE 5–5, shows how the change interval is affected by temperature.

Discharge Temperature	AEON 4000 Change Interval	AEON 9000 SP Change Interval
Up to 180°F (82°C)	4000 hrs.	8000 hrs.
180° to 190°F (82° to 88°C)	3000 hrs.	6000 hrs.
190° to 200°F (88° to 93°C)	2000 hrs.	4000 hrs.
200°F+ (93°C)	1000 hrs.	2000 hrs.

FIGURE 5–5 – OIL CHANGE INTERVAL

When operating conditions are severe (very dusty, high humidity, etc.), it will be necessary to change the oil more frequently. Operating conditions and the appearance of the drained oil must be surveyed and the oil change intervals planned accordingly by the user. Gardner Denver® offers a free oil analysis program with the AEON™ lubricants and we recommend a sample be sent in at 100 hours on a new unit.

DRAINING AND CLEANING OIL SYSTEM

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

Always drain the complete system. Draining when the oil is hot will help to prevent varnish deposits and carry away impurities.

To drain the system, use one of the following methods:

1. If the unit is not elevated high enough to use the oil reservoir drain line to drain oil, a small hand, electric or air operated pump should be used to drain reservoir through the oil filler opening or from the drain valve.
2. If the unit is elevated so that the oil reservoir drain can be used, empty the oil reservoir through the drain valve to a suitable container or sump.
3. If the drained oil and/or the oil filter element are contaminated with dirt, flush the entire system: reservoir, oil cooler, mixing valve and lines. Inspect the oil separator elements for dirt accumulation; replace if necessary. If a varnish deposit exists, contact the factory for recommendations for removal of the deposit and prevention of varnish.

FILLING OIL RESERVOIR

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

1. Be sure the unit is completely off and that no air pressure is in the oil reservoir.
2. Disconnect, tag and lockout the power supply to the starter.
3. Wipe away all dirt around the oil filler plug.
4. Remove the oil filler plug and add oil as required to return the oil level to the center of the green range on the gauge.
5. Install the oil filler plug and operate the unit for about a minute allowing oil to fill all areas of the system. Check for leaks.
6. Shut down unit, allowing the oil to settle, and be certain all pressure is relieved.

	40 & 50 HP	60, 75 & 100 HP (45, 55 & 75 KW)
Refill Capacity For Normal Oil Change	5.5 U.S. Gallons	8.5 U.S. Gallons (32 Liters)
Red to Yellow Range	1.25 U.S. Gallons	2.0 U.S. Gallons (7.5 Liters)

FIGURE 5-6 – APPROXIMATE OIL SYSTEM CAPACITIES

7. Add oil, if necessary, to bring level to the center of the green range on the gauge.

On unloaded operation and after shutdown some oil will drain back into the oil reservoir and the oil level gauge will read "FULL." DO NOT DRAIN OIL TO CORRECT. On the next start, oil will again fill the system and the gauge will indicate operating at the proper level. DO NOT OVERFILL as oil carryover will result. The quantity of oil required to raise the oil level from "ADD" to "FULL" is shown in FIGURE 5–6, page 39. Repeated addition of oil between changes may indicate excessive oil carryover and should be investigated.

Use only CLEAN containers and funnels so no dirt enters the reservoir. Provide for clean storage of oils. Changing the oil will be of little benefit if done in a careless manner.

⚠ CAUTION

Excessive oil carry–over can damage equipment. Never fill oil reservoir above the "FULL" marker.

COMPRESSOR OIL FILTER (FIGURE 5–1) – This screw on oil filter is a vital part in maintaining a trouble–free compressor, since it removes dirt and abrasives from the circulated oil. The oil filter relief valve is located in the oil filter head. The relief valve opens in the event the element becomes dirty enough to block the flow of oil.

⚠ CAUTION

Improper oil filter maintenance will cause damage to equipment. Replace filter element every 1000 hours of operation. More frequent replacement could be required depending on operating conditions. A filter element left in service too long may damage equipment.

Use only the replacement element shown on the filter tag or refer to the parts list for the part number. Use the following procedure to replace the filter element. Do not disturb the piping.

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

1. Stop the unit and be sure no air pressure is in the oil reservoir.
2. Remove the spin–on element.
3. Clean the gasket face of the filter body.
4. Coat the new element gasket with clean lubricant used in the unit.
5. Screw the new element on the filter body and tighten by hand. DO NOT OVERTIGHTEN THE ELEMENT.
5. Run the unit and check for leaks.

COMPRESSOR OIL COOLER – RADIATOR TYPE (FIGURE 1–5, page 3) – The oil cooler motor and fan is mounted on the oil cooler module; air is exhausted through the oil cooler and away from the unit. Do not obstruct air flow to and from the oil cooler. Allow a minimum of three (3) feet clearance around the cooler. Keep both faces of cooler core clean for efficient cooling of compressor oil.

THERMAL CONTROL (THERMOSTATIC MIXING) VALVE (FIGURE 5–7, page 41) is installed in system as shown in FIGURE 5–1, page 34. This valve is used to control temperature of the oil in both air–cooled radiator and water–cooled heat exchanger type oil cooler systems. On start–up with unit cold, element is open to bypass, allowing oil to pass directly from the reservoir to compressor during warm–up. As oil warms, element gradually closes to the bypass allowing more of the oil from the cooler to mix with oil from the bypass.

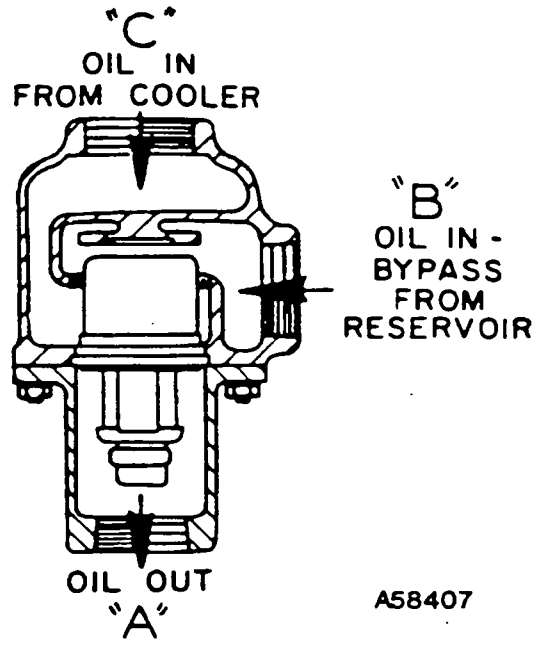


FIGURE 5–7 – THERMOSTATIC MIXING VALVE ELEMENT

After the unit is warmed up, the mixing valve maintains oil injection temperature into the compressor at a minimum of 150° F (66° C). This system provides proper compressor warm–up and helps prevent moisture contamination of oil.

To check element, heat in oil – it should be fully extended at 150° F (66° C). If unit shuts down due to high air discharge temperature, it may be that one or both thermostatic mixing valve elements (FIGURE 5–1, page 34) are stuck open. Remove mixing valve and clean all parts thoroughly when flushing the oil system.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be a high temperature during and after operation.

COMPRESSOR OIL COOLER – WATER–COOLED HEAT EXCHANGER (FIGURE 5–1, page 34) – The heat exchanger oil cooler is a multiple pass type, with water in the tubes and oil in the shell. The oil temperature is controlled by the thermal (thermostatic mixing) valve. The optional water control valve may be used to conserve water.

⚠ WARNING

It is mandatory that any water cooled unit be installed in a shelter heated to temperatures above freezing (32° F., 0° C).

Oil cooler malfunction may be traced by checking pressure at oil inlet and outlet. At normal operating air service pressure (65 to 150 psig, 4.5 to 10.3 Bars) with the unit warm, a pressure drop of 3 to 15 psi (.2 to 1 Bar) can be expected between the oil inlet and the oil outlet.

Water pressure drop from water inlet to outlet will vary with the inlet pressure and amount of water flowing. A normal pressure drop may range from 5 to 10 psi (.3 to .7 Bar). Any change in the pressure drop from that normally held may indicate tube leakage or fouling and should be investigated.

In many instances, the cooling water supply for the heat exchanger will contain impurities in solution and/or suspension. These substances can cause scale formation, corrosion and plugging of any water–cooled heat exchanger equipment. Disregarding the possibility that one or more of these conditions exist may result in increased maintenance and operation expense, reduced equipment life and emergency shutdown. It is strongly recommended that a reputable, local water treatment concern be engaged to establish the corrosion, scale forming and fouling tendency of the cooling water and take steps necessary to remedy the situation if a problem does exist. The need for water treatment may involve only filtration (screening) to remove debris, sand and/or salt in the cooling water supply. However, chemical treatment methods may be necessary in certain instances to inhibit corrosion and/or remove dissolved solids, to alter the water's tendency to form scale deposits, or prevent the growth of microorganisms. The normal maintenance program for the unit should also include periodic cleaning of the tubes (water side) of the heat exchanger to remove deposits which enhance fouling and corrosion.

Hex head zinc anodes are used in the return bonnet (opposite end to the water pipe connections) of heat exchangers to provide internal water system corrosion protection. These anodes should be inspected periodically and replaced when the zinc has been reduced to about 1/2 inch (13mm) in length.

WATER FLOW CONTROL VALVE FOR HEAT EXCHANGER (Optional Equipment) (FIGURE 5–8, page 42) – The water flow control valve is adjustable to compensate for varying water inlet temperatures and pressures and is to be mounted in the water outlet line

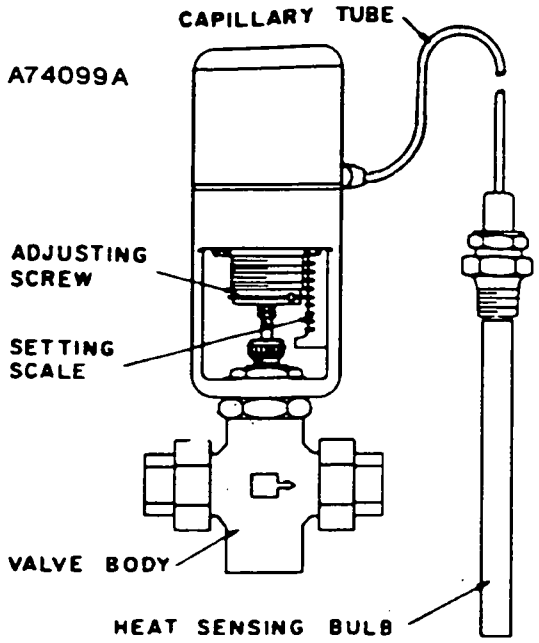


FIGURE 5–8 – WATER CONTROL VALVE

after the oil cooler (FIGURE 5–1, page 34). Use the compressor discharge air temperature gauge on the instrument panel in setting the flow control valve. The compressor discharge temperature must be maintained a minimum of 10° F (5° C) above the dew point temperature at the maximum anticipated ambient; refer to FIGURE 5–9 for the dew point temperature at the operating pressure and ambient temperature of the application.

To decrease water flow (increase compressor discharge air temperature) turn the adjusting screw from left to right, increasing spring tension. **To increase water flow** (decrease compressor discharge air temperature) turn the adjusting screw in the opposite direction. The groove at the lower edge of the adjusting screw is an index line for use with the index scale 0 to 8 in obtaining a desired setting.

These valves must be handled with care and proper tools and techniques must be used when working on the valve.

Care must be used when handling the capillary tube; a kink or break in the tubing or connections will make the valve inoperative. Never attempt to change capillary length. Excess capillary tube should be carefully coiled and placed so that damage will not occur in normal maintenance or traffic past the unit.

If the leak develops through the packing, tighten the packing gland nut firmly with a wrench to reseat the packing around the valve stem, then back off the nut until loose, and finally retighten the nut finger tight. Tightening the packing nut too tight may cause erratic operation. An occasional drop of oil on the valve stem at the packing nut will prolong packing life.

If valve malfunctions, check for bent or binding, paint or corrosion on valve stem, foreign material in valve, erosion, or thermal system (capillary) failure. If foreign material or scale is likely, the use of a strainer in the inlet water line is recommended.

WATER SHUTOFF VALVE – WATER–COOLED HEAT EXCHANGER (Optional Equipment) (FIGURE 5–1, page 34) – A magnetic solenoid–operated water shutoff valve rated at 150 psig (10.3 Bars) water pressure should be mounted in the water outlet

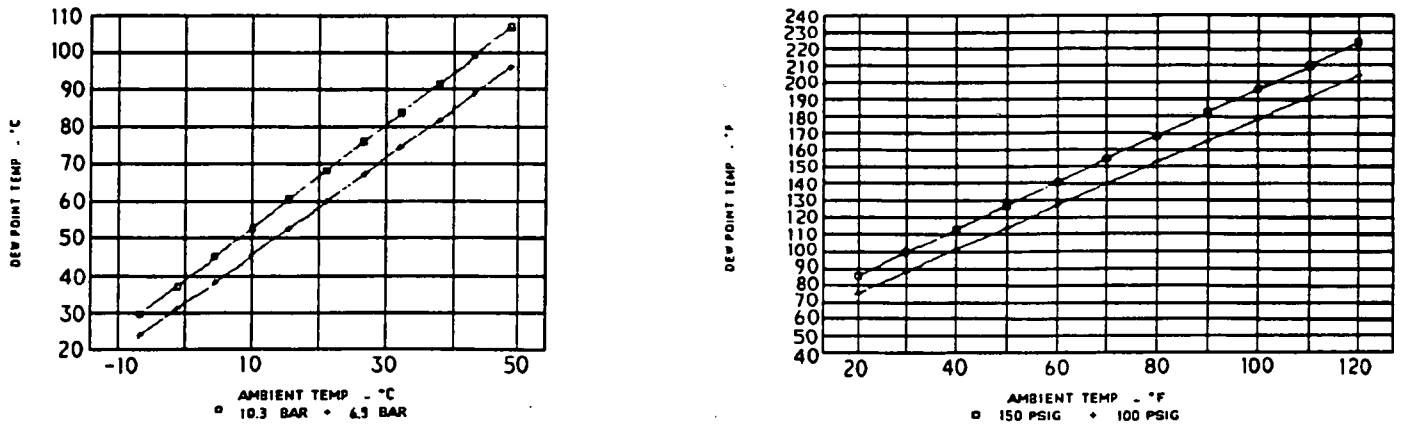


FIGURE 5–9 – DEW POINT TEMPERATURE VS. AMBIENT TEMPERATURE (100% RELATIVE HUMIDITY)

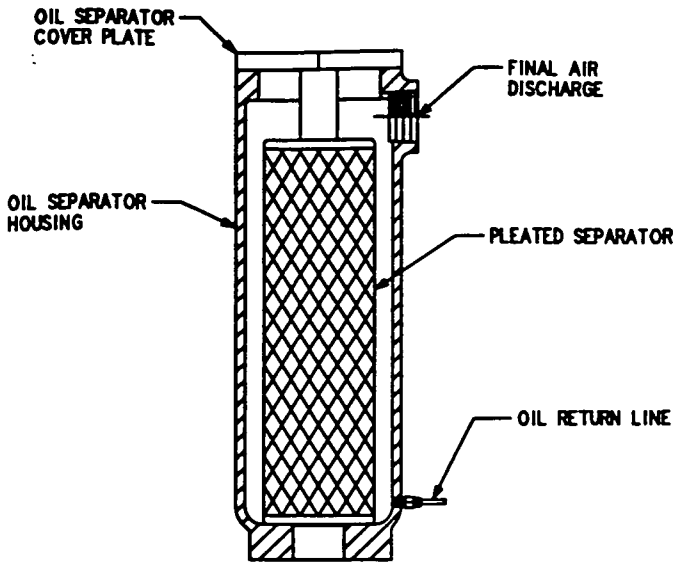


FIGURE 5–10 – OIL SEPARATOR

line after the oil cooler. The valve should be wired into the compressor control circuit so that the valve opens to allow water to flow any time the compressor is running. When compressor stops under automatic control, or is shut off manually, the valve should close, stopping water flow through the system. See Wiring Diagrams in Section 4, pages 30 through 32.

OIL RESERVOIR – The oil reservoir–separator combines multiple functions into one vessel. The lower half is the oil reservoir, providing oil storage capacity for the system and the top portion, a primary oil separation means. The reservoir also provides limited air storage for control and gauge actuation.

COMPRESSOR (GD ELIMINATOR) OIL SEPARATOR located in a separate housing, consists of a renewable cartridge–type separator element and provides the final removal of oil from the air stream (FIGURE 5–10).

Oil impinging on the inside of the separator element drains directly back into the oil reservoir by gravity. Oil collected outside the element is returned through tubing to the compressor cylinder.

Oil carryover through the service lines may be caused by a faulty oil separator, faulty minimum pressure valve, over–filling of the oil reservoir, oil that foams, oil return line malfunction or water condensate in the oil. If oil carryover occurs, inspect the separator only after it is determined that the oil level is not too high, the oil is not foaming excessively, the oil return line from the separator housing to the compressor cylinder is not clogged or pinched off, the check valve in the oil return line is functioning properly, and there is not water or an oil/water emulsion in the oil.

Oil carryover malfunctions of the oil separator are usually due to using elements too long, heavy dirt or varnish deposits caused by inadequate air filter service, use of improper oil or using oil too long for existing conditions. A ruptured or collapsed separator element is usually due to heavy dirt or varnish buildup in the filtering material. Excessive tilt angle of the unit will also hamper separation and cause oil carryover.

Oil separator element life cannot be predicted; it will vary greatly depending on the conditions of operation, the quality of the oil used and the maintenance of the oil and air filters. The condition of the separator can be determined by pressure differential gauging or by inspection.

Pressure Differential Gauging – The "CHANGE SEPARATOR" advisory will flash when the pressure differential across the oil separator reaches approximately 8 PSID (.55 Bar). Replace the oil separator element at this time. If ignored, the unit will shut down and the advisory will illuminate steadily when the pressure differential reaches 15 PSID (1 Bar).

⚠ CAUTION

Using an oil separator element at excessive pressure differential can cause damage to equipment. Replace the separator when the "Change Separator" advisory appears.

NOTICE

A sudden drop of zero pressure differential or sudden heavy oil carryover may indicate a ruptured element.

Inspection – After removal of separator element, shine a light inside the element to reveal areas of heavy dirt or varnish deposits or breaks (ruptures) in the element media.

Removal Of Oil Separator For Inspection Or Replacement:

> **⚠ DANGER**
>
> **Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.**

1. Be certain unit is completely off and that no air pressure is in the oil reservoir.
2. Disconnect, tag and lockout power supply to the starter.
3. Remove screws holding the top plate to the separator housing. Lift the top plate from the separator housing.
4. Lift the separator from the separator housing.
5. Inspect and/or replace the separator as necessary. Be sure the o–ring is not damaged. Before installing (or reinstalling) any separator apply grease to the o–ring. Oil will be wiped off by the chamfer and the o–ring could be damaged.
6. Remove any gasket material adhering to top plate or separator housing, and install new gasket.
7. Lower the separator into the housing and center the separator on the chamfer. Press separator down into the housing. Do not use excessive force as separator damage can occur.
8. Place the spacer on the indent in the separator. Seat the top plate to the separator, spacer and separator housing. Install and tighten all cap screws.
9. Run the unit and check for leaks.

COMPRESSOR OIL SYSTEM CHECK – The following readings are based on ambient temperature of 80° F (27° C) for air–cooled oil cooler and 80° F inlet water on water–cooled oil cooler, with the system in good condition. Compressor should be at operating temperature at the time of checks. One–half hour of loaded operation is usually sufficient to reach level–out operating temperatures.

Air and Oil Discharge Temperature – 165° to 19[illegible] F (74° to 91° C) – Read at gauge on the instrument panel or check with a thermometer at the discharge housing.

Compressor Oil Inlet Temperature – 150° to 160° F (66° to 71° C) – Install a tee at the oil filter outlet and check with a thermometer.

Oil Inlet Pressure – Check at the fitting in the line near the compressor oil inlet. With air receiver pressure at 100 psi (6.9 Bar), oil inlet pressure should be 55–60 psig(3.8–4.1 Bar).

Oil Cooler Oil Pressure Differential (Air–Cooled Radiator) – Check differential across oil system by measuring oil inlet pressure as described above.

Oil Cooler Oil Pressure Differential (Water–Cooled Heat Exchanger) – 2 to 25 PSID (.1 to 1.7 Bar) (65 to 150 PSIG, 4.5 to 10.3 Bars Receiver Pressure) – Check that oil inlet pressure is correct or measure the differential between drains on the oil cooler shell.

Oil Cooler Temperature Differential (Air–Cooled Radiator) – The oil temperature differential depends on the temperature of the air at the oil cooler fan and cleanliness of core faces. As ambient temperatures and core restrictions increase, the oil cooler outlet te[illegible] perature will increase. The oil inlet temperature [illegible] approximately the same as air discharge temperature – see the gauge on the instrument panel. The outlet oil temperature may be checked by installing a tee at the oil filter outlet.

Oil Cooler Temperature Differential (Water–Cooled Heat Exchanger) – The oil temperature differential depends on the inlet water temperature and the water flow rate permitted by the water flow control valve setting. The oil inlet temperature is approximately the same as the air discharge temperature – see the gauge on the instrument panel. The oil outlet temperature may be checked by installing a tee at the oil filter outlet.

Oil Cooler Water Pressure Differential (Water–Cooled Heat Exchanger) – The water pressure differential through the heat exchanger will depend on the supply pressure, flow rate, cooler tube cleanliness and outlet pressure. The inlet and outlet water pressure may be checked at the pipe fittings supplied by the customer.

SECTION 6
AIR FILTER

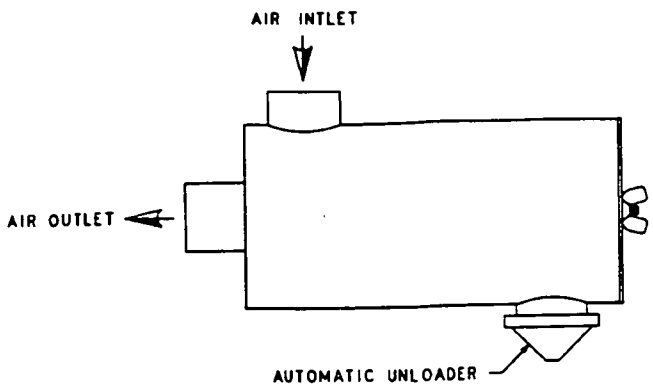


FIGURE 6–1 – HEAVY DUTY AIR FILTER

HEAVY–DUTY AIR FILTER (FIGURE 6–1) furnished as standard equipment on units with an enclosure is a heavy–duty washable element dry type air filter. The air filter must receive proper maintenance if maximum service is to be obtained from the unit. Establishing adequate and timely filter service is MOST IMPORTANT. An improperly maintained air filter can cause a loss of compressor air delivery.

Filter Element – Service the air filter element when the "CHANGE AIR FILTER" LED is illuminated. Clean every 50 to 150 operating hours depending on dust conditions.

NOTICE

Use only genuine Gardner Denver air filter elements on Gardner Denver compressor units. Genuine parts are available through your authorized Gardner Denver distributor.

To service:

1. Remove the wingnut and pull out the filter element.
2. Visually inspect the element. If cleaning is not necessary, reinstall the filter element. If the element requires cleaning, follow steps 3, 4 and 5.
3. Wash the element by soaking about 15 minutes in warm water with a mild nonsudsing detergent. Rinse the element thoroughly with clean water; a hose may be used if the water pressure does not exceed 40 psig (2.8 Bars).
4. Inspect the element for ruptures or cracks in the pleated media; replace the element if any are found. Inspect the gasket on the bottom (outlet end) of the element; replace the entire element if the gasket is damaged. A spare element will keep down time to a minimum.
5. Allow the element to air dry COMPLETELY. Do not expose the element to heat over 150° F (66° C). Install the element in the filter body and fasten securely with the wing nut.

⚠ WARNING

Do not oil this element. Do not wash in inflammable cleaning fluids. Do not use solvents other than water. Improper cleaning may damage the element.

NOTICE

Never operate the unit without the element. Never use elements that are damaged, ruptured or wet. Never use gaskets that won't seal. Keep spare elements and gaskets on hand to reduce downtime. Store elements in a protected area free from damage, dirt and moisture. Handle all parts with care.

Filter Element Life – The element should be replaced after six (6) cleanings or if:

1. Visual inspection indicates a rupture, crack or pin hole in the pleated media. Inspection should be done by placing a bright light inside the element.

2. Pressure drop through a filter with a freshly cleaned element is below three (3) inches (76 mm) of water with the compressor running at full load – this would indicate a rupture or crack.

Inlet Tube – Inspect the inlet screen and tube for dirt accumulation each time the filter is serviced. Clean the tube when required by ramming a clean dry cloth through the tube. Wipe the inside of the filter body to remove any dirt falling from the inlet tube before reinstalling the element.

Causes of short element life include: severe dust conditions, infrequent servicing, improper cleaning, or contamination by oil or chemical fumes.

SECTION 7
COUPLING

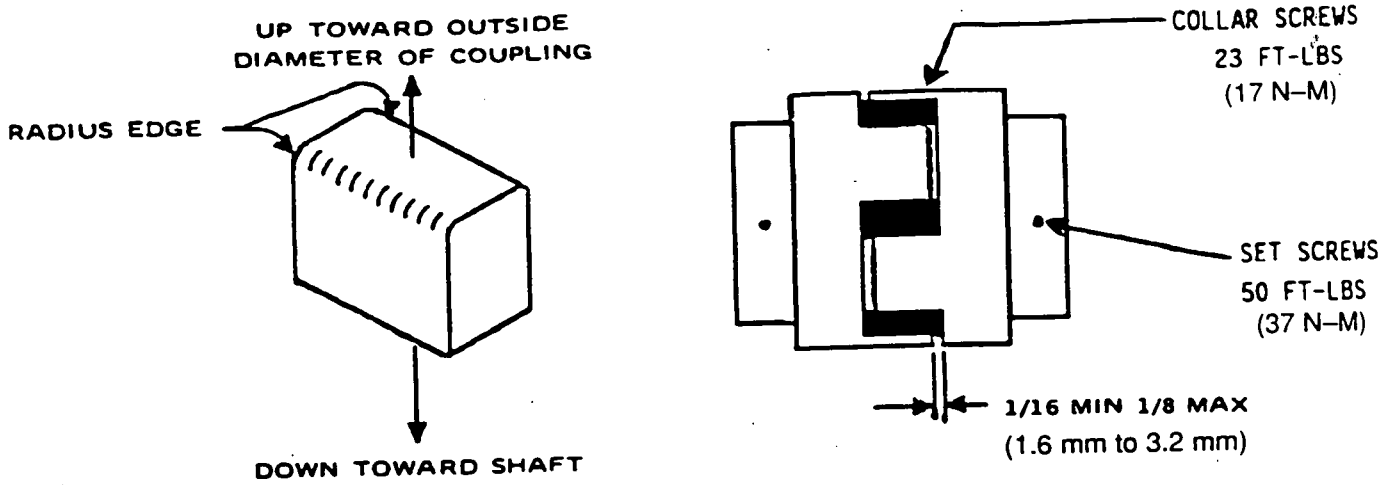


FIGURE 7–1 – INSTALLATION OF COUPLING CUSHIONS

⚠ DANGER

Rotating machinery can cause personal injury or death. Turn the unit completely off, open the main disconnect, tag and lockout before servicing the coupling.

COUPLING – The motor and compressor are direct connected by a resilient type flexible coupling with several individual cushions. The coupling does not require lubrication.

If maintenance on mating parts is requires, reassemble coupling as follows:

Individual Cushion Design (FIGURE 7–1)

1. Slide coupling halves over shaft extensions. Be sure the collar is installed on the shaft behind one coupling body.
2. Assemble the motor to the compressor.
3. Working through the coupling guard opening, center the coupling over the gap between the shafts, maintaining the gap as shown in FIGURE 7–1 between the ends of the jaws on one coupling body and the flange on the opposite coupling body. Tighten set screws in each coupling body.
4. Insert individual cushions as shown in FIGURE 7–1 and slide the collar over the cushions and secure with cap screws. Reinstall the cover plate.

⚠ DANGER

Rotating machinery can cause personal injury or death. Do not operate unit with either the coupling guard or the collar removed. All bolts and screws must be properly tightened.

Alignment – The coupling is permanently aligned by the flanges on the compressor and motor.

SECTION 8
MAINTENANCE SCHEDULE

SERVICE CHECK LIST –

Air Filter – Operating conditions determine frequency of service. If the "CHANGE AIR FILTER" message is displayed, air filter requires servicing or changing. See "Air Filter," Section 6, page 45.

Oil Separator – Operating conditions determine frequency of service. If the "CHANGE SEPARATOR" message is displayed, the oil separator element requires changing. See "Compressor Oil Separator" in Section 5, page 43, for further details.

Motor Lubrication – Refer to Section 2, page 14, and Maintenance Schedule Chart below.

Every 8 Hours Operation

1. Check the reservoir oil level – add oil if required. See Section 5, page 48. If oil consumption is high, refer to "Excessive Oil consumption, page 50. DO NOT MIX LUBRICANTS.
2. Observe if the unit loads and unloads properly.
3. Check discharge pressure and temperature.
4. Check Panel LED's for advisories.

Every 125 Hours Operation

1. Check for dirt accumulation on oil/aftercooler core faces and the cooling fan. If cleaning is required, clean the exterior fin surfaces of the cores by blowing compressed air carrying a nonflammable safety solvent in a direction opposite that of the cooling fan air flow. This cleaning operation will keep the exterior cooling surfaces clean and ensure effective heat dissipation.

Every 1000 Hours Operation

1. Change the oil filter element.

Every 8000 Hours Operation

1. Change the compressor lubricant. UNDER ADVERSE CONDITIONS, CHANGE MORE FREQUENTLY (refer to "Oil Change Interval", page 38). Flush system if required.

Every Year

1. Check the relief valve for proper operation. See Section 4, page 18.

MAINTENANCE SCHEDULE (See detail notes above)

Maintenance Action	As Indicated By Auto–Sentry® Controller	Every 8 Hours	Every 125 Hours	Every 1000 Hours	Every 8000 * Hours	Every Year
Change Air Filter	•					
Change Oil Separator	•					
Check Reservoir Oil Level		•				
Check For Proper Load/Unload		•				
Check Discharge Pressure/Temp		•				
Check Dirt Accumulation on Cooler			•			
Change Oil Filter Element	•			•		
Change Compressor Lubricant (AEON 9000 SP)	•				•	
Check Relief Valve						•

* See Oil Change Interval Chart, FIGURE 5–5, Page 38, for specific lubricant life.

SECTION 9
TROUBLE SHOOTING

SYMPTOM	POSSIBLE CAUSE	REMEDY
Compressor fails to start.	1. Wrong lead connections.	1. Change leads.
	2. Blown fuses in control box.	2. Replace fuse.
	3. Motor starter overload heaters tripped.	3. Reset and investigate cause of overload.
	4. Pressure in reservoir.	4. Inspect blowdown valve. and muffler.
	5. Read error message on control panel.	5. Take appropriate action. See Manual 13–9/10–647.
	6. Remote Contact is open (terminals 6 & 9).	6. Replace switch or jumper.
Compressor starts but stops after a short time.	1. High discharge temperature.	1. See "High Discharge Air Temperature," this section, page 50.
	2. High discharge temperature switch malfunction.	2. Replace switch.
	3. Blown fuse in starter/ control box.	3. Replace fuse (investigate if fuses continue to blow).
	4. Motor starter overload heaters trip.	4. Reset and investigate cause of overload.
Compressor does not unload (or load).	1. Improperly adjusted control.	1. Refer to Manual 13–9/10–647 and adjust control.
	2. Air leak in control lines.	2. Determine source of leak and correct.
	3. Restricted control line.	3. Clean control lines.
	4. Blowdown valve malfunction.	4. Repair, clean or replace valve.
Compressor cycles from load to unload excessively.	1. Insufficient receiver capacity.	1. Increase receiver size.
	2. Restriction in control tubing.	2. Inspect and clean control tubing.

SYMPTOM	POSSIBLE CAUSE	REMEDY
Compressor is low on delivery and pressure.	1. Restricted air filter.	1. Clean or replace filter.
	2. Sticking inlet valve.	2. Inspect and clean inlet valve.
	3. Unload pressure adjusted too low.	3. Adjust the unload pressure. See Manual 13–9/10–647.
	4. Minimum pressure valve stuck closed.	4. Disassemble and clean valve.
High discharge air temperature.	1. Thermostatic mixing valve stuck open.	1. Repair or replace valve.
	2. Dirty or clogged cooler face.	2. Clean cooler.
	3. Insufficient cooling air flow.	3. Provide unrestricted supply of cooling air.
	4. Clogged oil filter or cooler (interior).	4. Replace filter or clean cooler.
	5. Low compressor oil.	5. Add oil to proper level.
Excessive Oil Consumption	1. Oil carryover through lines.	1. See "Oil Carryover", below.
	2. Oil leaks at all fittings and gaskets.	2. Tighten or replace fittings or gasket.
Oil Carry–Over	1. Overfilling the reservoir.	1. Drain excess oil from system.

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

	2. Clogged, broken or loose oil return lines	2. Tighten or replace faulty lines.
	3. Ruptured oil separator element.	3. Replace element.
	4. Loose assembly.	4. Tighten all fittings and gaskets.
	5. Foam caused by use of incorrect oil.	5. Use Gardner Denver® AEON™ 9000 SP Lubricating Coolant.
	6. Inoperative minimum pressure valve.	6. Clean out or replace valve.

SYMPTOM	POSSIBLE CAUSE	REMEDY
Oil Carry–Over (Continued)	7. Operation at elevated discharge temperatures.	7. Reduce temperature. See High Discharge Air Temperature, page 50, this section.
	8. Scavenge line check valve failure.	8. Replace check valve.
	9. Water condensate in oil.	9. Check oil reservoir temperature and if low, change thermal mixing valve element to higher temperature.

NOTICE

Gardner Denver factory remanufactured replacement compressor air end units are available from your authorized distributor, on an exchange basis, for all rotary screw compressor units.

Gardner Denver

WARRANTY
ROTARY SCREW COMPRESSORS
OIL INJECTED • OIL FREE

GENERAL PROVISIONS AND LIMITATIONS

Gardner Denver (the "Company") warrants to each original retail purchaser ("Purchaser") of its new products from the Company or its authorized distributor that such products are, at the time of delivery to the Purchaser, made with good material and workmanship. No warranty is made with respect to:

1. Any product which has been repaired or altered in such a way, in the Company's judgment, as to affect the product adversely.
2. Any product which has, in the Company's judgment been subject to negligence, accident, improper storage, or improper installation or application.
3. Any product which has not been operated or maintained in accordance with the recommendations of the Company.
4. Components or accessories manufactured, warranted and serviced by others.
5. Any reconditioned or prior owned product.

Claims for items described in (4) above should be submitted directly to the manufacturer.

WARRANTY PERIOD

The Company's obligation under this warranty is limited to repairing or, at its option, replacing, during normal business hours at an authorized service facility of the Company, any part which in its judgment proved not to be as warranted within the applicable Warranty Period as follows.

COMPRESSOR AIR ENDS

Compressor air ends, consisting of all parts within and including the compressor cylinder and gear housing, are warranted for 24 months from date of initial use or 27 months from date of shipment to the first purchaser, whichever occurs first.

Any disassembly or partial disassembly of the air end, or failure to return the "unopened" air end per Company instructions, will be cause for denial of warranty.

OTHER COMPONENTS

All other components are warranted for 12 months from date of initial use or 15 months from date of shipment to first purchaser, whichever occurs first.

LABOR TRANSPORTATION AND INSPECTION

The Company will provide labor, by Company representative or authorized service personnel, for repair or replacement of any product or part thereof which in the Company's judgment is proved not to be as warranted. Labor shall be limited to the amount specified in the Company's labor rate schedule.

Labor costs in excess of the Company rate schedule amounts or labor provided by unauthorized service personnel is not provided for by this warranty.

All costs of transportation of product, labor or parts claimed not to be as warranted and, of repaired or replacement parts to or from such service facilities shall be borne by the Purchaser. The Company may require the return of any part claimed not to be as warranted to one of its facilities as designated by Company, transportation prepaid by Purchaser, to establish a claim under this warranty.

Replacement parts provided under the terms of the warranty are warranted for the remainder of the Warranty Period of the product upon which installed to the same extent as if such parts were original components.

DISCLAIMER

THE FOREGOING WARRANTY IS EXCLUSIVE AND IT IS EXPRESSLY AGREED THAT, EXCEPT AS TO TITLE, THE COMPANY MAKES NO OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY.

THE REMEDY PROVIDED UNDER THIS WARRANTY SHALL BE THE SOLE, EXCLUSIVE AND ONLY REMEDY AVAILABLE TO PURCHASER AND IN NO CASE SHALL THE COMPANY BE SUBJECT TO ANY OTHER OBLIGATIONS OR LIABILITIES. UNDER NO CIRCUMSTANCES SHALL THE COMPANY BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOSSES OR DELAYS HOWSOEVER CAUSED.

No statement, representation, agreement, or understanding, oral or written, made by any agent, distributor, representative, or employee of the Company which is not contained in this Warranty will be binding upon the Company unless made in writing and executed by an officer of the Company.

This warranty shall not be effective as to any claim which is not presented within 30 days after the date upon which the product is claimed not to have been as warranted. Any action for breach of this warranty must be commenced within one year after the date upon which the cause of action occurred.

Any adjustment made pursuant to this warranty shall not be construed as an admission by the Company that any product was not as warranted.

Gardner Denver

For additional information contact your local representative or
Gardner Denver, Customer Service Department,
1800 Gardner Expressway, Quincy, Illinois 62301
Telephone: (800) 682–9868 FAX: (217) 224–7814

Sales and Service in all major cities.

For parts information, contact Gardner Denver,
Master Distribution Center, Memphis, TN
Telephone: (800) 245–4946 FAX: (901) 542–61

http://www.gardnerdenver.com mktg@gardnerdenver.com

GARDNER DENVER®

13–910–647
2nd Edition
January, 1999

AUTO SENTRY®–ES+ CONTROLS

AUTO SENTRY®–ES CONTROLS

OPERATING AND SERVICE MANUAL

Gardner Denver

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INTRODUCTION

This manual descirbes the operation and maintenance of electonic controllers used on oil–flooded rotary screw compressor packages. The controller is the key component of the ES control system described in the Operating and Service Manual for the compressor package. Either of two controllers may be installed on the compressor package, and both perform similar functions. The controllers are:

AUTO SENTRY®–ES+

This offers all of the control functions of the controller below plus additional features and performance. A graphic display and keypad provides service lights and rapid access to compressor data. The controller features enhanced continuous modulation, or may be run in full–load/no–load systems. The adjustments are grouped to provide fast access to common adjustments. The AUTO SENTRY®–ES+ multi–compressor sequencing retains the simple installation and operation with improved performance for reduced operating cost. A dedicated RS–232 data port is provided for connection into local or plantwide data collection systems.

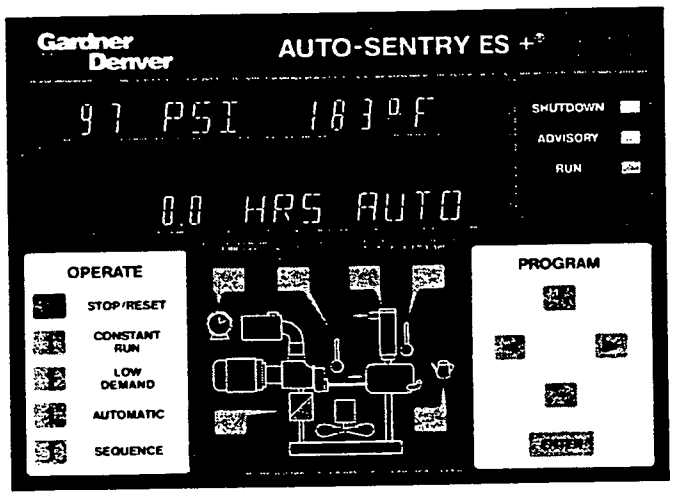
Section 1 describes software version 2.12 (which covers the ES+ controller).

AUTO SENTRY®–ES

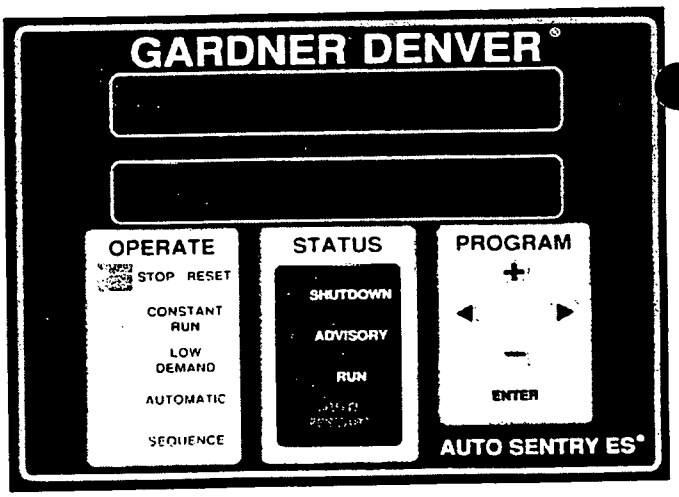
This offers complete electronic control of all compressor functions, including motor starting and modulation. It monitors pressures and temperatures within the package, and presents them on a large alpha–numeric display. All user input is from a simple keypad, allowing selection of operating mode at any time and adjustment of the compressor to meet needs of the application. This controller may also be easily connected to other AUTO SENTRY®–ES controllers to operate multiple units as a single compressed air system.

Section 2 describes software version 1.60 (which covers the ES controller).

Sections 3 through 5 cover special control topics common to either controller.



AUTO SENTRY®–ES+ DISPLAY



AUTO SENTRY®–ES DISPLAY

SECTION 1
AUTO SENTRY® –ES+ CONTROLLER

GENERAL DESCRIPTION – The Gardner Denver rotary screw compressor is prewired with all controls, motor, and starter for the voltage and horsepower at the time of ordering. It is necessary only to connect the compressor unit to the correct power supply and to the shop air line (and to the appropriate water supply if water cooled). A standard compressor unit consists of the compressor, oil reservoir, oil cooling system and filter, motor type as specified, NEMA 12 starter / control box, and control components as described in the package instruction manual.

This compressor unit features the "AUTO SENTRY®–ES+" controller, which integrates all the control functions under microprocessor control. Its functions include safety and shutdown, compressor regulation, operator control, and advisory / maintenance indicators. The keypad and display provide the operator with a logical and easily operated control of the compressor and indication of its condition.

AUTO SENTRY®–ES+ OPERATION

Operation of the "AUTO SENTRY® ES+" is dependent on selection of an operating mode (described below) from the controller keypad. Prior to starting, the [STOP/RESET] key must be pressed to place the controller into its READY state (as indicated on the display). Compressor operation may then be started by pressing an operating mode key. Once operating, the mode may be changed at any time by pressing a key, and the selected mode will be displayed in the lower right corner of the message window. Press the [STOP/RESET] key at any time to stop the compressor under normal conditions. If the compressor has been running, the reservoir will first be relieved of pressure before stopping the motor. The display will count down to zero during the normal stop.

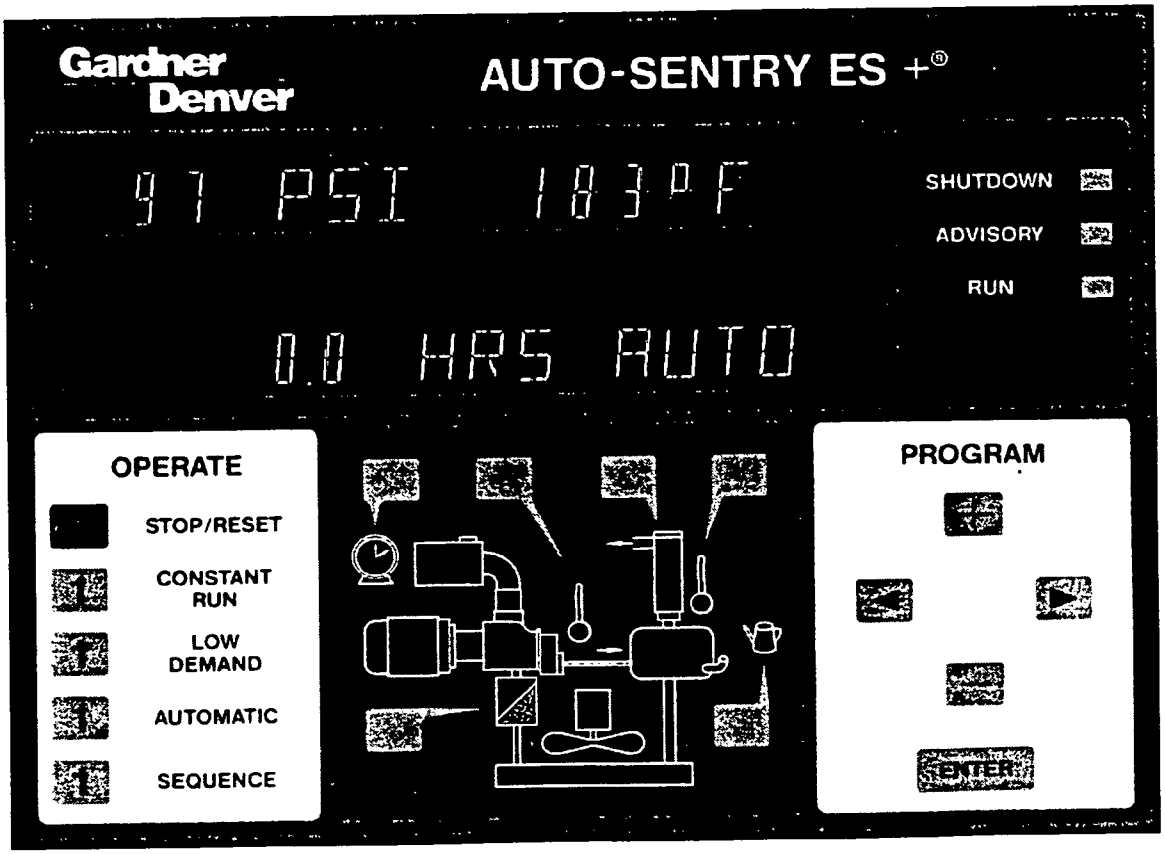


FIGURE 1–1 – AUTO SENTRY® ES+ DISPLAY

⚠ WARNING

Automatic restarting or electrical shock can cause injury or death. Open, tag and lockout main disconnect and any other circuits before servicing the unit.

If any alternate display is on, press the operating mode key to return to the "normal" display. While operating and running, the unit may be manually unloaded by pressing and holding the operating mode key. This unloads a running compressor after several seconds, and will prevent loading while the key is held down. When the key is released, the control will resume its normal operation as required.

An optional control may be wired into the "Auto Sentry® ES+" controller to interrupt and restart the unit based on controls by others. When stopped by these controls, the display indicates "**REMOTE HALT**."

In any mode, the compressor will start only if reservoir pressure is below 5 psig. The display will indicate if the control is waiting for a reservoir blowdown, along with the remaining pressure. The controls also delay initial loading of the compressor until a startup delay has been completed.

Constant Run Mode Operation – This mode is best used in applications where there are no long periods of unloaded operation, or for minimum response time to sudden demands. The compressor unit will start and run continuously, using its modulation controls to match delivery to demand.

As demand falls below the compressor capacity, the pressure will rise to the setpoint of the control. When the pressure reaches the setpoint, the "Auto Sentry® ES+ controller operates the solenoid valves TVO (turn valve open), TVC (turn valve close), IVO (inlet valve open) and IVC (inlet valve close) to control the CFM of the compressor to match the CFM demand of the air system. As the demand changes, the controller will continue adjustment for the best compressor operation. At moderate to heavy demand, the inlet will be held open, and the turn valve will control delivery. At lighter demands, the turn valve will be fully open, and the inlet valve will control capacity. At very light demand, the compressor will unload, but will not blow down the reservoir. It will reload just below the set pressure. The controller will thus maintain the pressure within a few psi of the set pressure.

On compressor units without turn valve, the controller operates valves IVO and IVC to position the inlet valve. This continuously adjusts delivery to match demand.

If the controller is programmed for "load–unload" operation, the controller will deliver full capacity until the system pressure reaches the set pressure. It will then unload (but not blow down) and will not deliver any air to the system. When the system pressure falls to halfway between the set and reset pressure, the "Auto Sentry®–ES+" controller again fully loads the compressor.

When first starting, the controller will keep the compressor fully unloaded and blown down until the system pressure drops below the reset pressure. Once loaded, the reservoir will remain fully charged, regardless of demand. Responses to demand are thus immediate, as soon as system pressure drops below the setpoint.

Low Demand Mode Operation – The low demand mode reduces power consumption by relieving pressure in the reservoir during unloaded operation. This mode is best used where there is moderate air storage and there are unloaded periods during the day, but frequent motor starting and stopping is undesirable. During periods of moderate to high demands, this mode is identical to the constant–run mode described above.

During low demand periods, the controller will open the blowdown valve and fully close the inlet valve to minimize the motor load. A timer is reset when this occurs. While in this state, control air pressure is supplied from the plant air system (as are any plant loads). When the system air pressure drops to the reset pressure due to increased demand, the blowdown valve recloses and the controls resume their normal modulation to maintain the system pressure near the set pressure.

Subsequent blowdown periods are not allowed until the timer has completed its cycle. This cycle eliminates frequent blowdowns during moderate loads, and the energy required to repressurize the reservoir. It also eliminates the problems of oil foaming and carryover that can occur if the oil reservoir of an oil–flooded compressor is blown down too often. The timer is adjustable from 5 to 20 minutes.

Automatic Mode Operation – This mode provides automatic start and timed stop, and is best used in applications with long unloaded periods (e.g. idle shifts or weekends) and adequate storage to allow the compressor to be stopped for periods of light demands. Operation during periods of moderate to heavy demands are identical to the low demand mode.

The automatic time delay is adjustable from 5 to 20 minutes. If the controller operates unloaded for this period with no demand, the compressor drive motor is halted to eliminate its power consumption. The con-

trols will remain in this state until demand is again indicated by a drop in pressure.

This is the most common selected mode of operation, as it automatically will operate the compressor unit in the most efficient manner for the demand of the air system.

Sequence Mode Operation – This mode provides for communication between controllers, operating only as many as are required for economical operation. This is best used on applications with large storage capacity and diverse loads. The lead unit will operate identically to the automatic mode; operation will be automatically staged for each lag unit (up to 8 total). For more information, refer to "Sequencing Compressors With The Auto Sentry® ES+", page 10,.

Communication between controllers is achieved by interconnection of a communications cable to circuit board connectors. A "unit number" must be assigned to each unit in this mode, but the display will indicate the unit's actual operating ranking.

AUTO SENTRY®–ES+ CONTROL DISPLAY

The display above the keypad is used to provide operating information to the user. If a shutdown has occurred, the display will indicate the cause.

During normal operation, the display will show the system (plant) pressure, compressor discharge temperature, total running hours, and operation mode. Alternate displays are available by pressing the keys on the diagram or the [<][>] keypad keys, and will be identified on the display. These include:

1. Air/oil reservoir pressure
2. Separator differential pressure
3. Air/oil reservoir & separator temperature
4. System discharge pressure
5. Air end discharge temperature
6. Remaining blowdown time
7. Remaining auto time
8. Total running hourmeter
9. Loaded operation hourmeter

Remaining blowdown and auto times are only available in Low Demand, Automatic, and Sequence modes, as appropriate.

Service information may also be displayed while the compressor is running. Press the [+][–] keys to display the following:

1. Main motor current (optional)
2. Est. hours till next recommended oil change
3. Hours till next recommended oil filter change
4. List of any active advisory messages

If no keys are pressed for 5 seconds, the display will revert to its normal mode.

The display is also used as a service reminder for normal maintenance items. If service is recommended, the yellow advisory light will be on, and a message will alternate with the normal lower line display. Yellow lights on the diagram also indicate the area needing service. These messages are intended to advise of conditions which may lead to a shutdown.

If a protective shutdown occurs, the red shutdown light will be on and the top line of the display will indicate **"SHUTDOWN"**. The lower line will indicate the cause of the shutdown. A red indicator on the diagram indicates the area needing service.

SERVICE ADVISORIES

The "AUTO SENTRY®–ES+" controller turns on an advisory when it detects operation which needs service attention, but does not warrant shutting down the compressor. Some of these are normal maintenance procedures, and are intended to serve as a reminder to perform routine service. Others are conditions which can reduce the maximum compressor performance. It will remain in effect until reset. Check the display during routine inspections, and perform maintenance as suggested. Refer to the troubleshooting section for detailed information about each advisory.

Temperature advisories may be cleared while the unit is running by simply pressing the [ENTER] key. To reset the service advisories, press the [STOP/RESET] key to stop operation of the compressor. After it has stopped, disconnect power and service as required. After servicing, restore power and reset the board as indicated in "Maintenance Adustment," page 7.

PROTECTIVE SHUTDOWNS

The "AUTO SENTRY®–ES+" will shut down the unit following any fault detected in the following devices. Long–term problems will have a brief blowdown period before fully shutting down. Following a shutdown, a message will be displayed, with the top line indicating **"SHUTDOWN"** and the lower line indicating the cause. The shutdown light will be steadily lit if the cause still exists, or will flash if the cause has been cleared. Refer to the troubleshooting section for detailed information about each shutdown. To resume operation, the cause of the shutdown must be corrected and the controller reset by pressing the [STOP/RESET] key.

Motor Protective Devices – Overload heaters are furnished for the starter in the voltage range specified. There are three (3) overloads in the starter of proper size for the starter and its enclosure. Note that motor nameplate current must be multiplied by 0.577 for wye–

delta starters. The display will indicate that an overload relay has tripped. The overload relay is reset by pressing the button on the relay itself, then the controller may be reset. Motor current (amps) and voltage must be measured in the affected motor wiring to locate the cause for high current. Overload relays provided in standard units are sensitive to both overload and phase imbalance for improved motor protection. Proper starter coil and contact action is also monitored and errors in operation will cause a shutdown with the cause displayed as a starter or starter contact error.

High Temperature – The compressor is protected from high discharge temperature by a thermistor probe located in the compressor discharge elbow. The "AUTO SENTRY®–ES+" will shut the compressor down if temperature exceeds 225°F (or lower per user adjustment) or if rapid temperature rise is detected. Reservoir / separator temperature is also monitored, and will provide high temp shutdowns. The location of the temperature fault will be displayed. Thermistor probes are also checked for open or shorted circuits, and the display will indicate the location of the defective probe.

⚠ CAUTION

Machine damage will occur if compressor is repeatedly restarted after high temperature stops operation. Find and correct the malfunction before resuming operation.

Separator Differential Pressure – The pressure drop across the separator is continually monitored by "AUTO SENTRY®–ES+". The unit will be shut down at a differential pressure of approximately 15 psid.

The pressure drop can be monitored at any time by pressing the separator key on the diagram twice. This should be checked while the compressor is delivering at full capacity. A service advisory comes on to recommend maintenance prior to this shutdown.

High Pressure – The "AUTO SENTRY®–ES+" will first attempt to unload and blow down the unit if excessive pressures are detected in the reservoir or the plant system. If unsuccessful, a shutdown will occur. Shut down will also occur if a defective transducer is detected, or improper zero adjustments are detected. The display will indicate the location of the high sensed pressure or transducer (xducer) error. Check that all adjustments have been properly made, and all connections are secure.

Low Oil Pressure – The "AUTO SENTRY®–ES+" will shutdown the unit if inadequate oil pressure is detected after loading the compressor. If this occurs, check the wiring and piping to the solenoid valves.

Emergency Stop – Press the emergency stop button to shut down the unit and the controller. To restart, pull the button out to its normal position and reset the controller. This should be used for emergency purposes only – use the keypad [STOP/RESET] for normal controlled stopping.

Power Failure – Following power interruptions, the controller will remain in a shutdown state (unless programmed for auto restart).

External Device – This input is provided for user– or dealer– installed devices needed by specific applications. Other shutdown field selectable messages include: high vibration, phase relay, low voltage relay, water press, and motor overtemp.

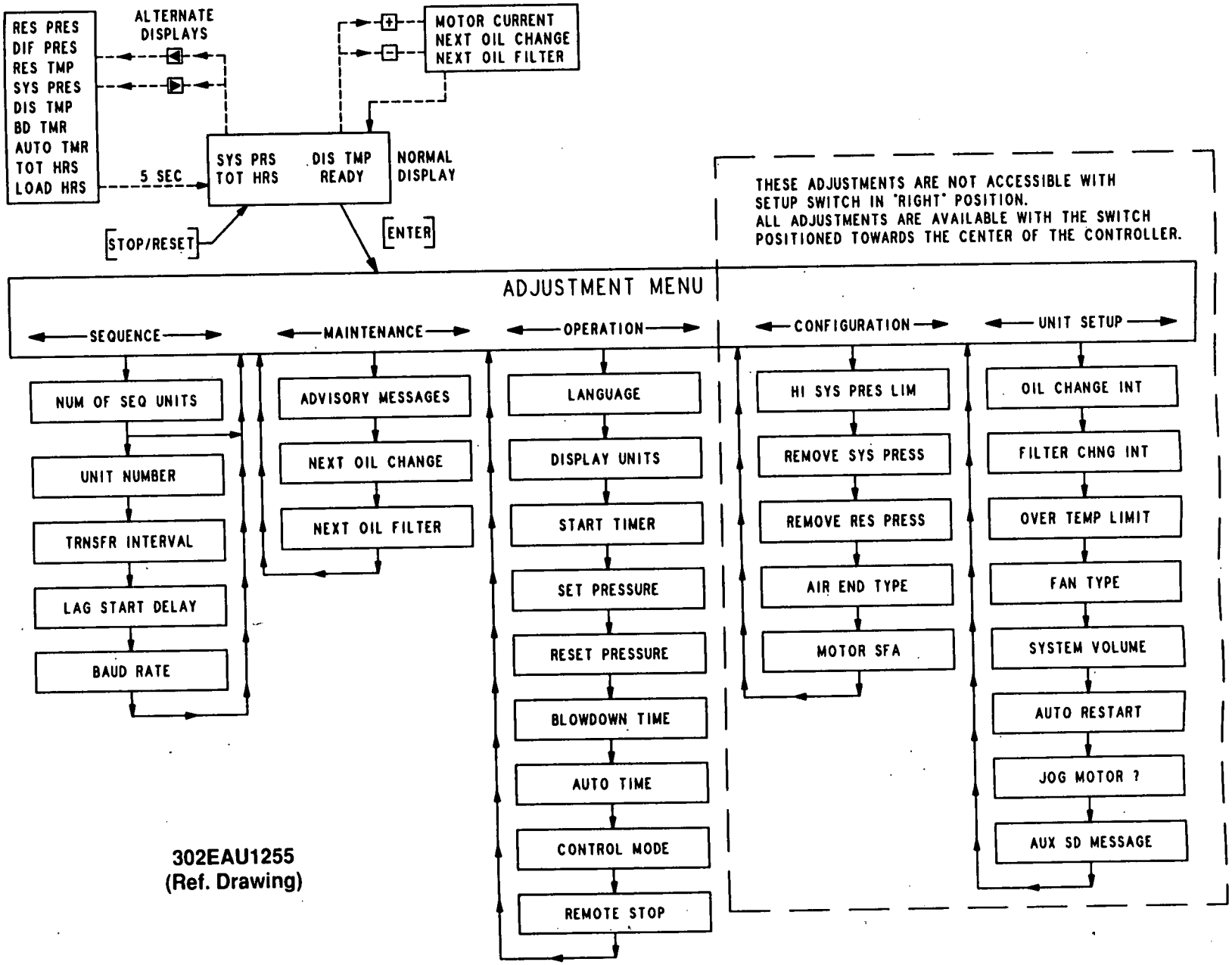
Amp Sensor Failure – The optional current sensor used with the ES+ controller is used for operational tuning and advisory purposes only. The only shutdown functions are those when the controller senses improper operation. These may be disabled if no sensor is installed.

Connection Failure – The ES+ controller checks input connectors and will shutdown if they become unplugged.

Other Shutdowns – The controller runs continuous diagnostic checks of its own operation and the sensors to which it is connected. Refer to the service section for a complete listing of shutdowns and remedial actions.

PROGRAMMING AND SETUP INSTRUCTIONS FOR THE "AUTO SENTRY® ES+" CONTROLLER

Programming and setup is accomplished with the PROGRAM keys. See FIGURE 1–1, page 1. In all steps, the [ENTER] key enters the displayed value into memory and advances to the next programming function. The plus [+] and minus [–] keys will increase and decrease displayed numeric values, or step through menu selections. During numeric adjustments, the left [<] and right [>] arrow keys, move the cursor (flashing digit) to the position desired. Use the [+] and [–] keys to change the number at the cursor. At any point in the programming and setup routine, the [STOP/RESET] key can be pressed to exit the adjustment mode without altering the adjustment. In all steps of the programming routine, the top line of the display will give a description of the parameter to be programmed, while the bottom line shows the variable that may be altered or stored.



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(Ref. Drawing)

FIGURE 1-2 – FLOW CHART FOR SET-UP PROGRAMMING – AUTO SENTRY-ES+

The following is a step by step guide to programming the "AUTO SENTRY®–ES+". Remember, between each step, it is necessary to press the [ENTER] key to store the new value and advance to the next step.

Main Adjustments Menu

1. The compressor must be stopped prior to making any adjustments. If the unit is running, press the [STOP/RESET] key to place the control in the "**READY**" state.

   Adjustments can also be performed from the "**SHUTDOWN**" state. After adjustments are completed, the "AUTO SENTRY®–ES+" controller returns to the this state until the cause is repaired and the controller is manually reset.

2. Press the [ENTER] key to begin programming. This enters the adjustments menu. The adjustments are broken into five groups as shown in FIGURE 1–2, page 5. To select a group, press [+] or [–] until the desired group is shown on the bottom line of the display. Press [ENTER] to proceed to the group adjustments detailed below.

Note: Configuration adjustments are normally required only at the time of assembly or after parts have been replaced. Unit setup adjustments are normally required only at the time of unit installation. To prevent accidental access, these will not be available if the "SET" switch is in the position closest to the corner. The "SET" switch is located on the bottom of the controller chassis, on the side behind the program keypad area. If the switch is towards the center of the controller, all five adjustment sections are accessible.

Operation Adjustments

1. In the top line, "**LANGUAGE**" is indicated. The bottom line will indicate "**ENGLISH**" or an alternate language for display messages. Select the desired display langauge and press [ENTER] to proceed.

   If a controller is set for another language, press the [STOP/RESET] key, press [ENTER] twice, and press the [+] or [–] key to select ENGLISH at this step. Then press [ENTER] to select the language.

2. In the top line, "**DISPLAY UNITS**" is indicated. The bottom line will indicate "**ENGLISH**" (PSIG, Fahrenheit) or "**METRIC**" (Bars, Celsius) units of measurement. Select the desired display units and press [ENTER] to proceed.

3. In the top line, "**START TIMER**" is displayed. The bottom line will indicate a time between 3 and 10 seconds. This is the time that the controller spends in the unloaded 'start' mode. This also controls the operation of package–mounted wye–delta starters, if so equipped. Set this adjustment for the amount of time needed for the motor to reach its highest speed while starting. This is typically 3 seconds for full–voltage starters, 7–9 seconds for wye–delta starters.

   If a remote–mounted, reduced voltage starter is used, set this adjustment 1–2 seconds longer than the starter's internal timer.

4. In the top line, "**SET PRESSURE**" is displayed. The bottom line will indicate a pressure value. It is to be set at the nameplate rating of the compressor for normal operation. Under NO circumstances, is this adjustment to be set in excess of the compressor nameplate pressure. It may be set lower, if desired, to reduce pressure and power consumption.

5. In the top line, "**RESET PRESSURE**" is displayed. The bottom line will indicate a pressure value. This setting determines the point at which machine startup occurs in AUTO and SEQUENCE modes and when the compressor will load up from the blown down condition. Note that RESET PRESSURE can be set up to 5 PSI below SET PRESSURE. Set this lower to reduce compressor cycling. All sequenced machines must have the same SET and RESET PRESSURE setpoints.

6. In the top line, "**BLOWDOWN TIME**" is displayed. The bottom line will indicate a time between 5 and 20 minutes. It is factory set at 10 minutes. This is the minimum time interval between blowdowns. A longer blowdown time minimizes wasteful dumping of compressed air when loading is likely to occur in a short time.

7. In the top line, "**AUTO TIME**" is displayed. The bottom line will indicate a time between 5 and 20 minutes. It too, is factory set at 10 minutes. Its function is to prevent too frequent motor starting, and to allow the motor a 'cool–down' period before stopping.

8. "**IV CONTROL MODE**" is displayed on the top line. Select "**MODULATING**" for standard operation. "**LOAD–UNLOAD**" may be selected for systems with large storage and wide pressure differential.

9. In the top line, "**REMOTE HALT**" is displayed. The bottom line indicates either "**TIMED**" or "**IMMEDIATE**". Refer to the description of "Remote On / Off" later in this section for additional details. Select the desired response to the remote input and press [ENTER] to proceed.

10. This completes the operational adjustments. The

controller will return to the main adjustments menu.

Maintenance Adjustments

1. If any service advisories are in effect (yellow ADVISORY indicator is on), they will be displayed on the top line. The bottom line indicates "**LEAVE ADVISORY**" (do not reset) or "**CLEAR ADVISORY**" (turn it off). Select the desired action and press [ENTER] to proceed.

   Note that both the "**CHANGE OIL**" and "**CHANGE OIL FILTER**" advisories are based on operating time. These timers are not automatically reset on the "AUTO SENTRY® ES+" when the advisory is turned off, and the advisory will come back on shortly after the unit starts running. If the oil or filter has been changed, clear the advisory as noted above, then proceed to the following steps to reset the appropriate timer back to its full value.

2. The top line displays "**NEXT OIL CHANGE**" and the estimated hours remaining are displayed on the bottom line. The actual time will be affected by operating conditions which affect oil life. Press the [+] or [–] keys to switch to the oil change interval (see UNIT SETUP) if service was performed early. Press again to change back to remaining time. When the desired value is shown, press [ENTER] to save and proceed to the next step.

   If the advisory message is on, it must be cleared as noted in step 1.

3. The top line displays "**NEXT OIL FILTER**" and the hours remaining are displayed on the bottom line. Press the [+] or [–] keys to switch to the oil filter interval (see UNIT SETUP) if service was performed early. Press again to change back to remaining time. When the desired value is shown, press [ENTER] to save and proceed.

   If the advisory message is on, it must be cleared as noted in step 1.

4. This completes the maintenance adjustments. The controller will return to the main adjustments menu.

Sequence Adjustments

See "Sequencing Compressors With The Auto Sentry® ES+", page 10, for more details on setting up and optimizing a sequenced compressor installation.

1. In the top line, "**NUM OF SEQ UNITS**" is displayed. The bottom line will indicate a number in the range of one through eight. This will be factory set at "1". This should be set to a number corresponding to the number of compressors that are currently installed on this air system that also have "AUTO SENTRY®–ES+" controllers. It should be noted that <u>all</u> "AUTO SENTRY®–ES+" compressors on the system must have the same number programmed here to operate correctly in SEQUENCE mode. Adjust as required, and press [ENTER] to proceed.

NOTICE

Setting the value in step 1 to one indicates that no sequencing is to take place. Consequently, steps 2, 3, and 4, which relate to sequencing, are skipped by the "AUTO SENTRY® ES+"; the adjustments will continue with step 5.

2. In the top line, "**UNIT NUMBER**" is displayed. The bottom line will again indicate a number of one through eight and be factory set at "1". Enter a different number for each "AUTO SENTRY®–ES+" in a sequenced system. The sequence mode will not function properly if two or more compressors have the same UNIT NUMBER. Example: 1, 2, and 3 for a three compressor installation.

   This is the only setting which must be different for each member of a sequenced system. All other settings should normally be the same for all members.

3. In the top line, "**TRANSFER INTERVAL**" is displayed. The bottom line will indicate a number of hours in the range of 1 to 5000. It is factory set at 24. This is the number of hours that this machine will stay in the role of "lead" compressor.

   Normally it is desirable to set this to the same value on all sequenced units to equalize running hours. Different values may be programmed, if desired, to help equalize hours.

4. In the top line, "**LAG START DELAY**" is displayed. The bottom line will indicate a number in the range of 1 to 600 seconds. It is factory set at 30. This is the length of time this machine will wait before starting when the pressure drops below the reset point. This delay period begins when a previous member of the system is loaded. This should be set to the same value for all sequenced units. Its setting will depend on the amount of air storage volume in the system. Too small a number will result in more compressors being started than is necessary to satisfy demand.

5. The controller displays "**BAUD RATE**" on the top line, and a selection between "**1200**" or "**9600**" on the lower line. The controller can operate at either speed. All units in the system must be set the same. Select the desired value, and press [ENTER].

6. This completes the sequence adjustments. The controller will return to the main adjustments menu.

Configuration Adjustments

1. In the top line, "**HI SYS PRES LIM**" is displayed. The bottom line will indicate a value that is factory set 20 – 25 PSI above name plate. This is the pressure that will cause a shutdown if exceeded due to a malfunction such as a stuck inlet valve or broken control line. This should be set at or slightly below the rating of the pressure relief valve. The controller will attempt a number of actions as it approaches to prevent the pressure from reaching this limit.

NOTICE

The controller will automatically adjust the set and reset pressures as required if this limit is lowered.

2. In the top line, "**REMOVE SYS PRESS**" is displayed. The bottom line displays the current pressure being sensed at the package discharge. At this point steps must be taken to ensure that system pressure is, in fact, zero psig. Remove the pressure line to the system pressure transducer. Pressing [ENTER] will now cause the "AUTO SENTRY® ES+" to calibrate the transducer output to zero PSIG. Obviously, pressure measurement errors will be encountered if 'zeroing' is done with pressure at the transducer. If large errors are detected, the controller will demand that the transducer be checked.

3. In the top line, "**REMOVE RES PRESS**" is displayed. The bottom line displays the current pressure being sensed in the reservoir. The reservoir pressure transducer may now be 'zeroed' by following the steps outlined in 2 above.

4. In the top line, "**AIR END TYPE**" is displayed. The bottom line displays the current selection. Set as appropriate for the compressor.

5. "**MOTOR SFA**" is displayed on the top line. This should normally be set for either the motor nameplate service factor amps (SFA, if given) or for the motor nameplate full load amps (FLA) times the motor nameplate service factor (SF). It may be set lower, if desired. Refer to other features, later in this section, for additional details. If current monitoring is not installed, set this to zero (0) to disable current monitoring.

6. This completes the configuration adjustments. The controller will return to the main adjustments menu.

Unit Setup Adjustments

1. In the top line, "**OIL CHANGE INTERVAL**" is displayed. The bottom line will indicate a time interval of 1000 to 8000 hours. After the machine has run for the programmed setting, an advisory will be displayed, requesting an oil change. Adjust as desired and press [ENTER] to proceed.

2. In the top line, "**FILTER CHNG INTERVAL**" is displayed. The bottom line will indicate a time interval of 500 to 1000 hours. After the machine has run for the programmed setting, an advisory will be displayed, requesting an oil filter change. Adjust as desired and press [ENTER] to proceed.

3. In the top line, "**OVER TEMP LIMIT**" is displayed. The bottom line will indicate 225° F. This is the maximum (and proper) setting for compressor operation. It may be temporarily lowered to verify the function of the temperature shutdown system.

4. "**FAN TYPE**" is displayed next on the top line. Select "**AIR COOLED**" for units with package–mounted air coolers only. This will delay fan start-up until the oil has warmed up in the package. Select "**WATER COOLED**" for water cooled units or any unit with a remote cooler. This will run the fan whenever the compressor motor runs.

5. In the top line, "**SYSTEM VOLUME**" is displayed. The bottom line may be selected as "**SMALL**", "**MEDIUM**", or "**LARGE**". This tunes the response of the modulation control loops to optimize loop stability. It is factory set to MEDIUM. Set as follows:

   SMALL if estimated volume is less than .25 gallon per CFM.

   MEDIUM if estimated volume is between .25 and 1.0 gallon per CFM.

   LARGE if estimated volume is greater than 1.0 gallon per CFM.

NOTICE

The setting of this parameter is not critical. When set to the most appropriate value, the controller will maintain the discharge pressure with minimized modulation changes.

6. In the top line, "**AUTO RESTART**" is displayed. The bottom line will indicate either "**OFF**" or "**ON**". The factory setting is "OFF", and the controller will display a power failure shutdown after power has been restored.

   Set this feature to "ON" when it is necessary to have the compressor automatically restart after a power interruption. There will be a brief delay, then the control resumes the mode it was in prior to the interruption. This feature shall only be enabled when the owner determines that it is safe to do so. It is recommended that compressor access be limited to only trained service personnel when this feature is used.

7. This step is only encountered if the AUTO RESTART function was set to ON in the previous step. In the top line, "**RESTART TIME**" is displayed. The bottom line will indicate a time between 5 and 60 seconds. It is factory set at 10 seconds. This is the amount of delay introduced before restarting after power has been restored. Set it as desired to allow time for power to stabilize before starting compressors.

8. The display now reads "**JOG MOTOR?**" and indicates the amount of time to energize the starter. Adjust with the [+] or [–] key to the smallest value needed to bump the motor and check rotation. 0.1 to 0.2 seconds is normally adequate for factory–furnished full–voltage starters; wye–delta or remote starters may require a little more time. Set back to zero to proceed to the next step.

9. In the top line, "**AUX SD MESSAGE**" is displayed. The bottom line will display the message which will appear if power is removed from terminal 7. Select the most appropriate message for user–furnished shutdown devices, and press [ENTER] to proceed.

10. This completes the unit setup adjustments. The controller will return to the main adjustments menu.

OTHER CONTROL FEATURES

Modulating – Load / Unload – The "AUTO SENTRY® ES+" controller offers two control modes, to suit the needs of different applications with different storage capacity.

When set for "**MODULATING**", the controller will start and load whenever the pressure drops below the reset pressure. Continuous modulation by the turn–valve (if so equipped) and the inlet valve will maintain the discharge pressure near the set pressure for any CFM demand from full capacity to very light demand. The inlet and turn valves are coordinated to always use the most efficient and appropriate control. At very light or zero demand, the compressor will completely unload, blowdown, and stop as appropriate for the selected operating mode. This is the normal control mode for the compressor, and is preferred for almost all applications.

When set for "**LOAD–UNLOAD**", the controller will start and load whenever the pressure drops below the reset pressure. When the pressure rises to the set pressure, it completely unloads. If the blowdown timer has not timed out, the compressor will reload when the system pressure drops below the midpoint between set and reset pressure. If the blowdown timer has timed out, the reservoir will blow down, and reload will not occur until the pressure drops below the reset pressure. Use a large receiver volume or wide difference between set and reset pressure to prevent rapid cycling.

Current Limiting – Current limiting is available when an "AUTO SENTRY® ES+" controller is used on a compressor unit with turn valve control and has current monitoring installed. This is based on the motor service factor amps programmed above.

On units with turn valves, the controller will unload as required to prevent operation above the programmed service factor amps. This continues operation of the compressor at reduced delivery, but within the programmed limit. This limiting will occur in either the modulating or the load–unload mode of operation.

This feature takes control only if operating conditions are outside of the compressor unit's design range. Low operating voltage, in particular, can cause high amp draw. This will heat the motor beyond its design, and will normally trip the overload relay to prevent motor failure. The "AUTO SENTRY® ES+", however, will automatically reduce the delivery to continue operation within design limits. If severe conditions persist, the controller will display "**HIGH MOTOR AMPS.**"

This feature is also coordinated with the "AUTO SENTRY® ES+" sequencing controls. During low voltage conditions, lead units will operate only up to their limits. If necessary, another compressor will start to meet the air demand.

Auto Restart After Power Failure – The "AUTO SENTRY® ES+" controller normally displays "**SHUT-**

DOWN – POWER FAILURE" after power has been interrupted and restored. Press the [STOP / RESET] key and select an operating mode to restart the compressor.

If programmed for automatic restart, the "AUTO SENTRY® ES+" controller pauses and begins counting down when power is restored. This time is adjustable in the programming steps noted above. This must be at least several seconds, but may be set longer to allow other plant loads to start up first. After the countdown is complete, the "AUTO SENTRY® ES+" controller resumes the mode of operation prior to the power interruption.

If this is enabled in a sequenced system, set all of the timers to the same value. All "AUTO SENTRY® ES+" controllers will the resume the same sequence numbers which they had prior to the interruption. The sequence controls will start the lead unit after the start timer countdown, and add units individually as required, based on the lag start delay.

SEQUENCING COMPRESSORS WITH THE "AUTO SENTRY® ES+"

General – The sequencing mode is used to operate multiple compressors in a common plant air system. The individual units operate similarly to operation in the automatic mode, except that the setpoints are under control of the sequencing system. This system is actually distributed among the individual "AUTO SENTRY®–ES+" controllers and compressor units, with communications between them to keep the system coordinated. Sequencing is intended to start, run, unload, blowdown, and stop compressors in response to changes in demand during the day or week.

The "AUTO SENTRY®–ES+" controller is designed for systems of two through eight compressors piped into a common air receiver for distribution to the plant. In any such system, the receiver is an important part of the application; it supplies air to the plant and allows compressor units to be unloaded and stopped. This stored reserve eliminates the need to operate "spinning reserve" of unloaded compressors. This storage may be an air receiver, or may be the volume of air in a large distribution system. In either case, the compressors must be piped to this volume with a minimum of restriction. The control system will operate only as many compressors as are needed to supply the CFM demand of the plant, and to maintain the compressor system pressure between the SET and RESET pressures programmed into the controllers.

The "AUTO SENTRY®–ES+" controllers are completely set up to operate this system. The only required additional part is the cable which runs from controller to controller. A kit, 200EAP752, is available which contains all material needed to sequence up to five compressors. This kit contains 500 feet of cable, eight modular connectors, and a crimping tool to install the connectors.

NOTICE

Though similar in operation and installation, this sequencing system is designed to take advantage of all of the internal features of the "AUTO SENTRY®–ES+" controller. Communications cables should not be connected to compressor units with "AUTO SENTRY®–ES+" controllers part number 201EAP1173 or 202EAP1173. Multiple compressors with each type controller may be operated as independent groups piped to the same plant demand.

In spite of the fact that it is a standard feature and its inherent installation simplicity, the sequencing function of a multi–compressor "AUTO SENTRY®–ES+" system is the most fully–featured, functionally–complete available today.

Compressor System – A proper sequencing installation requires two or more Gardner Denver rotary air compressors complete with "AUTO SENTRY®–ES+" controllers, piped into a common air system, interconnected as described above. For best performance, connect the units directly to a common header and receiver, without any intervening dryers, filters, or other restrictions. If any equipment must be installed on individual compressors, select equipment with minimum pressure drop. If filters are installed, establish a maintenance procedure to prevent clogging filters from upsetting the system. There should be no check valves or other devices which isolate a member from the air system. During operation, be sure that any unit is taken out of the sequence mode before closing its service valve.

The receiver should also be sized to prevent excessive drops or rapid rises in pressures during the operation as described below. Note that "receiver" really applies to the entire storage volume of a physical receiver and the volume of the air distribution throughout the plant. Modulating systems work best when the receiver is at least one gallon for the rated CFM of a member compressor in the system (the largest if they differ). If the system is operated load–unload, larger volume or wider differential may be needed to prevent unnecessary starts or rapid compressor cycles. Note that when demand exceeds the capacity of the running unit(s), there

will be a delay until the next unit starts and delivers additional air. The stored air serves the plant during this period. With a properly sized receiver, pressure changes on a receiver gauge should be very slow and gradual.

All standard practices common to sound air compressor installations such as proper sizing of piping, proper electrical supply and conductor sizing, and grounding are to be observed. Run the compressors in the system in Automatic mode for at least one week to evaluate system performance.

Sequencing Installation – Once the compressor system is set up, sequencing compressors with the "AUTO SENTRY®–ES+" controller is as simple as plugging in a telephone to a wall jack. The only item required to make the system functional is a cable similar to a phone cable. The cable and connectors used in kit 200EAP752 have been specially selected to meet the needs of an industrial application. One less cable than the number of compressors to be sequenced is required. For example, to sequence four compressors, three cables are required.

The serial communications interface meets RS–485 standards, the most widely used interface in harsh, industrial environments today. However, the communications cables should be routed through metallic conduit to provide them with both mechanical protection and electromagnetic shielding. Do not run the communications cable in a conduit with other wiring.

Each controller has two modular jacks which accept RJ–12 telephone plugs, located on the top of the controller case. One jack is vacant, the other has a short pigtail plugged into it. To interconnect two compressors, plug the cable into the vacant jack on each controller. For installations of more than two units, the pigtail plug must be disconnected on all controllers except the two at each end of the communications line. The order of interconnection has no effect on the system operation. The following conditions are necessary and sufficient for proper operation:

1. Every compressor must have a cable connecting it to another compressor. One less cable than the number of units sequenced must be used.

2. Each board that has only one cable connected to it must have its pigtail plugged into the unused jack. All installations will have two such units.

Program all members of the system, as described in the programming procedure on previous pages. All adjustments should be identical for each member, except for unit number. The sequencing system will make any necessary adjustments to the setpoints to properly run the compressed air system.

Operation – Press the [SEQUENCE] key on each of the compressors to start operation of the sequenced system. Once this is done, the member controllers will operate the compressor units as required to maintain the plant pressure between the programmed Set and Reset Pressures, for demands from 0 CFM up to the capacity of the system.

While operating, each controller will display a sequence number. As demand requires, the units will start and load in order, starting with sequence number 1 (lead unit). As demand falls, the higher sequence number units (lag units) will modulate, unload, and stop.

If any member of the system is taken out of sequence mode for any reason, other units with higher sequence numbers will automatically promote as required. Sequence numbers will start with 1, and will be assigned on other units up to the number of compressors in the system. This feature makes the system completely tolerant of any manual or protective stopping of any member.

ESTABLISHING THE INITIAL SEQUENCE

The first member compressor placed into sequence mode will become the lead unit. However, since any controller first placed into sequence has no way of knowing whether or not other members already exist, it will first assume the highest rotation number available. For example if the number of units to be sequenced is programmed at four, any compressor will start out in position four when placed in sequence mode. It will then listen for other units on the communications line.

If there is no member with the next lower sequence number, the controller will automatically promote itself. This movement is fairly rapid with the "AUTO SENTRY®–ES+" controller, and the number will advance to the lowest vacant position in several seconds.

To establish a desired order of units, press [STOP/RESET] or select any mode other than SEQUENCE (if already in sequence, put into auto mode if you wish to continue operation while doing this selection). Then put the desired lead unit back into sequence. Wait until it promotes one step (or longer), then put the desired #2 unit into sequence mode and wait until it promotes one step, and so forth until all units are back into the sequence mode.

During this procedure, the system is not deprived of air. This is due to one of the outstanding features of the "AUTO SENTRY®–ES+" sequencing system: control is always executed locally by each member controller. So while controllers count down towards the final order, they are also capable operating their compressor and will deliver air. Once the sequence order is finally established, setpoints will continue to be adjusted in each member to provide operation in the preferred order.

This may take several minutes after a manual change of sequence numbers.

"AUTO SENTRY®–ES+" SEQUENCE SYSTEM OPERATION

Each member compressor in the system operates similarly to the Automatic mode of operation. It will start, load, modulate, unload, blowdown, and automatically stop as necessary to meet system demand for air. There are several differences, however, when running in the Sequence mode.

The pressure shown on the top line of the display is the average system pressure of all the members. Each member communicates its local pressure through the communications cable, for use by others in the system for display and control. The system responds to this average. This number will be the same for all units in the system. To obtain the local package discharge pressure, select the **"DIS PRESS"** alternate display on the lower line.

Pressure setpoints are continuously adjusted, depending on the operation of the members. The last lag unit which is loaded will control its modulation to keep the system pressure near the programmed Set Pressure, and serves as the trim machine. Any running lead unit will be adjusted for slightly higher pressures, and will run at or near capacity. The first unloaded lag unit will have its reset pressure adjusted so it will come on line if the system pressure drops to the programmed Reset Pressure. The system is continuously adjusted to maintain the system pressure between the programmed Set and Reset Pressures.

If any lag unit is loaded, any preceding lead unit will be loaded. Its blowdown timer will reset and hold at full value. This ensures that the last lag unit will always be the first to unload and blow down, and lead units will be prepared to handle the demand.

When demand exceeds the capacity of the loaded lead compressor(s), the pressure will drop. If a lag unit is stopped, its restart will be delayed. This delay is the adjustable "Lag Start Delay". This allows time for lead units and stored air to serve intermittent demands, without starting another compressor. The next available member accumulates any time spent below Reset Pressure, and will start whether there are repeated brief demands or a sustained demand. The Lag Start Delay timer does not begin timing until the preceding member of the system is loaded.

SEQUENCED SYSTEM CHECKOUT

One of the best indicators of the stability of the system is to compare the local system pressure of a running unit with the system average pressure. To do this, simply press the [<] or [>] cursor keys until the lower line of the display shows DIS PRES and the local pressure. In a properly operating system, this value will be within 1–2 psi of the top line value, and will change slowly as demand and delivery are changing. Rapid and large changes in local pressure indicate system problems. Ensure that all compressor units are piped to a common system pressure with adequate storage to handle the plant demands. Select other operating modes if rapid response to large demand changes is needed.

The system is redundant, and will tolerate any breakdown in communications. If any unit is taken out of the Sequence mode, other members will "fill the gap" to keep the system operating. If a break should occur in the communications cable, the compressors will continue to function as two systems, one on each side of the break. Each will have its own lead unit (Seq 1) and may have lag units (depending on how many "AUTO SENTRY®–ES+" controllers are on that side of the break). Look for a cable break if there are multiple units with the same Sequence number displayed.

Each "AUTO SENTRY®–ES+" controller also monitors the communications data for errors. If these occur, the yellow advisory will come on, and the controller displays a message to check the communications port. If this message comes on, and one member changes to "AUTO" operation, then it has been mistakenly programmed with the same Unit Number as another member. Refer to programming instructions above for instructions on programming.

Automatic Rotation – A controller will be the lead compressor for the time programmed as TRANSFER INTERVAL. Then it assigns itself the highest available rotation number. The lag compressors detect the loss of the lead unit and decrement their rotation numbers. Number 2 becomes number 1, the new lead unit, number 3 becomes number 2, etc. The former lead unit will become the last lag unit.

The transfer interval timer operates whenever a member is the lead (Seq 1) unit of the system. It will continue to time out regardless of other units in the system. The remaining time is retained during power interruptions. It is reset back to full value if the controller is in any mode other than Seq 1.

Other Sequencing Features – Any air system will exhibit pressure differences from one point to the next. Even a well designed multi–compressor installation will show 'minor' pressure variations between one compressor's discharge point and another compressor's discharge. These points will also vary from the actual system storage (normally the air storage receiver). The "AUTO SENTRY®–ES+" sequencing system is designed to tolerate minor variations. The "AUTO SENTRY®–ES+" sequencing system will automatically adjust the system setpoint to maintain the average system pressure. Overpressures within any member compressor are prevented locally, and other members will load up to meet the demand. When a turn valve

compressor is provided with current monitoring, the controller will also shed some load on any overloaded unit, and lag units will load as required to service the demand. The dynamic setpoint control is completely automatic and is continuously adjusted.

If airflow is restricted between the compressor units and the common storage, the 'minor' variations described above become more significant. The pressure in the receiver will always be lower than that sensed by the compressor system. The "AUTO SENTRY®–ES+" system will tolerate this, and will still maintain the average pressure within limits. These restrictions will spread modulation over several units, rather than showing the strong preference to unload the last loaded lag unit.

The Lag Start Delay timer of any member does not begin timing until the preceding member of the system is loaded. This is particularly useful when starting up the system, as compressors will be started one at a time. This sequenced starting also happens if the members are controlled by their remote inputs. If programmed for automatic restart after power failure, the lead unit will be delayed by the automatic restart delay, then each additional unit will be delayed by the lag start delay.

CONNECTION TO EXTERNAL CONTROLS

The "AUTO SENTRY®–ES+" controller offers interconnection points for external controls and indicators. This allows simple connection to remote controls and indicators, or integration into any plantwide controls system.

Remote On / Off – Remote on–off control of the system requires only a simple two–wire control, with an isolated contact suitable for 120 volts, 1 amp. This may be a switch, a timer contact, a relay contact, or a PLC output. To connect, simply run the two wires to the control enclosure, remove the jumper between terminal 6 and terminal 9 on the terminal strip, and connect the two wires to terminal 6 and terminal 9.

The air compressor will operate normally in its selected mode whenever this contact is closed (turned on). Note that the keypad is always the master control; the operating mode must be selected at the keypad, and the remote is not capable of starting a unit after the [STOP/RESET] key has been pressed to place the controller in the READY state. When the contact is opened (turned off), operation depends on how the controller has been programmed and what it is doing prior to opening the contact.

If the compressor was already stopped in automatic or sequence modes, it will remain stopped and will not restart until the contact is closed. The display will flash the message **"REMOTE HALT"** to indicate that it is waiting for the remote signal.

If the compressor was running in any mode when the contact was opened, and the remote response is programmed for **"IMMEDIATE"**, the compressor will immediately unload, and will run only until the reservoir is blown down. Then the motors stop, and the unit will be in the **"REMOTE HALT"** mode as indicated above.

If the compressor was running in any mode when the contact was opened, and the remote response is programmed for **"TIMED UNLOAD"**, the compressor will immediately unload and blowdown. It will then continue to run unloaded for whatever period has been programmed for **"AUTO TIME"** (or will complete the remaining auto time if already blown down). The controller displays **"REMOTE UNLOAD"** during this period. After completion, the motors will stop, and the unit will be in the **"REMOTE HALT"** mode as indicated above.

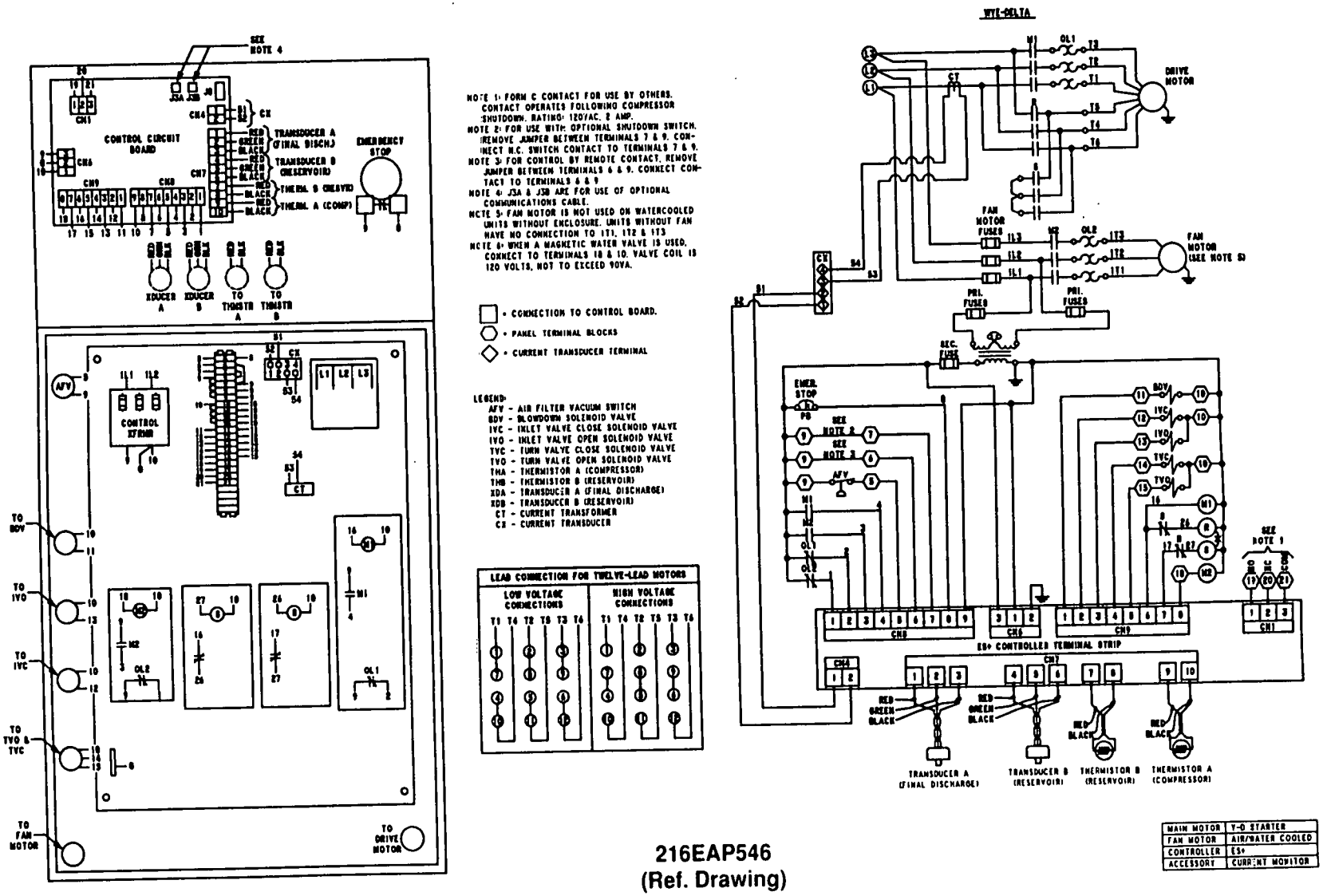
When the remote is turned back on, the unit will start immediately in the CONSTANT or LOW DEMAND modes. Loading in these modes, or starting in AUTO or SEQUENCE modes will occur when the pressure drops below the reset pressure.

Alarm Relay – The "AUTO SENTRY®–ES+" controller is provided with an alarm relay which may be connected to a remote mounted indicator light, horn, or into a PLC input of a plantwide control system. The contact is commercial rated 2 amps at 120 volts. The relay is turned on whenever there is a SHUTDOWN condition requiring service at the compressor, and remains off during normal operation, stopping, or power off conditions. The external connections from the controller are from an isolated form C (single–pole, double–throw) contact. This allows control of either a "compressor okay" or a "compressor shutdown" remote indicator.

To use this relay, connect the supply wire for the remote circuit to terminal 21 (relay common) on the terminal strip. Connect a wire to the indicator from either terminal 19 (normally open) or from terminal 20 (normally closed). Connect the other side of the indicator to its neutral.

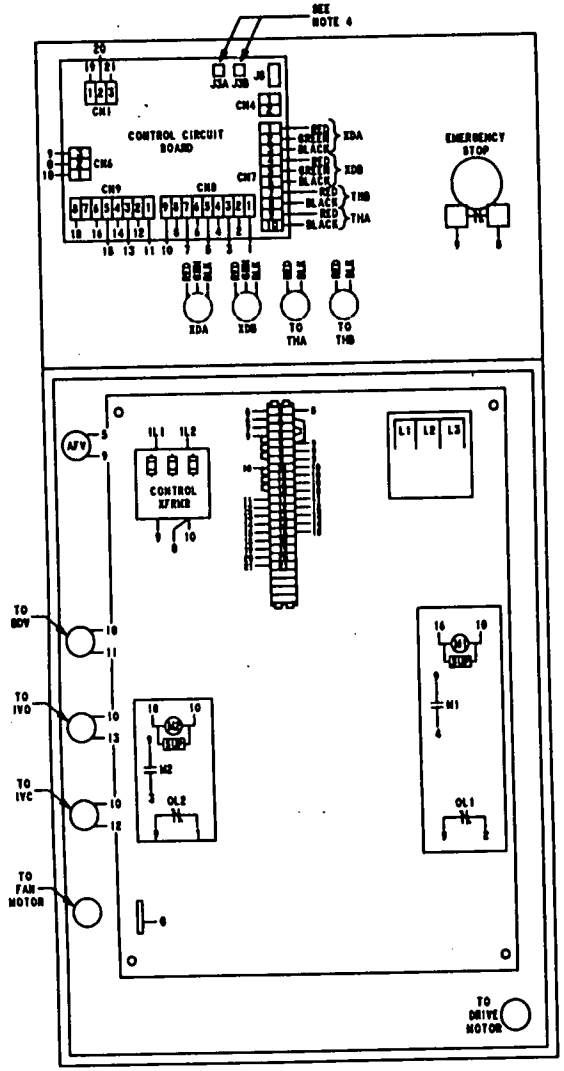
Serial Communications – The RS–232 port is available for serial communications of compressor data to external monitoring systems at any time. If units are NOT connected in sequence, the RS–485 port may be used for multi–drop communications of compressor data to external monitoring systems. Data available include all pressures and temperatures, and a report of internal service data. This is accessible with a PC or PLC with an appropriate communications port. For protocol information, request drawing 305EAU1255.

Wiring Diagrams – The following wiring diagrams show connections in typical units. Refer to the wiring diagram shipped with the compressor unit for actual connections.



216EAP546
(Ref. Drawing)

FIGURE 1-3 – WIRING DIAGRAM – ES+ CONTROLLER



NOTE 1: FORM C CONTACT FOR USE BY OTHERS. CONTACT OPERATES FOLLOWING COMPRESSOR SHUTDOWN. RATING: 120VAC, 2 AMP.

NOTE 2: FOR USE WITH OPTIONAL SHUTDOWN SWITCH. REMOVE JUMPER BETWEEN TERMINALS 7 & 9. CONNECT N.C. SWITCH CONTACT TO TERMINALS 7 & 9.

NOTE 3: FOR CONTROL BY REMOTE CONTACT, REMOVE JUMPER BETWEEN TERMINALS 6 & 9. CONNECT CONTACT TO TERMINALS 6 & 9.

NOTE 4: J3A & J3B ARE FOR USE OF OPTIONAL COMMUNICATIONS CABLE.

NOTE 5: FAN MOTOR IS NOT USED ON WATERCOOLED UNITS WITHOUT ENCLOSURE. UNITS WITHOUT FAN HAVE NO CONNECTION TO 1T1, 1T2 & 1T3.

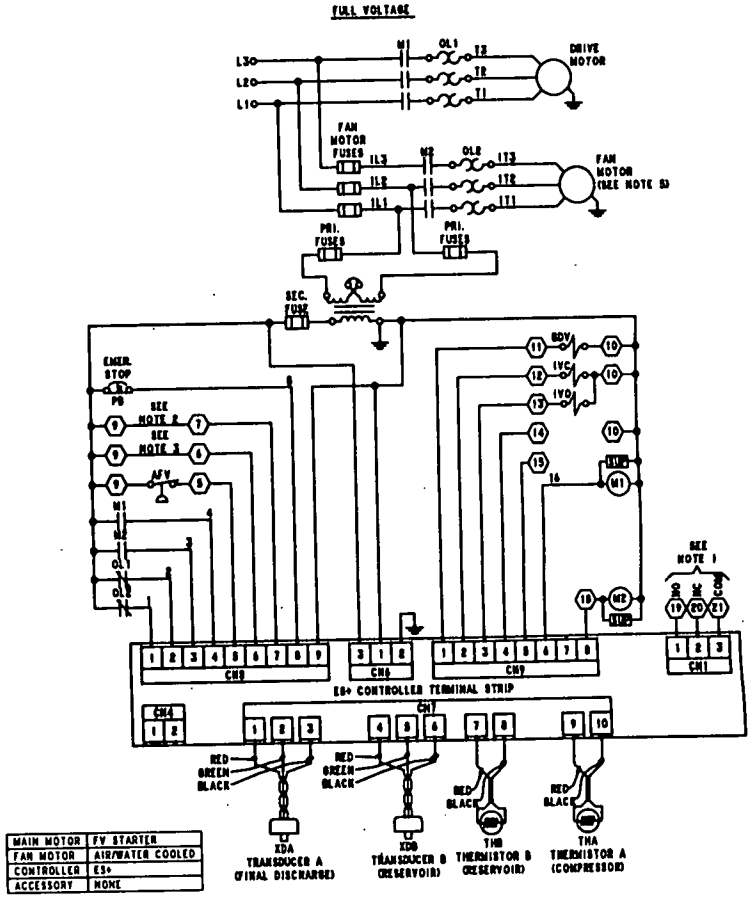
NOTE 6: WHEN A MAGNETIC WATER VALVE IS USED, CONNECT TO TERMINALS 10 & 10. VALVE COIL IS 120 VOLTS, NOT TO EXCEED 90VA.

□ = CONNECTION TO CONTROL BOARD.

⬡ = PANEL TERMINAL BLOCKS

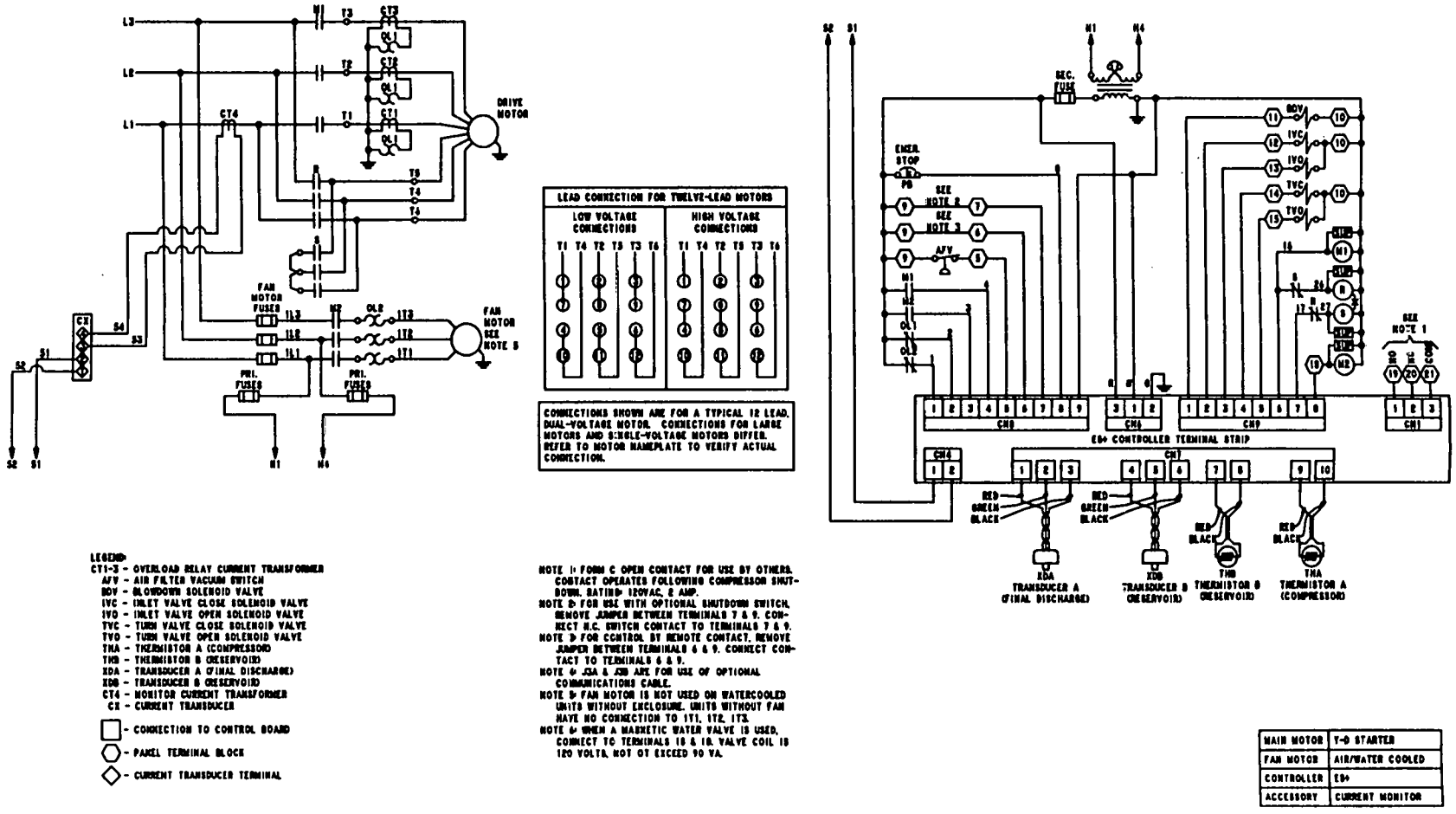
LEGEND:
AFV - AIR FILTER VACUUM SWITCH
BDV - BLOWDOWN SOLENOID VALVE
IVC - INLET VALVE CLOSE SOLENOID VALVE
IVO - INLET VALVE OPEN SOLENOID VALVE
TVC - TURN VALVE CLOSE SOLENOID VALVE
TVO - TURN VALVE OPEN SOLENOID VALVE
THA - THERMISTOR A (COMPRESSOR)
THB - THERMISTOR B (RESERVOIR)
XDA - TRANSDUCER A (FINAL DISCHARGE)
XDB - TRANSDUCER B (RESERVOIR)

304EBH546
(Ref. Drawing)



MAIN MOTOR	FV STARTER
FAN MOTOR	AIR/WATER COOLED
CONTROLLER	ES+
ACCESSORY	NONE

FIGURE 1-4 – WIRING DIAGRAM – ES+ CONTROLLER



LEGEND
CT1-3 - OVERLOAD RELAY CURRENT TRANSFORMER
AFV - AIR FILTER VACUUM SWITCH
BDV - BLOWDOWN SOLENOID VALVE
IVC - INLET VALVE CLOSE SOLENOID VALVE
IVO - INLET VALVE OPEN SOLENOID VALVE
TVC - TURN VALVE CLOSE SOLENOID VALVE
TVO - TURN VALVE OPEN SOLENOID VALVE
THA - THERMISTOR A (COMPRESSOR)
THB - THERMISTOR B (RESERVOIR)
XDA - TRANSDUCER A (FINAL DISCHARGE)
XDB - TRANSDUCER B (RESERVOIR)
CT4 - MONITOR CURRENT TRANSFORMER
CX - CURRENT TRANSDUCER

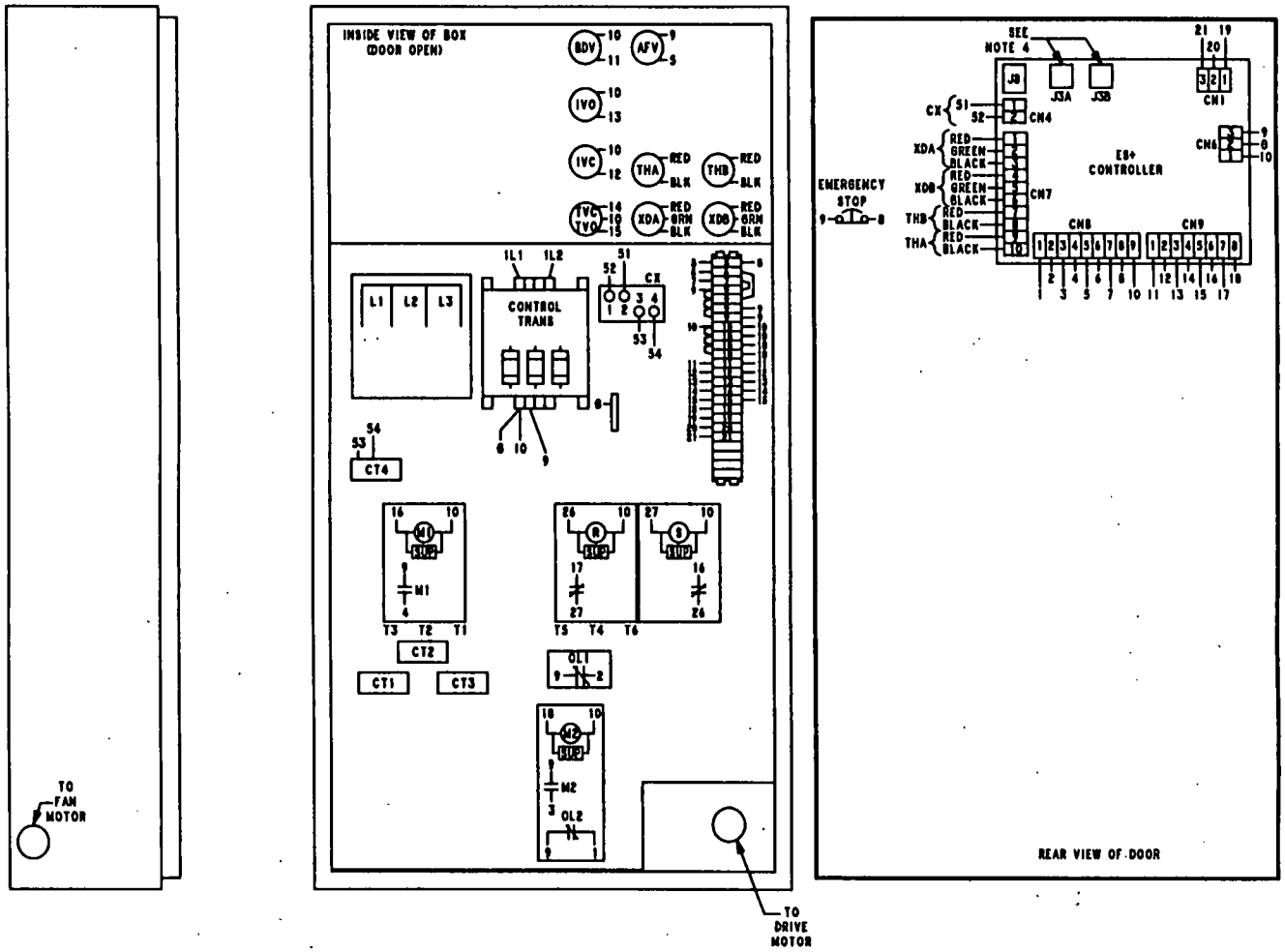
□ - CONNECTION TO CONTROL BOARD
⬡ - PANEL TERMINAL BLOCK
◇ - CURRENT TRANSDUCER TERMINAL

NOTE 1: FORM C OPEN CONTACT FOR USE BY OTHERS. CONTACT OPERATES FOLLOWING COMPRESSOR SHUTDOWN. RATING: 120VAC, 2 AMP.
NOTE 2: FOR USE WITH OPTIONAL SHUTDOWN SWITCH. REMOVE JUMPER BETWEEN TERMINALS 7 & 9. CONNECT N.C. SWITCH CONTACT TO TERMINALS 7 & 9.
NOTE 3: FOR CONTROL BY REMOTE CONTACT. REMOVE JUMPER BETWEEN TERMINALS 6 & 9. CONNECT CONTACT TO TERMINALS 6 & 9.
NOTE 4: XDA & XDB ARE FOR USE OF OPTIONAL COMMUNICATIONS CABLE.
NOTE 5: FAN MOTOR IS NOT USED ON WATERCOOLED UNITS WITHOUT ENCLOSURE. UNITS WITHOUT FAN HAVE NO CONNECTION TO 1T1, 1T2, 1T3.
NOTE 6: WHEN A MAGNETIC WATER VALVE IS USED, CONNECT TO TERMINALS 18 & 19. VALVE COIL IS 120 VOLTS, NOT TO EXCEED 90 VA.

MAIN MOTOR	Y-D STARTER
FAN MOTOR	AIR/WATER COOLED
CONTROLLER	ES+
ACCESSORY	CURRENT MONITOR

301EAQ546-A
(Ref. Drawing)

FIGURE 1-5 – WIRING DIAGRAM – ES+ CONTROLLER



301EAQ546
(Ref. Drawing)

FIGURE 1–6 – WIRING DIAGRAM – ES+ CONTROLLER

DISPLAY MODES

The normal display indicates the package service pressure, the airend discharge temperature, the total running hours, and one of the following operating modes. The green light will be on for any operating mode, whether the compressor is running or not.

READY	The compressor has been stopped by pressing the [STOP/RESET] key.
CON	The compressor is operating in the Constant Run mode.
LDM	The compressor is operating in the Low Demand mode.
AUTO	The compressor is operating in the Automatic mode.
SEQ n	The compressor is operating in the Sequence mode.

The following alternate displays may be called by pressing a cursor [<] or [>] key

RES PRES	The pressure in the oil reservoir
DIF PRES	The pressure drop across the separator
RES TMP	The temperature at the separator
DIS PRES	The pressure at the service connection
DIS TMP	The temperature at the airend discharge
BD TMR	The time remaining before a blowdown will be allowed
AUTO TMR	The time remaining of unloaded motor operation
TOT HRS	The total hours of compressor running
LOAD HRS	The hours of compressor delivery

The following alternate displays may be called by pressing the [+] or [–] key

MOTOR CURRENT	The main motor current in amps
NEXT OIL CHANGE	The estimated remaining time until the next recommended change
NEXT OIL FILTER	The remaining time until the next recommended filter change

The compressor schematic area keys may be used to select alternate displays.

CLOCK KEY	First press shows the total run hourmeter.
CLOCK KEY	Second press shows the loaded hourmeter.
CLOCK KEY	Third press shows the remaining blowdown time.
CLOCK KEY	Fourth press shows the remaining auto time.
DISCH THERM KEY	Shows temperature at the compressor discharge.
SEPARATOR KEY	First press shows the pressure in the reservoir.
SEPARATOR KEY	Second press shows the separator pressure drop.
SEPAR THERM KEY	Shows temperature at the reservoir / separator.
OIL CAN KEY	Shows estimated remaining time until next recommended oil change.
OIL FILTER KEY	Shows remaining time until next recommended oil filter change.

The compressor schematic area has red shutdown and yellow service advisory indicator lights.

AIR FILTER	yellow indicates that the filter needs to be changed
DISCH THERM	yellow indicates high temperature operation

DISCH THERM	red indicates a high temperature shutdown
SEPARATOR	yellow indicates the separator needs to be changed
SEPARATOR	red indicates a change separator shutdown
SEPAR THERM	yellow indicates high temperature operation
SEPAR THERM	red indicates a high temperature shutdown
OIL CAN SYMBOL	yellow indicates that the oil needs to be changed
FAN MOTOR	red indicates a fan motor overload or starter shutdown
OIL FILTER	yellow indicates that the filter needs to be changed
DRIVE MOTOR	yellow indicates operation with high motor amps
DRIVE MOTOR	red indicates a main motor overload or starter shutdown

ADVISORY TROUBLESHOOTING GUIDE

All advisories are indicated on the keypad by a yellow indicator in the Status area, and one of the following messages alternating with the normal lower line display. Perform service or maintenance as indicated, then clear the advisory as instructed in "Maintenance Adustment," page 7.

Message	Action Needed
CHECK COMM PORT	The controller has detected a communications problem while running in Sequence mode. Check for proper cable installation. If the controller switches from Sequence to Auto mode, reprogram a different unit number.
CHNG AIR FILTER	Excessive vacuum has been detected after the air filter, indicating it has become full. Change the air filter to ensure maximum air delivery.
CHNG SEPARATOR	The differential pressure across the separator has risen to over 8 psid. Change the separator to ensure peak compressor performance.
CHNG OIL FILTER	The unit has been operated for the programmed number of hours since the last filter replacement. Change the filter to ensure an adequate flow of lubricant.
CHANGE OIL	The unit has been operated for the programmed number of hours since the last oil change. Change the oil to ensure lubricant quality.
HIGH DISCH TEMP	The temperature was greater than 210 degrees F (99 degrees C) at the airend discharge. Ensure that the compressor receives adequate cooling air or water, and that the coolers are not plugged.
HIGH MOTOR AMPS	The unit has been operated with motor current in excess of the programmed service factor amps. Turn valve units will unload during moderate overcurrent to prevent sustained operation.
HIGH RESRVR TEMP	The temperature was greater than 210 degrees F (99 degrees C) at the separator. Ensure that the compressor receives adequate cooling air or water, and that the coolers are not plugged.
LOW AMB TEMP	The temperature was less than 40 degrees F (4 degrees C) at: (A) the airend discharge, (B) the separator. Ensure that the compressor is located in a room kept above freezing.

SHUTDOWN TROUBLESHOOTING GUIDE

All shutdowns are indicated on the keypad by the word **"SHUTDOWN"** on the top line of the display, and one of the following messages on the lower line of the display. The red indicator in the Status area will be steadily lit while the conditions exist, and will flash after the condition has been corrected. Perform service as indicated. Press the [STOP/RESET] key to clear the shutdown.

Message	Action Needed
CHANGE SEPARATOR	The differential pressure across the air / oil separator has risen to over 15 psid. Change the separator to ensure maximum compressor performance.
CHECK CN7	All inputs at connector 7 of the controller are off. The most common cause for this is that the connector plug has been pulled out. Plug the connector back in firmly.
CHECK CN8	120 volts has been removed from ALL inputs to connector 8 of the controller. The most common cause for this is that the connector plug has been pulled out. Plug the connector back in firmly. This may also occur during brief power interruptions.
CONTROLLER ERROR	The Auto Sentry ES+ controller performs several internal diagnostic checks of its own operation. Follow instructions on lower line, or replace if the controller indicates "REPAIR REQUIRED."
EMERGENCY STOP	The Emergency Stop button has been pressed. Pull it back out to its normal position. If the button has not been pressed, check that the contact block is firmly mounted in the right or left (not center) position of the operator. Check for loose connections which would remove 120 volts from connector 8–8 of the controller.
EXTERNAL DEVICE	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
FAN OVERLOAD	The motor overload relay for the fan motor, located within the electrical control box, has tripped. This indicates high motor shaft load, low voltage, or excessive imbalance in the incoming power (such as a blown fuse). Disconnect and lock out power, open the box, and press the reset button – it will click when reset. Measure motor amps, and take corrective actions to get all currents within the motor nameplate rating. If the overload relay has not tripped, check for the cause that 120 volts was removed from connector 8–1 of the controller.
FAN STARTER	The controller has attempted to start the fan, but did not receive a return signal from the starter's auxiliary contact. If the starter does not pick up when attempting to start, check that connector 9 of the controller is plugged in firmly, and check the starter coil. If the starter does pick up, but this message appears, check that the auxiliary contact block is properly installed on the starter and wired to connector 8, terminal 3.
FAN STRT CONTACT	The controller has attempted to turn off the fan, but is still receiving a return signal from the starter's auxiliary contact. Check that the starter operates freely and that the contact block is properly installed on the starter.
HI SYSTEM PRESS	Pressure in excess of the programmed high pressure limit has been detected. The most likely cause is other, higher pressure compressors on the same air system; separate these from this compressor unit. Other possible causes are loose connections to the transducer, electrical noise and transients, or improper setting of the high pressure limit.
HIGH AMP SENSOR	The controller is sensing current to the main motor when it is turned off. Check that the main starter is operating properly. Check for proper installation of the current transformer and current transducer.

Message	Action Needed
HIGH DISCH TEMP	This indicates that the controller has detected temperature in excess of the programmed high temperature limit at the airend discharge. The most common cause for this is inadequate package cooling. Ensure proper air flow for air-cooled units, or adequate cooling water for water cooled units. Check for proper oil level, and fill as required. Monitor the temperature carefully during restarts after servicing.
HIGH DISCH TEMR	This indicates that the controller has detected a rapid temperature rise in the airend discharge. This normally would indicate a loss of coolant injection into the airend. Check oil level, and fill if required. Completely check all oil piping, the filter, and flow controls for blockage or freezing. This may also be caused by a loose connection at connector 7 of the controller. Monitor the temperature carefully during restarts after servicing.
HIGH RESVR PRESS	Pressure in excess of the programmed high pressure limit has been detected. This shutdown will occur if a loss of pneumatic controls occurs. Check the inlet valve, all control piping, solenoid valves, and all other control devices to find the cause for the inlet valve not closing. Other possible causes are loose connections to the transducer, electrical noise and transients, or improper setting of the high pressure limit.
HIGH RESRVR TEMP	This indicates that the controller has detected temperature in excess of the programmed high temperature limit at the air / oil separator. The most common cause for this is inadequate package cooling. Ensure proper air flow for air-cooled units, or adequate cooling water for water cooled units. Check separator element, replace non–standard separators with recommended separator. Monitor the temperature carefully during restarts after servicing.
HIGH RESRVR TEMR	This indicates that the controller has detected a rapid temperature rise in the air / oil separator. Use only recommended separators; replace non–standard separators. This may also be caused by a loose connection at connector 7 of the controller. Monitor the temperature carefully during restarts after servicing.
HIGH VIBRATION	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
LOW OIL PRESSURE	The controller has attempted to start and load the compressor, but pressure is not building up in the oil reservoir. This may indicate either a failure of the motor to turn the compressor, or a failure of the inlet valve to open. If the latter, check also the wiring and piping to solenoid valves IVO and IVC; these are both turned on to load up the compressor.
LV RELAY	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
MAIN OVERLOAD	The overload relay for the main compressor drive motor, located within the electrical control box, has tripped. This indicates high motor shaft load, low voltage, or excessive imbalance in the incoming power (such as a blown fuse). Disconnect and lock out power, open the box, and press the reset button – it will click when reset. Measure motor amps, and take corrective actions to get all currents within the motor nameplate rating. Check that the programmed Set Pressure is at or below the compressor nameplate rating. If the overload relay has not tripped, check for the cause that 120 volts was removed from connector 8 –2 of the controller.

SHUTDOWN TROUBLESHOOTING GUIDE (Continued)

Message	Action Needed
MAIN STARTER	The controller has attempted to start the compressor, but did not receive a return signal from the starter's auxiliary contact. If the starter does not pick up when attempting to start, check that connector 9 of the controller is plugged in firmly, and check the starter coil. If the starter does pick up, but this message appears, check that the auxiliary contact block is properly installed on the starter and wired to connector 8, terminal 4.
MAIN STRT CONTCT	The controller has attempted to turn off the compressor, but is still receiving a return signal from the starter's auxiliary contact. Check that the starter operates freely and that the contact block is properly installed on the starter.
MOTOR OVERTEMP	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
OPEN AMP SENSOR	The controller is not sensing current to the main motor when it is turned on. Check that the main starter is operating properly. Check for a loose or broken connection at connector 4. Check wiring and proper installation of the current transformer and current transducer.
OPEN THERM	The controller has detected an open connection to thermistor: (A) airend discharge or (B) separator. This normally indicates a loose or broken connection at the controller connector 7; check and correct the connection. This could also be indicating a broken wire or thermistor probe, or exposure to excessively low temperatures.
OPEN XDUCER	Signal voltage has fallen too low at transducer: (A) Final discharge or (B) Reservoir. This probably indicates a loose connection of the red or green wire the transducer or an unplugged transducer. It connections are good, this is indicating a defective transducer. Check connections, or replace transducer if necessary.
PHASE RELAY	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
POWER FAILURE	The power to the compressor unit has been turned off and back on. Press [STOP/RESET] and select an operating mode.
SHORTED THERM	The controller has detected a shorted connection to thermistor: (A) airend discharge or (B) separator. This normally indicates a faulty connection (e.g. wire strands touching) at the controller connector 7; check and correct the connection. This could also be indicating a damaged wire or thermistor probe.
SHORTED XDUCER	Signal voltage has exceeded approximately 4.6 volts at transducer: (A) Final discharge or (B) Reservoir. This may indicate a loose connection of the black wire to the transducer or a defective transducer. Check connections, or replace transducer if necessary.
WATER PRESS	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
ZERO XDUCER	Signal voltage has fallen too low at transducer: (A) Final discharge or (B) Reservoir. This error is usually the result of the transducers being improperly zeroed. Disconnect the air lines to the transducers and follow the procedure indicated in the adjustment instructions. This shutdown for transducer B m also be the result of reverse compressor rotation. Check connections, or r place transducer if necessary.

CONTROLS TROUBLESHOOTING GUIDE

The following are recommended service actions. Observe all instructions noted elsewhere in this manual. All electrical service is to be performed only by a qualified electrician.

Symptom	Recommended Action
No display, compressor stopped	Check incoming power to the compressor unit. Ensure that the disconnect is on and that fuses have not blown (or circuit beaker tripped). If power is being properly supplied to the control box, check the fuses located at the fan starter, the control transformer fuses, and the wiring to connector CN–6.
Compressor will not start.	To operate, the controller must be placed into an operating mode (e.g. "AUTO); press the [STOP/RESET] key to put the control into the READY state, then select a mode with the operating mode keys. In AUTOMATIC and SEQUENCE modes, compressors will not start until the pressure drops below the reset pressures.
Display indicates **"NOT BLOWN DOWN"**	The controller prevents attempts to start the main motor if the reservoir pressure is over 5 psig. Pressure continues to be relieved from the reservoir while this message is on, and the compressor will start automatically after the pressure has dropped. If this message remains with NO pressure in the reservoir, follow the transducer zeroing procedure found in the controls adjustment section.
Display indicates **"REMOTE HALT"**	The controller is provided with an input for user–furnished remote controls. This display indicates that 120 volt is removed from terminal 6 of the terminal strip. Check all connections of the factory installed jumper, or the customer–provided controls, if applicable.
Display indicates **"SHUTDOWN"**	If the display indicates "SHUTDOWN", refer to the shutdown troubleshooting section for assistance. In addition to the messages shown, there are several internal and system diagnostics performed by the controller. Consult the factory for additional assistance.
Compressor runs, but does not load	In the CONSTANT RUN and LOW DEMAND modes, the compressor will not load until the pressure drops below reset pressure. Refer to the operating instructions for further information. If pressure is below the reset pressure,check that the inlet valve operates freely. Check that the TVO, TVC, IVO and IVC valves are wired and operating properly.
Compressor runs, unloads at low pressure	If the inlet valve closes at low pressure, check the wiring to the blowdown valve and the piping and check valves in its discharge line.
Compressor does not modulate	On units with turn valve control, the turn valve will control delivery for moderate to heavy demands to maintain the system near the programmed set pressure, with the inlet valve held open. At light demands, the inlet valve controls the compressor delivery to maintain pressure approximately 3 psi above the programmed set pressure, with the turn valve held open. If the pressure continues to rise above these pressures, check that the turn valve and inlet valve operate freely, and check wiring and piping to control valves TVO, TVC, IVO and IVC. If normal modulation does occur, the inlet valve will be closed during a blowdown as pressure approaches the high pressure limit.
Compressor cycles between load and unload	The external air receiver should be sized appropriately to prevent rapid rapidly cycles. The rapid response time in the CONSTANT RUN mode will operate with small receivers, but any plant air system will operate more efficiently with adequately sized storage. Refer to the operating instructions for further information.

Symptom	Recommended Action
Low reservoir pressure in CONSTANT mode or other modes before blowdown	The Auto Sentry ES+ controller will maintain a minimum pressure in the oil reservoir while in CONSTANT or in other modes while the blowdown valve is closed. This occurs only after initially loading the compressor unit. If reservoir pressure drops while the blowdown valve is closed, check for leaks between at the reservoir, separator, and connected piping.
Erratic pressures in SEQUENCE only	The sequencing system transmits low–level signal between units to communicate pressures. Units must be properly grounded to a good ground system, the communications cable should use only appropriate quality cable, and the cable should be run in its own conduit.
Compressor cycles rapidly in SEQUENCE mode only	In the sequence mode, the operating system requires all compressors be piped directly to receiver, such that all transducers sense the same pressure. Check valves or restrictions between compressors and the storage will cause system instability. Run units in AUTOMATIC mode until the system is corrected.
Error in displayed pressure or **"CHECK XDUCER"** while zeroing	Pressure measurement errors are almost always the result of poor zero adjustment. This must be done after replacement of a controller or a transducer. The proper display with all pressure removed is 0 +/–1 psig. The adjustment procedure will prevent large zeroing errors, and recommend that the transducers be checked.

SECTION 2
AUTO SENTRY® –ES CONTROLLER

GENERAL DESCRIPTION – The Gardner Denver rotary screw compressor is prewired with all controls, motor, and starter for the voltage and horsepower at the time of ordering. It is necessary only to connect the compressor unit to the correct power supply, to the shop air line, and to the appropriate shop water line, if the compressor is water–cooled. A standard compressor unit consists of the compressor, oil reservoir, oil cooling system and filters, motor type as specified, NEMA 12 starter / control box, and control components as described in the package instruction manual.

This compressor unit features the "AUTO SENTRY®–ES" controller, which integrates all the control functions under microprocessor control. Its functions include safety and shutdown, compressor regulation, operator control, and advisory / maintenance indicators. The keypad and display provide the operator with a logical and easily operated control of the compressor and indication of its condition.

AUTO SENTRY®–ES OPERATION

Operation of the "AUTO SENTRY®–ES" is dependent on selection of an operating mode (described below) from the controller keypad. Before starting, press the [STOP/RESET] key to place the controller into its READY state (as indicated on the display). Compressor operation may then be started by pressing an operating mode key. Once operating, the mode may be changed at any time by pressing a key, and the selected mode will be displayed in the lower right corner of the message window. Press the [STOP/RESET] key at any time to stop the compressor under normal conditions.

An optional control may be wired into the "AUTO SENTRY®–ES" controller to interrupt and restart the unit based on controls by others. When stopped by these controls, the display indicates **"REMOTE STOP"**.

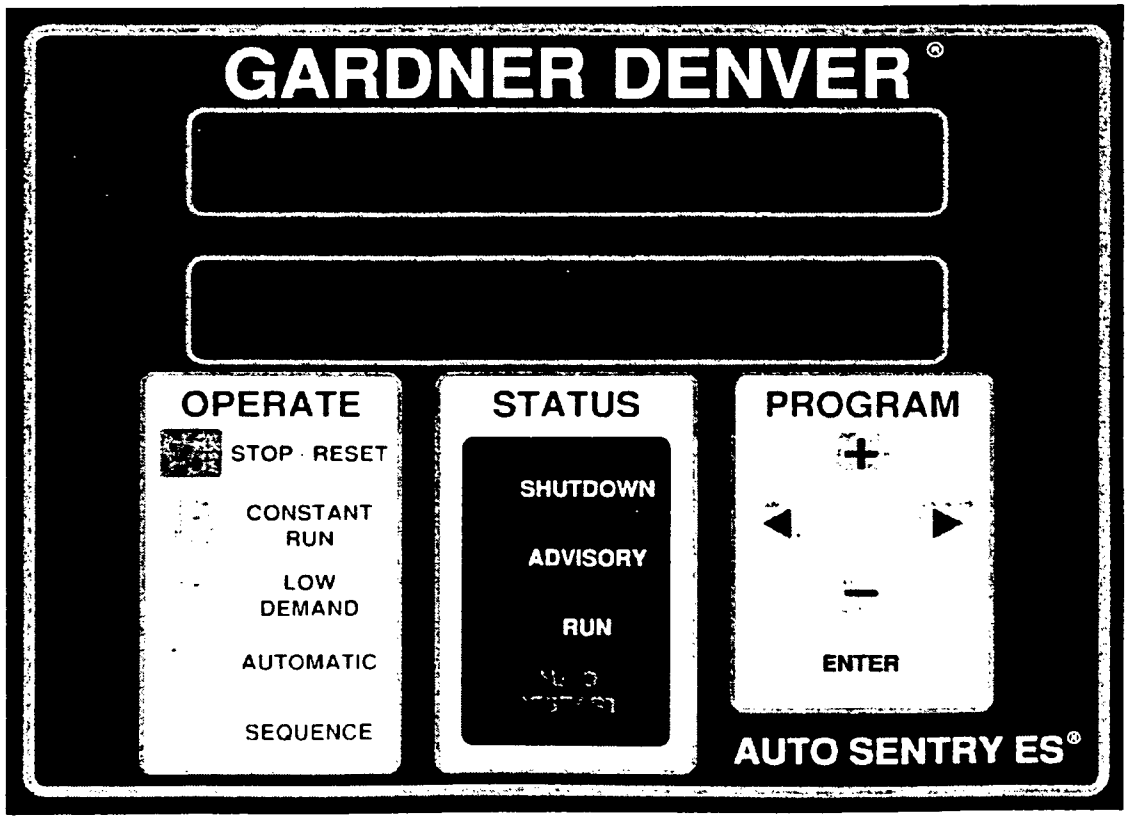


FIGURE 2–1 – AUTO SENTRY® –ES DISPLAY

⚠ WARNING

Automatic restarting or electrical shock can cause injury or death. Open, tag and lockout main disconnect and any other circuits before servicing the unit.

In any mode, the compressor will start only if reservoir pressure is below 5 psig. The display will indicate if the control is waiting for a reservoir blowdown, along with the remaining pressure. The controls also delay initial loading of the compressor until a startup delay has been completed.

Constant Run Mode Operation – This mode is best used in applications where there are no long periods of unloaded operation, or for minimum response time to sudden demands. The compressor unit will start and run continuously, using its modulation controls to match delivery to demand.

As demand falls below the compressor capacity, the pressure will rise to the setpoint of the control. When the pressure reaches the setpoint, the "AUTO SENTRY®–ES" controller operates the solenoid valves TVO (turn valve open), TVC (turn valve close), IVO (inlet valve open) and IVC (inlet valve close) to control the CFM of the compressor to match the CFM demand of the air system. As the demand changes, the controller will continue adjustment for the best compressor operation. At moderate to heavy demand, the inlet is open, and the turn valve controls delivery. At lighter demands, the turn valve will be open, and the inlet valve will control delivery. The controller maintains the pressure within a few psi of the set pressure.

On compressor units without turn valve, the controller operates valves IVO and IVC to position the inlet valve. This continuously adjusts delivery to match demand.

When first starting, the controller will keep the compressor fully unloaded and blown down until the system pressure drops below the reset pressure. Once loaded, the reservoir will remain fully charged, regardless of demand. Responses to demand are thus immediate, as soon as system pressure drops below the setpoint.

Low Demand Mode Operation – The low demand mode reduces power consumption by relieving pressure in the reservoir during unloaded operation. Use this mode where there is moderate air storage and there are unloaded periods during the day, but frequent motor starting and stopping is undesirable. During periods of moderate to high demands, this mode is identical to the constant–run mode described above.

During low demand periods, the controller will open the blowdown valve and fully close the inlet valve to minimize the motor load. A timer is reset when this occurs. While in this state, the plant air system supplies control air pressure (as well as any plant loads). When the system air pressure drops to the reset pressure due to increased demand, the blowdown valve recloses and the controls resume their normal modulation to maintain the system pressure near the set pressure.

Subsequent blowdown periods are not allowed until the timer has completed its cycle. This cycle eliminates frequent blowdowns during moderate loads, and the energy required to repressurize the reservoir. It also eliminates the problems of oil foaming and carryover that can occur if the oil reservoir of an oil–flooded compressor is blown down too often. The timer is adjustable from 5 to 20 minutes.

Automatic Mode Operation – This mode provides automatic start and timed stop, and is best used in applications with long unloaded periods (e.g. idle shifts or weekends) and adequate storage to allow stopping the compressor for periods. Operation during periods of moderate to heavy demands is identical to the low demand mode.

The automatic time delay is adjustable from 5 to 20 minutes. If the controller operates unloaded for this period with no demand, the compressor drive motor is halted to eliminate its power consumption. The controls will remain in this state until demand is again indicated by a drop in pressure.

This is the most common selected mode of operation, as it automatically will operate the compressor unit in the most efficient manner for the demand of the air system.

Sequence Mode Operation – This mode provides for communication between controllers, operating only as many as are required for economical operation. Use this on applications with large storage capacity and diverse loads. The lead unit will operate identically to the automatic mode; operation will be automatically staged for each lag unit (up to 8 total). For more information, refer to the sequencing instructions later in this chapter.

Communication between controllers is achieved by interconnection of a communication cable to circuit board connectors. A "unit number" must be assigned to each unit in this mode, but the display will indicate the unit's actual operating ranking.

AUTO–SENTRY®–ES CONTROL DISPLAY

The display above the keypad is used to provide operating information to the user. If a shutdown has occurred, the display will indicate the cause.

During normal operation, the display will show the system (plant) pressure, compressor discharge temperature, total running hours, and operation mode. If one of the operating modes has been selected, the green "RUN" indicator will be lit.

Alternate displays are available by pressing the [<] [>] keypad keys, and will be identified on the display. These include:

1. Reservoir pressure
2. Separator differential pressure
3. Reservoir temperature
4. System pressure
5. Compressor discharge temperature
6. Remaining blowdown time
7. Remaining auto time

Remaining blowdown and auto times are only available in Low Demand, Automatic, and Sequence modes, as appropriate.

If no keys are pressed for 5 seconds, the display will revert to its normal mode.

The display is also used as a service reminder for normal maintenance items. When these conditions are sensed, the yellow "ADVISORY" light will come on, and the message will alternate with the normal lower line message. These messages are intended to advise of conditions that require service or may lead to a shutdown.

If a protective shutdown has occurred, the display will indicate **"SHUTDOWN"** and the cause and the red shutdown indicator will be lit. The compressor may not be operated until the conditions are corrected and the controller is reset.

SERVICE ADVISORIES

The "AUTO SENTRY®–ES" controller turns on an advisory when it detects operation which needs service attention, but does not warrant shutting down the compressor. Some of these are normal maintenance procedures, and are intended to serve as a reminder to perform routine service. Others are conditions which can reduce the maximum compressor performance. It will remain in effect until reset. Check the display during routine inspections, and perform maintenance as suggested. Refer to the troubleshooting section for detailed information about each advisory.

Temperature advisories may be cleared while the unit is running by simply pressing the [ENTER] key.

To reset the service advisories, perform the following steps:

1. Press the [STOP/RESET] key to stop operation of the compressor.
2. Relieve all air pressure.
3. Disconnect, tag, and lock out power supply.
4. Perform necessary maintenance, and record it on maintenance log.
5. Following service, put the enable switch in the down, "+" position.
6. Restore power to the unit. The display will read: **"SHUTDOWN–POWER FAILURE"** (or **"READY"** if auto–restart is enabled).
7. Press the [STOP/RESET] key. The display will indicate **"READY"** in the lower right hand corner.
8. Press [ENTER]. The display will read: **"ENTER TO SETUP – AUTO TO SERVICE"**
9. Press [AUTO]. The display will read: **"OIL FILTER – HOURS TILL CHANGE"**
10. Press [ENTER]. The display will read: **"HOURS TILL NEXT OIL CHANGE"**
11. Press [ENTER]. If an advisory is present, it will be displayed at this time.
12. Press [ENTER] to clear the advisory. When all are cleared, the display will read: **"ENTER TO SETUP – RESET TO EXIT"**
13. Press [STOP/RESET] to return to the READY state.

To prevent unauthorized programming, disconnect, tag, and lockout power supply and return the ENABLE switch to the up, SET position. Restore power, press [STOP/RESET] to place the controller into the READY state, and select an operating mode to start compressor operation.

PROTECTIVE SHUTDOWNS

The "AUTO SENTRY®–ES" will shut down the unit following any fault detected in the following devices. Following a shutdown, a message will be displayed, with the top line indicating **"SHUTDOWN"** and the lower line indicating the cause. The shutdown light will be steadily lit if the cause still exists, or will flash if the cause has been cleared. Refer to the troubleshooting section for detailed information about each shutdown. To resume operation, the cause of the shutdown must be corrected and the controller reset by pressing the [STOP/RESET] key.

Motor Protective Devices – Overload heaters are furnished for the starter in the voltage range specified. There are three (3) overloads in the starter of proper size for the starter and its enclosure. Note that motor nameplate current must be multiplied by 0.577 for wye–delta starters. The display will indicate which overload relay has tripped. The overload relay is reset by press-

ing the button on the relay itself, then the controller may be reset. Measure motor current (amps) and voltage in the affected motor wiring to locate the cause for high current. Overload relays provided in standard units are sensitive to both overload and phase imbalance for improved motor protection. Proper starter coil and contact action are also monitored and errors in operation will cause a shutdown with the cause displayed as a start error

High Temperature – The compressor is protected from high discharge temperature by a thermistor probe located in the compressor discharge elbow. The "AUTO SENTRY®–ES" will shut the compressor down if temperature exceeds 225° F (or lower per user adjustment) or if rapid temperature rise is detected. Reservoir / separator temperature is also monitored, and will provide high temp shutdowns. The location of the temperature fault will be displayed. Thermistor probes are also checked for open or shorted circuits, and the display will indicate the location of the defective probe.

⚠ CAUTION

Machine damage will occur if compressor is repeatedly restarted after high temperature stops operation. Find and correct the malfunction before resuming operation.

Separator Differential Pressure – The "AUTO SENTRY®–ES" continually monitors the pressure drop across the oil separator. The unit shuts down at a differential pressure of approximately 15 psid. This becomes active only after the compressor has been running and pressures have had time to stabilize.

High Pressure – The "AUTO SENTRY®–ES" will first attempt to unload and blow down the unit if excessive pressures are detected in the reservoir or the plant system. If unsuccessful, a shutdown will occur.

Shut down will also occur if a defective transducer is detected. The display will indicate the location of the high sensed pressure or transducer (xducer) error. Check that all adjustments have been properly made, and all connections are secure.

Low Oil Pressure – The "AUTO SENTRY®–ES" will shutdown the unit if inadequate oil reservoir pressure is detected after starting and loading. If this occurs, check the wiring and piping to the solenoid valves.

Emergency Stop – Press the emergency stop button to shut down the unit and the controller. To restart, pull the button out to its normal position and reset the controller. This should be used for emergency purposes only – use the keypad [STOP/RESET] for normal controlled stopping.

Power Failure – Following power interruptions, the controller will remain in a shutdown state (unless programmed for auto restart).

High Vibration (optional) – This optional feature will shut down the unit if abnormally high vibration is detected.

Connection Failure – The "AUTO SENTRY®–ES" controller checks input connectors and will shutdown if they become unplugged.

Other Shutdowns – The controller runs continuous diagnostic checks of its own operation and the sensors to which it is connected. Refer to the service section for a complete listing of shutdowns and remedial actions.

PROGRAMMING AND SETUP INSTRUCTIONS FOR THE AUTO SENTRY®–ES CONTROLLER

All compressor control adjustments are made through the controller keypad. This provides a single location for all adjustments, coordinates all related controls, and eliminates the need for additional gauges and meters. The controller stores all adjustments digitally. These are permanent unless changed by further programming.

General – Programming and setup is accomplished with the PROGRAM keys. In all steps, the [ENTER] key will cause the controller to accept the displayed value into memory and advance to the next programming function. The plus [+] and minus [–] keys will increase and decrease displayed numeric values, or step through menu selections. During numeric adjustments, the right [<] and left [>] arrow keys move the cursor (flashing digit) to the position desired. The number at the cursor will be the number that is changed by the [+] and [–] keys. At any point in the programming and setup routine, press the [STOP/RESET] key to exit and return to the READY state without altering the adjustment.

In all steps of the programming routine, the top line of the display will give a description of the parameter to be programmed, while the bottom line shows the variable that is capable of being altered by programming.

The following is a step by step guide to programming the "AUTO SENTRY®–ES" controller. Remember, between each step, it is necessary to press the [ENTER] key to store the new value and advance to the next step.

Programming Steps:

1. The compressor must be stopped prior to making any adjustments. If the unit is running, press the [STOP/RESET] key to place the control in the

"READY" state.

Adjustments can also be performed from the **"SHUTDOWN"** state. After adjustments are completed, the "AUTO SENTRY®–ES" controller returns to the this state until the cause is repaired and the controller is manually reset.

2. Press the [ENTER] key to begin programming. If the enable switch on the circuit board is in the set (up) position, the control proceeds to step 7 below. If the switch is in the "+" (down) position, the controller will display **"ENTER TO SETUP – AUTO TO SERVICE"**. Press [ENTER] to go directly to step 7 below. Press [AUTO] to perform the following steps.

3. The display shows **"OIL FILTER"** and the hours remaining until the next advisory are displayed on the bottom line. Press [ENTER] to go to step 4 without any change.

   Press [AUTO] only if the oil filter change has been performed early. This will reset this timer back to the oil filter interval (see step 19).

4. The display shows **"OIL CHANGE"** and the hours remaining until the next advisory are displayed on the bottom line. Press [ENTER] to go to step 5 without any change.

   Press [AUTO] only if the oil change has been performed early. This will reset this timer back to the oil change interval (see step 20).

5. If any service advisories are in effect (yellow ADVISORY indicator is on), they will be displayed. Press [ENTER] to clear the advisory.

6. The display will indicate **"ENTER TO SETUP – RESET TO EXIT"**. This indicates that all the maintenance adjustments have been completed. Press [STOP/RESET] to go back to the READY state, or press [ENTER] to go on to step 7.

7. The top line shows **"DISPLAY UNITS"**. The bottom line indicates **"ENGLISH"** (PSIG, Fahrenheit) or **"METRIC"** (Bars, Celsius) units of measurement. Select the desired display units and press [ENTER] to proceed.

8. The top line displays **"NUM OF SEQ UNITS"**. The bottom line indicates a number in the range of one through eight. This will be factory set at "1". Set this to a number corresponding to the number of compressors that are currently installed on this air system that also have "AUTO SENTRY®–ES" controllers. It should be noted that all "AUTO SENTRY®–ES" compressors on the system must have the same number programmed here to operate correctly in SEQUENCE mode.

NOTICE

Setting the value in step 8 to one indicates that no sequencing is to take place. Consequently, steps 9, 10, and 11, which relate to sequencing, are skipped by the "AUTO SENTRY®–ES"; Programming commences at step 12.

9. The top line displays **"UNIT NUMBER"**. The bottom line will again indicate a number of one through eight and be factory set at "1". Each "AUTO SENTRY®–ES" in a sequenced system must have a unique number here. The sequence mode will not function if two or more compressors have the same UNIT NUMBER. Use low numbers for the most efficient machine–to–machine communications. Example: Use 1, 2, and 3 for a three compressor installation.

   This is the only setting which must be different for each member of a sequenced system. All other settings should normally be the same for all members.

10. The top line displays **"TRANSFER INTERVAL"**. The bottom line indicates a number of hours from 1 to 5000. It is factory set at 24. This is the number of hours that this machine will stay in the role of "master" or "lead" compressor.

    Normally it is desirable to set this to the same value on all sequenced units to equalize running hours. Different values may be programmed, if desired, to help equalize hours.

11. The top line displays **"LAG START DELAY"**. The bottom line indicates a number from 15 to 600 seconds. It is factory set at 30. This is the length of time this machine will wait before starting when the pressure drops below the reset point. Set this to the same value for all sequenced units. Its setting will depend on the amount of air storage volume in the system. Too small a number will result in more compressors being started than is necessary to satisfy demand. See "Sequencing Compressors With The Auto Sentry® ES", page 31, for more details on optimizing a sequenced installation.

12. The top line displays **"BLOWDOWN TIME"**. The bottom line indicates a time between 5 and 20 minutes. It is factory set at 10 minutes. This is the minimum time interval between blowdowns. A longer blowdown time minimizes wasteful dumping of compressed air when loading is likely to occur in a short time. Longer periods also have been

shown to prevent oil foaming.

13. The top line displays "**AUTO TIME**". The bottom line indicates a time between 5 and 20 minutes. It too, is factory set at 10 minutes. Its function is to prevent frequent motor starting, and to allow the motor a 'cool–down' period before stopping.

14. In the top line, "**START TIMER**" is displayed. The bottom line will indicate a time between 3 and 10 seconds. This is the time that the controller spends in the unloaded 'start' mode. This also controls the operation of package–mounted wye–delta starters, if so equipped. Set this adjustment for the amount of time needed for the motor to reach its highest speed while starting. This is typically 3 seconds for full–voltage starters, 7–9 seconds for wye–delta starters.

    If a remote–mounted, reduced voltage starter is used, set this adjustment 1–2 seconds longer than the starter's internal timer.

    If the setup switch is in the up position, the controller returns to the READY state after this adjustment.

NOTICE

Unit setup adjustments are normally required only at the time of unit installation. To prevent accidental access, these will not be available if the "SET" switch is in the up position. The "SET" switch is located beneath the power transformer mounting plate on the left edge of the main circuit board.

15. If the switch is in the down position, "**HI SYS PRES LIM**" is displayed on the top line. The bottom line indicates a value that is factory set 20 – 25 PSI above name plate. This is the pressure that will cause a forced blowdown if approached due to a malfunction such as a stuck inlet valve or broken control line. The controller will shut down if this pressure is exceeded.

    The upper limits for the following two adjustments are based on the setting of the high system pressure limit. If necessary, the controller automatically reduces them following this step, and the display will briefly indicate "**ADJUSTING PSET AND PRES**".

16. In the top line, "**SET PRESSURE**" is displayed. The bottom line will indicate a pressure value. It is to be set at the nameplate rating of the compressor for normal operation. Under NO circumstances, is this adjustment to be set in excess of the compressor nameplate pressure. It may be set lower, if desired, to reduce pressure and power consumption.

17. In the top line, "**RESET PRESSURE**" is displayed. The bottom line will indicate a pressure value. This setting determines the point at which machine startup occurs in AUTO and SEQUENCE modes and when the compressor will load up from the blown down condition. Note that RESET PRESSURE can be set up to 5 PSI below SET PRESSURE. Set this lower to reduce compressor cycling. All sequenced machines must have the same SET and RESET PRESSURE setpoints.

18. The top line displays "**REMOTE STOP**". The bottom line indicates either "**TIMED**" or "**IMMEDIATE**". Refer to the description of "Remote On / Off" later in this section for additional details. Select the desired response to the remote input and press [ENTER] to proceed.

19. The top line displays "**FILTER CHNG INTERVAL**". The bottom line indicates a time interval of 500 to 1000 hours. After the machine has run for the programmed setting, an advisory will be displayed, requesting an oil filter change. Adjust as desired and press [ENTER] to go on.

20. The top line displays "**OIL CHANGE INTERVAL**". The bottom line indicates a time interval of 1000 to 8000 hours. After the machine has run for the programmed setting, an advisory will be displayed, requesting an oil change. Adjust as desired and press [ENTER] to proceed.

21. The top line displays "**OVERTEMP LIMIT**". The bottom line indicates 225° F. This is the maximum (and proper) setting for compressor operation. It may be temporarily lowered to verify the function of the temperature shutdown system.

22. "**FAN TYPE**" is displayed next on the top line. Select "**AIR COOLED**" for units with package–mounted air coolers only. This will delay fan startup until the oil has warmed up in the package. Select "**WATER COOLED**" for water cooled units or any unit with a remote cooler. This will run the fan whenever the compressor motor runs.

23. In the top line, "**AUTO RESTART**" is displayed. The bottom line will indicate either "**OFF**" or "**ON**". The factory setting is "**OFF**", and the controller will display a power failure shutdown after power has been restored.

    Set this feature to ON when it is necessary to have the compressor automatically restart after a power interruption. There will be a brief delay, then the

control resumes the mode it was in prior to the interruption. This feature shall only be enabled when the owner determines that it is safe to do so. It is recommended that compressor access be limited to only trained service personnel when this feature is used.

24. This step happens only if the AUTO RESTART function was set to ON in step 23. The top line displays **"RESTART TIME"**. The bottom line indicates a time between 5 and 60 seconds. It is factory set at 10 seconds. This is the amount of delay introduced before restarting after power has been restored to ensure a stable supply and staggered starting. Adjust to any value per user preference.

25. The top line displays **"AIR END TYPE"**. The bottom line indicates either **"TURNVALVE"** or **"NON TURN VALVE"**. Set as appropriate for the compressor.

26. In the top line, **"SYSTEM VOLUME"** is displayed. The bottom line may be selected as **"SMALL"**, **"MEDIUM"**, or **"LARGE"**. This tunes the response of the modulation control loops to optimize loop stability. It is factory set to MEDIUM. Set as follows:

    SMALL if estimated volume is less than .25 gallon per CFM.

    MEDIUM if estimated volume is between .25 and 1.0 gallon per CFM.

    LARGE if estimated volume is greater than 1.0 gallon per CFM.

NOTICE

This setting is not critical. When set to its most appropriate value, the controller will maintain discharge at the closest possible value. If not set correctly, pressure will vary from the desired setpoint to a somewhat greater degree but the compressor and its components will not be adversely affected.

27. The top line displays **"REMOVE SYS PRESS"**. The bottom line displays the current pressure being sensed at the package discharge. At this point steps must be taken to ensure that system pressure is really zero psig. Remove the line to the system pressure transducer. Pressing [ENTER] will now cause the "AUTO SENTRY®–ES" to calibrate the transducer output to zero PSIG. Obviously, pressure measurement errors will occur if 'zeroing' is done with pressure at the transducer. If large errors are detected, the controller will demand that the transducer be checked.

28. The top line shows **"REMOVE RES PRESS"**. The bottom line displays the current pressure being sensed in the reservoir. The reservoir pressure transducer may now be 'zeroed' by following the steps outlined in 27 above.

29. The display now reads **"PRESS CNST RUN TO JOG MOTOR"**. Press the [CONSTANT RUN] key to briefly energize the starters, and rotate the compressor 1/4 to 1–1/2 revolutions to allow a rotation check. This is limited to three tests.

30. This completes the programming and setup procedures for the "AUTO SENTRY®–ES" controller. Press the [STOP/RESET] key to return the compressor to the READY state.

OTHER CONTROL FEATURES

Auto Restart After Power Failure – The "AUTO SENTRY®–ES" controller normally displays "SHUTDOWN – POWER FAILURE" after power has been interrupted and restored. Press the [STOP / RESET] key and select an operating mode to restart the compressor.

If programmed for automatic restart, The "AUTO SENTRY®–ES" controller pauses and begins counting down when power is restored. This time is adjustable in the programming steps noted above. This must be at least several seconds, but may be set longer to allow other plant loads to start up first. After the countdown is complete, the "AUTO SENTRY®–ES" controller resumes the mode of operation prior to the power interruption.

SEQUENCING COMPRESSORS WITH THE "AUTO SENTRY®–ES"

General – The sequencing mode is used to operate multiple compressors in a common plant air system. The individual units operate similarly to operation in the automatic mode, except that the setpoints are under control of the sequencing system. One of the units assumes the role of a master, with the remainder of the control distributed among the individual "AUTO SENTRY®–ES" controllers and compressor units. Communications between the controllers keep the system coordinated. Sequencing is intended to start, run, unload, blowdown, and stop compressors in response to changes in demand during the day or week.

The "AUTO SENTRY®–ES" controller is designed for systems of two through eight compressors piped into a common air receiver for distribution to the plant. In any such system, the receiver is an important part of the application; it supplies air to the plant and allows

compressor units to be unloaded and stopped. This stored reserve eliminates the need to operate "spinning reserve" of unloaded compressors. This storage may be an air receiver, or may be the volume of air in a large distribution system. In either case, the compressors must be piped to this volume with a minimum of restriction. The control system will operate only as many compressors as are needed to supply the CFM demand of the plant, and to maintain the compressor system pressure between the SET and RESET pressures programmed into the controllers.

The "AUTO SENTRY®–ES" controllers are completely set up to operate this system. The only required additional part is the cable which runs from controller to controller. A kit, 200EAP752, is available which contains all material needed to sequence up to five compressors. This kit contains 500 feet of cable, eight modular connectors, and a crimping tool to install the connectors.

NOTICE

Though similar in operation and installation, this sequencing system is designed specifically for the "AUTO SENTRY®–ES" controller. Communications cables should not be connected to compressor units with "AUTO SENTRY®–ES+" controllers part numbers 200EAU1173, 300EAU1173, or 301EAU1173. Multiple compressors with each type controller may be operated as independent groups piped to the same plant demand.

In spite of the fact that it is a standard feature and its inherent installation simplicity, the sequencing function of a multi–compressor "AUTO SENTRY®–ES" system contains all necessary functions for operation.

Compressor System – A proper sequencing installation requires two or more Gardner–Denver rotary air compressors complete with "AUTO SENTRY®–ES" controllers, piped into a common air system, interconnected as described above. Connect the units directly to a common header and receiver, without any intervening dryers, filters, or other restrictions. There should be no check valves or other devices which isolate a member from the air system. During operation, be sure that any unit is taken out of the sequence mode before closing its service valve.

The receiver should also be sized to prevent excessive drops or rapid rises in pressures during the operation as described below. Note that "receiver" really applies to the entire storage volume of a physical receiver and the volume of the air distribution throughout the plant. Modulating systems work best when the receiver is at least one gallon for the rated CFM of a member compressor in the system (the largest if they differ). Note that when demand exceeds the capacity of the running unit(s), there will be a delay until the next unit starts and delivers additional air. The stored air serves the plant during this period. With a properly sized receiver, pressure changes on a receiver gauge should be very slow and gradual.

All standard practices common to sound air compressor installations such as proper sizing of piping, proper electrical supply and conductor sizing, and grounding are to be observed. Run the compressors in the system in Automatic mode for at least one week to evaluate system performance.

Sequencing installation – Once the compressor system is set up, sequencing compressors with the "AUTO SENTRY®–ES" controller is as simple as plugging in a telephone to a wall jack. The only item required to make the system functional is a cable similar to a phone cable. The cable and connectors used in kit 200EAP752 have been specially selected to meet the needs of an industrial application. One less cable than the number of compressors to be sequenced is required. For example, to sequence four compressors, three cables are required.

The serial communications interface meets RS–485 standards, the most widely used interface in harsh, industrial environments today. However, the communications cables should be routed through metallic conduit to provide them with both mechanical protection and electromagnetic shielding. Do not run the communications cable in a conduit with other wiring.

Each controller has two modular jacks which accept RJ–12 telephone plugs, located on the side of the controller. One jack is vacant, the other has a short pigtail plugged into it. To interconnect two compressors, plug the cable into the vacant jack on each controller. For installations of more than two units, the pigtail plug must be disconnected on all controllers except the two at each end of the communications line. The order of interconnection has no effect on the system operation. The following conditions are necessary and sufficient for proper operation:

1. Every compressor must have a cable connecting it to another compressor. One less cable than the number of units sequenced must be used.
2. Each board that has only one cable connected to it must have its pigtail plugged into the unused jack. All installations will have two such units.

Program all members of the system, as described in the programming procedure on previous pages. All adjustments should be identical for each member, except for unit number. The sequencing system will make any necessary adjustments to the setpoints to properly run the compressed air system.

Operation

1. ESTABLISHING THE INITIAL SEQUENCE

Press the [SEQUENCE] key on each of the compressors to start operation of the sequenced system. Since the sequencing algorithm includes provisions for automatic replacement of a failed master or 'lead' compressor, it is important for the operator to be aware of the hierarchy of events when starting the system.

The first compressor placed into sequence mode will become the master. However, since any compressor first placed into sequence has no way of knowing whether a master exists, it will first assume the highest rotation number available. For example, if the number of units to be sequenced is programmed at four, any compressor will start out in position four when placed in sequence mode. It will then listen on the communications line for a call from the master.

If no call is received, it will assume position three and again wait for a call from the master. After another lack of a master call, it assumes position two. Subsequently, it assumes position one, which makes it the master. As soon as a master is established, it immediately attempts to call all other units and assigns them successive rotation positions. The system is now active.

Before a master is established, the system is not deprived of air. This is due to one of the outstanding features of the "AUTO SENTRY®–ES" sequencing system: pressure control is always executed locally at each compressor. The effective setpoint for compressor control is the programmed setpoint minus 3 *(rotation number – 1). So while a compressor is counting down towards establishing a master, it is also capable of delivering air at a pressure determined by the above formula.

To ensure that two or more machines do not simultaneously decrement their rotation numbers and simultaneously become masters, place the desired master in sequence mode first and wait until the first decrement in rotation number is seen (about 7 seconds). Then place subsequent compressors in sequence mode. To dictate the complete initial sequence manually, wait until the previous machine decrements one position and then place the next desired compressor in sequence mode. To let the master determine the initial sequence, simply wait until the master has decremented its rotation number once, and then place all remaining compressors in sequence mode. Remember that once a master is established, no further self–decrementing is done by the individual compressors. Instead, they will wait until the master assigns them a rotation number.

Rotation numbers are displayed in the bottom display line, with the mode indication. For example, the mode indication for the current master is SEQ1; for the first lag compressor, SEQ2; second lag, SEQ3.

2. HOW THE "AUTO SENTRY®–ES" CONTROLS PRESSURE WHILE SEQUENCING

Each compressor operates exactly the same as if it were in AUTO mode with one exception: it has a dynamic setpoint. The initial setpoint is determined by the equation shown above. A compressor starts when the system pressure drops below its programmed reset point, after waiting for ['LAG START INTERVAL' times (rotation number – 1)] seconds. This prevents all lag compressors from starting at once. Note that a compressor's ['LAG START INTERVAL' times (rotation number – 1)] timer is not reset to zero until that compressor is started or until another unit in the system stops. This means that the time for the next lag compressor to come on may be somewhat less than 'LAG START INTERVAL'.

EXAMPLE:

In a three compressor sequence system, SET PRESSURE = 100 PSI; RESET PRESSURE = 90 PSI; LAG START INTERVAL = 15 seconds. The lead compressor is running alone, maintaining 100 PSI by modulation when an air tool comes on line and causes the air demand to exceed the capacity of the lead compressor. When the pressure drops to 90 PSI, the #2 unit times out its 15 second timer and starts. It takes 5 additional seconds for the pressure to rise above 90 PSI. The #3 unit whose timer was initially set at 30 seconds (15 x [3 – 1]), has counted down 20 seconds (the total time that system pressure was below 90 PSI). If air demand increases again, the pressure will have to fall below 90 PSI for only 10 seconds more to start unit #3.

As was previously stated, a lag compressor's modulation setpoint (PSET for short) is [SET PRESSURE – 3(rotation number – 1)]. Thus in the above example, the first lag compressor (rotation #2) has a PSET of 97 PSI; the second lag, 94 PSI, and so on. But look what happens in an eight compressor installation: The eighth compressor will have an initial setpoint of [100 – 3(8 – 1)], or 79 PSI. Does this mean that an eight compressor installation must operate 21 PSI below the desired operating point when all compressors are running? NO! This is where the "AUTO SENTRY®–ES" dynamic setpoint control takes over. This is how it works: Whenever the system pressure is below the programmed RESET PRESSURE, the PSET of each lag compressor is incremented 1 PSI every thirty seconds. Thus, after a short interval (about five minutes in this example), the PSET of the last sequenced compressor will climb until either it equals the RESET PRESSURE, or a decrease in demand causes the ac-

tual system pressure to rise above the RESET PRESSURE. The "AUTO SENTRY®–ES", with its dynamic setpoint control, will maintain system pressure between the limits of RESET PRESSURE and SET PRESSURE. Remember, RESET and SET PRESSURE values are programmed by the operator so the operating range is completely programmable and predictable.

Dynamic setpoint control will also work in reverse of the operation described above. Obviously, incrementing setpoints will cause overlap of the compressors' modulation ranges. While this enables us to maintain a higher pressure than competitor's sequencers, overlap is undesirable as demand decreases, because a system could end up with several compressors running partially loaded instead of running the minimum number of fully loaded compressors. To overcome this, as pressure rises through the range between RESET and SET, the lag compressors' PSET's are now decremented. This reverses the effect described above during periods of high demand. The "AUTO SENTRY®–ES" keeps track of all functions so there is never any mix–up of setpoints and the proper rotation sequence is always maintained.

The Automatic Sequence Change

A controller will be the master (lead) compressor for the time programmed as TRANSFER INTERVAL. Then it assigns itself the highest available rotation number. The lag compressors detect the loss of the master and decrement their rotation numbers. Number 2 becomes number 1, the new master; number 3 becomes number 2, etc.

Whenever the master detects a missing rotation number, such as when a compressor is turned off that was previously in the rotation, it will automatically 'close the gap' by decrementing the rotation numbers of all compressors whose rotation numbers were greater than the missing number. Likewise, if for whatever reason, the master compressor fails to carry out its role, all lag compressors begin decrementing their rotation number until a new master is established. Regardless of the scenario, the result will always be that the compressors that remain in rotation will always end up with the lowest possible rotation numbers.

Other Features

Any air system will exhibit pressure differences from one point to the next. Even a well–designed multi–compressor installation will show 'minor' pressure variations between one compressor's discharge point and another compressor's discharge. These points will also vary from the central system (normally the air storage receiver). The "AUTO SENTRY®–ES" sequencing system is designed to tolerate minor variations. These pressure differences wreak havoc with conventional sequencers. Central sequencers sense a lower pressure than is seen at each compressor. With such systems, there is always a chance that the sequencer could cause a compressor to over pressure due to this pressure drop. The alternative has been to set the central sequencer to a lower pressure to prevent this or allow local override of the sequencer by the local pressure control, neither of which is desirable in the scheme of maintaining plant pressure efficiently with sequencing. The "AUTO SENTRY®–ES" sequencing system will automatically adjust the system to prevent over pressures in any individuals.

The "AUTO SENTRY®–ES" sequencing system lets each compressor control itself independently about a setpoint (PSET) derived to cause staggered operation, or sequencing. The aforementioned pressure drops can also cause derogatory effects (mainly skewed, or out of sequence operation) to the sequencing algorithm used by the "AUTO SENTRY®–ES".

Since these pressure variations are not constant (they will vary due to demand changes, compressor load percentage changes, and number of compressors running), any scheme to compensate for the pressure variations must be dynamic. The exclusive dynamic setpoint control feature accomplishes this error correction scheme rather easily.

Here's how it works: The master continually receives system pressure values from every machine in the sequence rotation. The values are averaged and this average is distributed to all lag compressors. All compressors, lead and lag, then compare their local pressure reading to the average and adjust their PSET by the amount of error. The effect is that all compressors are controlling to a single pressure reading, a reading that is not one that is picked up somewhere removed from the compressor, but an average of actual discharge pressures.

The pressure displayed on the top line by all sequenced compressors is this average.

CONNECTION TO EXTERNAL CONTROLS

The "AUTO SENTRY®–ES" controller offers interconnection points for external controls and indicators. This allows simple connection to remote controls and indicators, or integration into any plantwide controls system.

Remote On / Off – Remote on–off control of the system requires only a simple two–wire control, with an isolated contact suitable for 120 volts, 1 amp. This may be a switch, a timer contact, a relay contact, or a PLC output. To connect, simply run the two wires to the control enclosure, remove the jumper between terminal 6 and terminal 9 on the terminal strip, and connect the two wires to terminal 6 and terminal 9.

The air compressor will operate normally in its selected mode whenever this contact is closed (turned on). Note that the keypad is always the master control; the

operating mode must be selected at the keypad, and the remote is not capable of starting a unit after the [STOP/RESET] key has been pressed to place the controller in the READY state. When the contact is opened (turned off), operation depends on how the controller has been programmed and what it is doing prior to opening the contact.

If the compressor was already stopped in automatic or sequence modes, it will remain stopped and will not restart until the contact is closed. The display will flash the message **"REMOTE STOP"** to indicate that it is waiting for the remote signal.

If the compressor was running in any mode when the contact was opened, and the remote response is programmed for **"IMMEDIATE"**, the compressor will immediately unload, blowdown and stop the motors. The unit is then in the **"REMOTE STOP"** mode as indicated above.

If the compressor was running in any mode when the contact was opened, and the remote response is programmed for **"TIMED UNLOAD"**, the compressor will immediately unload and blowdown. It will then continue to run unloaded for whatever period has been programmed for **"AUTO TIME"** (or will complete the remaining auto time if already blown down). After completion, the motors will stop, and the unit will be in the **"REMOTE STOP"** mode as indicated above. This is the preferred setting for automatic remote controls that may cycle in less than 1/2 hour, as the motor is always cooled evenly and rapid start cycles are prevented.

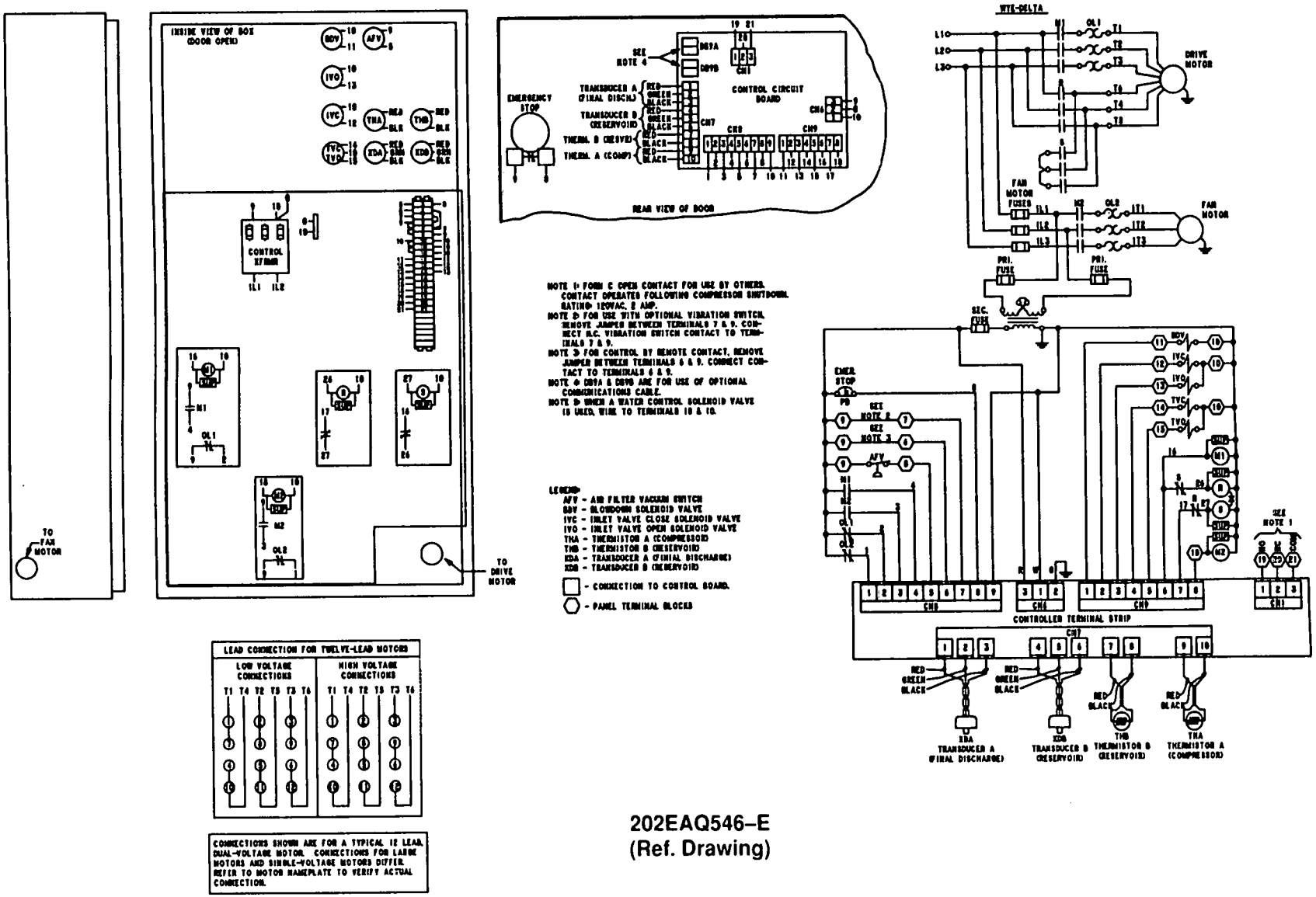
When the remote is turned back on, the unit will start immediately in the CONSTANT or LOW DEMAND modes. Loading in these modes, or starting in AUTO or SEQUENCE modes will occur when the pressure drops below the set pressure.

Alarm Relay – The "AUTO SENTRY®–ES" controller provides an alarm relay that may be connected to a remote mounted indicator light, horn, or into a PLC input of a plantwide control system. The contact is commercial rated 2 amps at 120 volts. The relay turns on whenever there is a shutdown condition requiring service at the compressor, and remains off during normal operation, stopping, or power off conditions. The external connections from the controller are from an isolated form C (single–pole, double–throw) contact. This allows control of either a "compressor okay" or a "compressor shutdown" remote indicator.

To use this relay, connect the supply wire for the remote circuit to terminal 21 (relay common) on the terminal strip. Connect a wire to the indicator from either terminal 19 (normally open) or from terminal 20 (normally closed). Connect the other side of the indicator to its neutral.

Serial Communications – If units are NOT connected in sequence, the serial port is available for communications of compressor data to external monitoring systems. Data available include all pressures and temperatures, and a report of internal service data. This is accessible with a PC or PLC with an RS–485 communications port. For protocol information, request drawing 200EAP1255.

Wiring Diagrams – The following wiring diagram shows connections in typical units. Refer to the wiring diagram shipped with the compressor unit for actual connections.



202EAQ546-E
(Ref. Drawing)

FIGURE 2-2 – WIRING DIAGRAM – ES CONTROLLER

TROUBLE SHOOTING AUTO SENTRY® ES CONTROLLER

DISPLAY MODES

The normal display indicates the package service pressure, the airend discharge, the total running hours, and one of the following operating modes. The green light will be on for any operating mode, whether the compressor is running or not.

READY	The compressor has been stopped by pressing the [STOP/RESET] key.
CON	The compressor is operating in the Constant Run mode.
LDM	The compressor is operating in the Low Demand mode.
AUTO	The compressor is operating in the Automatic mode.
SEQ n	The compressor is operating in the Sequence mode.

The following alternate displays may be called by pressing a cursor [<] or [>] key

SYS PRES	The pressure at the service connection
RES PRES	The pressure in the oil reservoir
DIF PRES	The pressure drop across the air/oil separator
TOT HRS	The total hour of compressor running
DIS TMP	The temperature at the airend discharge
RES TMP	The temperature in the reservoir / separator
BD TMR	The time remaining before a blowdown will be allowed (Low Demand, Auto, Sequence Modes)
AUTO TMR	The time remaining of unloaded motor operation (Auto, Sequence Modes)

ADVISORY TROUBLESHOOTING GUIDE

All advisories are indicated on the keypad by a yellow indicator in the Status area, and one of the following messages alternating with the normal lower line display. Perform service or maintenance as indicated, then clear the advisory as instructed on page 27.

Message	Action Needed
CHNG AIR FILTER	Excessive vacuum has been detected after the air filter, indicating it has become full. Change the air filter to ensure maximum air delivery.
CHNG SEPARATOR	The differential pressure across the air/oil separator has risen to over 8 psid. Change the separator to ensure maximum performance.
CHNG OIL FILTER	The unit has been operated for the programmed number of hours since the last filter replacement. Change the filter to ensure an adequate flow of lubricant.
CHANGE OIL	The unit has been operated for the programmed number of hours since the last oil change. If high operating temperatures are encountered, the "AUTO SENTRY®–ES" controller will automatically adjust the time interval for the change oil advisory. Change the oil to ensure lubricant quality.

ADVISORY TROUBLESHOOTING GUIDE (Continued)

Message	Action Needed
HIGH TEMP OPER	The temperature was greater than 210° F (99° C) at the airend discharge or the separator. Ensure that the compressor receives adequate cooling air or water, and that the coolers are not plugged.
LOW AMB TEMP	The temperature was less than 40° F (4° C) at the airend discharge or the separator. Ensure that the compressor is located in a room kept above freezing.

SHUTDOWN TROUBLESHOOTING GUIDE

All shutdowns are indicated on the keypad by the word "SHUTDOWN" on the top line of the display, and one of the following messages on the lower line of the display. The red indicator in the Status area will be steadily lit while the conditions exist, and will flash after the condition has been corrected. Perform service as indicated. Press the [STOP/RESET] key to clear the shutdown.

Message	Action Needed
CHANGE SEPARATOR	The differential pressure across the air / oil separator has risen to over 15 psid. Change the separator to ensure maximum compressor performance.
CHECK CN7	All inputs at connector 7 of the controller are off. The most common cause for this is that the connector plug has been pulled out. Plug the connector back in firmly.
CHECK CN8	120 volts has been removed from ALL inputs to connector 8 of the controller. The most common cause for this is that the connector plug has been pulled out. Plug the connector back in firmly.
EMERGENCY STOP	The Emergency Stop button has been pressed. Pull it back out to its normal position. If the button has not been pressed, check that the contact block is firmly mounted in the right or left (not center) position of the operator. Check for loose connections which would remove 120 volts from connector 8–8 of the controller.
FAN OVERLOAD	The motor overload relay for the fan motor, located within the electrical control box, has tripped. This indicates high motor shaft load, low voltage, or excessive imbalance in the incoming power (such as a blown fuse). Disconnect and lock out power, open the box, and press the reset button – it will click when reset. Measure motor amps, and take corrective actions to get all currents within the motor nameplate rating. If overload relay has not tripped, check for the cause that 120 volts was removed from connector 8–1 of the controller.
FAN START ERROR (while stopped)	The controller has attempted to turn off the fan, but is still receiving a return signal from the starter's auxiliary contact. Check that the starter operates freely and that the contact block is properly installed on the starter.
FAN START ERROR (while running)	The controller has attempted to start the fan, but did not receive a return signal from the starter's auxiliary contact. If the starter does not pick up when attempting to start, check that connector 9 of the controller is plugged in firmly, and check the starter coil. If the starter does pick up, but this message appears, check that the auxiliary contact block is properly installed on the starter and wired to connector 8, terminal 3.

Message	Action Needed
HIGH DISCH TEMP	This indicates that the controller has detected temperature in excess of the programmed high temperature limit, or a high temperature rate of rise, at the airend discharge. The most common cause for this is inadequate package cooling. Ensure proper air flow for aircooled units, or adequate water for water cooled units. Monitor temperature carefully during restarts after servicing.
HIGH RESVR PRESS	Pressure in excess of the programmed high pressure limit has been detected. This shutdown will occur if a loss of pneumatic controls occurs. Check the inlet valve, all control piping, solenoid valves, and all other control devices to find the cause for the inlet valve not closing. Other possible causes are loose connections to the transducer, electrical noise and transients, or improper setting of the high pressure limit.
HIGH RESRVR TEMP	This indicates that the controller has detected temperature in excess of the programmed high temperature limit, or a high temperature rate of rise, at the air/oil separator. The most common cause for this is inadequate package ventilation. Monitor the temperature carefully during restarts after servicing.
HIGH SYSTEM PRESS	Pressure in excess of the programmed high pressure limit has been detected. The most likely cause is other, higher pressure compressors on the same air system; separate these from this compressor unit. Other possible causes are loose connections to the transducer, electrical noise and transients, or improper setting of the high pressure limit.
HIGH VIBRATION	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
LOW OIL PRESS	The controller has attempted to start and load the compressor, but pressure is not building up in the oil reservoir. This may indicate either a failure of the motor to turn the compressor, or a failure of the inlet valve to open. If the latter, check also the wiring and piping to solenoid valves IVO and IVC; these are both turned on to load up the compressor.
MAIN OVERLOAD	The motor overload relay for the main compressor drive motor, located within the electrical control box, has tripped. This indicates high motor shaft load, low voltage, or excessive imbalance in the incoming power (such as a blown fuse). Disconnect and lock out power, open the box, and press the reset button – it will click when reset. Measure motor amps, and take corrective actions to get all currents within the motor nameplate rating. If overload relay has not tripped, check for the cause that 120 volts was removed from connector 8–2 of the controller.
MAIN START ERROR (while stopped)	The controller has attempted to turn off the compressor, but is still receiving a return signal from the starter's auxiliary contact. Check that the starter operates freely and that the contact block is properly installed on the starter.
MAIN START ERROR (while running)	The controller has attempted to start the compressor, but did not receive a return signal from the starter's auxiliary contact. If the starter does not pick up when attempting to start, check that connector 9 of the controller is plugged in firmly, and check the starter coil. If the starter does pick up, but the message appears, check that the auxiliary contact block is properly installed on the starter and wired to connector 8, terminal 4.

SHUTDOWN TROUBLESHOOTING GUIDE (Continued)

Message	Action Needed
OPEN THERM	The controller has detected an open connection to thermistor: (A) airend discharge, or (B) separator. This normally indicates a loose or broken connection at the controller connector 7; check and correct the connection. This could also be indicating a broken wire or thermistor probe. This may also occur from excessively low temperature.
OPEN XDUCER	Signal voltage has fallen too low at transducer: (A) Final discharge, or (B) Reservoir. This error is frequently the result of the transducers being improperly zeroed. Disconnect the air lines to the transducers and follow the procedure indicated in the adjustment instructions. This may also indicate a loose connection of the red wire to the transducer or a defective transducer. Check connections, or replace transducer if necessary.
POWER FAILURE	The power to the compressor unit has been turned off and back on. Press [STOP/RESET] and select an operating mode.
SHORTED THERM	The controller has detected a shorted connection to thermistor: (A) airend discharge or (B) separator. This normally indicates a faulty connection (e.g. wire strands touching) at the controller connector 7; check and correct the connection. This could also be indicating a damaged wire or thermistor probe.
SHORTED XDUCER	Signal voltage has exceeded approximately 4.6 volts at transducer: (A) Final discharge or (B) Reservoir. This may indicate a loose connection of the black wire to the transducer or a defective transducer. Check connections, or replace transducer if necessary.

CONTROLS TROUBLESHOOTING GUIDE

The following are recommended service actions. Observe all instructions noted elsewhere in this manual. All electrical service is to be performed only by a qualified electrician.

Symptom	Recommended Action
No display, compressor stopped.	Check incoming power to the compressor unit. Ensure that the disconnect is on and that fuses have not blown (or circuit breaker tripped). If power is being properly supplied to the control box, check the fuses located at the fan starter, the control transformer fuses, and the fuse located on the Auto Sentry®–ES controller chassis near connector CN–6.
Compressor will not start.	To operate, the controller must be placed into an operating mode (e.g. "AUTO"); press the [STOP/RESET] to put the control in the READY state, then select a mode with the operating mode keys. In AUTOMATIC and SEQUENCE modes, compressors will not start until the pressure drops below the reset pressures.
Display indicates "**NOT BLOWN DOWN**"	The controller prevents attempts to start the main motor if the reservoir pressure is over 5 psig (.35 Bar). Pressure continues to be relieved from the reservoir while this message is on, and the compressor will start automatically after the pressure has dropped. If this message remains with NO pressure in the reservoir, follow the transducer zeroing procedure found in the controls adjustment section.

CONTROLS TROUBLESHOOTING GUIDE

Symptom	Recommended Action
Display indicates "**REMOTE STOP**"	The controller is provided with an input for user–furnished remote controls. This display indicates that 120 volt is removed from terminal 6 of the terminal strip. Check all connections of the factory installed jumper, or the customer–provided controls, if applicable.
Display indicates "**SHUTDOWN**"	If the display indicates "SHUTDOWN", refer to the shutdown troubleshooting section for assistance. In addition to the messages shown, there are several internal and system diagnostics performed by the controller. Consult the factory for additional assistance.
Compressor runs, but does not load	In the CONSTANT RUN and LOW DEMAND modes, the compressor will not load until the pressure drops below reset pressure. Refer to the operating instructions for further information. If pressure is below the reset pressure, check that the inlet valve operates freely. Check that the IVO and IVC valves are wired and operating properly.
Compressor runs, unloads at low pressure	If the inlet valve closes at low pressure, check the wiring to the blowdown valve and the piping and check valves in its discharge line.
Compressor does not modulate	The Auto Sentry®–ES controller operates the inlet valve to maintain pressure near the set pressure, matching delivery to demand. If the pressure continues to rise above set pressure, check that the inlet valve operates freely, and that control air is supplied to the IVC valve. If modulation does not close the valve, it will be closed during a blowdown as pressure approaches the high pressure limit.
Compressor cycles rapidly between load and unload	The external air receiver should be sized appropriately to prevent rapid cycles. The rapid response time in CONSTANT RUN mode will operate with small receivers, but any plant air system will operate more efficiently with adequately sized storage. Refer to the operating instructions for further information.
Display is illegible	Extra segments or "ghosting" of characters indicates damage probably from excessive high voltage. Replace the controller, and install protection to prevent further damage to electrical equipment.
Erratic pressures in SEQUENCE only	The sequencing system transmits low–level signal between units to communicate pressures. Units must be properly grounded to a good ground system, the communications cable should use only appropriate quality cable, and the cable should be run in its own conduit.
Compressor cycles rapidly in SEQUENCE mode only	In the sequence mode, the operating system requires all compressors be piped directly to receiver, such that all transducers sense the same pressure. Check valves or restrictions between compressors and the storage will cause system instability. Run units in AUTOMATIC mode until the system is corrected.
LOW OIL PRESSURE in SEQUENCE mode only	If this shutdown occurs in the sequence mode only, it indicates instability due to rapid changes in pressure of the system. Remove restrictions between the compressor and receiver, increase receiver size if necessary to slow down the pressure swings.
Pressure display error	Accuracy of the pressure display and controls requires that the controller and transducers be calibrated together. This MUST be done with no pressure at the transducer, or errors will occur. This is easiest to check with all pressure removed. All pressure displays should indicate 0 psi (0.0 Bar) +/– 1 PSI. If the display indicates greater pressures, recalibrate the system as instructed in the configuration adjustments. Note: reservoir pressure may drop below zero psig when the compressor is stopped, but will return slowly to zero as the vacuum is relieved.

SECTION 3
REMOTE–MOUNTED MAIN MOTOR STARTERS

CONNECTION OF REMOTE–MOUNTED MAIN MOTOR STARTERS TO ES CONTROL SYSTEMS

The majority of our rotary screw compressor packages feature starters completely wired and tested at the factory. Some special applications and large units, however, do not have the main motor starter mounted on the package. The following information describes special requirements for applications with a remote–mounted main starter.

Starter

Regardless of starter type or brand, the following are required:

- The starter must have its own fused control circuit (and control transformer, if required for the starter).
- The starter must have provision for connection to a two–wire control circuit.
- The starter must have an isolated (dry contact) normally–open auxiliary contact.

Installation and Wiring

The starter should be mounted and wired in accordance with the National Electrical Code and the manufacturer's instructions. Wiring from the load terminals of the starter to the motor should include flexible conduit to the motor junction box to allow for normal movement of the motor in the package.

The compressor package control box must have its own disconnect and overcurrent protection. If the package has a fan, the wiring should be sized for the fan horsepower and voltage. If the package does not include a fan, the only package load is the control transformer.

Install a separate conduit from the starter to the package control box for control wiring. Label and pull four control wires through this conduit. Since two separate supplies are involved, run one pair of red wires and one pair of yellow wires for identification.

Controls Connections

Disconnect and remove any manual starter controls which may be mounted on the starter or elsewhere. The starter must be controlled by the compressor controls for proper operation. The following is general information; refer to the unit wiring diagram for detailed connection.

Connect the control relay contact in the control box to the starter terminals for two–wire control. The terminals are identified in the control box as 40 & 41 on standard packages. Refer to the starter instructions for identification of the control terminals for two–wire control. Use the pair of yellow wires to indicate that this circuit is from a different source.

Connect the starter auxiliary contact to the compressor control box. When connecting this contact, make sure that no other wires are connected to it in the starter – it has to be an isolated contact. These two wire connect to terminals 4 & 9 on standard packages. Use the pair of red wires; this is powered from the compressor control panel control transformer.

Controls Checkout

Lock the disconnect switch for the starter in the open position. Energize the compressor package control panel. If the display indicates **"SHUTDOWN – MAIN START ERROR"**, **"SHUTDOWN – MOTOR CONTACT,"** or **"SHUTDOWN – MAIN STRT CONTCT"**, the starter auxiliary contact is misconnected. Remove all power and correctly wire as indicated above.

Enter the adjustments menu and perform a jog to check for proper fan rotation. If it is incorrect, disconnect power and switch two of the three wires to the fan motor. Restore power to the control box when done.

With the main motor power still disconnected, press the [CONSTANT RUN] key. After a brief delay, The control should stop and display **"SHUTDOWN – MAIN START ERROR"**, **"SHUTDOWN – MOTOR STARTER"** ,or **"SHUTDOWN – MAIN STARTER"**. This properly indicates that the starter did not function because it is turned off by the disconnect switch.

Unlock and close the disconnect switch for the main motor. Enter the adjustments menu to jog the compressor and check rotation. If it is incorrect, disconnect and lockout all power, reverse two of the three power phases at the starter. Restore power when done.

Press the [CONSTANT RUN] key. If the controller displays **"SHUTDOWN – MAIN START ERROR"** , **"SHUTDOWN – MOTOR STARTER"** ,or **"SHUTDOWN – MAIN STARTER"** and stops the unit, the starter auxiliary contact is misconnected. Remove all power and correctly wire as indicated above.

Press the [STOP/RESET] key to stop the compressor. The control should perform an orderly stop of the compressor unit and motor.

SECTION 4
REMOTE COOLING MODULE STARTERS

CONNECTION OF REMOTE COOLING MODULE STARTERS TO ES CONTROL SYSTEMS

The majority of our rotary screw compressor packages feature starters completely wired and tested at the factory. Some applications and large units, however, will have the air cooled cooling module mounted remotely from the compressor package. Standard pratice is to provide a combination starter (with fused disconnect) for the cooling module. The following information describes connection requirements for these applications.

Starter

Regardless of starter type or brand, the following are required:

- The starter must have an isolated 120 volt coil.
- The starter must have an isolated (dry contact) normally closed overload relay contact.
- The starter must have an isolated (dry contact) normally–open auxiliary contact.

Standard starters are generally provided by the manufacturer with interconnecting wires between the coil, overload relay contact, and auxiliary contact. Remove all of these to isolate the three control components.

Installation and Wiring

The starter should be mounted and wired in accordance with the National Electrical Code and the manufacturer's instructions. Wiring from the load terminals of the starter to the motor should include flexible conduit to the motor junction box to allow for normal movement of the motor in the package. Use time–delay fuses in the disconnect, to allow for motor starting. Follow instructions in the starter for proper sizing and application of overload heaters.

Install a separate conduit from the starter to the package control box for control wiring.

Label five control wires: 9 , 10 , 18 , 22 , 23 ; pull through this conduit.

Controls Connections

Disconnect and remove any manual starter controls or other control wires which may be mounted on the starter or elsewhere. The starter must be controlled by the compressor controls for proper operation. The following is general information; refer to the unit wiring diagram for detailed connection.

Connect the five control wires to terminals 9, 10, 18, 22, 23 in the compressor control box.

At the cooling module starter, connect wire 10 to one terminal of the starter coil, wire 18 to the other coil terminal. Connect wire 9 to one terminal of the aux contact and to one terminal of the overload relay contact terminal. Connect wire 23 to the other aux relay contact. Connect wire 22 to the other overload relay contact terminal.

Controls Checkout

After installation is complete, energize both the module and the compressor package. In the controller adjustments, select **"WATERCOOLED"** fan type. This operates the fan whenever the compressor operates, and must be used with remote–cooled units as well as watercooled units. This ensures that the oil piping does not accumulate a large quantity of hot oil before the fan starts. This setting also starts the enclosure vent fan (if so equipped) whenever the compressor runs to cool the main drive motor. Check rotation of both the compressor and the cooling fan during the jog motor test.

Start the compressor unit by pressing the [CONSTANT RUN] key. The compressor and cooling module should both start. Run for approximately one minute. Stop the compressor by pressing [STOP/RESET]. The compressor and cooling module should both stop.

If the controller shuts down before a start is attempted and displays **"FAN STRT CONTACT"** or **"FAN START ERROR"**, check and correct wiring to the auxiliary contact.

If the cooling module fan does not start, and the controller shuts down and displays **"FAN STARTER"** or **"FAN START ERROR"**, check and correct the wiring to the starter coil.

If the cooling module fan does not start, check the fuses in the combination starter and ensure that the disconnect switch is closed.

If the cooling module fan starts, but the controller then shuts down and displays **"FAN STARTER"** or **"FAN START ERROR"**, check and correct the wiring to the auxiliary contact.

If the controller shuts down and displays **"FAN OVERLOAD"**, check both the cooling fan and the package fan (if applicable) motors for overload or misconnection.

SECTION 5
SERVICE AND FIELD MODIFICATION

CONTROLLER REPLACEMENT

The controller is mounted into the starter enclosure with fourteen nuts and lockwashers. On most slope–top enclosures (40–100HP models), these are visible when an access panel on the back of the box is removed. Drape cloths over the starters and other components in these boxes to prevent loose parts from falling into the electrical devices.

To maintain the enviromental integrity of the enclosure, all lockwashers and nuts must be used when installing the replacement controller.

CONTROLLER UPGRADES

The AUTO SENTRY®–ES and AUTO SENTRY®–ES+ controllers share all mounting dimensions and are field interchangeable. To upgrade controller types, order Kit number 204EAU6003. This contains all parts and instructions needed for retro fit of the AUTO SENTRY®–ES+ into older units.

PC SOFTWARE FOR AUTO–SENTRY® ES+

25–1–620 contains instructions and PC software for field revisions of AUTO SENTRY®–ES+ operating software. This requires a PC with approximately 3MB free disk space, a 3.5 inch floppy disk drive, and an available RS232 port at COM1. An RS232 cable is also needed, connected to the PC's COM1 port and the ES+ RS232 port. The PC software provides selection of any current ES+ operating software in English only, English–Spanish, or English–French.

ACCESSORIES FOR AUTO SENTRY®–ES+

The following kits contain all electrical parts and instructions for field installation of accessory inputs for units with AUTO SENTRY®–ES+ controllers.

Kit number 203EAU6003 provides a current monitor for units built without the monitor.

Kit number 205EAQ4014 provides a water pressure switch for installation on the water supply line.

Kit number 207EAQ4014 provides a voltage/phase monitor for 200–208 volt units.

Kit number 208EAQ4014 provides a voltage/phase monitor for 230–240 volt units.

Kit number 209EAQ4014 provides a voltage/phase monitor for 460–480 volt units.

Kit number 210EAQ4014 provides a voltage/phase monitor for 575–600 volt units.

Gardner Denver

For additional information contact your local representative or
Gardner Denver, Customer Service Department,
1800 Gardner Expressway, Quincy, Illinois 62301
Telephone: (800) 682–9868 FAX: (217) 224–7814

Sales and Service in all major cities.

For parts information, contact Gardner Denver,
Master Distribution Center, Memphis, TN
Telephone: (800) 245–4946 FAX: (901) 542–615[illegible]

http://www.gardnerdenver.com **mktg@gardnerdenver.com**

GARDNER DENVER®

13–9–560
1st Edition
February, 1999

ELECTRA–SAVER®
ELECTRA–SAVER II®
BASE–MOUNTED COMPRESSORS

AUTO SENTRY®–ES+ CONTROLS
AUTO SENTRY®–ES CONTROLS

MODELS

EBMQKF	–	AIR-COOLED	–	60 HP
EBMSKF	–	WATER-COOLED	–	60 HP
EBMQLF	–	AIR-COOLED	–	75 HP
EBMSLF	–	WATER-COOLED	–	75 HP
EAPQME	–	AIR-COOLED	–	100 HP
EAPSME	–	WATER-COOLED	–	100 HP
EBPQMD	–	AIR-COOLED	–	100 HP
EBPSMD	–	WATER-COOLED	–	100 HP

60 HZ DOMESTIC ONLY

PARTS LIST

Gardner Denver

INSTRUCTIONS FOR ORDERING REPAIR PARTS

When ordering parts, specify Compressor MODEL, Method of Cooling, HORSE-POWER and SERIAL NUMBER (see nameplate on unit). The Serial Number is also stamped on top of the cylinder flange to the right of the inlet housing.

All orders for Parts should be placed with the nearest authorized distributor.

Where NOT specified, quantity of parts required per compressor or unit is one (1); where more than one is required per unit, quantity is indicated in parenthesis. SPECIFY EXACTLY THE NUMBER OF PARTS REQUIRED.

DO NOT ORDER BY SETS OR GROUPS.

To determine the Right Hand and Left Hand side of a compressor, stand at the motor end and look toward the compressor. Right Hand and Left Hand are indicated in parenthesis following the part name, (RH) & (LH), when appropriate.

For Operating and Service Instructions see:

SERVICE MANUAL	**13–910–641**
CONTROLLER MANUAL	**13–910–647**

MAINTAIN COMPRESSOR RELIABILITY AND PERFORMANCE WITH GENUINE GARDNER DENVER® COMPRESSOR PARTS AND SUPPORT SERVICES

Gardner Denver® Compressor genuine parts, manufactured to design tolerances, are developed for optimum dependability —— specifically for Gardner Denver compressor systems. Design and material innovations are the result of years of experience with hundreds of different compressor applications. Reliability in materials and quality assurance are incorporated in our genuine replacement parts.

Your authorized Gardner Denver® Compressor distributor offers all the backup you'll need. A worldwide network of authorized distributors provides the finest product support in the air compressor industry. Your local authorized distributor maintains a large inventory of genuine parts and he is backed up for emergency parts by direct access to the Gardner Denver Master Distribution Center (MDC) in Memphis, Tennessee.

Your authorized distributor can support your Gardner Denver® air compressor with these services:

1. Trained parts specialists to assist you in selecting the correct replacement parts.
2. Factory warranted new and remanufactured rotary screw air ends. Most popular model remanufactured air ends are maintained in stock at MDC for purchase on an exchange basis with liberal core credit available for the replacement unit.
3. A full line of factory tested AEON™ compressor lubricants specifically formulated for use in Gardner Denver compressors.
4. Repair and maintenance kits designed with the necessary parts to simplify servicing your compressor.

Authorized distributor service technicians are factory–trained and skilled in compressor maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair services.

For the location of your local authorized Gardner Denver Air Compressor distributor refer to the yellow pages of your phone directory or contact:

Distribution Center:
Gardner Denver
Master Distribution Center
5585 East Shelby Drive
Memphis, TN 38141
Phone: (901) 542–6100
(800) 245–4946
Fax: (901) 542–6159

Factory:
Gardner Denver
1800 Gardner Expressway
Quincy, IL 62301
Phone: (217) 222–5400
Fax: (217) 224–7814

REMANUFACTURED AIR ENDS

Whenever an air end requires replacement or repair, Gardner Denver offers an industry unique, factory remanufactured air end exchange program. From its modern Remanufacturing Center in Indianapolis, IN, Gardner Denver is committed to supplying you with the highest quality, factory remanufactured air ends that are guaranteed to save you time, aggravation and money.

Immediately Available

Repair downtime costs you money, which is why there are over 200 remanufactured units in inventory at all times, ready for immediate delivery.

Skilled Craftsmen

Our Remanufacturing assembly technicians average over 20 years experience with air compression products.

Precision Remanufacturing

All potentially usable parts are thoroughly cleaned, inspected and analyzed. Only those parts that can be brought back to original factory specifications are remanufactured. Every remanufactured air end receives a new overhaul kit: bearings, gears, seals, sleeves and gaskets.

Extensive Testing

Gardner Denver performs testing that repair houses just don't do. Magnaflux and ultrasonic inspection spot cracked or stressed castings, monochromatic light analysis exposes oil leaks, and coordinate measurement machine inspects to +/– .0001", insuring that all remanufactured air ends meet factory performance specifications.

Warranty

Gardner Denver backs up every remanufactured air end with a new warranty . . . 18 months from purchase, 12 months from service.

Gardner Denver remanufactured air ends deliver *quality without question . . . year in and year out.*

Call Gardner Denver for information on the air end exchange program and the name of your authorized distributor.

Phone Number: 800–245–4946 or
FAX: 901–542–6159

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ELECTRA–SAVER II® COMPRESSORS – MODELS EBM_KF & EBM_LF
60 & 75 HP Air / Water–Cooled Base–Mounted Units – 60 Hz Only – Matrix/Menu

NOTICE TO CUSTOMER – To find the construction options for your compressor unit, FILL IN THE BALANCE OF LETTERS OR NUMBERS FROM YOUR UNIT NAMEPLATE.

	E	B	M			F							
COLUMN NUMBER:	1	2	3	4	5	6	7	8	9	10	11	12	13

Follow the line down and over from each space thus filled in to find the appropriate construction option with which your machine is equipped. The number "9" in any column space indicates "NOT APPLICABLE." The number "8" in any column space indicates SPECIAL DESIGN – REFER TO FACTORY ORDER TICKET.

COLUMNS 1, 2 & 3 – ELECTRA–SAVER II® FAMILY – Single Stage

COLUMN 4 – TYPE OF CONSTRUCTION
- Q. Air–Cooled Base Mounted (Std.)
- S. Water–Cooled Base Mounted (Std.)

COLUMN 5 – HORSEPOWER
- L. 60 HP
- M. 75 HP

COLUMN 6 – ENGINEERING SPECIFICATION

COLUMN 7 – PRESSURE & HZ
- A. 100 PSIG – 60 HZ
- B. 125 PSIG – 60 HZ
- C. 150 PSIG – 60 HZ

COLUMN 8 – CONTROL BOX & MAIN MOTOR STARTING
- A. 200 V – 60 HZ – Full Voltage
- B. 230 V – 60 HZ – Full Voltage
- C. 460 V – 60 HZ – Full Voltage
- D. 575 V – 60 HZ – Full Voltage
- E. 200 V – 60 HZ – Wye Delta
- F. 230 V – 60 HZ – Wye Delta
- G. 460 V – 60 HZ – Wye Delta
- H. 575 V – 60 HZ – Wye Delta

COLUMN 9 – CONTROL BOX / STARTER
- A. ES Control – Nema 12 – With Starter
- B. ES Control – Nema 4 – With Starter
- C. ES Control – Nema 12 – Without Starter
- D. ES Control – Nema 4 – Without Starter
- E. ES+ Control – Nema 12 – With Starter – Without Current Monitor
- F. ES+ Control – Nema 4 – With Starter – Without Current Monitor
- G. ES+ Control – Nema 12 – Without Starter – Without Current Monitor
- H. ES+ Control – Nema 4 – Without Starter – Without Current Monitor
- I. ES+ Control – Nema 12 – With Starter – With Current Monitor
- J. ES+ Control – Nema 4 – With Starter – With Current Monitor
- K. ES+ Control – Nema 12 – Without Starter – With Current Monitor
- L. ES+ Control – Nema 4 – Without Starter – With Current Monitor

COLUMN 10 – ENCLOSURE
- A. No Enclosure
- B. With Enclosure

COLUMN 11 – OIL COOLERS – AIR & WATER
- A. Standard Coolers with Aftercooler (Air or Water Cooled)
- B. Seacoast (Salt Water) Cooler With Aftercooler (Air or Water Cooled)
- C. Standard Coolers Less Aftercooler (Water Cooled Only)
- D. Salt Water Cooler Less Aftercooler (Water Cooled Only)

COLUMN 12 – COOLER ELECTRICS
- A. Air Cooled
- B. Water Cooled – Without Water Temperature Regulator – Without Shutoff Valve
- C. Water Cooled – With Water Temperature Regulator – With Shutoff Valve
- D. Water Cooled – With Water Temperature Regulator – Without Shutoff Valve
- E. Water Cooled – Without Water Temperature Regulator – With Shutoff Valve

COLUMN 13 – COMPRESSOR DRIVE MOTOR
- A. ODP
- B. TEFC
- C. ODP High Efficiency
- D. TEFC High Efficiency
- E. Less Main Motor – SSH Air End
- F. Less Main Motor – SSM Air End

ELECTRA–SAVER II® COMPRESSORS – MODELS EBP_MD
100 HP Air / Water–Cooled Base–Mounted Units – 60 Hz Only – Matrix/Menu

NOTICE TO CUSTOMER – To find the construction options for your compressor unit, FILL IN THE BALANCE OF LETTERS OR NUMBERS FROM YOUR UNIT NAMEPLATE.

Follow the line down and over from each space thus filled in to find the appropriate construction option with which your machine is equipped. The number "9" in any column space indicates "NOT APPLICABLE." The number "8" in any column space indicates SPECIAL DESIGN – REFER TO FACTORY ORDER TICKET.

	E	B	P			D							
COLUMN NUMBER:	1	2	3	4	5	6	7	8	9	10	11	12	13

COLUMNS 1, 2 & 3 – ELECTRA–SAVER II® FAMILY – Single Stage

COLUMN 4 – TYPE OF CONSTRUCTION
- Q. Air–Cooled Base Mounted (Std.)
- S. Water–Cooled Base Mounted (Std.)

COLUMN 5 – HORSEPOWER
- M. 100 HP

COLUMN 6 – ENGINEERING SPECIFICATION

COLUMN 7 – PRESSURE & HZ
- A. 100 PSIG – 60 HZ
- B. 125 PSIG – 60 HZ
- C. 150 PSIG – 60 HZ

COLUMN 8 – CONTROL BOX & MAIN MOTOR STARTING
- A. 200 V – 60 HZ – Full Voltage(Less Starter)
- B. 230 V – 60 HZ – Full Voltage(Less Starter)
- C. 460 V – 60 HZ – Full Voltage
- D. 575 V – 60 HZ – Full Voltage
- E. 200 V – 60 HZ – Wye Delta
- F. 230 V – 60 HZ – Wye Delta
- G. 460 V – 60 HZ – Wye Delta
- H. 575 V – 60 HZ – Wye Delta

COLUMN 9 – CONTROL BOX / STARTER
- A. ES Control – Nema 12 – With Starter
- B. ES Control – Nema 4 – With Starter
- C. ES Control – Nema 12 – Without Starter
- D. ES Control – Nema 4 – Without Starter
- E. ES+ Control – Nema 12 – With Starter – Without Current Monitor
- F. ES+ Control – Nema 4 – With Starter – Without Current Monitor
- G. ES+ Control – Nema 12 – Without Starter – Without Current Monitor
- H. ES+ Control – Nema 4 – Without Starter – Without Current Monitor
- I. ES+ Control – Nema 12 – With Starter – With Current Monitor
- J. ES+ Control – Nema 4 – With Starter – With Current Monitor
- K. ES+ Control – Nema 12 – Without Starter – With Current Monitor
- L. ES+ Control – Nema 4 – Without Starter – With Current Monitor

COLUMN 10 – ENCLOSURE
- A. No Enclosure
- B. With Enclosure

COLUMN 11 – OIL COOLERS – AIR & WATER
- A. Standard Coolers with Aftercooler (Air or Water Cooled)
- B. Seacoast (Salt Water) Cooler With Aftercooler (Air or Water Cooled)
- C. Standard Coolers Less Aftercooler (Water Cooled Only)
- D. Salt Water Cooler Less Aftercooler (Water Cooled Only)

COLUMN 12 – COOLER ELECTRICS
- A. Air Cooled
- B. Water Cooled – Without Water Temperature Regulator – Without Shutoff Valve
- C. Water Cooled – With Water Temperature Regulator – With Shutoff Valve
- D. Water Cooled – With Water Temperature Regulator – Without Shutoff Valve
- E. Water Cooled – Without Water Temperature Regulator – With Shutoff Valve

COLUMN 13 – COMPRESSOR DRIVE MOTOR
- A. ODP
- B. TEFC
- C. ODP High Efficiency
- D. TEFC High Efficiency
- E. Less Main Motor – 404 TSC Frame – ODP
- F. Less Main Motor – 405 TSC Frame – TEFC

ELECTRA–SAVER® COMPRESSORS – MODELS EAP_ME
100 HP Air /Water–Cooled Base–Mounted Units – 60 Hz Only – Matrix/Menu

NOTICE TO CUSTOMER – To find the construction options for your compressor unit, FILL IN THE BALANCE OF LETTERS OR NUMBERS FROM YOUR UNIT NAMEPLATE.

Follow the line down and over from each space thus filled in to find the appropriate construction option with which your machine is equipped. The number "9" in any column space indicates "NOT APPLICABLE." The number "8" in any column space indicates SPECIAL DESIGN – REFER TO FACTORY ORDER TICKET.

	E	A	P			E							
COLUMN NUMBER:	1	2	3	4	5	6	7	8	9	10	11	12	13

COLUMNS 1, 2 & 3 – ELECTRA–SAVER® FAMILY – Single Stage

COLUMN 4 – TYPE OF CONSTRUCTION
- Q. Air–Cooled Base Mounted (Std.)
- S. Water–Cooled Base Mounted (Std.)

COLUMN 5 – HORSEPOWER
- M. 100 HP

COLUMN 6 – ENGINEERING SPECIFICATION

COLUMN 7 – PRESSURE & HZ
- A. 100 PSIG – 60 HZ
- B. 125 PSIG – 60 HZ
- C. 150 PSIG – 60 HZ

COLUMN 8 – VOLTAGE
- A. 200 V – 60 HZ – Wye Delta
- B. 230 V – 60 HZ – Wye Delta
- C. 460 V – 60 HZ – Wye Delta
- D. 575 V – 60 HZ – Wye Delta

COLUMN 9 – CONTROL BOX / STARTER
- A. ES Control – Nema 12 – With Starter
- B. ES Control – Nema 4 – With Starter
- C. ES Control – Nema 12 – Without Starter
- D. ES Control – Nema 4 – Without Starter
- E. ES+ Control – Nema 12 – With Starter – With Current Monitor
- F. ES+ Control – Nema 4 – With Starter – With Current Monitor
- G. ES+ Control – Nema 12 – Without Starter – With Current Monitor
- H. ES+ Control – Nema 4 – Without Starter – With Current Monitor

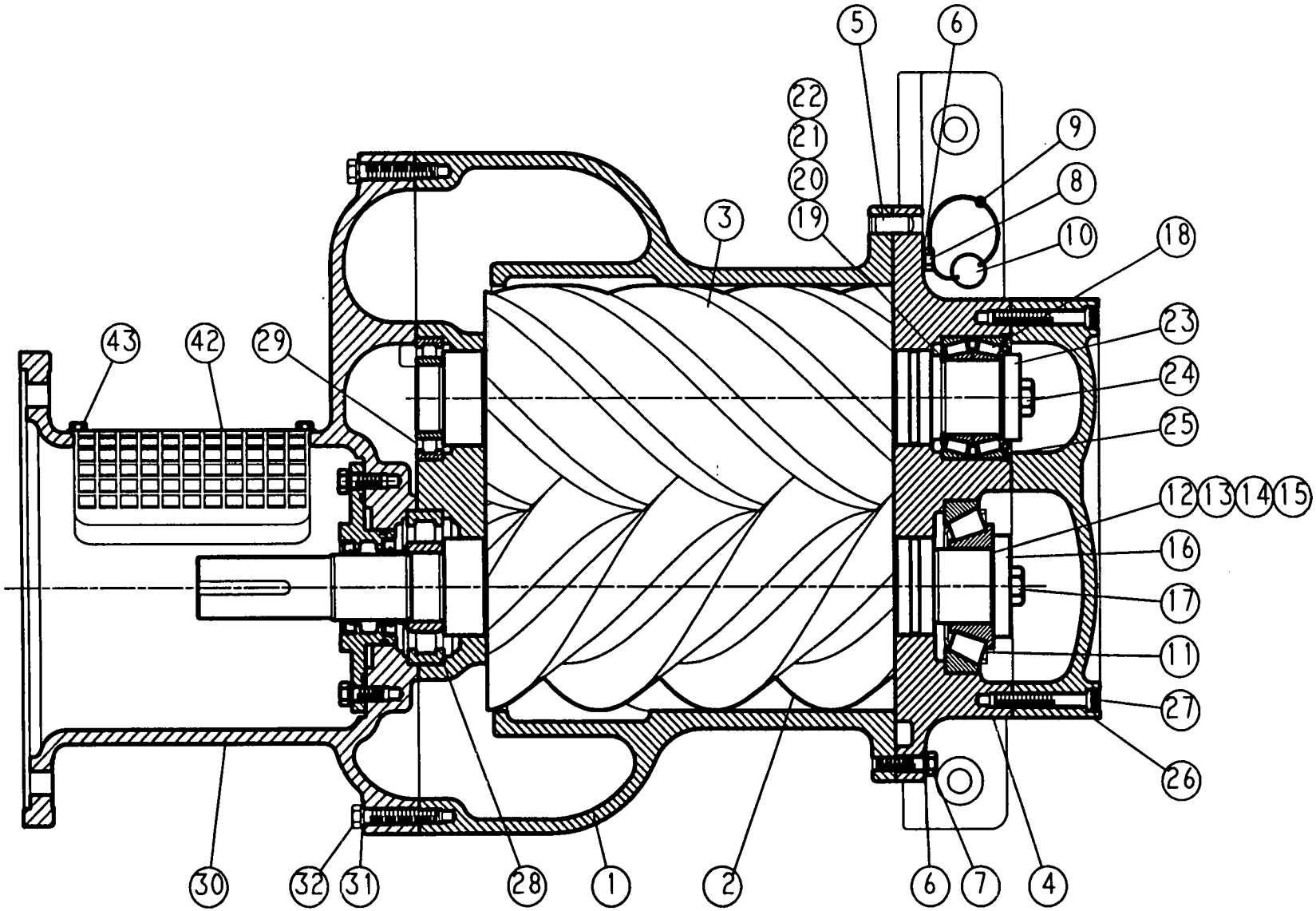
COLUMN 10 – ENCLOSURE
- A. No Enclosure
- B. With Enclosure

COLUMN 11 – OIL COOLERS – AIR & WATER
- A. Standard Coolers with Aftercooler (Air or Water Cooled)
- B. Seacoast (Salt Water) Cooler With Aftercooler (Air or Water Cooled)
- C. Standard Coolers Less Aftercooler (Water Cooled Only)
- D. Salt Water Cooler Less Aftercooler (Water Cooled Only)

COLUMN 12 – COOLER ELECTRICS
- A. Air Cooled
- B. Water Cooled – Without Water Temperature Regulator – Without Shutoff Valve
- C. Water Cooled – With Water Temperature Regulator – With Shutoff Valve
- D. Water Cooled – With Water Temperature Regulator – Without Shutoff Valve
- E. Water Cooled – Without Water Temperature Regulator – With Shutoff Valve

COLUMN 13 – COMPRESSOR DRIVE MOTOR
- A. ODP
- B. TEFC
- C. ODP High Efficiency
- D. TEFC High Efficiency
- E. Less Main Motor – 404 TSC Frame – ODP
- F. Less Main Motor – 405 TSC Frame – TEFC

BARE COMPRESSOR – 60 HP – 125 & 150 PSI – SSH, EBM PACKAGE



207SSH810–C
(Ref. Drawing)

BARE COMPRESSOR – 60 HP – 125 & 150 PSI – SSH, EBM PACKAGE

Ref. No.	Name of Part	Qty.	Part No.
1	CYLINDER	1	**
2	ROTOR	1	**
3	ROTOR	1	**
4	HOUSING–BEARING	1	**
5	PIN–DOWEL	2	**
6	LOCKWASHER	14	**
7	SCREW	10	**
8	SCREW	2	**
9	SEAL	1	**
10	TAG–INSTRUCTION	1	**
* 11	BEARING–ROLLER	1	12BA91
* 12	SHIM	2	77H54015
* 13	SHIM	3	77H54005
* 14	SHIM	3	77H54003
* 15	SHIM	3	77H54002
16	PLATE–BEARING RETAINER	1	**
17	SCREW	1	**
* 18	BEARING–ROLLER	1	12BA90
* 19	SHIM	2	77H53015
* 20	SHIM	3	77H53005
* 21	SHIM	3	77H53003
* 22	SHIM	3	77H53002
23	PLATE BEARING RETAINER	1	**
24	SCREW	1	**
* 25	SPRING	1	78W48
26	PLATE–BEARING COVER	1	**
27	SCREW	18	**
* 28	BEARING–ROLLER	1	12BA130
* 29	BEARING–ROLLER	1	12BA136
30	ADAPTOR	1	**
31	LOCKWASHER	16	**
32	SCREW	16	**
42	GUARD COUPLING	1	**
43	SCREW–FLANGED	4	**

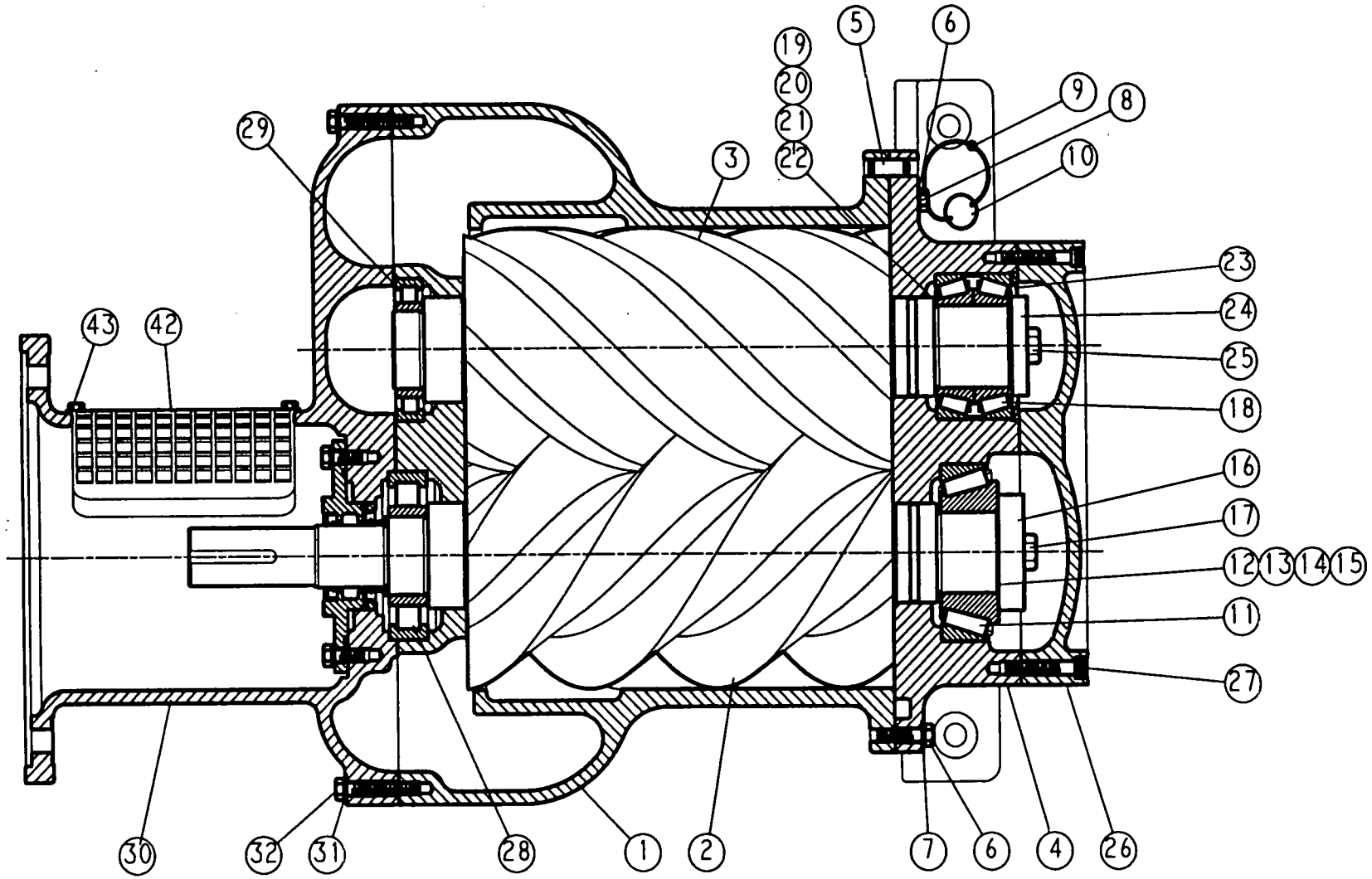
* Parts included in Periodic Overhaul Kit. Refer to page 54.

** Shown for reference only.

AIR END SELECTION BY PSI – 60 HP

125 PSI	150 PSI
SSHCBD01	SSHCBD02

BARE COMPRESSOR – 60 HP – 100 PSI, AND 75 HP – 100, 125 & 150 PSI – SSM, EBM PACKAGE



209SSM810–B
(Ref. Drawing)

BARE COMPRESSOR – 60 HP – 100 PSI, AND 75 HP – 100, 125 & 150 PSI – SSM, EBM PACKAGE

Ref. No.	Name of Part	Qty.	Part No.
1	CYLINDER	1	**
2	ROTOR	1	**
3	ROTOR	1	**
4	HOUSING–BEARING	1	**
5	PIN–DOWEL	2	**
6	SCREW	14	**
7	LOCKWASHER	16	**
8	SCREW	2	**
9	SEAL	1	**
10	TAG–INSTRUCTION	1	**
* 11	BEARING–ROLLER	1	12BA92
* 12	SHIM	2	77H56015
* 13	SHIM	3	77H56005
* 14	SHIM	3	77H56003
* 15	SHIM	3	77H56002
16	PLATE–BEARING RETAINER	1	**
17	SCREW	1	**
* 18	BEARING–ROLLER	1	12BA94
* 19	SHIM	2	77H57015
* 20	SHIM	3	77H57005
* 21	SHIM	3	77H57003
* 22	SHIM	3	77H57002
* 23	SPRING, WAVE (SSM)	1	78W53
24	PLATE BEARING RETAINER	1	**
25	SCREW	1	**
26	PLATE–BEARING COVER	1	**
27	SCREW	18	**
* 28	BEARING–ROLLER	1	12W34
* 29	BEARING–ROLLER	1	12BA93
30	ADAPTOR	1	**
31	LOCKWASHER	16	**
32	SCREW	16	**
42	GUARD COUPLING	1	**
43	SCREW–FLANGED	4	**

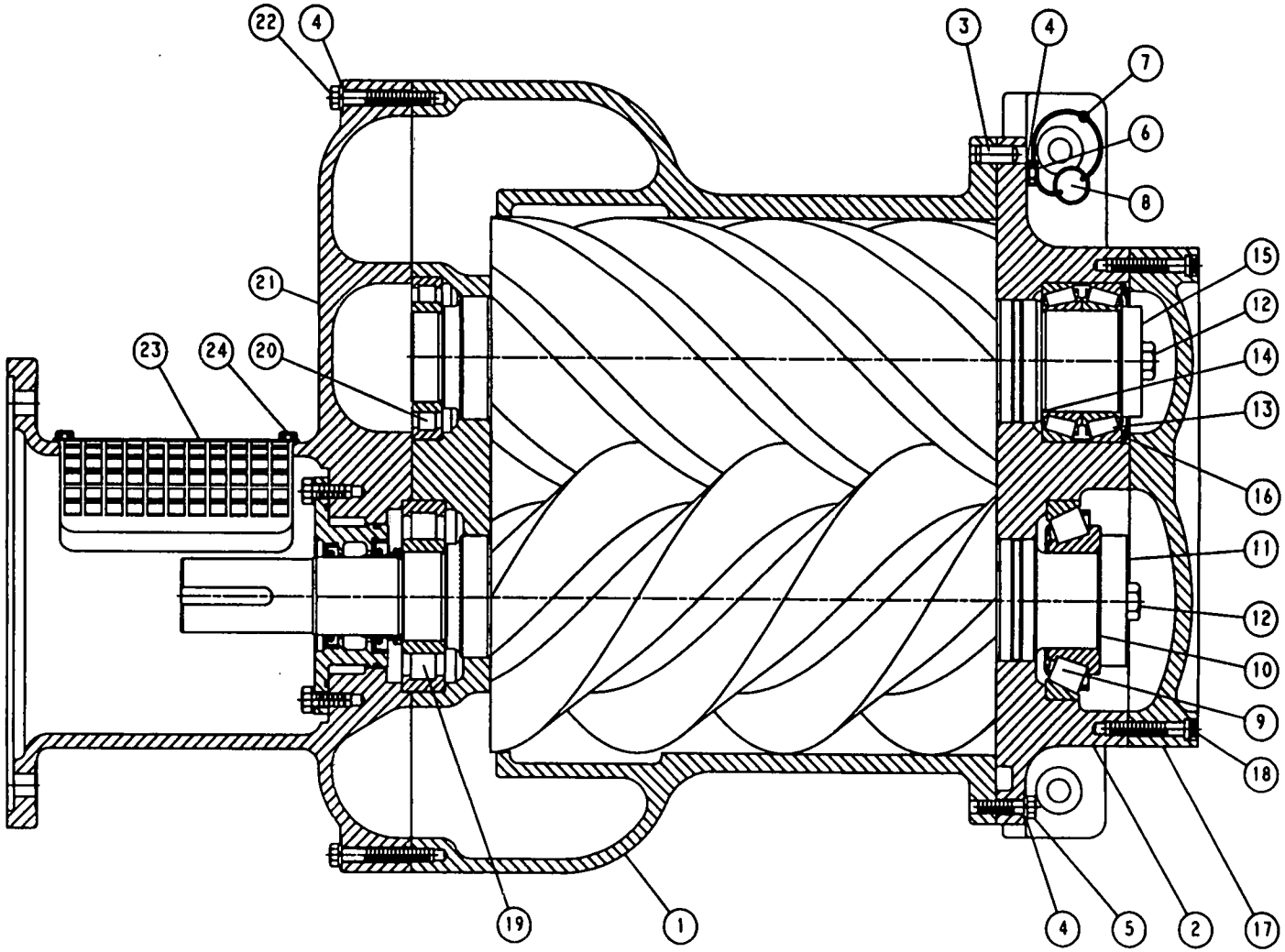
* Parts included in Periodic Overhaul Kit. Refer to page 54.

** Shown for reference only.

AIR END SELECTION BY PSI

60 HP 100 PSI	75 HP 100 PSI	75 HP 125 PSI	75 HP 150 PSI
SSMNBB03	SSMNBB01	SSMNBB02	SSMNBB03

BARE COMPRESSOR – 100 HP – 100, 125 & 150 PSI – EAP AND EBP PACKAGE



216SSP810–A
(Ref. Drawing)

BARE COMPRESSOR – 100 HP – 100, 125 & 150 PSI – EAP AND EBP PACKAGE

Ref. No.	Name of Part	Qty.	Part No.
1	CYLINDER	1	**
2	HOUSING–BEARING	1	**
3	PIN–DOWEL	2	**
4	LOCKWASHER	36	**
5	SCREW	14	**
6	SCREW	2	**
7	SEAL	1	**
8	TAG–INSTRUCTION	1	**
* 9	BEARING–ROLLER	1	12BA105
* 10	SHIM	1	77H63
11	PLATE–BEARING RETAINER	1	**
12	SCREW	2	**
* 13	BEARING–ROLLER	1	12BA106
* 14	SHIM	1	77H62
15	PLATE BEARING RETAINER	1	**
* 16	SPRING	1	78W52
17	PLATE–BEARING COVER	1	**
18	SCREW	18	**
* 19	BEARING–ROLLER	1	12BA104
* 20	BEARING–ROLLER	1	12BA103
21	ADAPTOR	1	**
22	SCREW	20	**
23	GUARD COUPLING	1	**
24	SCREW–FLANGED	4	**

* Parts included in Periodic Overhaul Kit. Refer to page 54.

** Shown for reference only.

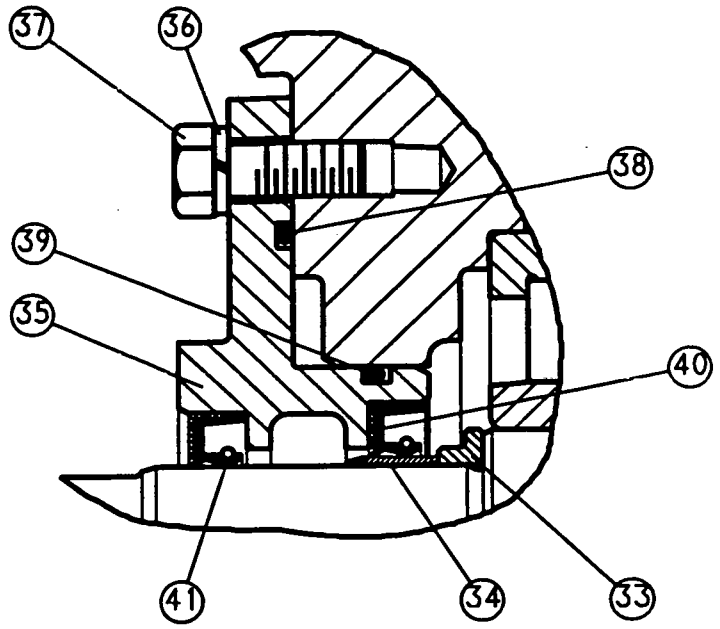
AIR END SELECTION – EAP

100 PSI	125 PSI	150 PSI
SSPABD01	SSPABD01	SSPABD01

AIR END SELECTION – EBP

100 PSI	125 PSI	150 PSI
SSPNBB01	SSPNBB02	SSPNBB03

Order by Part Number and Description. Reference Numbers are for your convenience only.



207SSH810–C
209SSM810–B
(Ref. Drawing)

OIL SEAL DETAIL – EBM

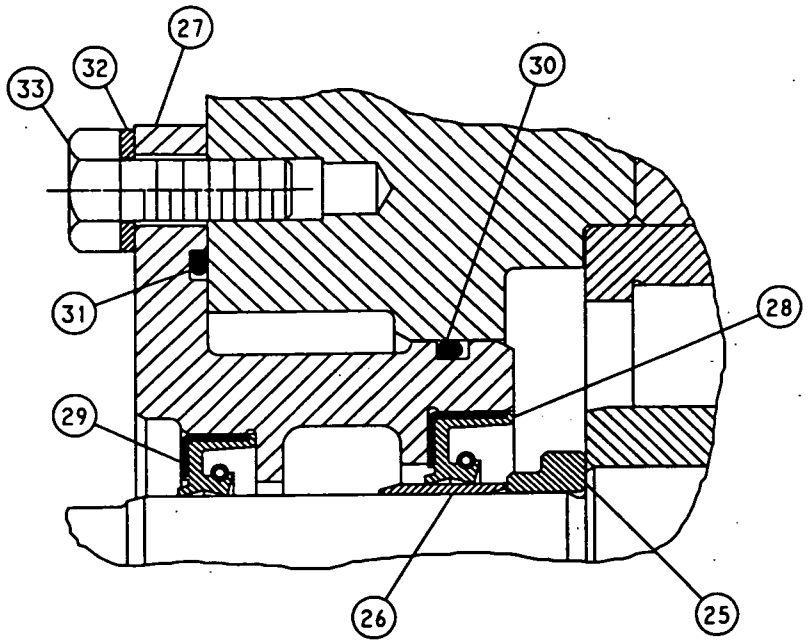
Ref. No.		Name of Part	Qty.	Part No.
33		SPACER–SHAFT	1	200SSH600
34	*	SLEEVE	1	80M12
35		HOUSING–SEAL	1	202SSH362
36		LOCKWASHER	8	95B5
37		SCREW	8	655EE050
38	*	O–RING	1	8502140
39	*	O–RING	1	25BC165
40	*	SEAL–OIL	1	60DD679
41	*	SEAL–OIL	1	60DD690
*		CHECK VALVE (Not shown)	1	90AR923

* Included in Oil Seal Kit, see page 54.

To replace Oil Seal, order kit # 302SSH6013 consisting of reference items 34, 38, 39, 40, 41 and Check Valve.

Wear Sleeve installation and removal kit part # 200SSH4017 (includes Wear Sleeve Puller and installation tool). See Wear Sleeve Installation / Removal Kit, page 54.

Order by Part Number and Description. Reference Numbers are for your convenience only.



216SSP810–A
(Ref. Drawing)

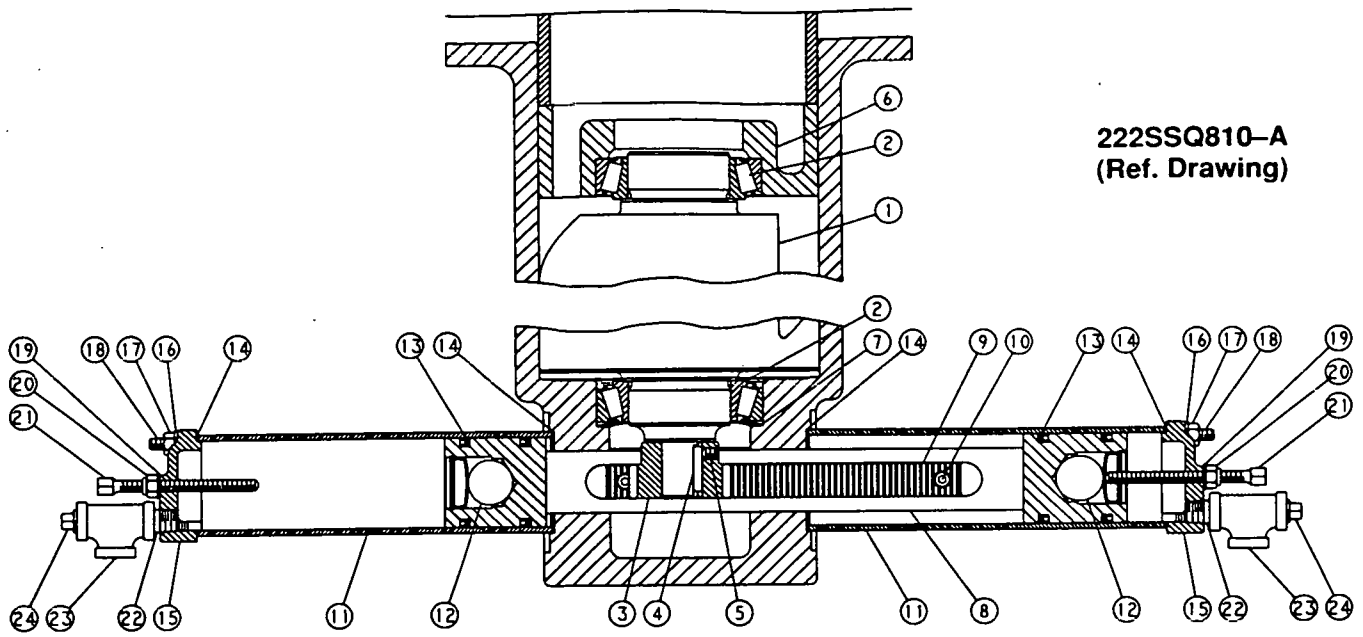
OIL SEAL DETAIL – EAP & EBP

Ref. No.	Name of Part	Qty.	Part No.
25	SPACER–SHAFT	1	200SSP600
26 *	SLEEVE–WEAR	1	200SSP1458
27	HOUSING–SEAL	1	204SSP362
28 *	SEAL–OIL	1	60DD693
29 *	SEAL–OIL	1	60DD692
30 *	O–RING	1	25BC380
31 *	O–RING	1	8502140
32	LOCKWASHER	8	95B5
33	SCREW	8	655EE050
*	CHECK VALVE (Not shown)	1	90AR923

* Included in Oil Seal Kit, see page 55.

To replace oil seal, order kit # 300SSP6013 consisting of reference items 26, 28, 29, 30, 31 and Check Valve.

Wear Sleeve installation and removal kit part # 200SSP4017 (includes Wear Sleeve Puller and installation tool). See Wear Sleeve Installation / Removal Kit, page 55.

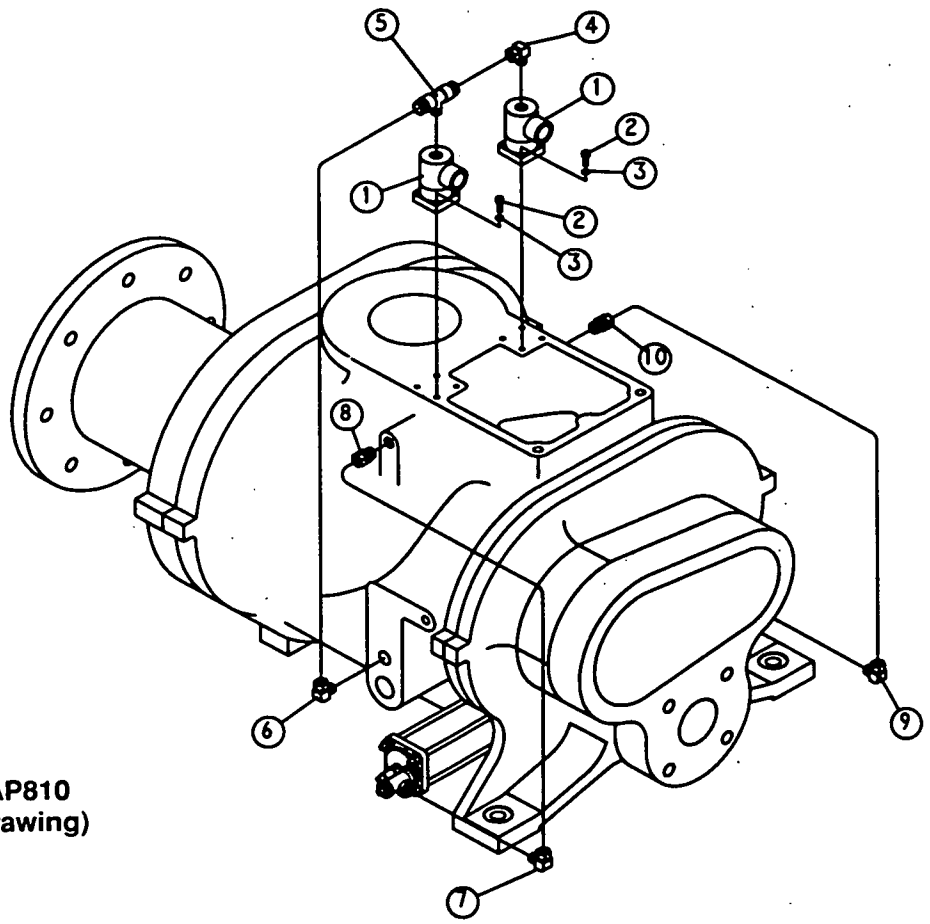


222SSQ810–A
(Ref. Drawing)

TURN VALVE & PARTS
(EAP UNITS ONLY)

Ref. No.	Name of Part	Qty.	Part No.
1	VALVE	1	202SSQ238
2	BEARING–ROLLER	2	12BA51
3	GEAR–AUXILIARY	1	200SSU031
4	KEY–SQUARE	1	35C114
5	SETSCREW	1	76G21N
6	HOUSING–BEARING	1	215SSQ006
7	SPRING	1	78W50
8	SHAFT–CONTROL	1	200SSU081
9	RACK	1	200SSU360
10	SCREW	2	75P11N
11	CYLINDER–CONTROL	2	200SSU082
12	ASM CONTROL PISTON	2	SSU80565
13	PACKING–RING	4	60AM46
14	GASKET	4	25BC138N
15	HEAD–CONTROL CYLINDER	2	200RPA083
16	LOCKWASHER	8	95B1
17	NUT	8	50B1
18	STUD	8	79AL5
19	SEAL–FASTENER	2	60DD65
20	NUT	2	50AW24
21	SET SCREW	2	76D226
22	NIPPLE	2	63D1G
23	TEE–PIPE	2	64G3G
24	PLUG	2	64AA5

Order by Part Number and Description. Reference Numbers are for your convenience only.



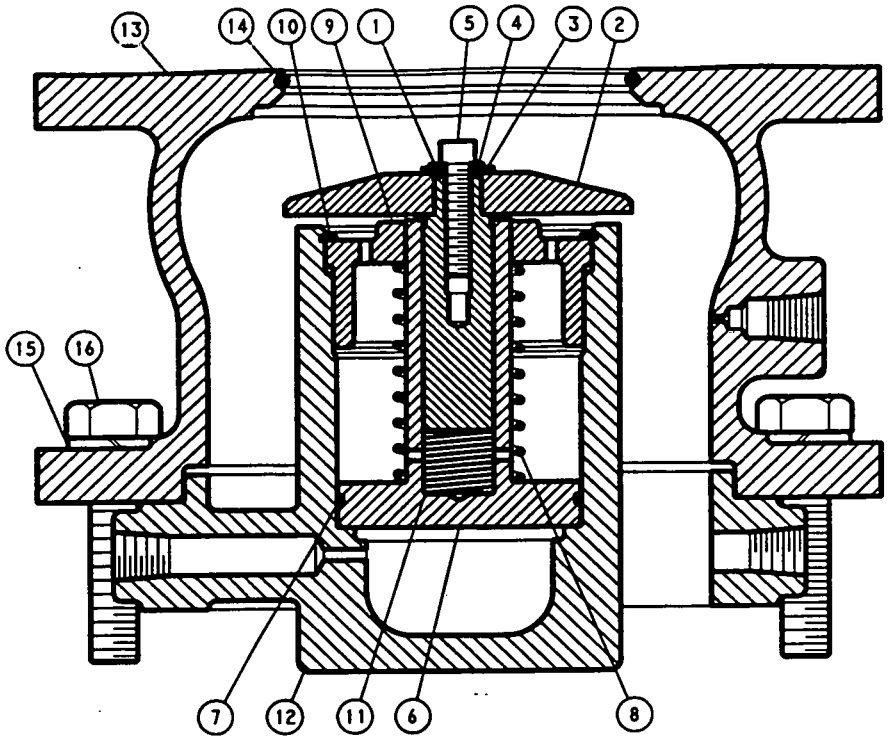
203EAP810
(Ref. Drawing)

TURN VALVE SOLENOID VALVE (EAP UNITS ONLY)

Ref. No.	Name of Part	Qty.	Part No.
1	VALVE, SOLENOID	2	91B82
2	SCREW	8	75V3
3	LOCKWASHER	8	95B13
4	ELBOW–TUBE	1	86E60
5	TEE–TUBE	1	86E119
6	ELBOW–TUBE	1	86E60
7	ELBOW–TUBE	1	86E60
8	CONNECTOR–TUBE	1	86E4
9	ELBOW–TUBE	1	86E60
10	CONNECTOR–TUBE	1	86E4
*	TUBE	10 Ft.	85K3
*	O–RING, SOLENOID VALVE TO CYLINDER (Small)	1	25W7
*	O–RING, SOLENOID VALVE TO CYLINDER (Large)	1	126156

* Not shown on drawing.

Order by Part Number and Description. Reference Numbers are for your convenience only.



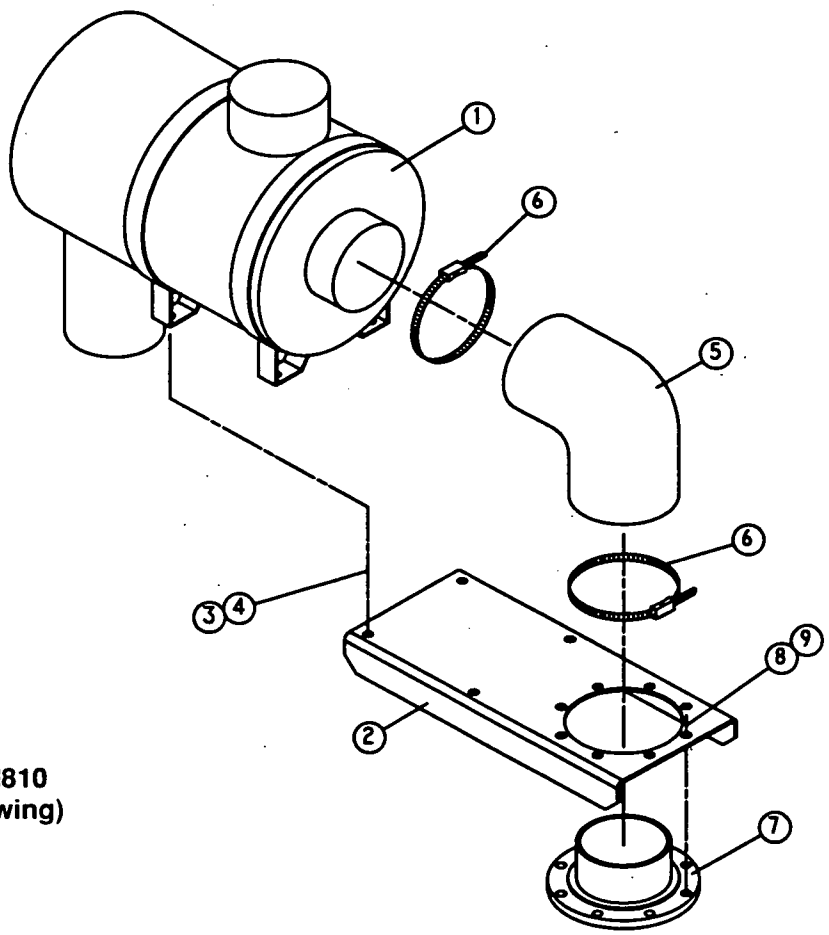
208SSM810–C
(Ref. Drawing)

INLET VALVE

	Ref. No.	Name of Part	Qty.	Part No.
	1	GUIDE–VALVE	1	200SSM483
	2	VALVE–INLET	1	200SSM044
	3	WASHER	1	95A1
	4	LOCKWASHER	1	95H56
	5	SCREW	1	655EC05N
	6	PISTON–INLET VALVE	1	201SSM043
*	7	O–RING	1	25BC447
*	8	SPRING	1	78G19
	9	RETAINER	1	200SSM205
*	10	RING–RETAINING	1	74D88
*	11	SPRING	1	78W63
	12	HOUSING–INLET	1	205SSM041
	13	SEAT	1	203SSM256
*	14	O–RING	1	25AM29
	15	LOCKWASHER	8	95B5
	16	SCREW	8	655ED100

* Parts included in Periodic Maintenance Kit, Part # 302SSM6013. Refer to page 53.

Order by Part Number and Description. Reference Numbers are for your convenience only.



289ECM810
(Ref. Drawing)

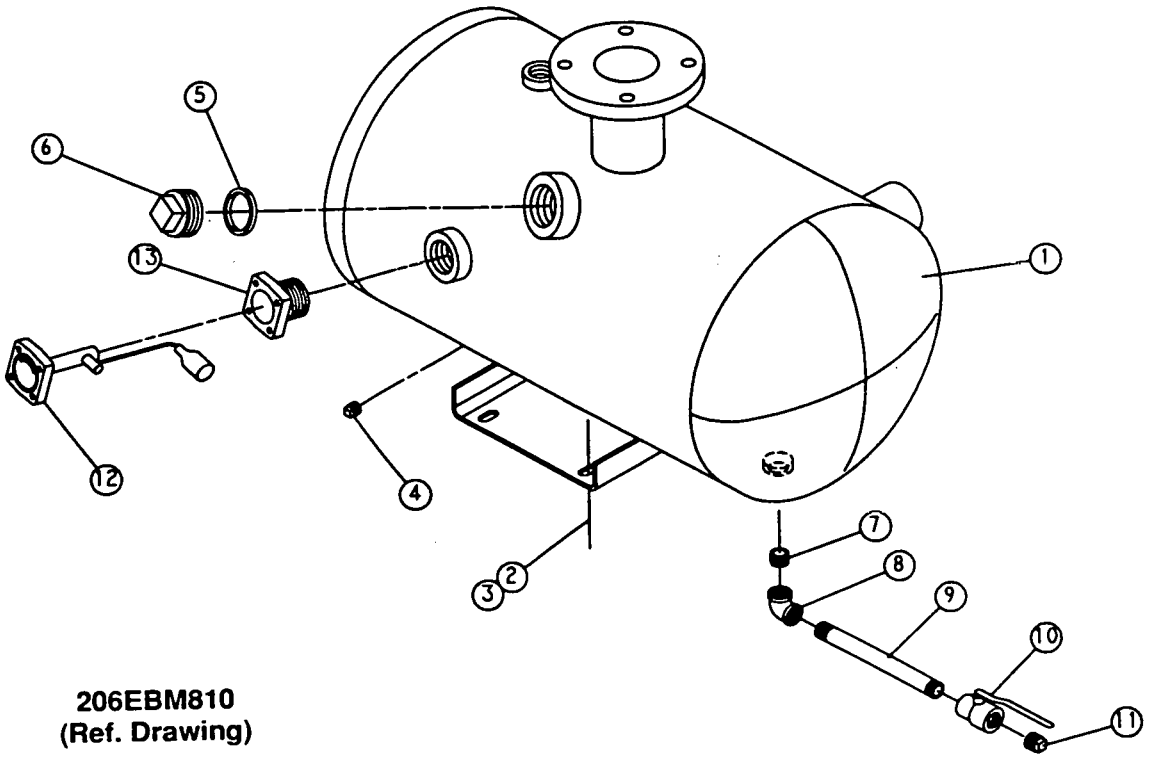
AIR FILTER

Ref. No.	Name of Part	Qty.	Part No.
1	FILTER–AIR	1	5L263
2	BRACKET–FILTER	1	202ECM389
3	SCREW–FLANGED	4	75LM51
4	NUT–FLANGED	4	50AW5
5	HOSE MOLDED	1	2009503
6	CLAMP–HOSE	2	2009644
7	ADAPTOR–FILTER	1	200EBM070
8	SCREW	8	655EE060
9	LOCKWASHER	8	95B5
*	GASKET–ELIMINATOR	1	25BC256
**	ELEMENT, AIR FILTER	1	2116713

* Not shown.

** Repair element for air filter.

Order by Part Number and Description. Reference Numbers are for your convenience only.

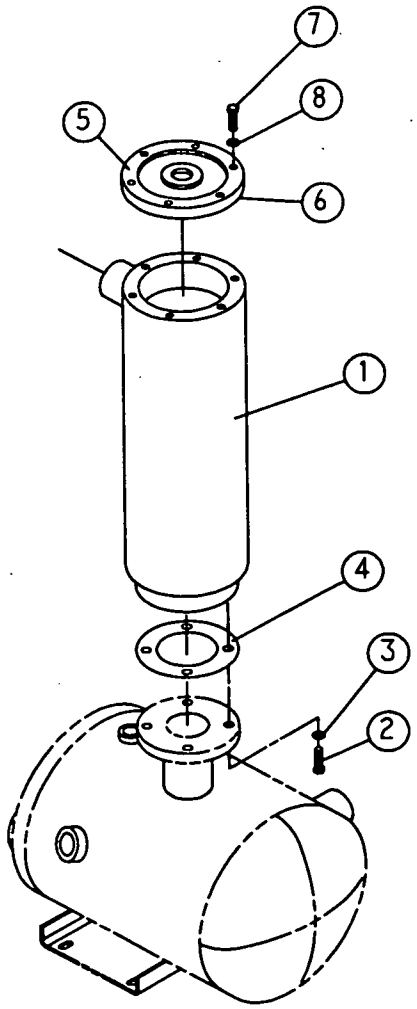


206EBM810
(Ref. Drawing)

OIL RESERVOIR GROUP

Ref. No.	Name of Part	Qty.	Part No.
1	RESERVOIR–OIL	1	200EBM037
2	SCREW–FLANGED	4	75LM135
3	NUT–FLANGED	4	50AW35
4	PLUG	1	64AA5
5	O–RING	1	54C214
6	COVER–FILLER	1	200SPF156
7	NIPPLE	1	63F1G
8	ELBOW	1	64C4G
9	NIPPLE	1	63F13G
10	VALVE–BALL	1	90AR360
11	PLUG	1	64AA7
12	GAUGE–FLOAT	1	300EBM303
13	ADAPTOR–GAUGE	1	200EDE058

Order by Part Number and Description. Reference Numbers are for your convenience only.

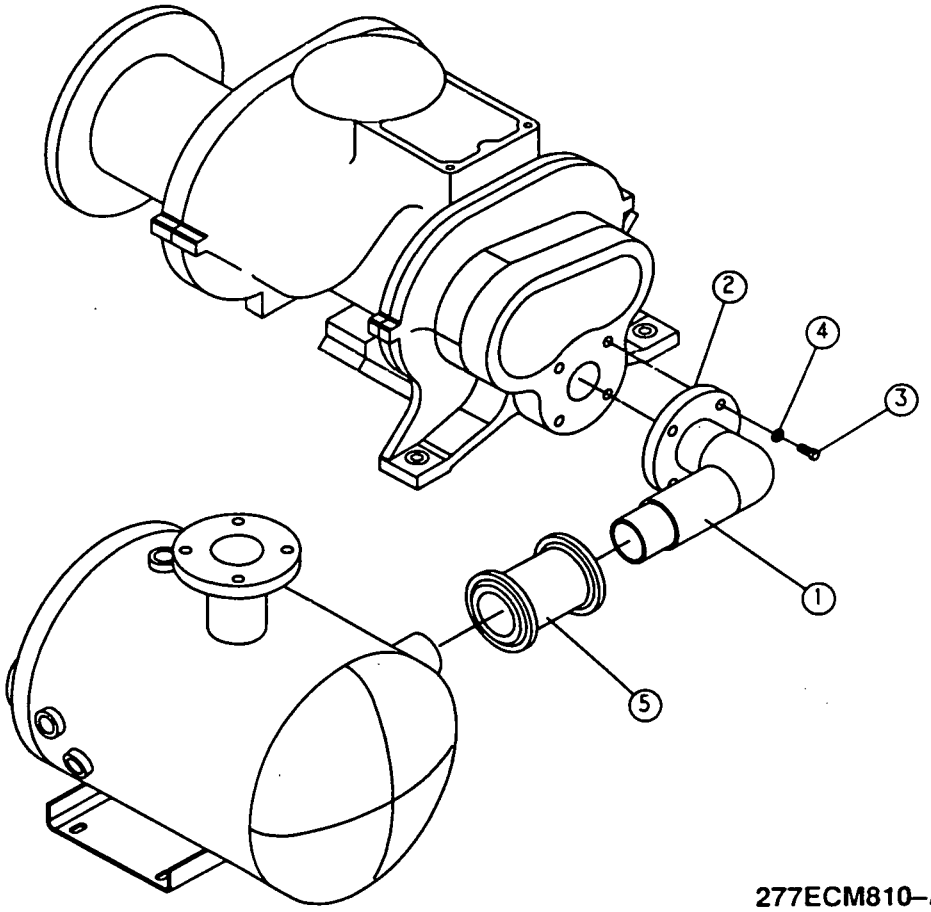


274ECM810–B
(Ref. Drawing)

SEPARATOR HOUSING GROUP

Ref. No.	Name of Part	Qty.	Part No.
1	HOUSING	1	200ECM405
2	SCREW	4	655EF070
3	LOCKWASHER	4	95B7
4	GASKET	1	25C802
5	COVER	1	203ECM225
6	GASKET ELIMINATOR	1	25BC222
7	SCREW	6	655EE070
8	LOCKWASHER	6	95B5

Order by Part Number and Description. Reference Numbers are for your convenience only.



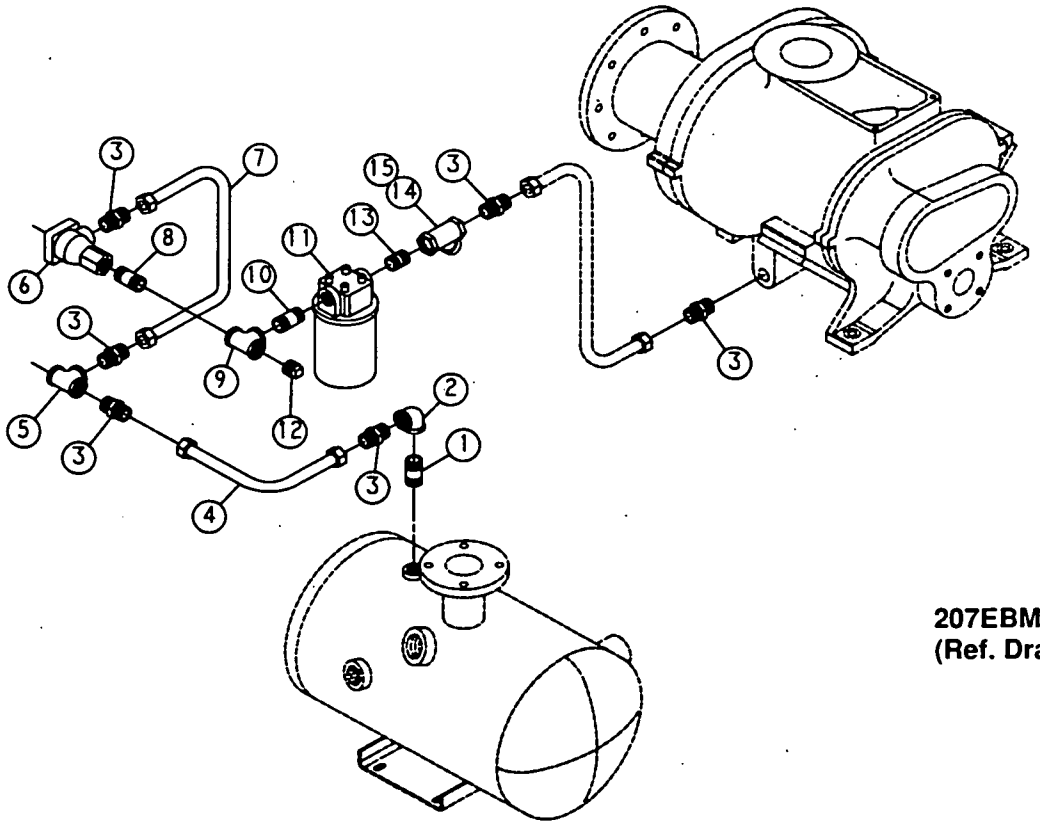
277ECM810–A
(Ref. Drawing)

DISCHARGE PIPING

Ref. No.	Name of Part	Qty.	Part No.
1	MANIFOLD	1	201ECM286
2	GASKET ELIMINATOR	1	25BC222
3	SCREW	4	655EF070
4	LOCKWASHER	4	95B7
5	COUPLING–FLEXIBLE	1	64EB802
*	GASKET, FLEXIBLE COUPLING (For Repair)	2	2117160

* Not shown.

Order by Part Number and Description. Reference Numbers are for your convenience only.



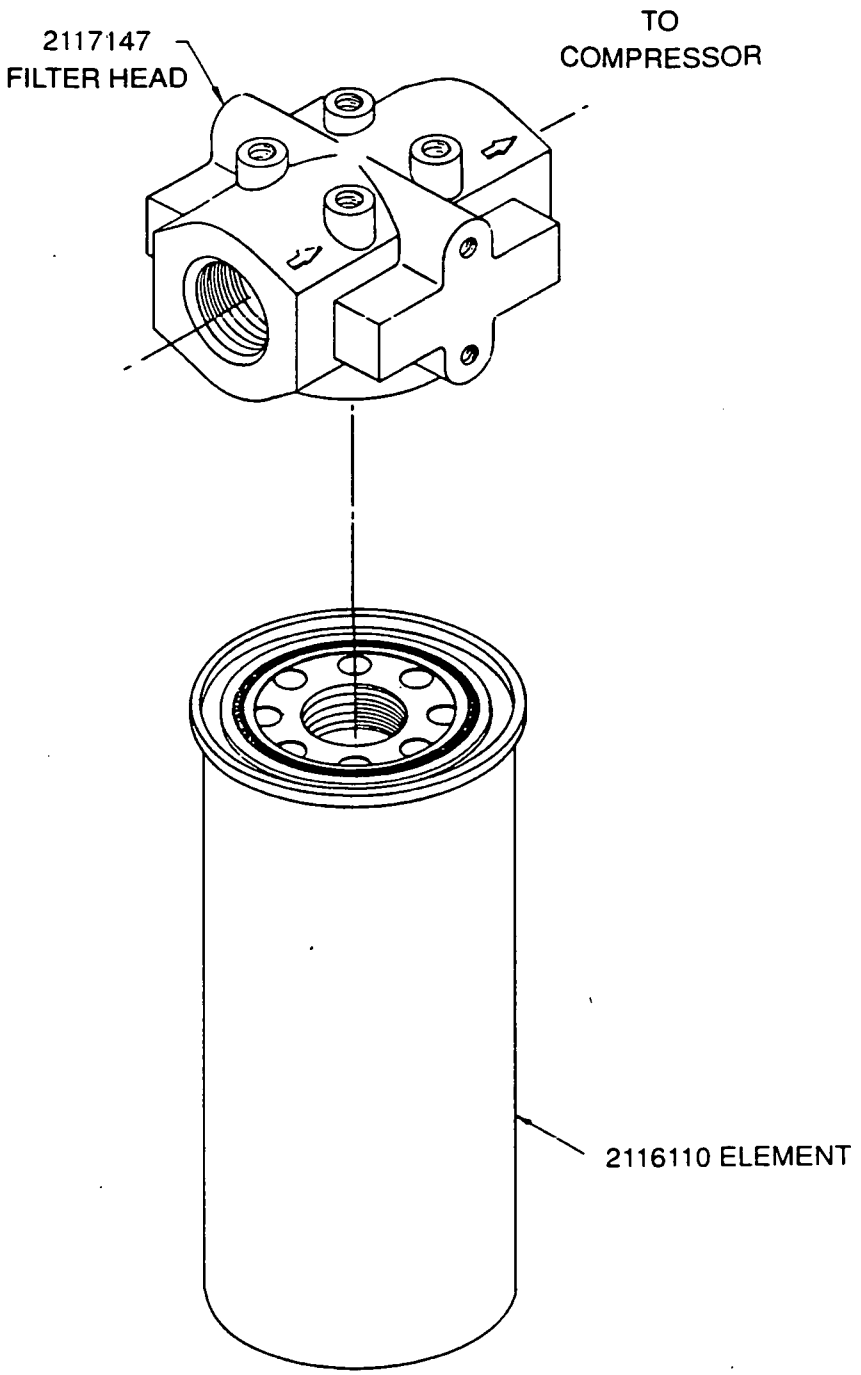
207EBM810–A
(Ref. Drawing)

OIL PIPING GROUP

Ref. No.		Name of Part	Qty.	Part No.
1		NIPPLE	1	63H2G
2		ELBOW	1	64C6G
3		CONNECTOR–TUBE	6	86H138
4		TUBE–WITH FITTINGS	1	202EBM863
5		TEE–PIPE	1	64G8G
6		VALVE–THERMAL (See page 27)	1	90AR167
7		TUBE–WITH FITTINGS	1	201EBM863
8		NIPPLE	1	63H1G
9		TEE–PIPE	1	64G8G
10		NIPPLE	1	63H1G
11	*	FILTER–OIL	1	200EBM369
12		PLUG	1	64AA1
13		NIPPLE	1	63H1G
14		STRAINER	1	82E39
15		PLUG	1	64AA3

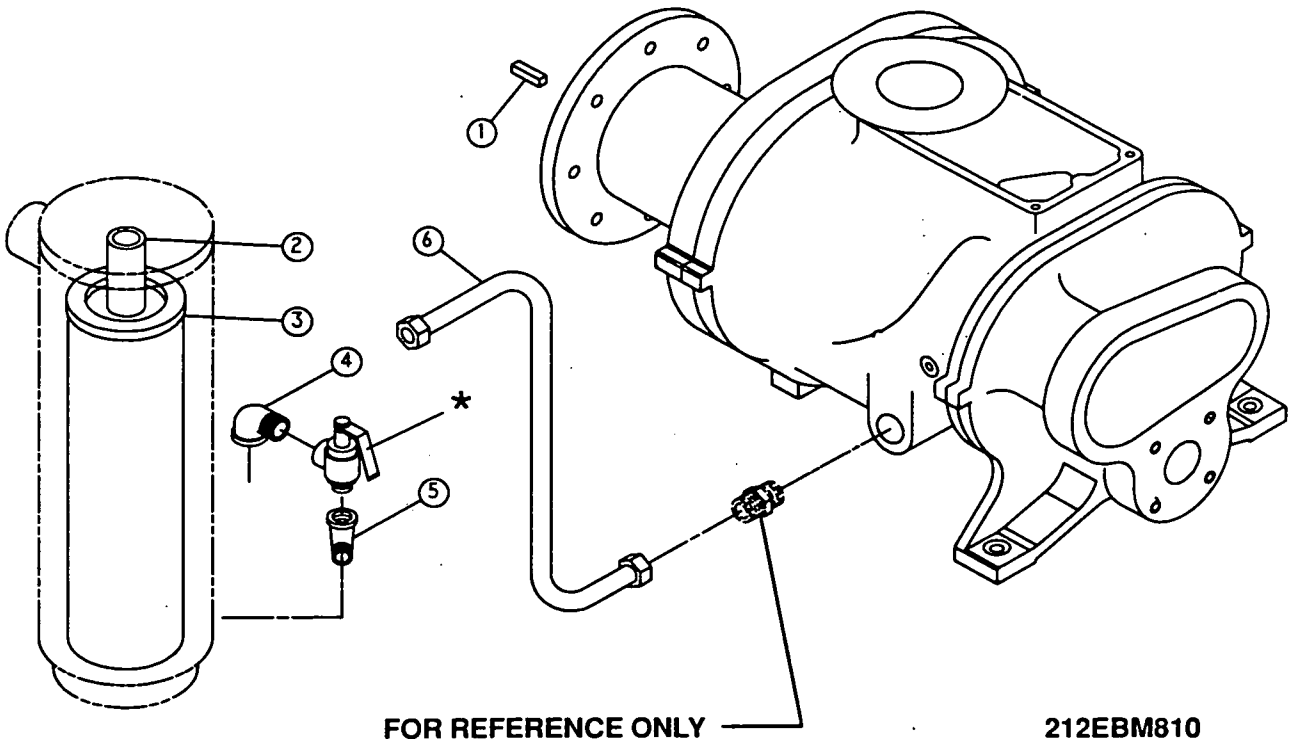
* FOR REPAIR:
FILTER ELEMENT – Order Part Number 2116110

OIL FILTER – 200EBM369



WITH 212ECM077 DECAL AFFIXED TO ELEMENT

Order by Part Number and Description. Reference Numbers are for your convenience only.



FOR REFERENCE ONLY
SEE PAGE 21

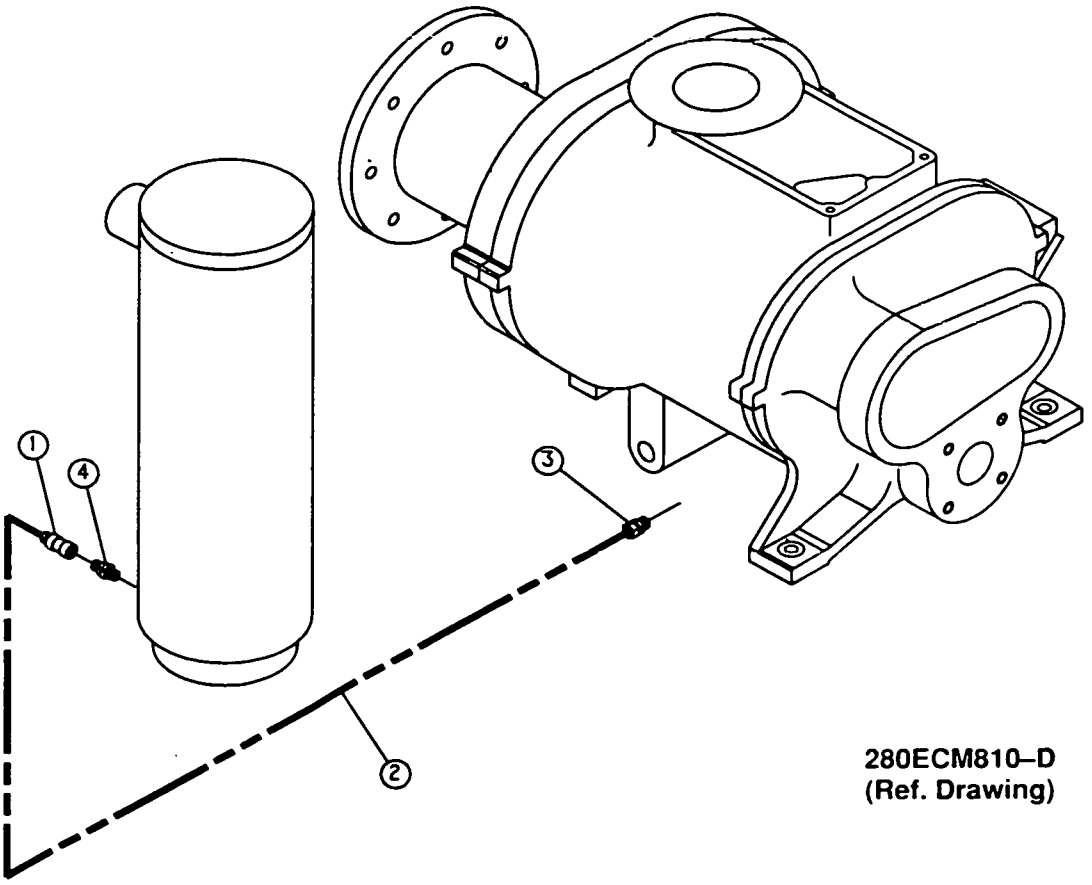
212EBM810
(Ref. Drawing)

OIL PIPING LINE

Ref. No.		Name of Part	Qty.	Part No.
1		KEY–SQUARE (SSH and SSM Air Ends)	1	8500109
		KEY–SQUARE (SSP Air Ends)	1	35L37
2		SPACER (PIPE)	1	200ECM392
3	**	SEPARATOR (For Reference Only. See Kit Part Number below)	1	
4		ELBOW	1	64D10G
5		ELBOW	1	64D6G
6		TUBE WITH FITTINGS – EBM	1	200EBM863
6		TUBE WITH FITTINGS – EAP	1	200EAP863
6		TUBE WITH FITTINGS – EBP	1	200EBP863
		BUSHING–PIPE, EBP Units Only (Not Shown)	1	64E13
*		RELIEF VALVES		
		100 PSI UNITS		90AR381
		125 PSI UNITS		90AR382
		150 PSI UNITS		90AR146

** Refer to page 53, Separator Kit 208EAP6013, for parts listing.

Order by Part Number and Description. Reference Numbers are for your convenience only.

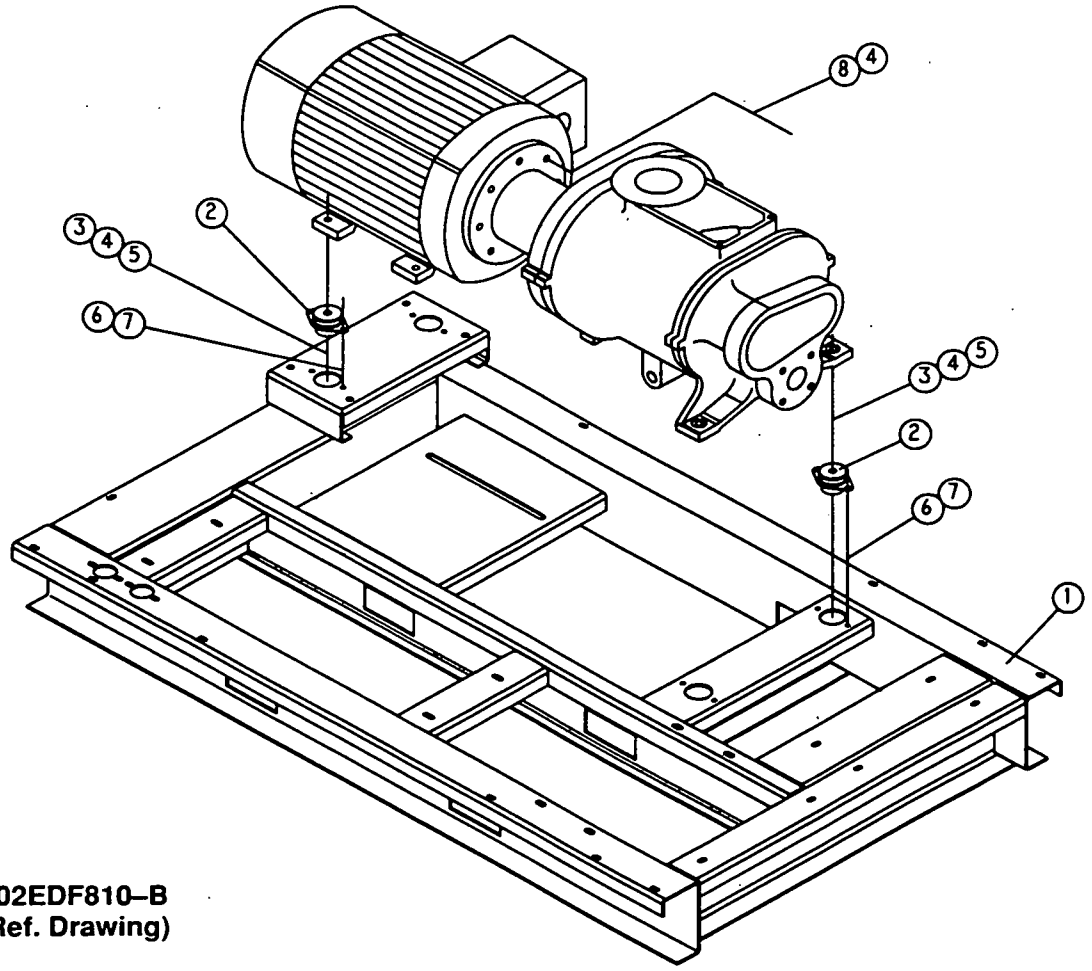


280ECM810–D
(Ref. Drawing)

OIL SCAVENGE LINE

Ref. No.	Name of Part	Qty.	Part No.
1	ELBOW–TUBE	1	86E28
2	TUBE	5 Ft.	85K3
3	CONNECTOR–TUBE	1	86E4
4	VALVE–CHECK	1	90AR261

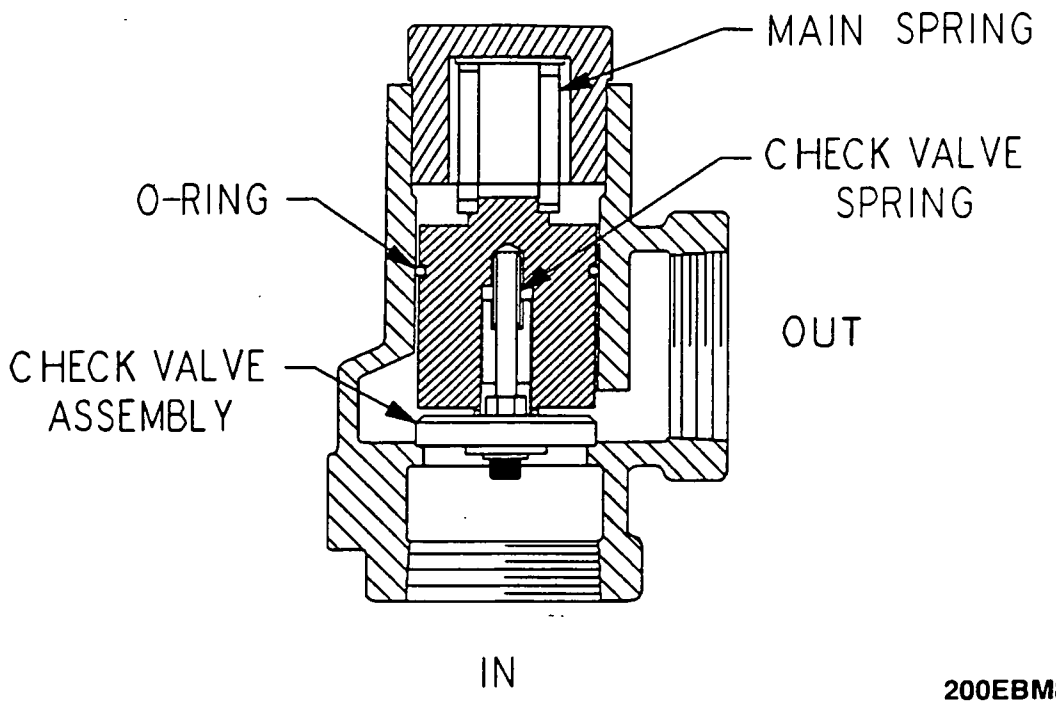
Order by Part Number and Description. Reference Numbers are for your convenience only.



202EDF810–B
(Ref. Drawing)

COMPRESSOR BASE GROUP

Ref. No.	Name of Part	Qty.	Part No.
1	BASE	1	201EDF285
2	VIBRATION–ISOLATOR	4	49C47
3	SCREW	4	655EF200
4	LOCKWASHER	12	95B7
5	NUT	4	50B7
6	SCREW–FLANGED	8	75LM51
7	NUT–FLANGED	8	50AW5
8	SCREW	8	655EF070

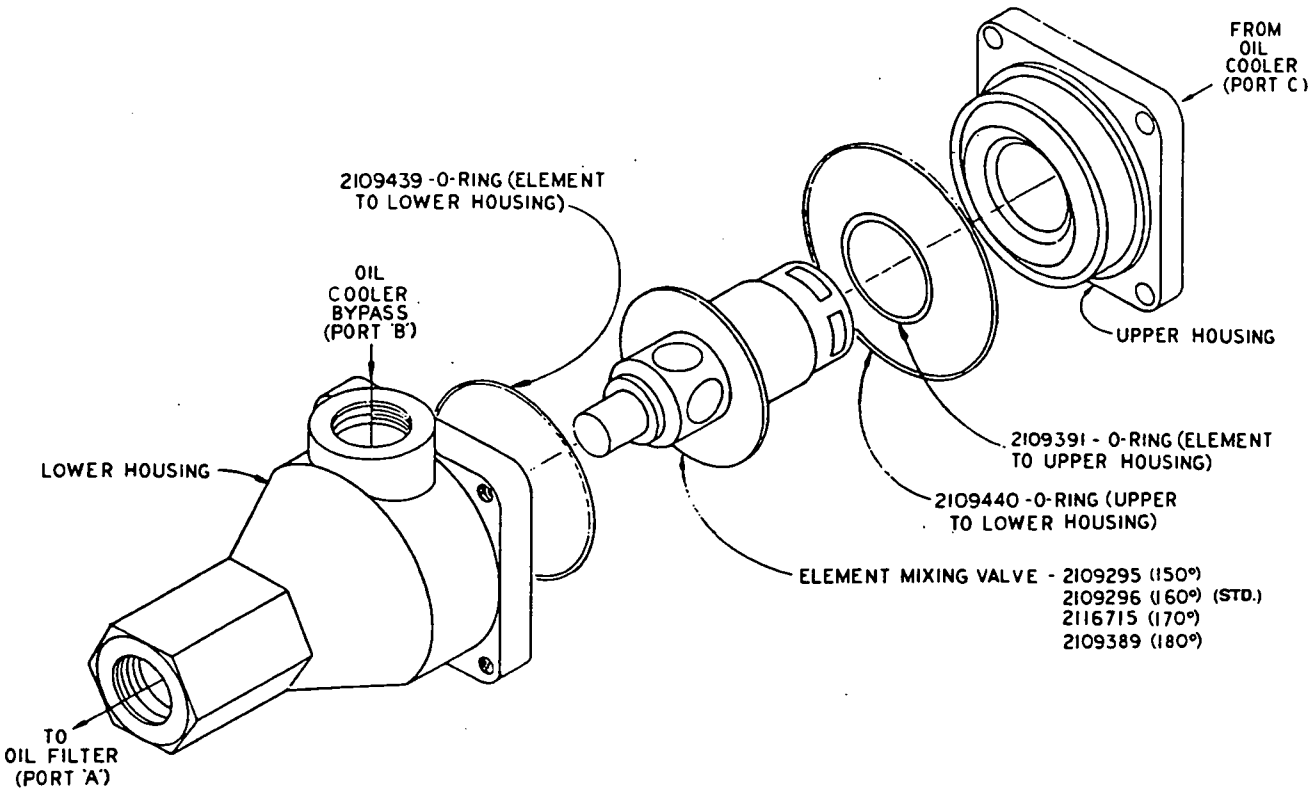


200EBM810
(Ref. Drawing)

MINIMUM PRESSURE VALVE

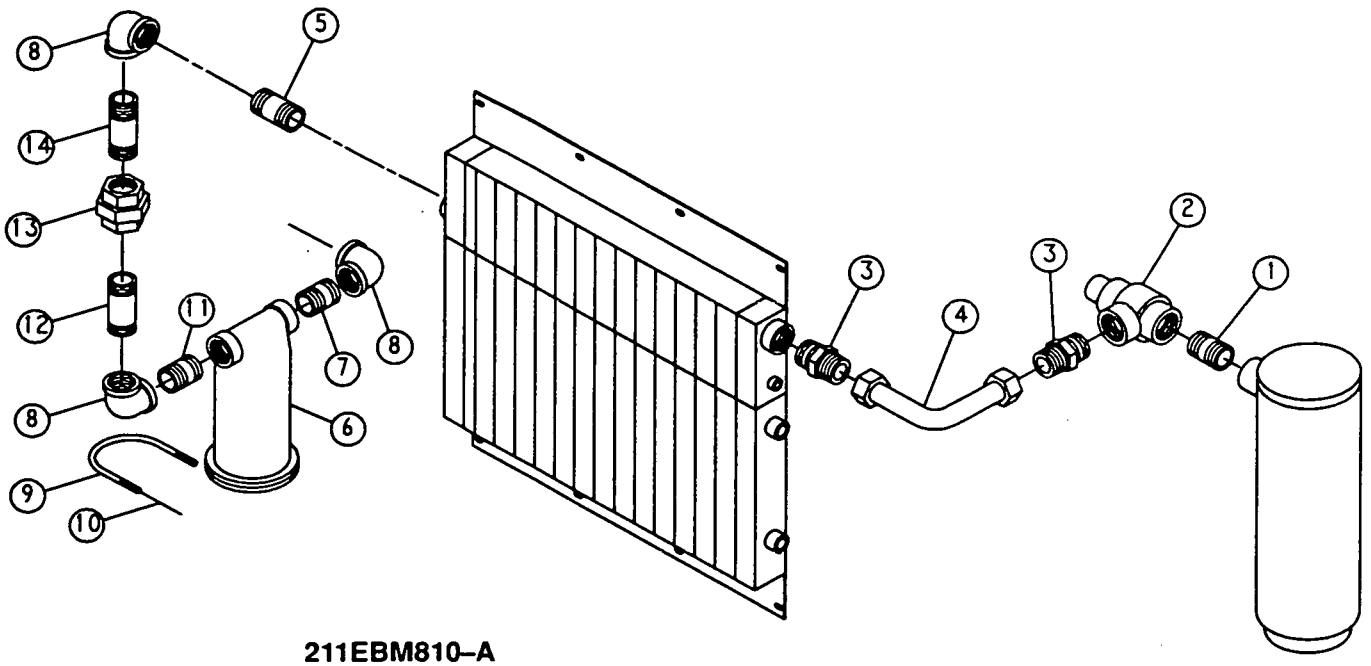
Ref. No.	Name of Part	Qty.	Part No.
	MINIMUM PRESSURE VALVE ASSEMBLY	1	200EBM527
	REPAIR KIT – Includes the following:	1	2116854
	O–RING	1	
	SPRING, CHECK VALVE	1	
	CHECK VALVE ASSEMBLY	1	
	SPRING, MAIN	1	

THERMAL VALVE
(THERMOSTATIC MIXING)



90AR167 THERMAL VALVE (ALUMINUM HOUSING)

Order by Part Number and Description. Reference Numbers are for your convenience only.



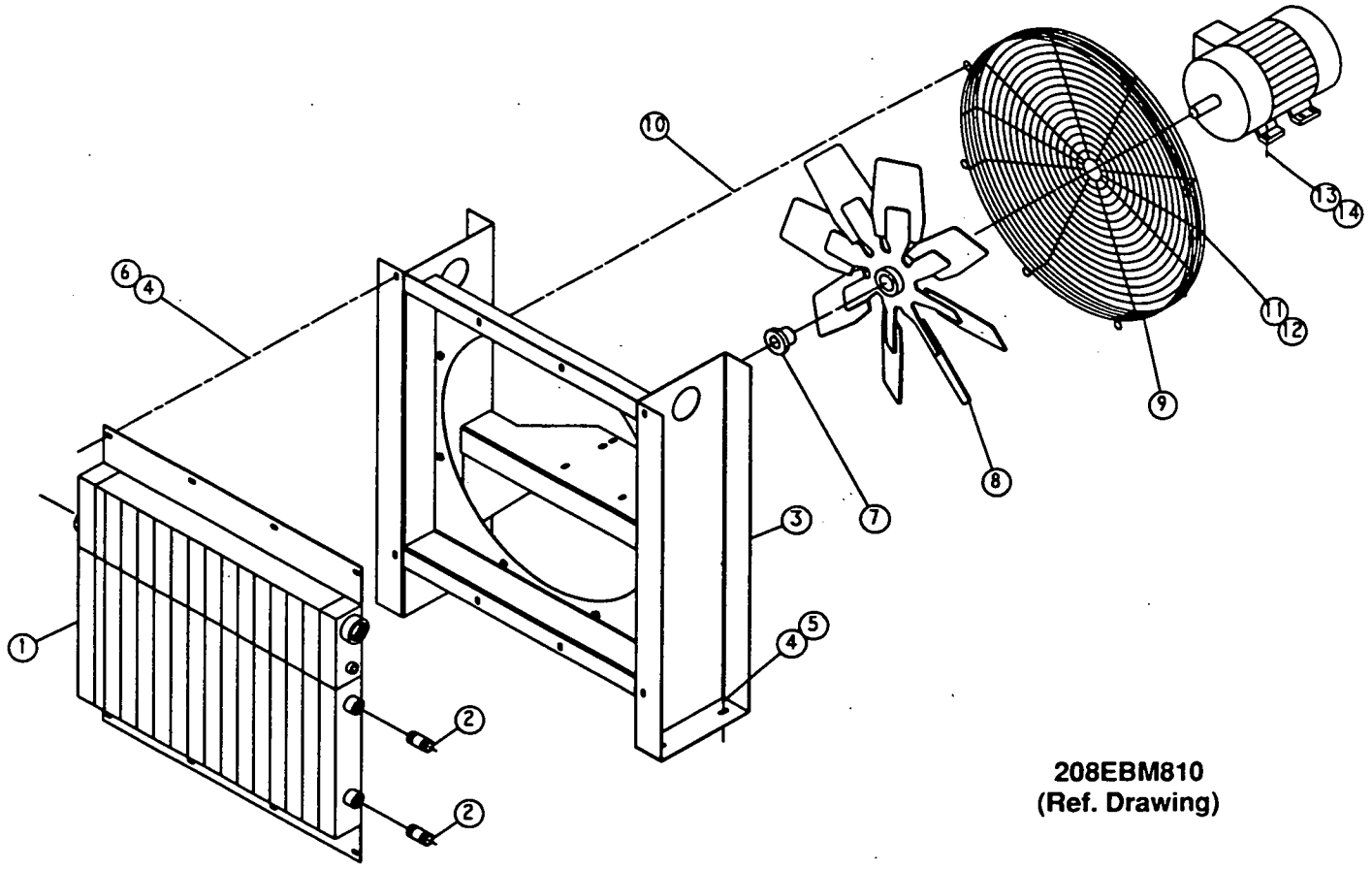
211EBM810–A
(Ref. Drawing)

AIR DISCHARGE PIPING

Ref. No.	Name of Part	Qty.	Part No.
1	NIPPLE	1	63L1G
2	VALVE–MINIMUM PRESSURE (See page 26)	1	200EBM527
3	CONNECTOR–TUBE	2	86H142
4	TUBE WITH FITTINGS	1	204EBM863
5	NIPPLE	1	63L15G
6 *	TRAP	1	83C84
7	NIPPLE	1	63L1G
8	ELBOW	3	64C9G
9	U–BOLT	1	15U64
10	NUT–FLANGED	2	50AW5
11	NIPPLE	1	63L9G
12	NIPPLE	1	63L20G
13	UNION–STRAIGHT	1	64Z2
14	NIPPLE	1	63L22G

* Repair Gasket for Trap – 2117588
Repair Valve & Seat Kit – 2117587
Repair Float – 2117589

Order by Part Number and Description. Reference Numbers are for your convenience only.

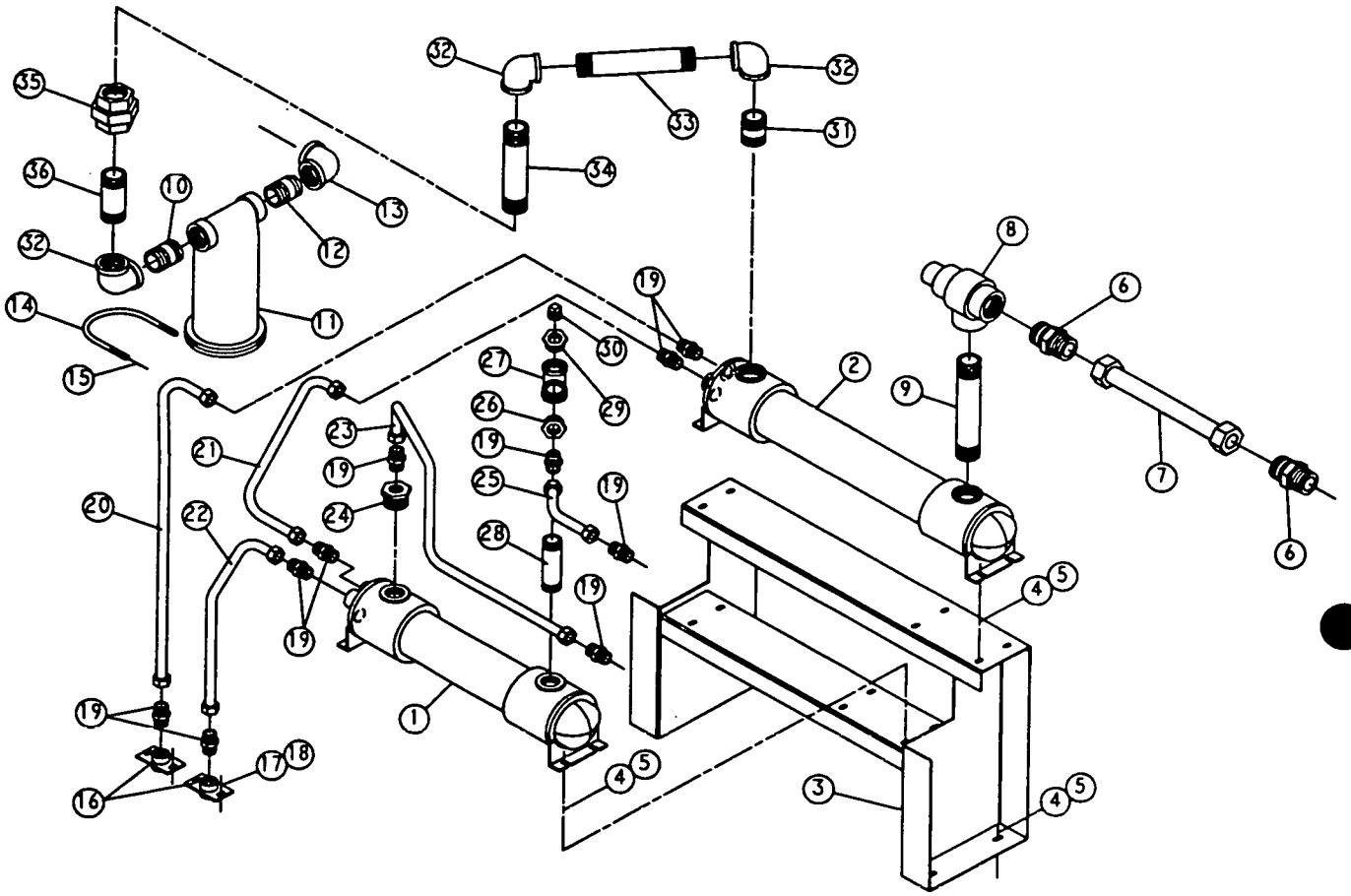


208EBM810
(Ref. Drawing)

AIR COOLED COOLER GROUP

Ref. No.	Name of Part	Qty.	60 – 75 HP Part No.	100 HP Part No.
1	COOLER–OIL/AIR	1	200EBM201	200EBP201
	COOLER–OIL/AIR SEACOAST (OPTIONAL)	1	201EBM201	201EBP201
2	NIPPLE–PIPE	2	63H4G	63H4G
3	SUPPORT	1	200EBM165	200EBM165
4	SCREW–FLANGED	12	75LM51	75LM51
5	NUT–FLANGED	12	50AW5	50AW5
6	WASHER	8	95A3	95A3
7	BUSHING–HUB	1	22G2	22G2
8	FAN	1	201ECM701	201ECM701
9	GUARD–FAN	1	200EBM393	200EBM393
10	SCREW–FLANGED	8	75LM51	75LM51
11	SCREW–FLANGED	4	75LM50	75LM50
12	NUT–FLANGED	4	50AW4	50AW4
13	SCREW–FLANGED	4	75K48	75LM78
14	NUT–FLANGED	4	50AW5	50AW5

WATER COOLED HEAT EXCHANGER – WITH AFTERCOOLER



209EBM810–A
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

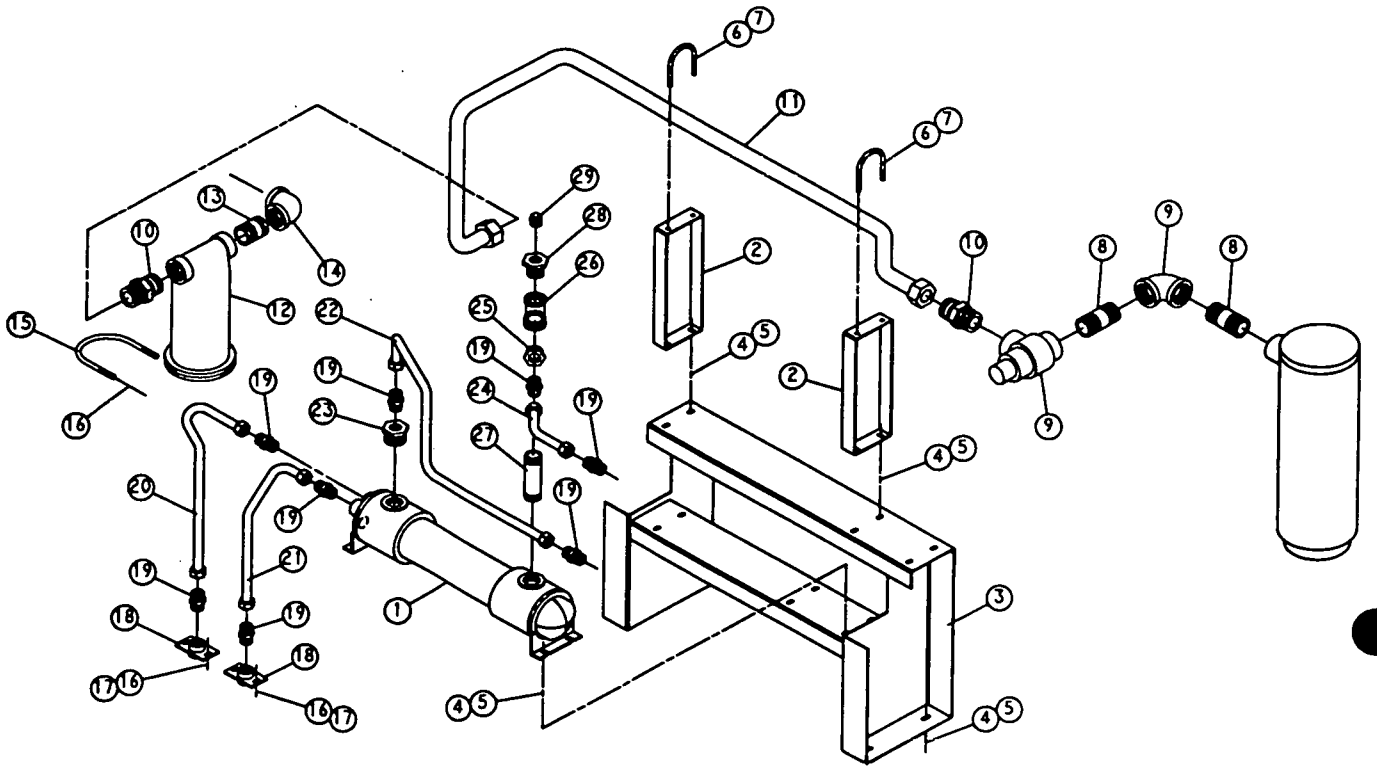
WATER COOLED HEAT EXCHANGER – WITH AFTERCOOLER

Ref. No.	Name of Part	Qty.	60 HP Part No.	75/100 HP Part No.
1	EXCHANGER–HEAT (OIL/WATER)	1	202ESJ349	204ESM349
	EXCHANGER–HEAT (OIL/WATER) – SEACOAST OPTION	1	203ESJ349	203ESM349
	BONNET–IN & OUT (For Repair)	1	2109060	2109060
	BONNET–RETURN (For Repair)	1	2109061	2109061
	GASKET–IN & OUT (For Repair)	1	2109058	2109058
	GASKET–RETURN (For Repair)	1	2109059	2109059
2	AFTERCOOLER	1	200ESL292	201ESM292
	AFTERCOOLER – SEACOAST OPTION	1	201ESL292	202ESM292
	BONNET–IN & OUT (For Repair)	1	2109060	2109060
	BONNET–RETURN (For Repair)	1	2109061	2109061
	GASKET–IN & OUT (For Repair)	1	2109058	2109058
	GASKET–RETURN (For Repair)	1	2109059	2109059
3	SUPPORT	1	213ECM165	213ECM165
4	SCREW–FLANGED	12	75LM51	75LM51
5	NUT–FLANGED	12	50AW5	50AW5
6	CONNECTOR–TUBE	2	86H142	86H142
7	TUBE WITH FITTINGS	1	206EBM863	202EBP863
8	VALVE–MINIMUM PRESSURE	1	200EBM527	200EBM527
9	NIPPLE	1	63L28G	63L28G
10	NIPPLE	1	63L9G	63L9G
11 **	TRAP	1	83C84	83C84
12	NIPPLE	1	63L9G	63L9G
13	ELBOW	1	64C9G	64C9G
14	U–BOLT	1	15U64	15U64
15	NUT–FLANGED	2	50AW5	50AW5
16	MANIFOLD–WATER	2	200ECM072	200ECM072
17	SCREW–FLANGED	4	75LM51	75LM51
18	NUT–FLANGED	4	50AW5	50AW5
19	CONNECTOR–TUBE	10	86H138	86H138
20	TUBE WITH FITTINGS	1	209EBM863	209EBM863
21	TUBE WITH FITTINGS	1	208EBM863	208EBM863
22	TUBE WITH FITTINGS	1	210EBM863	210EBM863
23	TUBE WITH FITTINGS	1	207EBM863	207EBM863
24	BUSHING–PIPE	1	64E13	64E13
25	TUBE WITH FITTINGS	1	205EBM863	201EBP863
26	BUSHING–PIPE	1	64E13	64E13
27	TEE	1	64G11G	64G11G
28	NIPPLE	1	63K6G	63K6G
29	BUSHING–PIPE	1	64E13	64E13
30	PLUG–SQHD PIPE	1	64AA1	64AA1
31	NIPPLE	1	63L9G	63L9G
32	ELBOW	3	64C9G	64C9G
33	NIPPLE	1	63L34G	63L34G
34	NIPPLE	1	63L27G	63L27G
35	UNION–STRAIGHT	1	64Z2	64Z2
36	NIPPLE	1	63L20G	63L20G
*	TEMPERATURE REGULATOR	1	90AR326	90AR326
*	SOLENOID VALVE (NEMA 1)	1	90AC118	90AC118
*	SOLENOID VALVE (NEMA 4)	1	90AC103	90AC103

* Not Shown.

** Repair Gasket for Trap – 2117588
Repair Valve & Seat Kit – 2117587
Repair Float – 2117589

WATER COOLED HEAT EXCHANGER – WITHOUT AFTERCOOLER



210EBM810
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

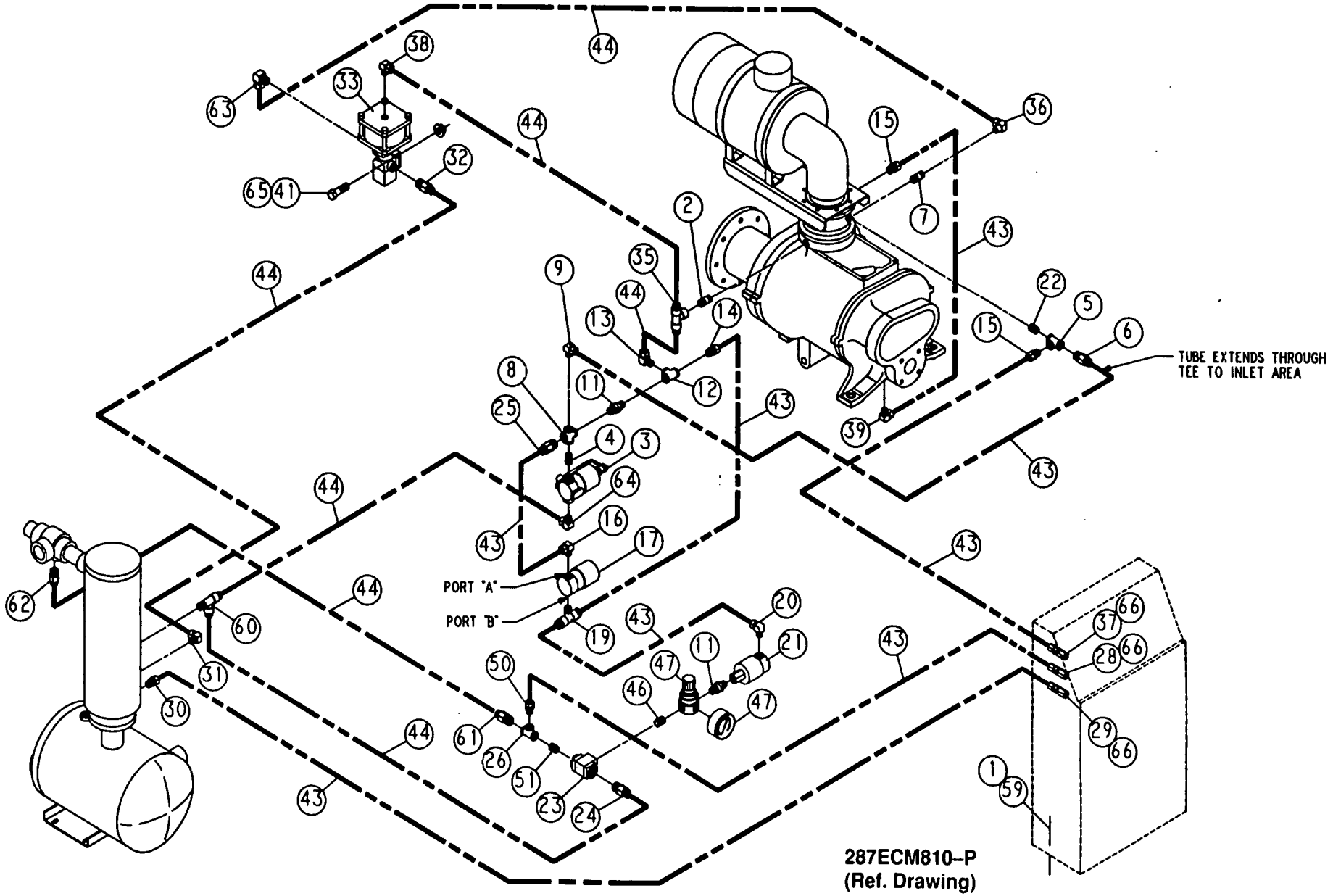
WATER COOLED HEAT EXCHANGER – WITHOUT AFTERCOOLER

Ref. No.	Name of Part	Qty.	60 HP Part No.	75/100 HP Part No.
1	EXCHANGER–HEAT (OIL/WATER)	1	202ESJ349	204ESM349
	EXCHANGER–HEAT (OIL/WATER) – SEACOAST OPTION	1	203ESJ349	203ESM349
	BONNET–IN & OUT (For Repair)	1	2109060	2109060
	BONNET–RETURN (For Repair)	1	2109061	2109061
	GASKET–IN & OUT (For Repair)	1	2109058	2109058
	GASKET–RETURN (For Repair)	1	2109059	2109059
2	BRACKET–PIPE	2	201ECM108	201ECM108
3	SUPPORT	1	213ECM165	213ECM165
4	SCREW–FLANGED	12	75LM51	75LM51
5	NUT–FLANGED	12	50AW5	50AW5
6	U–BOLT	2	15U111	15U111
7	NUT–FLANGED	4	50AW5	50AW5
8	NIPPLE	2	63L9G	63L9G
9	VALVE–MINIMUM PRESSURE	1	200EBM527	200EBM527
10	CONNECTOR–TUBE	2	86H142	86H142
11	TUBE WITH FITTINGS	1	213EBM863	213EBM863
12	TRAP	1	83C84	83C84
13	NIPPLE	1	63L1G	63L1G
14	ELBOW	1	64C9G	64C9G
15	U–BOLT	1	15U64	15U64
16	NUT–FLANGED	6	50AW5	50AW5
17	SCREW–FLANGED	4	75LM51	75LM51
18	MANIFOLD–WATER	2	200ECM072	200ECM072
19	CONNECTOR–TUBE	8	86H138	86H138
20	TUBE WITH FITTINGS	1	211EBM863	211EBM863
21	TUBE WITH FITTINGS	1	210EBM863	210EBM863
22	TUBE WITH FITTINGS	1	207EBM863	207EBM863
23	BUSHING–PIPE	1	64E13	64E13
24	TUBE WITH FITTINGS	1	205EBM863	201EBP863
25	BUSHING–PIPE	1	64E13	64E13
26	TEE	1	64G11G	64G11G
27	NIPPLE	1	63K6G	63K6G
28	BUSHING–PIPE	1	64E13	64E13
29	PLUG.	1	64AA1	64AA1
*	TEMPERATURE REGULATOR	1	90AR326	90AR326
*	SOLENOID VALVE (NEMA 1)	1	90AC118	90AC118
*	SOLENOID VALVE (NEMA 4)	1	90AC103	90AC103

* Not Shown.

** Repair Gasket for Trap – 2117588
Repair Valve & Seat Kit – 2117587
Repair Float – 2117589

CONTROL PIPING SCHEMATIC

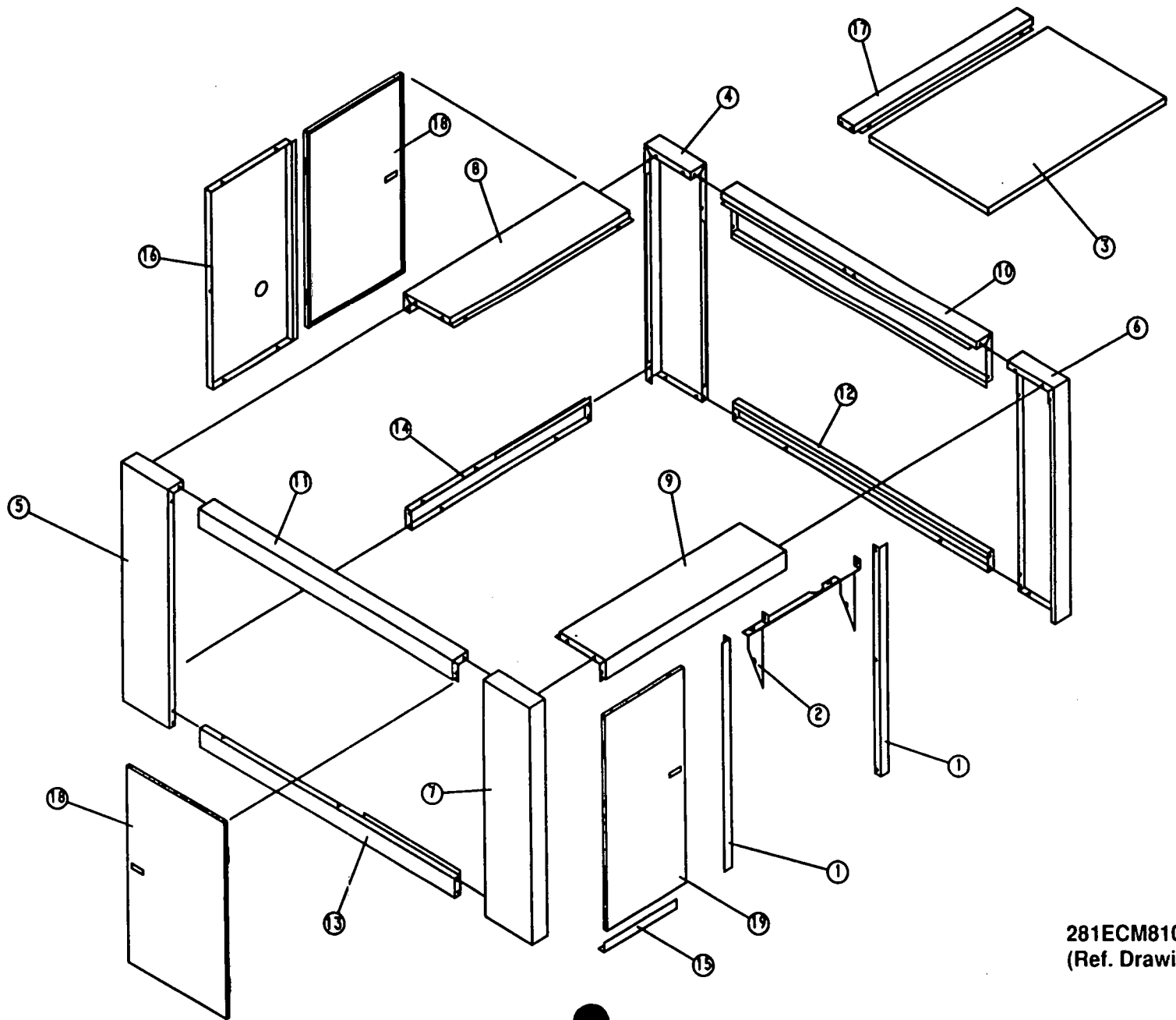


CONTROL PIPING SCHEMATIC

Ref. No.	Name of Part	Qty.	Part No.
1	SCREW–FLANGED	4	75LM51
2	NIPPLE	1	63D5G
3	VALVE–SOLENOID	1	91B70
4	NIPPLE	1	63D1G
5	TEE–PIPE	1	64G3G
6	CONNECTOR	1	86N272
7	NIPPLE	1	63D5G
8	CROSS	1	64K1G
9	ELBOW	1	86E60
11	VALVE–CHECK	1	90AR261
12	TEE	1	64G3G
13	CONNECTOR–TUBE	1	86E64
14	ORIFICE	1	86N289
15	CONNECTOR–TUBE	2	86E4
16	ELBOW	1	86E60
17	VALVE–SOLENOID	1	91B81
18	BUSHING–PIPE	1	64E2G
19	TEE	1	86E119
20	ELBOW	1	86E60
21	VALVE–SOLENOID	1	91B80
22	NIPPLE	1	63D1G
23	VALVE–CONTROL	1	90AR107
24	CONNECTOR–TUBE	1	86E9
25	CONNECTOR–TUBE	1	86E4
26	TEE	1	64G3G
28	CONNECTOR–TUBE	1	86N287
29	CONNECTOR–TUBE	1	86N287
30	CONNECTOR–TUBE	1	86E4
31	ELBOW	1	86E64
32	CONNECTOR–TUBE	1	86E9
33 *	VALVE–CONTROL	1	90AR1082
35	TEE	1	86E147
36	ELBOW	1	86E82
37	CONNECTOR–TUBE	1	86N287
38	ELBOW	1	86E64
39	ELBOW	1	86E60
41	NUT–FLANGED	2	50AW3
43	TUBE	28	85K3
44	TUBE	24	85K5
46	NIPPLE	1	63D1G
47	REGULATOR	1	88H139
	GAUGE (For Repair)	1	2116732
50	CONNECTOR–TUBE	1	86E4
51	NIPPLE	1	63D1G
59	NUT–FLANGED	4	50AW5
60	TEE	1	86E136
61	CONNECTOR–TUBE	1	86E9
62	CONNECTOR–TUBE	1	86E9
63	ELBOW	1	86E64
64	ELBOW	1	86E64
65	SCREW	2	75P4
66	O–RING	3	165011

* For Repair of U–Cup (Piston Seal) order Part Number 2117904. For Repair of O–Ring (Top Plate) order Part Number 2117905.

ENCLOSURE
(COMMON PARTS – AIR/WATER COOLED)

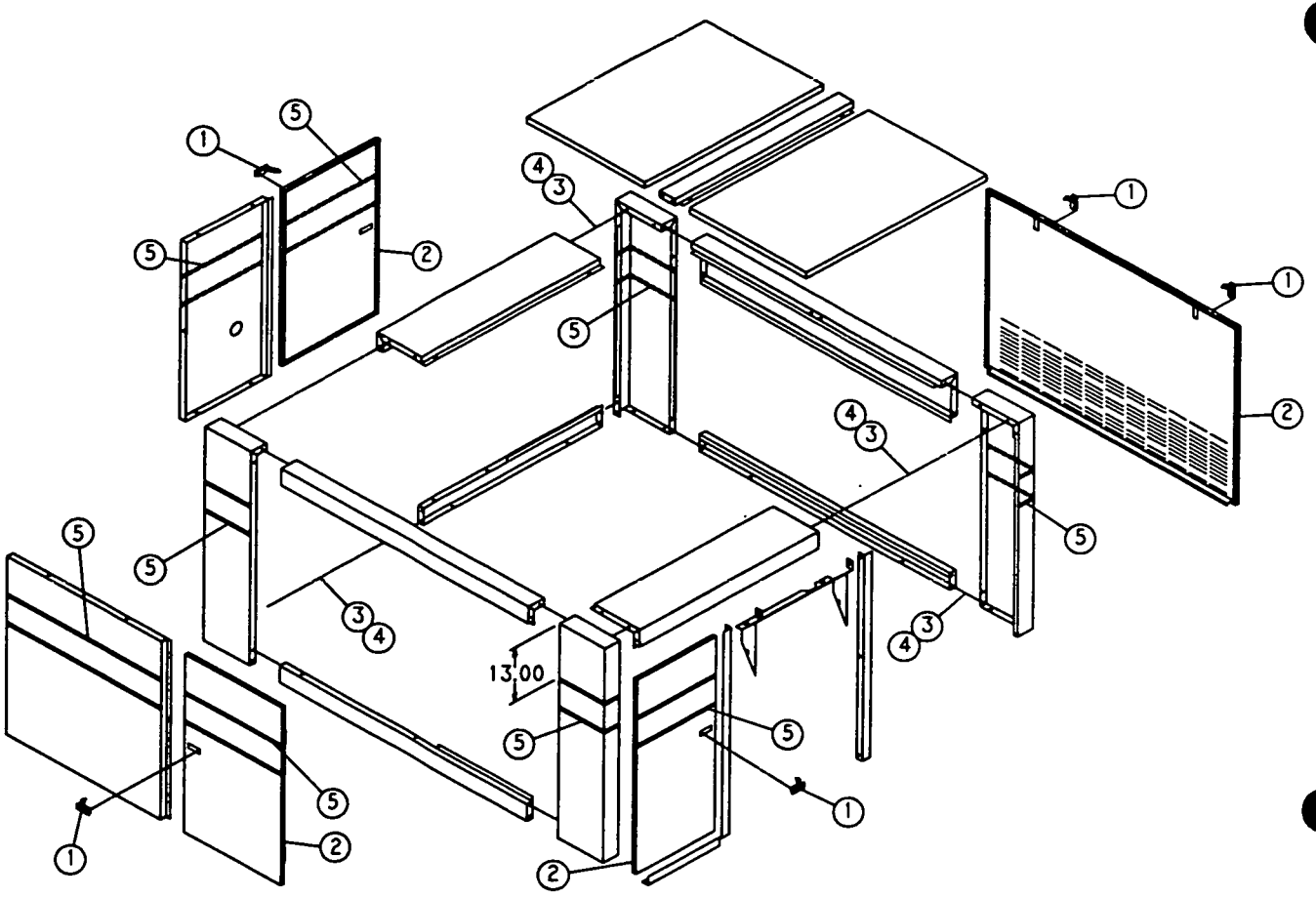


281ECM810–A
(Ref. Drawing)

ENCLOSURE
(COMMON PARTS – AIR/WATER COOLED)

Ref. No.	Name of Part	Qty.	Part No.
1	BRACKET	2	215ECM142
2	BRACKET	1	216ECM142
3	PANEL	1	217ECM216
4	POST	1	208ECM313
5	POST	1	209ECM313
6	POST	1	213ECM313
7	POST	1	214ECM313
8	FRAME	1	215ECM314
9	FRAME	1	216ECM314
10	FRAME	1	217ECM314
11	FRAME	1	218ECM314
12	FRAME	1	219ECM314
13	FRAME	1	220ECM314
14	FRAME	1	221ECM314
15	FRAME	1	222ECM314
16	BRACE	1	206ECM326
17	BRACE	1	205ECM326
18	DOOR–CANOPY	2	210ECM334
19	DOOR–CANOPY	1	211ECM334

Order by Part Number and Description. Reference Numbers are for your convenience only.

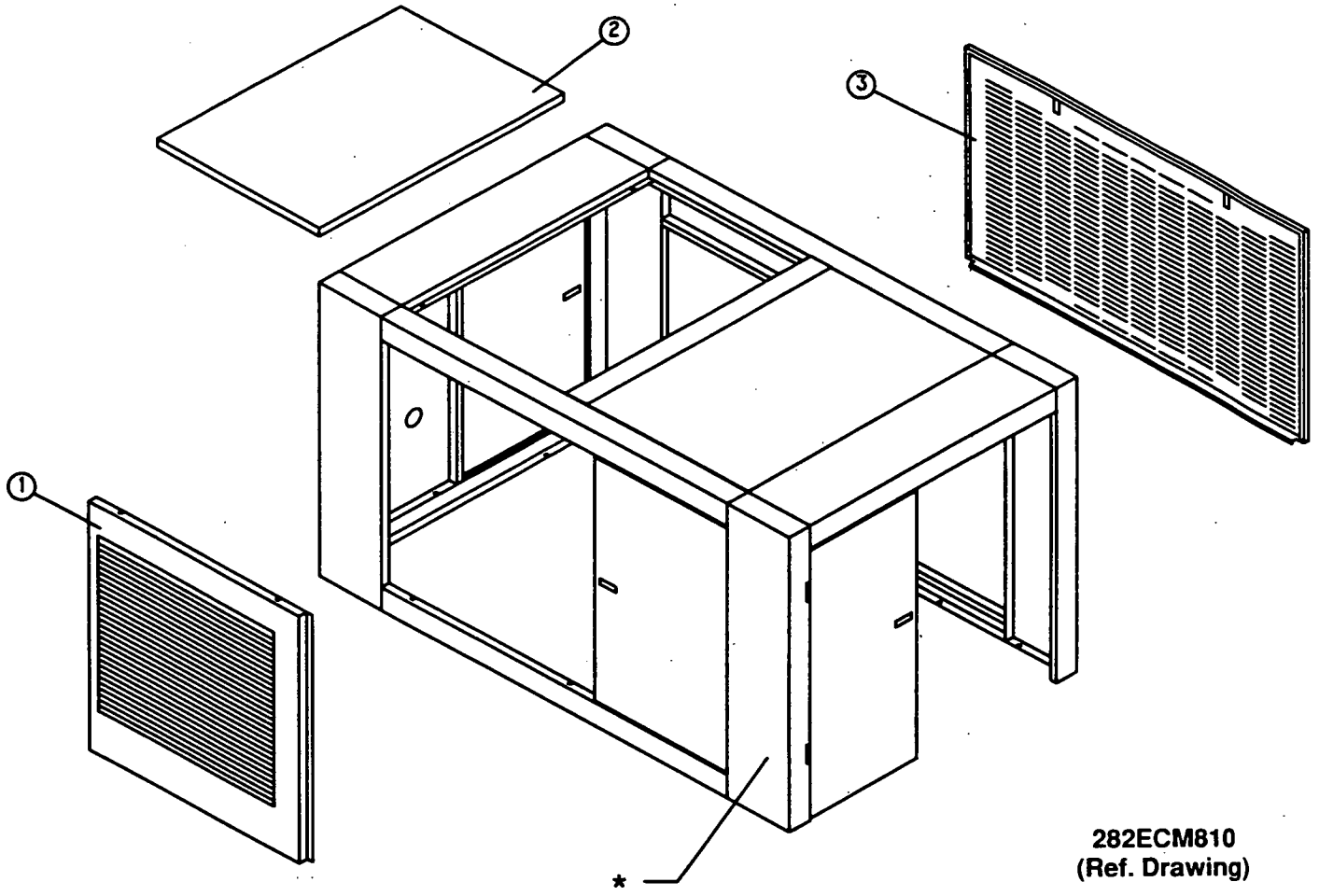


205EBM810–B
(Ref. Drawing)

ENCLOSURE – HARDWARE

Ref. No.	Name of Part	Qty.	Part No.
1	LATCH	5	31D58
2	SEAL	51 Ft.	32E12
3	SCREW–FLANGED	86	75LM51
4	NUT–FLANGED	78	50AW5
5	DECAL	6	203ESO077

Order by Part Number and Description. Reference Numbers are for your convenience only.



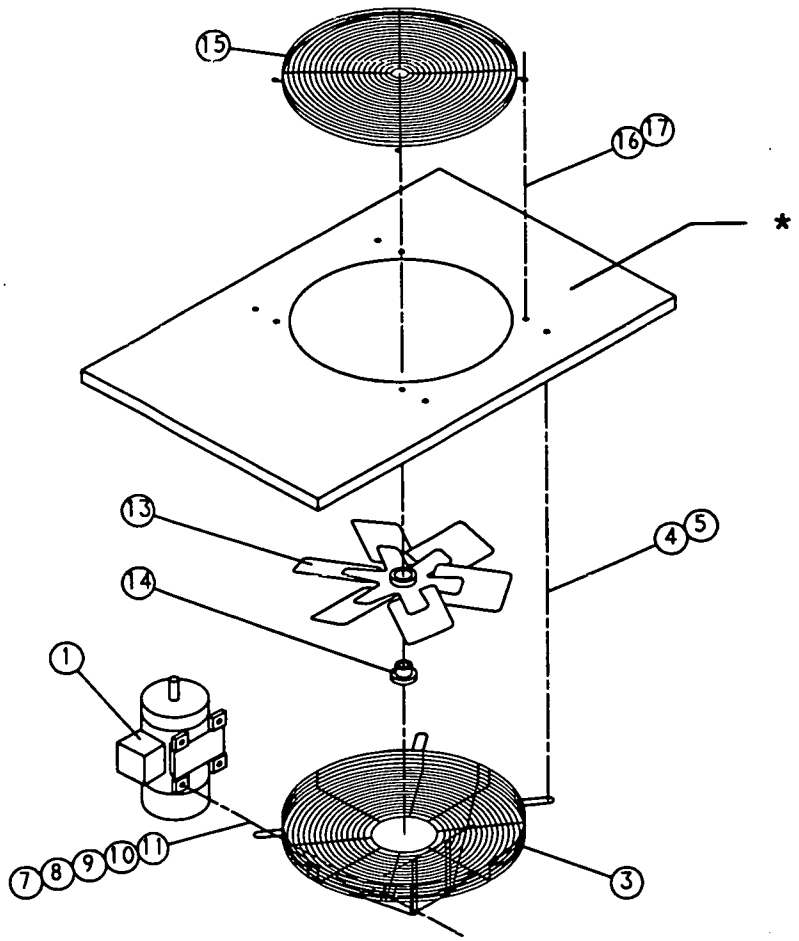
282ECM810
(Ref. Drawing)

ENCLOSURE – AIR COOLED UNITS

Ref. No.	Name of Part	Qty.	Part No.
1	PANEL	1	220ECM216
2	PANEL	1	217ECM216
3	PANEL	1	215ECM216

* Refer to pages 36 and 37 for Enclosure Parts and page 38 for Enclosure Hardware.

Order by Part Number and Description. Reference Numbers are for your convenience only.



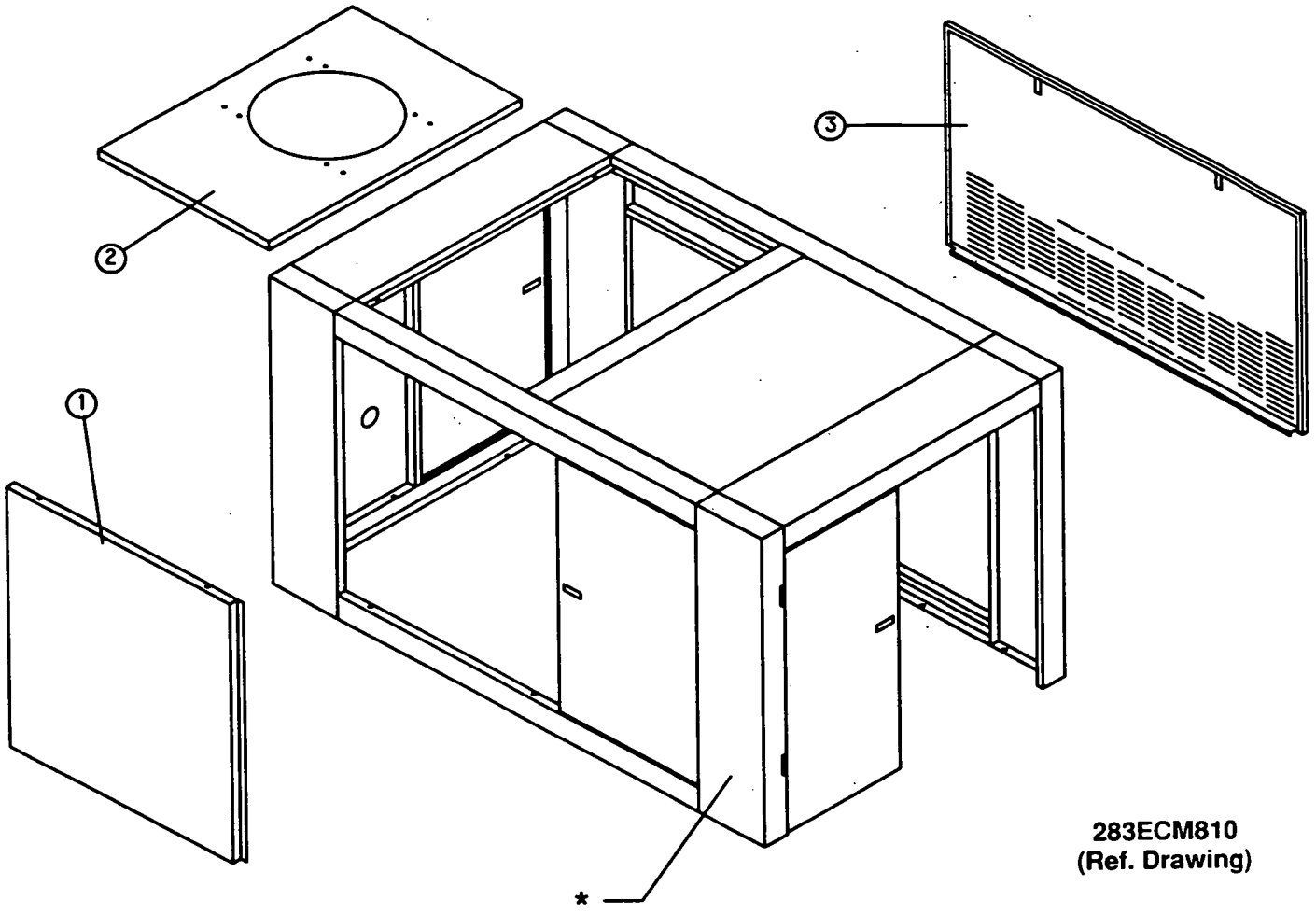
285ECM810
(Ref. Drawing)

ENCLOSURE – VENT FAN ASSEMBLY (WATER COOLED UNITS ONLY)

Ref. No.	Name of Part	Qty.	Part No.
1	MOTOR	1	See Page 51
3	GUARD–FAN	1	202ECM393
4	SCREW–FLANGED	4	75K48
5	WASHER	4	95A5
7	SCREW	4	75A35
8	RETAINER	4	2014731
9	WASHER	4	95A2
10	LOCKWASHER	4	95B2
11	NUT	4	50B2
13	FAN	1	202ECM701
14	HUB BUSHING	1	22G27
15	GUARD–FAN	1	200ECM393
16	SCREW–FLANGED	4	75LM51
17	NUT–FLANGED	4	50AW5

* Refer to page 41 for Vent Fan Panel.

Order by Part Number and Description. Reference Numbers are for your convenience only.



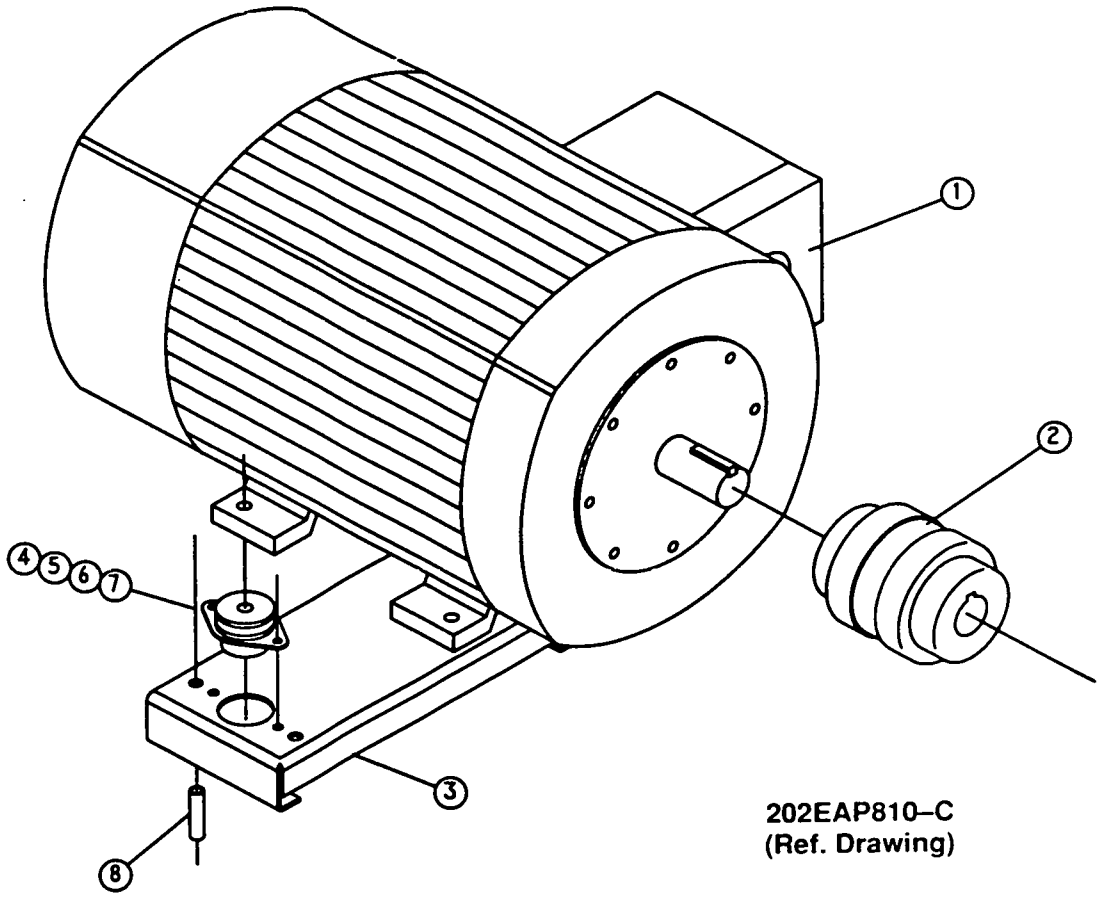
283ECM810
(Ref. Drawing)

ENCLOSURE – WATER COOLED UNITS

Ref. No.	Name of Part	Qty.	Part No.
1	PANEL	1	219ECM216
2	PANEL	1	216ECM216
3	PANEL	1	218ECM216

* Refer to pages 36 and 37 for Enclosure Parts and page 38 for Enclosure Hardware.

Order by Part Number and Description. Reference Numbers are for your convenience only.



202EAP810–C
(Ref. Drawing)

MAIN MOTOR GROUP

Ref. No.	Name of Part	Qty.	Part No.
1	MOTOR	1	*
2	COUPLING–FLEXIBLE (SSH and SSM Air Ends)	1	51L167***
	COUPLING–FLEXIBLE (SSP Air Ends)	1	51L10**
3	SUPPORT–MOTOR – 326 FRAME MOTOR	1	202EDF620
	SUPPORT–MOTOR – 364 & 365 FRAME MOTOR	1	201EDF620
	SUPPORT–MOTOR – 404 & 405 FRAME MOTOR	1	202EAP620
4	SCREW	4	655EF160
5	WASHER	4	95A7
6	LOCKWASHER	4	95B7
7	NUT	4	50B7
8	NIPPLE	4	63AM12X26G

* Selective – see page 51.

** Drive Coupling Kit – ECK77781 (Includes (6) 2109116 Cushions)

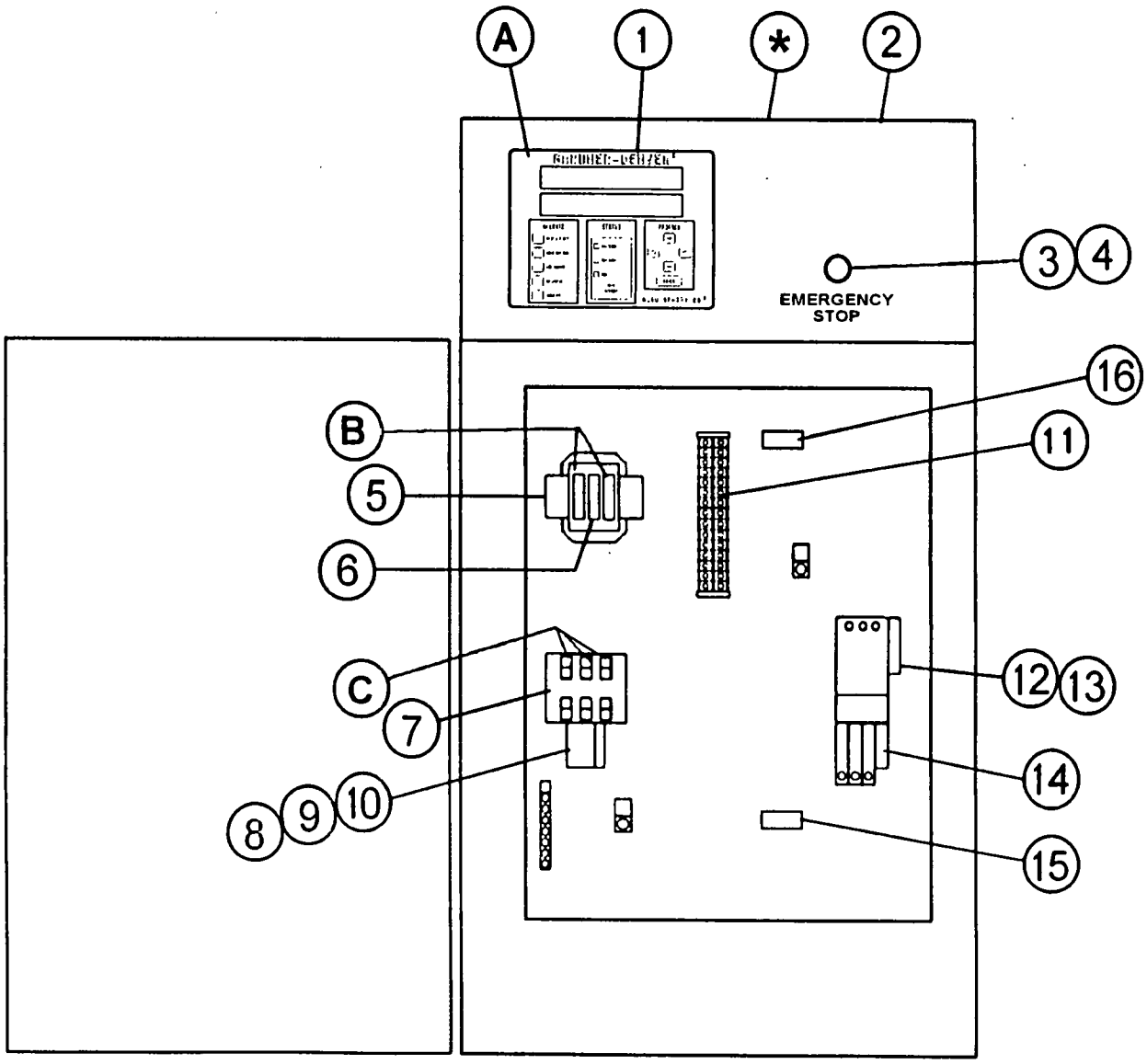
*** Drive Coupling Cushion – 2117297 – 1 piece required.

OVERLOAD RELAY HEATER CONVERSION LISTING

Refer to Motor Nameplate "Amperage" and Decal in Control Panel for Selection of Overload Relay Heater Packs.

CUTLER–HAMMER PART NUMBER	GARDNER DENVER PART NUMBER
H2002B	24CA4101
H2003B	24CA4102
H2004B	24CA4103
H2005B	24CA4104
H2006B	24CA4105
H2007B	24CA4106
H2008B	24CA4107
H2009B	24CA4108
H2010B	24CA4109
H2011B	24CA4110
H2012B	24CA4111
H2013B	24CA4112
H2014B	24CA4113
H2015B	24CA4114
H2016B	24CA4115
H2017B	24CA4116
H2018	24CA2924
H2019	24CA2925
H2020	24CA2926
H2021	24CA2927
H2022	24CA2893
H2023	24CA2894
H2024	24CA2928

CONTROLLER ASSEMBLY
(60/75/100 HP FULL VOLTAGE STARTERS)



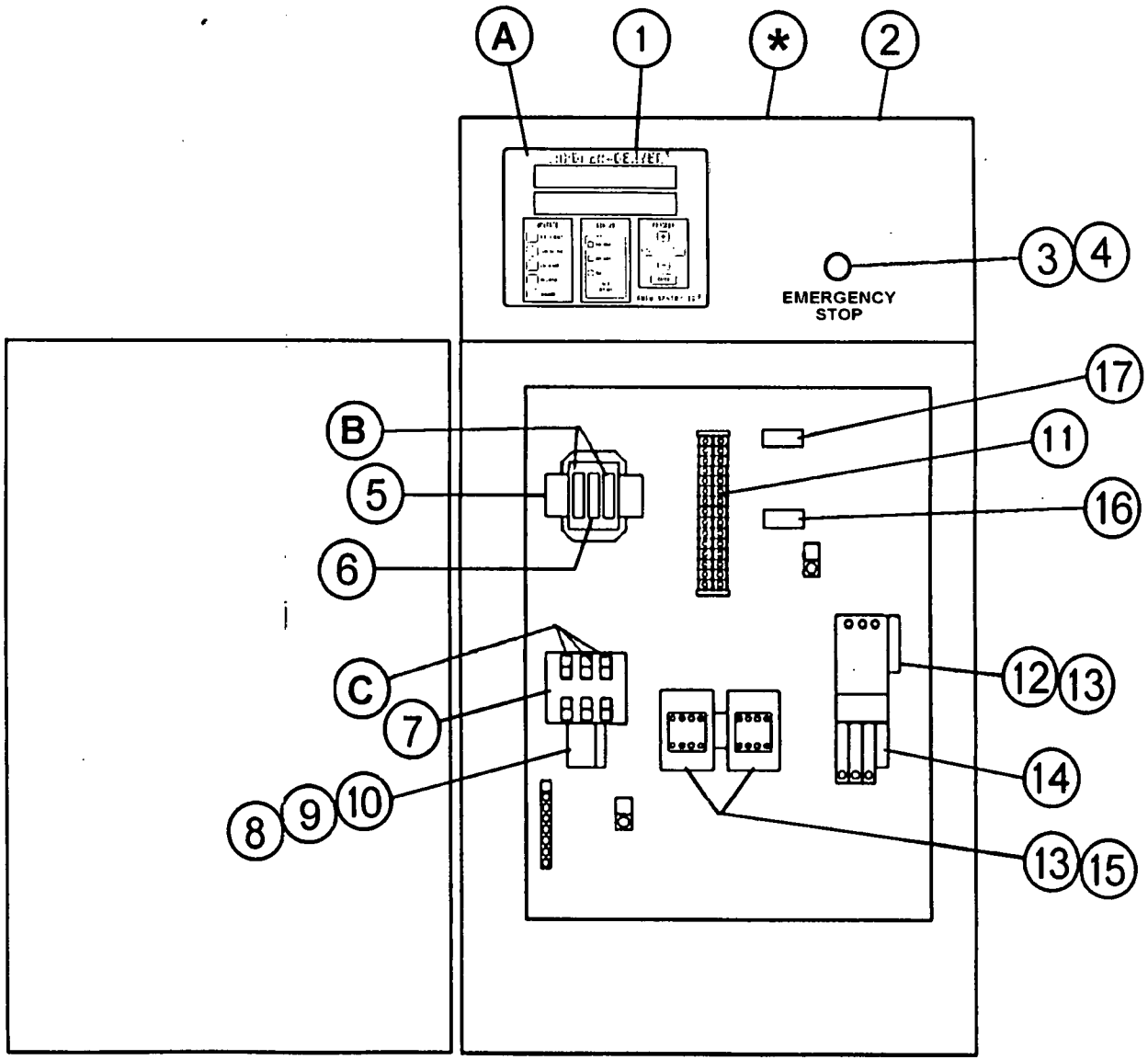
Refer to parts list on page 45.

CONTROLLER ASSEMBLY
(60/75/100 HP FULL VOLTAGE STARTERS)
(Refer to drawing on page 44)

		QTY.	60 – 75 HP 200V	60 – 100 HP 230V	60 – 100 HP 460V	60 – 100 HP 575V
*	ASSEMBLED PANEL – **ES**: NEMA 12	1	384EAP466	381EAP466	380EAP466	390EAP466
*	ASSEMBLED PANEL – **ES**: NEMA 4	1	385EAP466	383EAP466	382EAP466	391EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 12, W/O Current Monitor	1	320EAP466	317EAP466	316EAP466	326EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 4, W/O Current Monitor	1	321EAP466	319EAP466	318EAP466	327EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 12, With Current Monitor	1	352EAP466	349EAP466	348EAP466	358EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 4, With Current Monitor	1	353EAP466	351EAP466	350EAP466	359EAP466
A	FUSE, CONTROL BOARD	1	24CA2932	24CA2932	24CA2932	24CA2932
B	FUSE, TRANSFORMER PRIMARY	2	24CA2786	24CA2786	24CA2783	24CA3722
C	FUSE, FAN MOTOR, AIR COOLED	3	24CA4097	24CA3952	24CA4095	24CA4094
C	FUSE, FAN MOTOR, WATER COOLED	3	24CA4093	24CA4093	24CA4091	24CA4090
1	ELECTRICAL CONTROL ASSEMBLY – **ES CONTROLLER**	1	202EAP1173	202EAP1173	202EAP1173	202EAP1173
1	ELECTRICAL CONTROL ASSEMBLY WITH CONNECTORS – **ES CONTROLLER**	1	200EAP2006	200EAP2006	200EAP2006	200EAP2006
1	ELECTRICAL CONTROL ASSEMBLY – **ES+ CONTROLLER**	1	200EAU1173	200EAU1173	200EAU1173	200EAU1173
1	ELECTRICAL CONTROL ASSEMBLY WITH CONNECTORS – **ES+ CONTROLLER**	1	200EAU2006	200EAU2006	200EAU2006	200EAU2006
2	ELECTRICAL CONTROL ENCLOSURE	1	200EAP179	200EAP179	200EAP179	200EAP179
3	OPERATOR, 22mm PUSH/PULL EMERGENCY STOP	1	24CA2907	24CA2907	24CA2907	24CA2907
4	CONTACT BLOCK, 22mm SPNC	1	24CA2908	24CA2908	24CA2908	24CA2908
5	CONTROL TRANSFORMER	1	2116371	2116372	2116372	2116373
6	FUSE, TRANSFORMER SECONDARY	1	24CA3728	24CA3728	24CA3728	24CA3728
7	FUSEHOLDER	1	24CA4098	24CA4098	24CA4098	24CA4098
8	STARTER, FAN MOTOR	1	24CA4408	24CA4408	24CA4408	24CA4408
9	REPLACEMENT COIL FOR ITEM 8	1	2115950	2115950	2115950	2115950
10	OVERLOAD RELAY	1	24CA4086	24CA4086	24CA4086	24CA4086
11	TERMINAL BLOCK	6	24CA2633	24CA2633	24CA2633	24CA2633
12	STARTER, MAIN MOTOR	1	24CA3490	24CA3490	24CA3881	24CA3881
13	REPLACEMENT COIL FOR ITEM 12	1	2115952	2115952	2115952	2115952
14	OVERLOAD RELAY	1	24CA4086	24CA4086	24CA4086	24CA4086
15	CURRENT TRANSFORMER (SEE NOTE BELOW)	1	24CA4242	24CA4242	24CA4242	24CA4242
16	CURRENT TRANSDUCER (SEE NOTE BELOW)	1	24CA4241	24CA4241	24CA4241	24CA4241

NOTE: USED WITH ES+ WITH CURRENT MONITORING UNITS ONLY.

CONTROLLER ASSEMBLY
(60/75/100 HP WYE DELTA STARTERS)



Refer to parts list on page 47.

CONTROLLER ASSEMBLY
(60/75/100 HP WYE DELTA STARTERS)
(Refer to drawing on page 46)

		QTY.	60 HP 200V	60 – 75 HP 230V	60 HP 460V	75 – 100 HP 460V
*	ASSEMBLED PANEL – **ES**: NEMA 12	1	364EAP466	361EAP466	360EAP466	361EAP466
*	ASSEMBLED PANEL – **ES**: NEMA 4	1	365EAP466	363EAP466	362EAP466	363EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 12, W/O Current Monitor	1	300EAP466	297EAP466	296EAP466	297EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 4, W/O Current Monitor	1	301EAP466	299EAP466	298EAP466	299EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 12, With Current Monitor	1	332EAP466	329EAP466	328EAP466	329EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 4, With Current Monitor	1	333EAP466	331EAP466	330EAP466	331EAP466
A	FUSE, CONTROL BOARD	1	24CA2932	24CA2932	24CA2932	24CA2932
B	FUSE, TRANSFORMER PRIMARY	2	24CA2786	24CA2786	24CA2783	24CA2783
C	FUSE, FAN MOTOR, AIR COOLED	3	24CA4097	24CA3952	24CA4095	24CA4095
C	FUSE, FAN MOTOR, WATER COOLED	3	24CA4093	24CA4093	24CA4091	24CA4091
1	ELECTRICAL CONTROL ASSEMBLY – **ES CONTROLLER**	1	202EAP1173	202EAP1173	202EAP1173	202EAP1173
1	ELECTRICAL CONTROL ASSEMBLY WITH CONNECTORS – **ES CONTROLLER**	1	200EAP2006	200EAP2006	200EAP2006	200EAP2006
1	ELECTRICAL CONTROL ASSEMBLY – **ES+ CONTROLLER**	1	200EAU1173	200EAU1173	200EAU1173	200EAU1173
1	ELECTRICAL CONTROL ASSEMBLY WITH CONNECTORS – **ES+ CONTROLLER**	1	200EAU2006	200EAU2006	200EAU2006	200EAU2006
2	ELECTRICAL CONTROL ENCLOSURE	1	200EAP179	200EAP179	200EAP179	200EAP179
3	OPERATOR, 22mm PUSH/PULL EMERGENCY STOP	1	24CA2907	24CA2907	24CA2907	24CA2907
4	CONTACT BLOCK, 22mm SPNC	1	24CA2908	24CA2908	24CA2908	24CA2908
5	CONTROL TRANSFORMER	1	2116371	2116372	2116372	2116372
6	FUSE, TRANSFORMER SECONDARY	1	24CA3728	24CA3728	24CA3728	24CA3728
7	FUSEHOLDER	1	24CA4098	24CA4098	24CA4098	24CA4098
8	STARTER, FAN MOTOR	1	24CA4408	24CA4408	24CA4408	24CA4408
9	REPLACEMENT COIL FOR ITEM 8	1	2115950	2115950	2115950	2115950
10	OVERLOAD RELAY	1	24CA4086	24CA4086	24CA4086	24CA4086
11	TERMINAL BLOCK	6	24CA2633	24CA2633	24CA2633	24CA2633
12	STARTER, MAIN MOTOR	1	24CA3255	24CA3255	24CA4142	24CA3255
13	REPLACEMENT COIL FOR ITEMS 12 AND 15	3	2116555	2116555	2116124	2116555
14	OVERLOAD RELAY	1	24CA4086	24CA4086	24CA4087	24CA4086
15	CONTACTOR	2	24CA3259	24CA3259	24CA3258	24CA3259
16	CURRENT TRANSFORMER (SEE NOTE BELOW)	1	24CA4242	24CA4242	24CA4242	24CA4242
17	CURRENT TRANSDUCER (SEE NOTE BELOW)	1	24CA4241	24CA4241	24CA4241	24CA4241

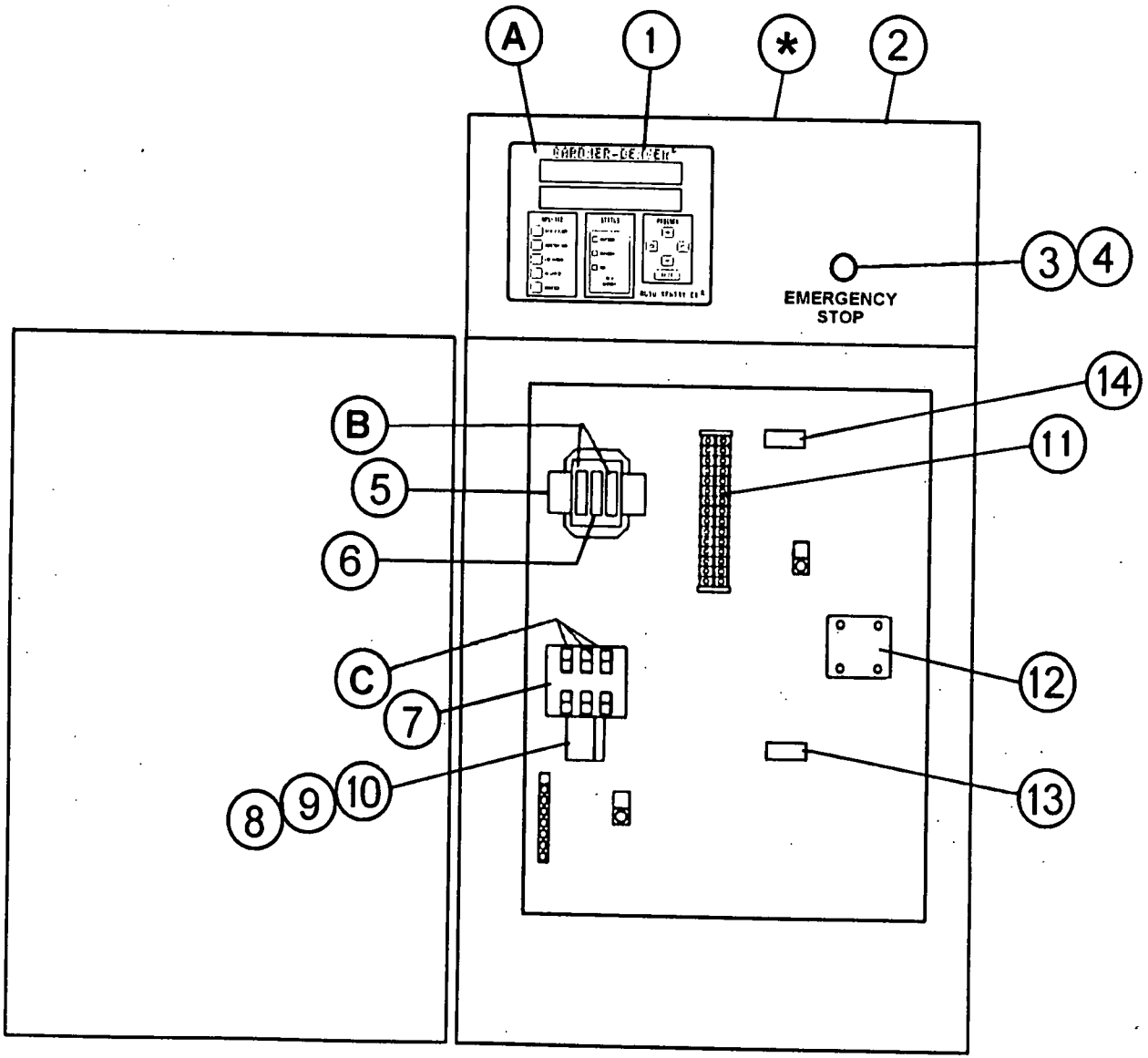
NOTE: USED WITH ES+ WITH CURRENT MONITORING UNITS ONLY.

CONTROLLER ASSEMBLY
(60/75/100 HP WYE DELTA STARTERS)
(Refer to drawing on page 46)

		QTY.	60 – 75 HP 575V	100 HP 575V
*	ASSEMBLED PANEL – **ES**: NEMA 12	1	368EAP466	369EAP466
*	ASSEMBLED PANEL – **ES**: NEMA 4	1	370EAP466	371EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 12, W/O Current Monitor	1	304EAP466	305EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 4, W/O Current Monitor	1	306EAP466	307EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 12, With Current Monitor	1	336EAP466	337EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 4, With Current Monitor	1	338EAP466	339EAP466
A	FUSE, CONTROL BOARD	1	24CA2932	24CA2932
B	FUSE, TRANSFORMER PRIMARY	2	24CA3722	24CA3722
C	FUSE, FAN MOTOR, AIR COOLED	3	24CA4094	24CA4094
C	FUSE, FAN MOTOR, WATER COOLED	3	24CA4090	24CA4090
1	ELECTRICAL CONTROL ASSEMBLY – **ES CONTROLLER**	1	202EAP1173	202EAP1173
1	ELECTRICAL CONTROL ASSEMBLY WITH CONNECTORS – **ES CONTROLLER**	1	200EAP2006	200EAP2006
1	ELECTRICAL CONTROL ASSEMBLY – **ES+ CONTROLLER**	1	200EAU1173	200EAU1173
1	ELECTRICAL CONTROL ASSEMBLY WITH CONNECTORS – **ES+ CONTROLLER**	1	200EAU2006	200EAU2006
2	ELECTRICAL CONTROL ENCLOSURE	1	200EAP179	200EAP179
3	OPERATOR, 22mm PUSH/PULL EMERGENCY STOP	1	24CA2907	24CA2907
4	CONTACT BLOCK, 22mm SPNC	1	24CA2908	24CA2908
5	CONTROL TRANSFORMER	1	2116373	2116373
6	FUSE, TRANSFORMER SECONDARY	1	24CA3728	24CA3728
7	FUSEHOLDER	1	24CA4098	24CA4098
8	STARTER, FAN MOTOR	1	24CA4408	24CA4408
9	REPLACEMENT COIL FOR ITEM 8	1	2115950	2115950
10	OVERLOAD RELAY	1	24CA4086	24CA4086
11	TERMINAL BLOCK	6	24CA2633	24CA2633
12	STARTER, MAIN MOTOR	1	24CA4142	24CA3255
13	REPLACEMENT COIL FOR ITEMS 12 AND 15	3	2116124	2116555
14	OVERLOAD RELAY	1	24CA4087	24CA4086
15	CONTACTOR	2	24CA3258	24CA3259
16	CURRENT TRANSFORMER (SEE NOTE BELOW)	1	24CA4242	24CA4242
17	CURRENT TRANSDUCER (SEE NOTE BELOW)	1	24CA4241	24CA4241

NOTE: USED WITH ES+ WITH CURRENT MONITORING UNITS ONLY.

CONTROLLER ASSEMBLY
(60/75/100 HP LESS MAIN MOTOR STARTER)



Refer to parts list on page 50.

CONTROLLER ASSEMBLY
(60/75/100 HP LESS MAIN MOTOR STARTER)
(Refer to drawing on page 49)

		QTY.	200V	230V	460V	575V
*	ASSEMBLED PANEL – **ES**: NEMA 12	1	373EAP466	372EAP466	372EAP466	375EAP466
*	ASSEMBLED PANEL – **ES**: NEMA 4	1	377EAP466	376EAP466	376EAP466	379EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 12, W/O Current Monitor	1	309EAP466	308EAP466	308EAP466	311EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 4, W/O Current Monitor	1	313EAP466	312EAP466	312EAP466	315EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 12, With Current Monitor	1	341EAP466	340EAP466	340EAP466	343EAP466
*	ASSEMBLED PANEL – **ES+**: NEMA 4, With Current Monitor	1	345EAP466	344EAP466	344EAP466	347EAP466
A	FUSE, CONTROL BOARD	1	24CA2932	24CA2932	24CA2932	24CA2932
B	FUSE, TRANSFORMER PRIMARY	2	24CA2786	24CA2786	24CA2783	24CA3722
C	FUSE, FAN MOTOR, AIR COOLED	3	24CA4097	24CA3952	24CA4095	24CA4094
C	FUSE, FAN MOTOR, WATER COOLED	3	24CA4093	24CA4093	24CA4091	24CA4090
1	ELECTRICAL CONTROL ASSEMBLY – **ES CONTROLLER**	1	202EAP1173	202EAP1173	202EAP1173	202EAP1173
1	ELECTRICAL CONTROL ASSEMBLY WITH CONNECTORS – **ES CONTROLLER**	1	200EAP2006	200EAP2006	200EAP2006	200EAP2006
1	ELECTRICAL CONTROL ASSEMBLY – **ES+ CONTROLLER**	1	200EAU1173	200EAU1173	200EAU1173	200EAU1173
1	ELECTRICAL CONTROL ASSEMBLY WITH CONNECTORS – **ES+ CONTROLLER**	1	200EAU2006	200EAU2006	200EAU2006	200EAU2006
2	ELECTRICAL CONTROL ENCLOSURE	1	200EAP179	200EAP179	200EAP179	200EAP179
3	OPERATOR, 22mm PUSH/PULL EMERGENCY STOP	1	24CA2907	24CA2907	24CA2907	24CA2907
4	CONTACT BLOCK, 22mm SPNC	1	24CA2908	24CA2908	24CA2908	24CA2908
5	CONTROL TRANSFORMER	1	2116371	2116372	2116372	2116373
6	FUSE, TRANSFORMER SECONDARY	1	24CA3728	24CA3728	24CA3728	24CA3728
7	FUSEHOLDER	1	24CA4098	24CA4098	24CA4098	24CA4098
8	STARTER, FAN MOTOR	1	24CA4408	24CA4408	24CA4408	24CA4408
9	REPLACEMENT COIL FOR ITEM 8	1	2115950	2115950	2115950	2115950
10	OVERLOAD RELAY	1	24CA4086	24CA4086	24CA4086	24CA4086
11	TERMINAL BLOCK	7	24CA2633	24CA2633	24CA2633	24CA2633
12	CONTROL RELAY	1	24CA3896	24CA3896	24CA3896	24CA3896
13	CURRENT TRANSFORMER (SEE NOTE BELOW)	1	24CA4242	24CA4242	24CA4242	24CA4242
14	CURRENT TRANSDUCER (SEE NOTE BELOW)	1	24CA4241	24CA4241	24CA4241	24CA4241

NOTE: USED WITH ES+ WITH CURRENT MONITORING UNITS ONLY.

MOTOR GROUP (MAIN DRIVE MOTORS)

	FULL VOLTAGE *			WYE–DELTA		
	60 HP PART NO.	75 HP PART NO.	100 HP PART NO.	60 HP PART NO.	75 HP PART NO.	100 HP PART NO.
OPEN DRIP PROOF (60 HZ – ODP – STANDARD EFFICIENCY)						
MOTOR, 200V	24CA3740	24CA3743	24CA3746	24CA2952	24CA2956	24CA2960
MOTOR, 230V	24CA3741	24CA3744	24CA3747	24CA3013	24CA3014	24CA3015
MOTOR, 460V	24CA3741	24CA3744	24CA3747	24CA3013	24CA3014	24CA3015
MOTOR, 575V	24CA3742	24CA3745	24CA3748	24CA2955	24CA2959	24CA2963
OPEN DRIP PROOF (60 HZ – ODP – HIGH EFFICIENCY)						
MOTOR, 200V	24CA3755	24CA3758	24CA3761	24CA2968	24CA2972	24CA2976
MOTOR, 230V	24CA3756	24CA3759	24CA3762	24CA3017	24CA3018	24CA3019
MOTOR, 460V	24CA3756	24CA3759	24CA3762	24CA3017	24CA3018	24CA3019
MOTOR, 575V	24CA3757	24CA3760	24CA3763	24CA2971	24CA2975	24CA2979
TOTALLY ENCLOSED FAN COOLED (60 HZ – TEFC)						
MOTOR, 200V	24CA3770	24CA3773	24CA3776	24CA2984	24CA2988	24CA2992
MOTOR, 230V	24CA3771	24CA3774	24CA3777	24CA3021	24CA3022	24CA3023
MOTOR, 460V	24CA3771	24CA3774	24CA3777	24CA3021	24CA3022	24CA3023
MOTOR, 575V	24CA3772	24CA3775	24CA3778	24CA2987	24CA2991	24CA2995
TOTALLY ENCLOSED FAN COOLED (60 HZ – TEFC – HIGH EFFICIENCY)						
MOTOR, 200V	24CA3785	24CA3788	24CA3791	24CA2996	24CA3000	24CA3004
MOTOR, 230V	24CA3786	24CA3789	24CA3792	24CA3024	24CA3025	24CA3026
MOTOR, 460V	24CA3786	24CA3789	24CA3792	24CA3024	24CA3025	24CA3026
MOTOR, 575V	24CA3787	24CA3790	24CA3793	24CA2999	24CA3003	24CA3007

MOTOR GROUP (FAN MOTORS)

AIR COOLED FAN MOTOR (COOLING MODULE) (T.E.F.C., 3 HP, 1200 RPM, 60 HZ, 1.33 S.F.)

VOLTAGE	P/N
MOTOR, 200V	24CA4259
MOTOR, 230V	24CA4260
MOTOR, 460V	24CA4260
MOTOR, 575V	24CA4261

WATER COOLED FAN MOTOR (ENCLOSURE VENT FAN) (T.E.F.C., 1200 RPM, 60 HZ, 1.0 S.F.)

VOLTAGE	P/N
MOTOR, 200V	24CA4177
MOTOR, 230V	24CA2464
MOTOR, 460V	24CA2464
MOTOR, 575V	24CA4178

* EBM AND EPB PACKAGES ONLY. EAP PACKAGES ARE ONLY OFFERED AS WYE DELTA.

IDENTIFICATION AND INSTRUCTION GROUP

Ref. No.	Name of Part	Qty.	Part No.
1	DECAL, OPERATION & MAINTENANCE	1	217ECM077
2	DECAL, WARNING	1	227EAQ077
3	DECAL, PARTS LIST/SERVICE MANUAL #	1	204EDE077
4	DECAL, WARNING – ELECTRICAL SHOCK	1	216EAQ077
5	DECAL, DANGER – DO NOT MODIFY	1	218EAQ077
6	DECAL, WARNING – ELECTRICAL SHOCK	1	213EAQ077
7	DECAL, WARNING – READ OPERATOR MANUAL	1	215EAQ077
8	DECAL, CAUTION – USE FLOOR PLATE	1	221EAQ077
9	DECAL, WARNING – SEE WIRING DIAGRAM	1	222EAQ077
10	DECAL, DANGER – HOT OIL UNDER PRESSURE	1	212EAQ077
11	DECAL, WARNING – INSPECT OIL RESERVOIR	1	217EAQ077
12	DECAL	1	243EAQ077
13	DECAL, NOTICE – USE GARDNER DENVER PARTS	1	214EAQ077
14	DECAL, NOTICE – USE GARDNER DENVER PARTS	1	214EAQ077
15	DECAL, CAUTION – DO NOT LIFT	1	208EAQ077
16	DECAL, WARNING – ROTATING MACHINERY	1	211EAQ077
17	DECAL, DANGER – DO NOT BREATHE	1	206EAQ077
18	DECAL, DRAIN MOISTURE DAILY	1	205ESO077
19	DECAL, GARDNER DENVER LOGO	1	69F18
20	RIVET	4	70E13
21	DECAL, HEAT EXCHANGER "IN"	1	200ESP077
22	DECAL, HEAT EXCHANGER "OUT"	1	201ESP077
23	DECAL, SAVER II LOGO	1	201ECP077
24	DECAL, SAVER II LOGO	3	200ECP077
25	TAG–INSTRUCTION	1	203EAQ304
26	DECAL, NAMEPLATE	1	69F64
28	DECAL	1	240EAQ077
29	DECAL	1	251EAQ077
30	TAG–INSTRUCTION	1	204EAQ304
31	TAG–INSTRUCTION	1	205EAQ304

REPAIR KITS

Name of Part	Qty.	Part No.
ROUTINE MAINTENANCE KIT – HEAVY DUTY AIR FILTER		202ECM6013
(Includes next two items)		
ELEMENT, AIR FILTER	2	2116713
ELEMENT, OIL FILTER	3	2116110
PERIODIC MAINTENANCE KIT (INLET VALVE) (Includes next five items)		302SSM6013
O–RING	1	25BC447
SPRING	1	78G19
SPRING	1	78W63
O–RING	1	25AM29
RETAINER RING	1	74D88
SEPARATOR KIT (Includes next three items)		208EAP6013
OIL SEPARATOR	1	200ECM035
GASKET	1	25C1788N
LUBRICANT	1	2116755
PNEUMATIC CONTROLS & GAUGES (Includes next five items)		302EAQ6013
CHECK VALVE	2	90AR261
CONTROL VALVE	2	90AR1034
CONTROL VALVE	1	90AR1082
PRESSURE REGULATOR	1	88H139
PRESSURE GAUGE	1	2116732
ELECTRICAL CONTROL KIT (Includes next six items)		206EAP6013
SOLENOID VALVE	1	91B70
SOLENOID VALVE	1	91B80
SOLENOID VALVE	1	91B81
THERMISTOR PROBE	2	21D264
TRANSDUCER	1	88H242
VACUUM SWITCH	1	88H195
DRIVE COUPLING KIT (Includes next item)	1	ECK77781
CUSHIONS (Includes 6)		2109116
LUBRICANT (AEON 9000 SP)		
5–GALLON PAIL	1	28H109
55–GALLON DRUM	1	28H110
TOUCH–UP PAINT, WHITE		
5–GALLON PAIL	1	28H76
1–GALLON CAN	1	28H84
1–QUART CAN	1	28H83
WATER TEMPERATURE REGULATOR (Optional)		90AR326
MAGNETIC WATER SHUTOFF VALVE – NEMA 4 (Optional)		ECH75596

REPAIR KITS (Continued)

Name of Part	Qty.	Part No.
PERIODIC OVERHAUL KIT (SSM AIR END) (Includes next seven items)		303SSM6013
GASKET KIT (SEE BELOW)	1	304SSM6013
OIL SEAL KIT (SEE BELOW)	1	302SSH6013
ROLLER BEARING	1	12BA92
ROLLER BEARING	1	12BA94
ROLLER BEARING	1	12W34
ROLLER BEARING	1	12BA93
SPRING	1	78W53
GASKET KIT (SSM AIR END) (Includes next five items)		304SSM6013
PERIODIC MAINTENANCE KIT (SEE ABOVE)	1	302SSM6013
SHIM SET (SHAFT)	1	77H56
SHIM SET	1	77H57
GASKET (AIR END TO DISCHARGE MANIFOLD)	1	25C1230N
GASKET ELIMINATOR	1	25BC222
PERIODIC OVERHAUL KIT (SSH AIR END) (Includes next seven items)		303SSH6013
GASKET KIT (SEE BELOW)	1	304SSH6013
OIL SEAL KIT (SEE BELOW)	1	302SSH6013
ROLLER BEARING	1	12BA91
ROLLER BEARING	1	12BA90
ROLLER BEARING	1	12BA130
ROLLER BEARING	1	12BA136
SPRING	1	78W48
GASKET KIT (SSH AIR END) (Includes next five items)		304SSH6013
PERIODIC MAINTENANCE KIT (SEE ABOVE)	1	302SSM6013
SHIM SET (SHAFT)	1	77H54
SHIM SET	1	77H53
GASKET (AIR END TO DISCHARGE MANIFOLD)	1	25C1230N
GASKET ELIMINATOR	1	25BC222
OIL SEAL KIT (SSH AND SSM AIR ENDS) (Includes next seven items)		302SSH6013
WEAR SLEEVE	1	80M12
OIL SEAL	1	60DD679
OIL SEAL	1	60DD690
O–RING	1	8502140
O–RING	1	25BC165
GASKET ELIMINATOR	1	25BC222
CHECK VALVE	1	90AR923
WEAR SLEEVE INSTALLATION / REMOVAL KIT (SSH and SSM Air Ends) (Includes next seven items)		200SSH4017
PULLER	1	200SSH219
PLATE–PULLER	1	200SSH340
SCREW	1	75LM192
SCREW	1	655ED120
SCREW	2	75D176
GUIDE	1	200SSH450
TOOL	1	200SSH074

ITEM 5

Air Compressor Receiver Tank

Ancillaries

Bronze Safety Valves
Automatic Electric Timed Valves
Compressed Air Filters
Regulators
Gauges

SILVAN INDUSTRIES Inc.

2121 Cleveland Avenue
Marinette, Wisconsin 54143
(715) 735-9311

Industrial Air Receiver Tanks

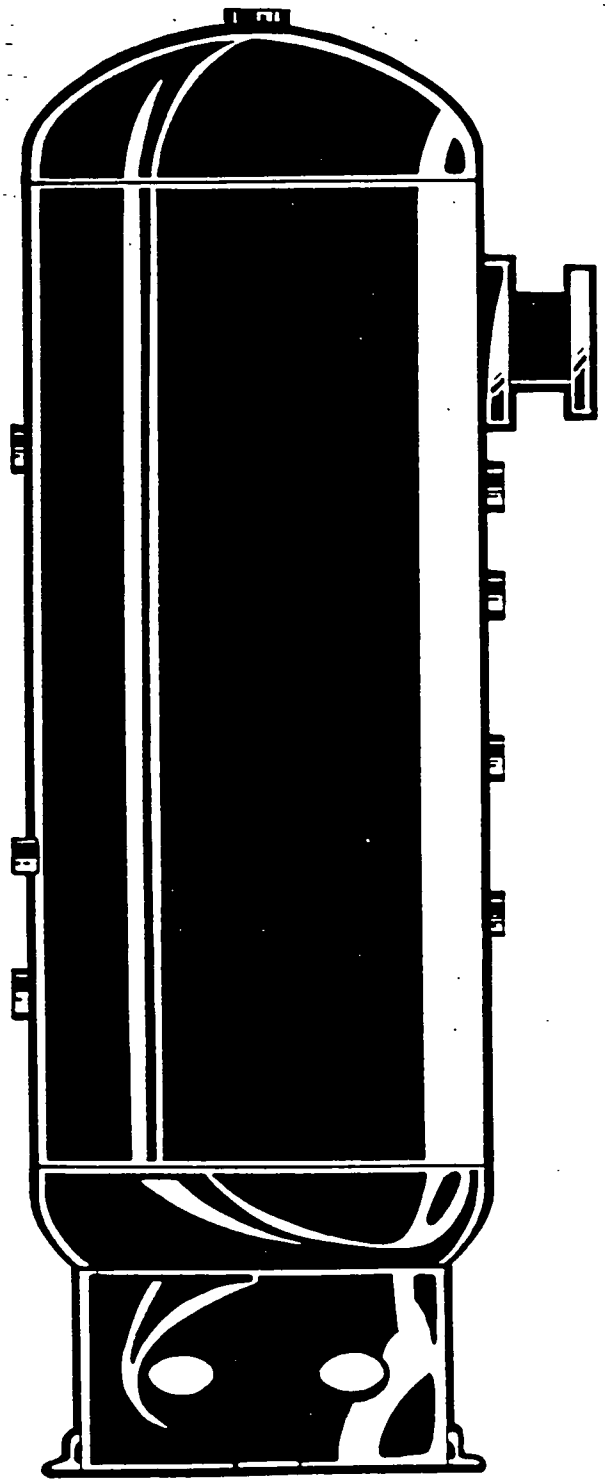
Silvan supplies Industrial Air Receiver Tanks in two basic designs. Both are designs for A.S.M.E. approved tanks, manufactured from mild carbon steel, shot blasted to commercial tolerance and provided with a primer paint coating. They are available in these configurations:

- *Diameters from 24 to 72 inches*
- *Capacities from 120 to 3,750 gallons*
- *Tank only (91 Series)*
- *Tank with 12 inch base ring (92 Series)*

How to order:

*Each type of tank carries a **Silvan Stock Number.** For example, **92-54-1550-150** The **92** indicates a 92 Series tank (supplied with a 12 inch base ring) . . . the **54** refers to the tank's diameter in inches . . . the **1550** indicates the tank's capacity in gallons . . . and the **150** means the tank is rated for a working pressure of 150 pounds per square inch.*

To order, simply select the tank diameter that meets your requirements, check to see what capacities are available with the diameter you've chosen, select Design 'A' or 'B', or 'C', and determine how you want your tank supplied . . . tank only (91 Series) or with base ring (92 Series). Once you've made your selection, call Silvan at 800-AIR-TANK and give us the Silvan Stock Number, quantity and shipping information for the tanks you want. We'll do the rest.



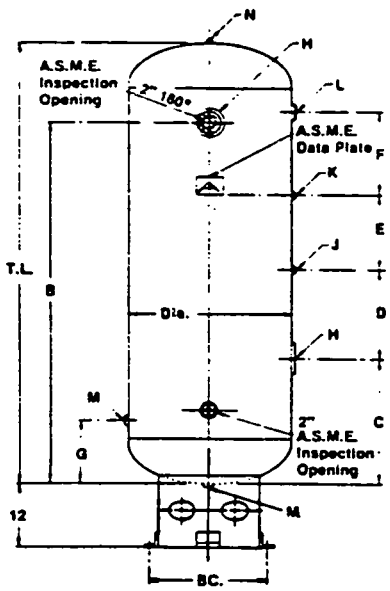
For all your stock and custom tank requirements, call Silvan first . . . 800-AIR-TANK.

Manufacturers of Tanks and Code Pressure Vessels . . . D.O.T. Tanks • Halon Vessels • Oil Separators • Air Receivers

Industrial Air Receiver Tanks

	Dia.	T.L.	B.C.	B	C	D	E	F	G	H	J	K	L	M	N	Nom. Cap. Gals.	Work. Pres. P.S.I.	Catalog Number
		Nominal Dimensions: Inches								N.P.T. Openings								
A	24	68¼		58	16	13½	15	15⁹⁄₁₆	9½	3	1	¼	¾	1	½	125	150	91-24-125-150
		68¼	16½	58	16	13½	15	15⁹⁄₁₆	9½	3	1	¼	¾	1	½	125	150	92-24-125-150
	36	92		77	21	29¾	14	13¼	13	3	1	¼	1	1	½	400	137	91-36-400-137
		92	21½	77	21	29¾	14	13¼	13	3	1	¼	1	1	½	400	137	92-36-400-137
	36	92		75¾	20¾	30	14	13¼	13	3	½	¼	1½	1	½	400	200	91-36-400-200
		92	21½	75¾	20¾	30	14	13¼	13	3	½	¼	1½	1	½	400	200	92-36-400-200
B	42	113		93⅜	26⅛	13½	13½	32⅞	41⅛	3	¾	¾		1	2	620	150	91-42-620-150
		113	35	93⅜	26⅛	13½	13½	32⅞	41⅛	3	¾	¾		1	2	620	150	92-42-620-150
	48	144		114⅜	29⅝	17	17	38⅛	45¾	6" 150#	¾	¾		1	2	1040	150	91-48-1040-150
		144	42	114⅜	29⅝	17	17	38⅛	45¾	6" 150#	¾	¾		1	2	1040	150	92-48-1040-150
	54	168		127	45½	25	20	41	41	6" 150#	¾	2		1	2	1550	150	91-54-1550-150
		168	42	127	45½	25	20	41	41	6" 150#	¾	2		1	2	1550	150	92-54-1550-150
	60	192		152½	45½	38	25	41	41	6" 150#	¾	2		1	2	2200	150	91-60-2200-150
		192	42	152½	45½	38	25	41	41	6" 150#	¾	2		1	2	2200	150	92-60-2200-150
	66	216⅝	54	164⁹⁄₁₆	56⁹⁄₁₆	36	25	47¾	47¾	8" 150#	¾	2		1	2	3000	150	92-66-3000-150
	72	229¾	54	180	60	40	30	50	50	8" 150#	¾	2		1	2	3750	150	92-72-3750-150
C	24	65	16½	8¹³⁄₁₆	22⁹⁄₁₆	24⁹⁄₁₆	47¹³⁄₁₆			2	1½	¼	¾	1	1½	120	200	92-24-120-200
	30	74	21½	11½	24½	26½	51			2	2	¼	¾	1	1½	200	200	92-30-200-200
	30	83¾	21½	12½	30¼	28½	59¾			2	2	¼	¾	1	1½	240	200	92-30-240-200

A



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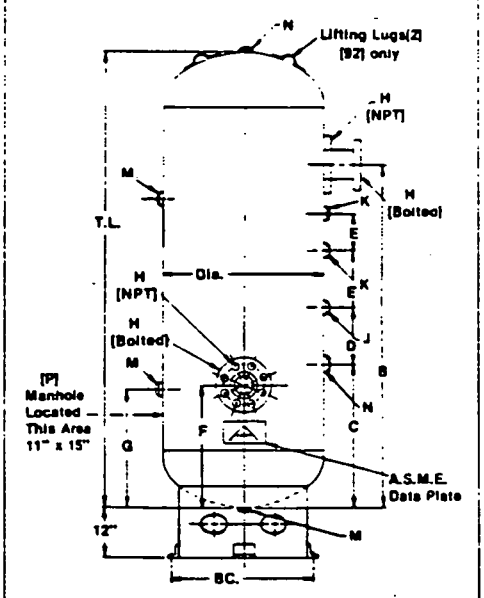

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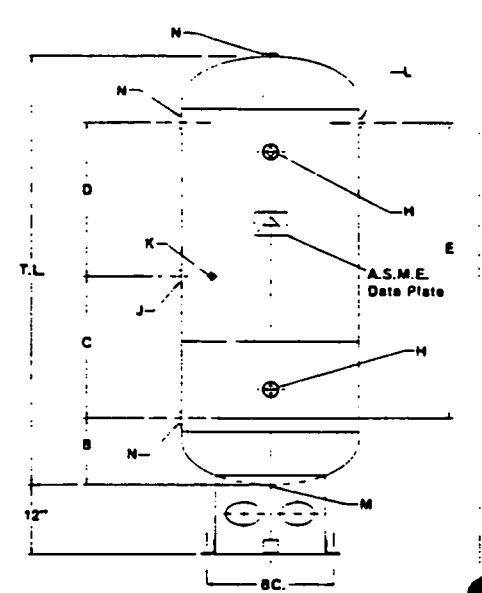


All industrial air receivers are available less ring base (91) or complete as illustrated (92). (93) 6" ht. base ring optional.

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(Alternative Form for Single Chamber, Completely Shop-Fabricated Vessels Only)
As Required by the Provisions of the ASME Code Rules, Section VIII, Division 1

Job 12683

1. Manufactured and certified by SILVAN INDUSTRIES, INC., 2121 Cleveland Avenue, Marinette, WI 54143
(Name and address of manufacturer)

2. Manufactured for Silvan STD Model
(Name and address of purchaser)

3. Location of installation Unknown
(Name and address)

4. Type: Vertical (Horiz. or vert. tank) | 294701-294720 (Mfg's serial No.) | (CRN) | 102-762 R.A (Drawing no.) | 294701-294720 (Nat'l Bd. No.) | 1999 (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1 1998 (Year)

to 1998 (Addenda (Date)) | 2290 (Code Case Nos.) | None (Special Service per UG 120(d))

6. Shell: SA414 GrG (Mat'l (Spec. No., Grade)) | .187 (Nom. Thk. (in.)) | 0 (Corr. Allow. (in.)) | 3' 0" OD (Diam. I.D. (ft. & in.)) | 5' 10-3/8" (Length (overall) (ft. & in.))

7. Seams: Type 1 (Long. (Welded, Dbl., Sngl., Lap, Butt)) | None (R.T. (Spot or Full)) | 70 (Eff. (%)) | No (H.T. Temp (F)) | No (Time (hr)) | Type 2 (Girth (welded, Dbl., Sngl., Lap, Butt)) | None (R.T. (Spot, Partial, or Full)) | 1 (No. of Courses)

8. Heads: (a) Matl. SA414 GrG (Spec No., Grade) (b) Matl. SA414 GrG (Spec No., Grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	Top	.187	0			2:1				concave
(b)	Bottom	.187	0			2:1				concave

If removable, bolts used (describe other fastenings) None
(Matl., Spec. No., Gr., Size, No.)

9. MAWP 150 psi at max. temp. 450 °F

Min. design metal temp. -20 °F at 150 psi. Hydro., ~~Pneu.~~, or ~~Comb.~~ test pressure 195 psi

10. Nozzles, inspection and safety valve openings:

Purpose (Inlet, Outlet, Drain)	No.	Diam. or Size	Type	Mat'l.	Nom. Thk.	Reinforcement Mat'l.	How Attached	Location
Inlet/Outlet	1,1	1/4", 1/2"	Flg	SA181	STD	Inherent	Weld	
Inlet/Drain	4	1"	"	"	"	"	"	
Inlet/Outlet	2	3"	Cplg	SA105	300#	"	"	
Insp	2	2"	Flg	SA181	STD	"	"	Shell

11. Supports: Skirt 0 (Yes or no) Lugs 0 (No.) Legs 0 (No.) Other Base Ring (Describe) Attached Head/Weld (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of this report:
(Name of part, item number, Mfgr's name and identifying stamp)

ASME Air Receiver
Pressure Relief Valve Supplied by Other Than Mfgr
"CONSTRUCTED UNDER THE PROVISIONS OF PAR. UG90(c)(2), UG79, UG20(f)"

CERTIFICATE OF SHOP COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME Code for Pressure Vessels, Section VIII, Division 1. "U" Certificate of Authorization No. 16,802 expires June 13, 2000.

Date 6/11/99 Co. Name SILVAN INDUSTRIES, INC. (Manufacturer) Signed Sue McGowan (Representative)

CERTIFICATE OF SHOP INSPECTION

Vessel constructed by SILVAN INDUSTRIES, INC. at Marinette, WI 54143

I, the undersigned, holding a valid commission issued by The National Board of Boiler and Pressure Vessel Inspectors and the State or Province of WI and employed by Hartford Steam Boiler Inspection & Insurance Co. Hartford, CT have inspected the component described in this Manufacturer's Data Report on June 11 1999 and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date 6/14/99 Signed R.Rowe (Authorized Inspector) Commissions N.B.#10105A WIS#100181 (Nat'l Board (incl. endorsements) State, Prov. and No.)

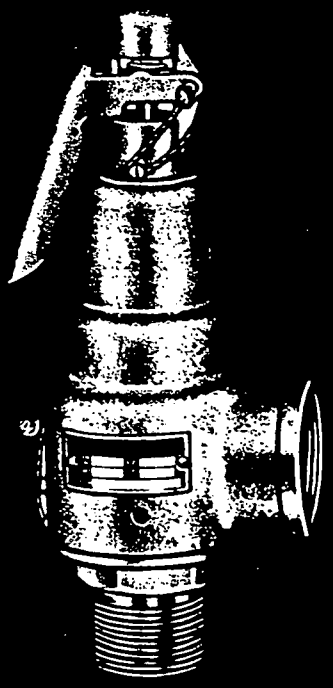
KUNKLE®
Valve Division

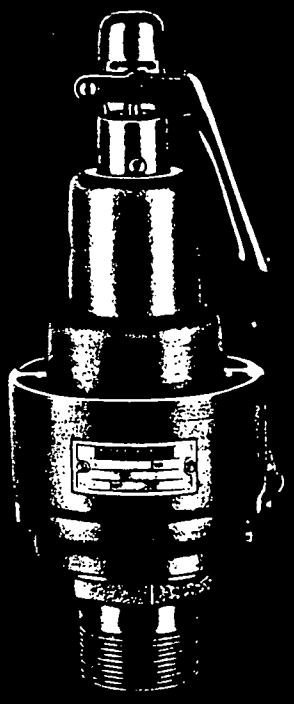
MODEL
6000
SERIES

BRONZE SAFETY VALVES

FOR AIR, GAS, STEAM SERVICE

3/4" 6010EA

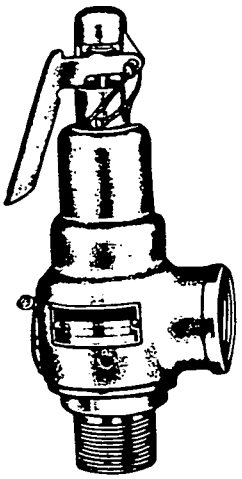




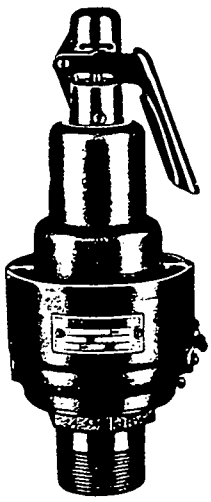
KUNKLE®
Valve Division

BRONZE SAFETY VALVES FOR AIR, STEAM, NON-HAZARDOUS GAS

MODEL 6000 SERIES



MODELS
6010-6021-6030
6221-6230-6283



MODELS
6121-6130
6182-6186

PRESSURE LIMITS

Steam to 250 PSIG 406°F
Air/Gas to 300 PSIG 300°F
Models 6030, 6130,6230 to 300 PSIG Steam 422°F
Model 6186 to 150 PSIG Air/Gas 300°F

APPLICATIONS

- Steam Boilers and Generators.
- Air/Gas Compressors — reciprocating or rotary — portable or stationary, intercoolers and aftercoolers.
- Pressure Vessels — containing steam, air or non-hazardous gas. Including tanks, receivers, sterilizers and autoclaves.
- Pressure Reducing Valves — protection of the discharge or low pressure side of system.

FEATURES

Valve housing is heavy duty casting. Wide hex on valve body provides clearance for easy installation. Seats lapped to optical flatness. Dual control rings offer easy adjustability for precise opening with minimum preopen or simmer and exact blowdown control. Ball bearing pivot between disc and spring corrects misalignment and compensates for spring side thrust. Grooved piston type disc reduces sliding area and friction. Heavy duty lift lever assembly. Every valve is 100% tested/inspected for pressure setting, blowdown and leakage. All adjustments are factory sealed to prevent tampering or dis-assembly. Models 6021, 6121, 6221 and 934 offer teflon (PFA) disc insert for exceptional leak free performance (Use on steam only) Models 6030, 6130, 6230 and 935 supplied with stainless steel disc and nozzle for use on severe applications and/or set pressure up to 300 psi.

MODEL 6010	Side outlet. Full nozzle design with Bronze/Brass trim.
MODEL 6021	Same as 6010 with Teflon (PFA) Disc Insert. For exceptional leak free performance. (Use on steam only).
MODEL 6030	Same as 6010 except S/S Trim. (Nozzle and Disc).
MODEL 6182	Top outlet. Full nozzle design with Bronze/Brass trim. Replaces Model 82-4.
MODEL 6121	Same as 6182 with Teflon (PFA) Disc Insert. For exceptional leak free performance. (Use on steam only).
MODEL 6130	Same as 6182 except S/S Trim. (Nozzle and Disc).
MODEL 6186	Top outlet. Full nozzle design with Bronze/Brass trim. 150 PSI Maximum set pressure. Replaces Model 86. (Original Equipment Only).
MODEL 6283	Side outlet. Full nozzle design with Bronze/Brass trim. Replaces Model 83-4.
MODEL 6221	Same as 6283 with Teflon (PFA) Disc Insert. For exceptional leak free performance. (Use on steam only).
MODEL 6230	Same as 6283 except S/S Trim. (Nozzle and Disc).
MODEL 933	Same as 6010 except Certified for ASME code Sec. IV-Low Pressure Steam Heating Boilers set 15 PSIG only.
MODEL 934	Same as 6021 except Certified for ASME code Sec. IV-Low Pressure Steam Heating Boilers set 15 PSIG only.
MODEL 935	Same as 6030 except Certified for ASME code Sec. IV-Low Pressure Steam Heating Boilers set 15 PSIG only.

V HV UV

ASME Standard — N.B. Certified

DIMENSIONS/SPECIFICATIONS

MODEL NO.	INLET MALE NPT	ORIFICE	OUTLET FEMALE NPT	A	B	C	APPROX. WT. LBS.
60**DC	½	D	¾	6½	1⅝	2⅛	1½
60**DD	¾	D	¾	6½	1⅝	2⅛	1¾
61**DC	½	D	—	6½	—	—	1¼
60**ED	¾	E	1	7½	1¾	2⅜	2½
60**EE	1	E	1	7⅝	1¾	2½	2¾
61**ED	¾	E	—	7½	—	—	2¼
62**ED	¾	E	1¼	7½	1¾	2⅞	2¾
60**FE	1	F	1¼	8½	2	2⅝	3½
60**FF	1¼	F	1¼	8¾	2	2⅞	3¾
61**FE	1	F	—	8½	—	—	3¼
62**FE	1	F	1½	8½	2	2⅞	3¾
60**GF	1¼	G	1½	9⅝	2⅜	3⅛	5½
60**GG	1½	G	1½	10	2⅜	3⅜	5¾
61**GF	1¼	G	—	9⅝	—	—	5
62**GF	1¼	G	2	9⅝	2¼	3⅜	5¾
60**HG	1½	H	2	10⅝	2¾	3⅝	7¾
60**HH	2	H	2	11⅛	2¾	4⅛	8
61**HG	1½	H	—	10⅝	—	—	7¼
62**HG	1½	H	2½	10⅝	3	3⅞	8
60**JH	2	J	2½	13⅝	3⅜	4¼	15½
60**JJ	2½	J	2½	14	3⅜	4½	15¾
61**JH	2	J	—	13⅝	—	—	15
62**JH	2	J	3	13⅝	3⅜	4⅝	15½

** Replace asterick with desired model number.

Model 6030 available only ½" x ¾", ¾ x 1", 1" x 1¼", 1¼" x 1½", 1½" x 2" and 2" x 2½".

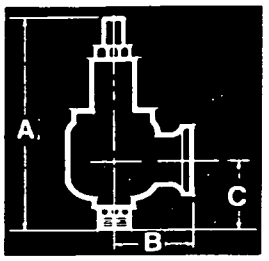
Models 933, 934 and 935 have same dimensions as model 6010.

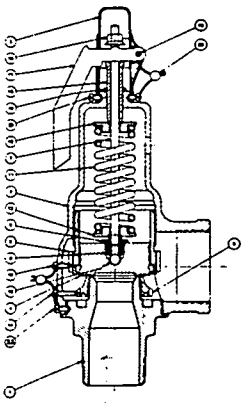
PARTS AND MATERIALS

NO.	PART NAME	MATERIAL
1	Nozzle	Bronze/Brass/St. St'l.
2	Body	Bronze①
3	Cap-Plain Lift	Brass
4	Disc	Brass/St. St'l.
5	Warn Ring	Brass
6	Control Ring	Brass
7	Stem	Brass
8	Retainer	Brass
9	Locknut-Retainer	Brass
10	Ball	Stainless Steel
11	Spring	Stainless Steel
12	Spring Step	Brass
13	Screw-Compression	Brass
14	Screw-Warn Ring	Steel/Pltd.
15	Screw-Control Ring	Steel/Pltd.
16	Lift Nut	Steel/Pltd.
17	Lever	Steel/Pltd.
18	Rivet	Steel
19	Locknut-Comp. Scr.	Brass
20	Screw-Plain Lift Cap	Steel/Pltd.
21	Drive Screw	Steel/Pltd.
22	Seal	Lead & Wire
23	Screw-Body	Steel/Pltd.
24	Spring Vib. Damp.②	Bronze
25	Nameplate	Aluminum
26	Spring Warn Ring	Stainless Steel

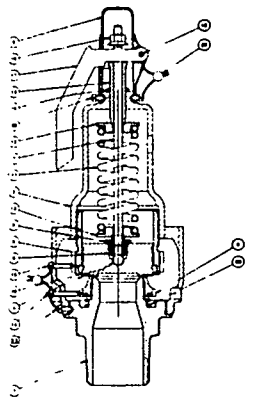
①Cast Iron Body may be furnished at our option.

②Optional at extra cost.

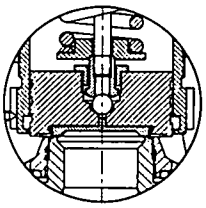




MODELS
6010-6030-6230
6283-933-935



MODELS
6130-6182
6186



Disc Assembly
Models 6021, 6121, 6221
and 934

MODEL NUMBER/ORDER GUIDE

MODEL NO. POSITION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
EXAMPLE	6	0	1	0	H	G	0	1	—	A	M	0	1	5	0
	6	0	2	1											
	6	0	3	0											
	6	1	8	2											
	6	1	2	1											
	6	1	3	0											
	6	1	8	6											
	6	2	8	3											
	6	2	2	1											
	6	2	3	0											
	0	9	3	3											
	0	9	3	4											
	0	9	3	5											

SET PRESSURE, i.e.
0005 — 5 PSIG.
0025 — 25 PSIG.
0300 — 300 PSIG.

SPRING MATERIAL
M — Stainless Steel

VALVE SERVICE
A — Steam ASME Sec. I.
K — Air/Gas ASME Sec. VIII.
L — Steam ASME Sec. VIII.
G — Steam ASME Sec. IV.
(Models 933, 934 & 935 only.)

DESIGN REVISION
Indicates Non-Interchangeable Revision. Dash (-) If Original Design.

ORIFICE
D G
E H
F J

INLET SIZE
C — ½" G — 1½"
D — ¾" H — 2"
E — 1" J — 2½"
F — 1¼"

VARIATION (01 thru 99)
Number Provided Only by Kunkle to Cover Specific Feature or Option.

IMPORTANT: Kunkle Valve Division is not liable for any damage resulting from misuse or misapplication of its products (see warranty).

KUNKLE®
Valve Division

STEAM/AIR RELIEVING CAPACITIES 6000 SERIES

To correct capacities for superheat or temperature other than 60°F, see Engineering Catalog.

Orifice	D			E			F			G			H			J		
Area	.121 Sq. In.			.216 Sq. In.			.338 Sq. In.			.554 Sq. In.			.863 Sq. In.			1.414 Sq. In.		
Set Press. PSIG	Lbs./Hr. Steam (V)	Lbs./Hr. Steam (UV)	SCFM Air (UV)	Lbs./Hr. Steam (V)	Lbs./Hr. Steam (UV)	SCFM Air (UV)	Lbs./Hr. Steam (V)	Lbs./Hr. Steam (UV)	SCFM Air (UV)	Lbs./Hr. Steam (V)	Lbs./Hr. Steam (UV)	SCFM Air (UV)	Lbs./Hr. Steam (V)	Lbs./Hr. Steam (UV)	SCFM Air (UV)	Lbs./Hr. Steam (V)	Lbs./Hr. Steam (UV)	SCFM Air (UV)
10	133	152	54	237	271	96	371	423	151	607	694	247	946	1081	385	1550	1771	630
15	157	179	64	281	319	114	440	500	178	721	819	292	1123	1276	454	1840	2091	744
20	182	206	73	325	368	131	509	576	205	835	944	336	1300	1471	524	2131	2410	858
25	207	234	83	370	417	148	579	653	232	948	1070	381	1478	1666	593	2421	2730	972
30	232	261	93	414	466	166	648	729	259	1062	1195	425	1655	1861	663	2711	3050	1086
35	257	291	104	458	520	185	717	813	289	1176	1333	474	1832	2076	739	3001	3401	1211
40	282	321	114	503	573	204	787	897	319	1290	1470	523	2009	2291	815	3292	3753	1336
45	307	351	125	547	627	223	856	981	349	1403	1608	572	2186	2505	892	3582	4105	1461
50	331	381	136	592	681	242	926	1065	379	1517	1746	621	2363	2720	968	3872	4456	1586
55	356	411	146	636	734	261	995	1149	409	1631	1884	671	2540	2934	1045	4163	4808	1711
60	381	442	157	680	788	281	1064	1233	439	1745	2022	720	2718	3149	1121	4453	5160	1837
65	406	472	168	725	842	300	1134	1317	469	1858	2159	769	2895	3364	1197	4743	5511	1962
70	431	502	179	770	896	319	1205	1401	499	1974	2297	818	3076	3578	1274	5039	5863	2087
75	457	532	189	815	949	338	1276	1486	529	2091	2435	867	3258	3793	1350	5338	6215	2212
80	482	562	200	861	1003	357	1347	1570	559	2209	2573	916	3440	4008	1426	5637	6566	2337
85	508	592	211	907	1057	376	1419	1654	589	2326	2710	965	3623	4222	1503	5936	6918	2462
90	534	622	221	952	1110	395	1490	1738	619	2443	2848	1014	3805	4437	1579	6235	7270	2588
95	559	652	232	998	1164	414	1562	1822	648	2560	2986	1063	3988	4651	1656	6534	7621	2713
100	585	682	243	1044	1218	434	1633	1906	678	2677	3124	1112	4170	4866	1732	6833	7973	2838
105	610	712	254	1089	1272	453	1705	1990	708	2794	3262	1161	4353	5081	1808	7132	8325	2963
110	636	742	264	1135	1325	472	1776	2074	738	2911	3399	1210	4535	5295	1885	7431	8676	3088
115	661	773	275	1181	1379	491	1848	2158	768	3029	3537	1259	4718	5510	1961	7730	9028	3213
120	687	803	286	1226	1433	510	1919	2242	798	3146	3675	1308	4900	5725	2038	8029	9380	3339
125	713	833	296	1272	1487	529	1991	2326	828	3263	3813	1357	5083	5939	2114	8328	9731	3464
130	738	863	307	1318	1540	548	2062	2410	858	3380	3950	1406	5265	6154	2190	8627	10080	3589
135	764	893	318	1364	1594	567	2134	2494	888	3497	4088	1455	5448	6368	2267	8926	10430	3714
140	789	923	329	1409	1648	586	2205	2578	918	3614	4226	1504	5630	6583	2343	9225	10780	3839
145	815	953	339	1455	1701	606	2277	2662	948	3731	4364	1553	5813	6798	2420	9524	11130	3964
150	841	983	350	1501	1755	625	2348	2746	978	3849	4502	1602	5995	7012	2496	9823	11480	4090
160	892	1043	371	1592	1863	663	2491	2915	1037	4083	4777	1700	6360	7442	2649	10420	12190	4340
170	943	1104	393	1683	1970	701	2634	3083	1097	4317	5053	1798	6725	7871	2802	11010	12890	4590
180	994	1164	414	1775	2077	739	2777	3251	1157	4551	5328	1897	7090	8300	2954	11610	13590	4841
190	1045	1224	436	1866	2185	778	2920	3419	1217	4786	5604	1995	7455	8729	3107	12210	14300	5091
200	1096	1284	457	1957	2292	816	3063	3587	1277	5020	5879	2093	7820	9159	3260	12810	15000	5341
210	1148	1344	478	2049	2400	854	3206	3755	1337	5254	6155	2191	8185	9588	3413	13410	15700	5592
220	1199	1404	500	2140	2507	892	3349	3923	1396	5489	6430	2289	8550	10010	3565	14000	16410	5842
230	1250	1465	521	2231	2615	931	3492	4091	1456	5723	6706	2387	8915	10440	3718	14600	17110	6092
240	1301	1525	543	2323	2722	969	3634	4259	1516	5957	6981	2485	9280	10870	3871	15200	17810	6343
250	1352	1585	564	2414	2829	1007	3777	4428	1576	6191	7257	2583	9645	11300	4024	15800	18520	6593
260	1403	1645	586	2505	2937	1045	3920	4596	1636	6426	7533	2681	10000	11730	4177	16400	19220	6843
270	1455	1705	607	2597	3044	1084	4063	4764	1696	6660	7808	2779	10370	12160	4329	16990	19920	7094
280	1506	1766	628	2688	3152	1122	4206	4932	1755	6894	8084	2877	10730	12590	4482	17590	20630	7344
290	1557	1826	650	2779	3259	1160	4349	5100	1815	7128	8359	2975	11100	13020	4635	18190	21330	7594
300	1608	1886	671	2871	3367	1198	4492	5268	1875	7363	8635	3073	11460	13450	4788	18790	22030	7845
Approx. 1 PSIG Increments	5	6	2	9	11	4	14	17	6	24	28	10	37	43	15	60	70	25
Approx. 5 PSIG Increments	25	30	11	46	54	19	72	84	30	118	138	49	183	215	77	299	350	125
Approx. 10 PSIG Increments	51	60	21	92	107	38	143	168	60	235	275	98	365	430	153	598	700	250

(V) 2 PSIG or 3% Acc. ASME Sec. I Steam

(UV) 3 PSIG or 10% Acc. ASME Sec. VII Air/Gas/Steam

Valves set under 15 PSIG are not stamped with ASME Code Symbol stamp.

STEAM RELIEVING CAPACITIES MODELS 933, 934, 935 LBS./HOUR STEAM 33⅓% ACC. (HV)

Set Press. PSIG	D	E	F	G	H	J
15	190	338	530	868	1352	2215

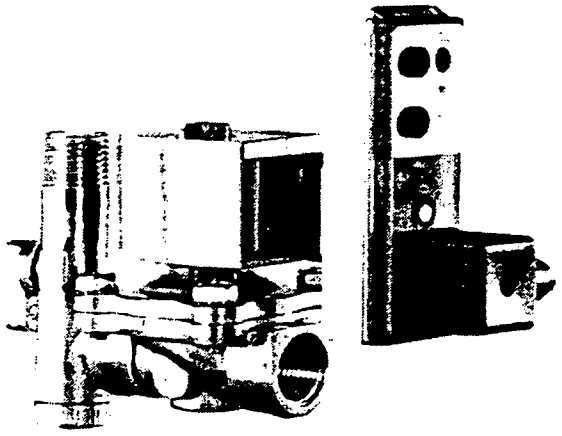
IMPORTANT: Kunkle Valve Division is not liable for any damage resulting from misuse or misapplication of its products (see warranty).

KUNKLE®
Valve Division
8222 Bluffton Road
Box 1740
Fort Wayne, Indiana 46801-1740
219-747-1533 FAX 219-747-7958

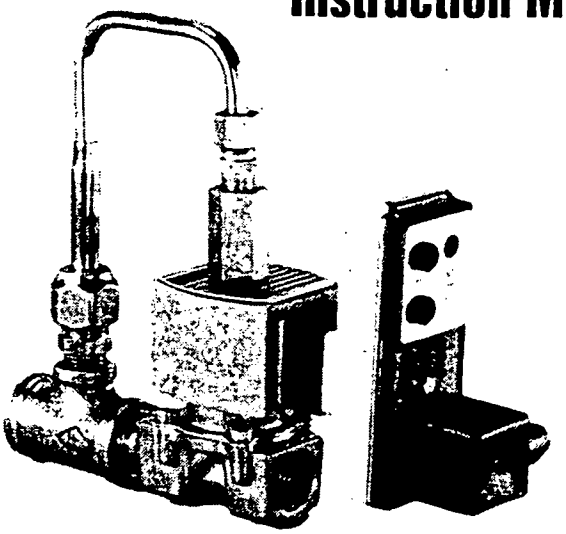
Rev. 11/91

HANKiSON®

530 SERIES AUTOMATIC ELECTRIC TIMED DRAINS Instruction Manual



MODELS 532-04-200S and 532-04-300S



MODEL 533-04-300F with integral filter

IMPORTANT
READ PRIOR TO STARTING THIS EQUIPMENT

UNPACKING

This shipment has been thoroughly checked, packed and inspected before leaving our plant. It was received in good condition by the carrier and was so acknowledged.

1) Check for Visible Loss or Damage. If this shipment shows evidence of loss or damage at time of delivery to you, insist that a notation of this loss or damage be made on the delivery receipt by the carrier's agent.

2) Check for Concealed Loss or Damage. When a shipment has been delivered to you in apparent good order, but concealed damage is found upon unpacking, notify the carrier immediately and insist on his agent inspecting the shipment. Fifteen days from receipt of shipment is the maximum time limit for requesting such inspection. Concealed damage claims are not our responsibility as our terms are F.O.B. point of shipment.

GENERAL SAFETY INFORMATION

CAUTION

1. Pressurized devices-

This equipment is a pressure containing device.

- Do not exceed maximum operating pressure as shown on equipment serial number tag.
- Make sure equipment is depressurized before working on or disassembling it for servicing.

2. Electrical-

This equipment requires electricity to operate.

- Install equipment in compliance with national and local electrical codes.

CONTENTS

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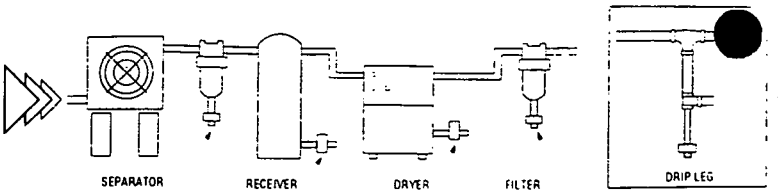
I. General

1. Function:
Automatic Electric Timed Drains are used to discharge condensate from receiver tanks, separators, dryers, filters, and drip legs.



2. Description:
Condensate is discharged by an electrically operated solenoid valve. The valve is opened and closed by a solid state electronic timer that can be adjusted within the following time limits:
Valve open, "ON" time: 1 to 15 seconds
Valve closed, "OFF" time (time between valve operations): 1 to 45 minutes

II. Installation

1. Location

- **a.** Do not install in areas where ambient temperatures are lower than 2°C, 35°F or exceed 50°C, 120°F
- **b.** Standard valve is NEMA 4. Make sure that electrical enclosure, wiring, and electrical connections are suitable for the operating environment.

2. Piping

- **a.** Remove inlet and outlet thread protectors.
- **b.** Flow direction: Install so that flow direction is in the direction of the markings on the valve body.
- **c.** Mounting: The valve will perform properly mounted in any position, however, for longest service life mount vertical and upright to reduce possibility of foreign matter accumulating in core tube area.
- **d.** Use pipe sealant or teflon tape when installing piping into inlet and outlet ports.

Note: Apply pipe compound sparingly to male pipe threads only to avoid excess compound entering valve.
Note: When tightening pipe, do not use valve as a lever. Use wrenches as close as possible to connection point.
Note: Pipe strain should be avoided by proper support and alignment of pipe.

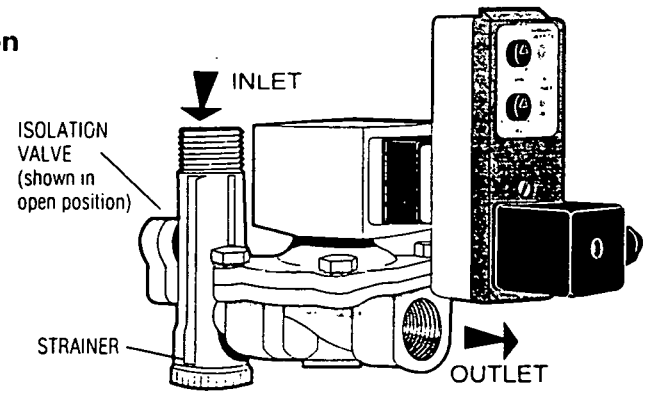
- **c.** Inlet piping:
  1) The inlet piping should not be smaller than the inlet connection to the valve so that flow is not restricted.
  2) Install drain below level of device being drained to allow condensate to flow to drain by gravity.
- **f.** Outlet piping:
  1) Piping may be run from the outlet connection of the drain to an adequate sump, condensate treatment device, or floor drain.

Note: In many cases condensate contains oil. Check regulations in your area for proper disposal methods for oil contaminated condensate.

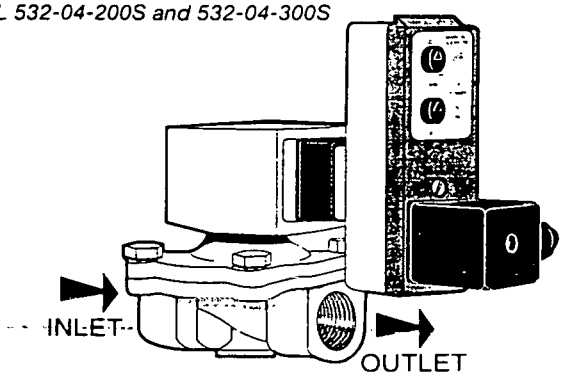
  2) Make sure that drain line is not obstructed.
  3) Liquid discharge is at system pressure and may require that the drain line be anchored.

- **g.** Models 533-04-300 - Pilot air line
  Pilot air must be supplied to the pilot port of this model. Run air line from a place in the system where air is clean (i.e. outlet of filter) to pilot port.

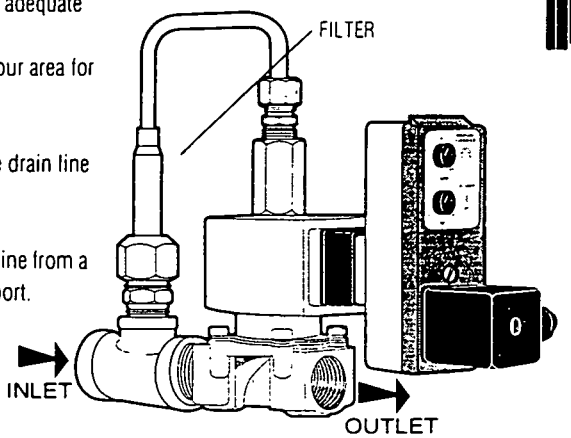
Note: Pressure to pilot port should be equal to pressure in valve.



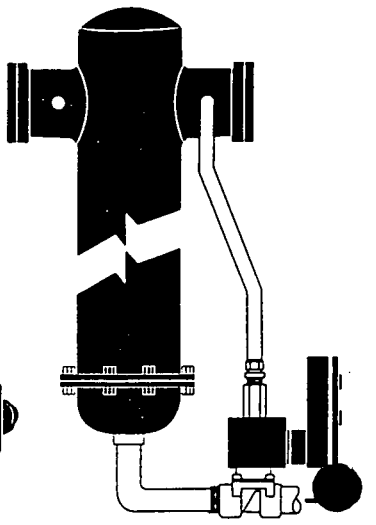
MODEL 532-04-200S and 532-04-300S



MODEL 532-02-1500



MODEL 533-04-300F with integral filter



MODEL 533-04-300 with pilot air supplied from outside source

3. Electrical connections

Note: Wiring must comply with local codes and the National Electrical Code.

a. Power supply: Make certain that power supply matches power requirements of valve as listed on the serial number tag.

b. If power cord is supplied, plug into a grounded receptacle of proper voltage.

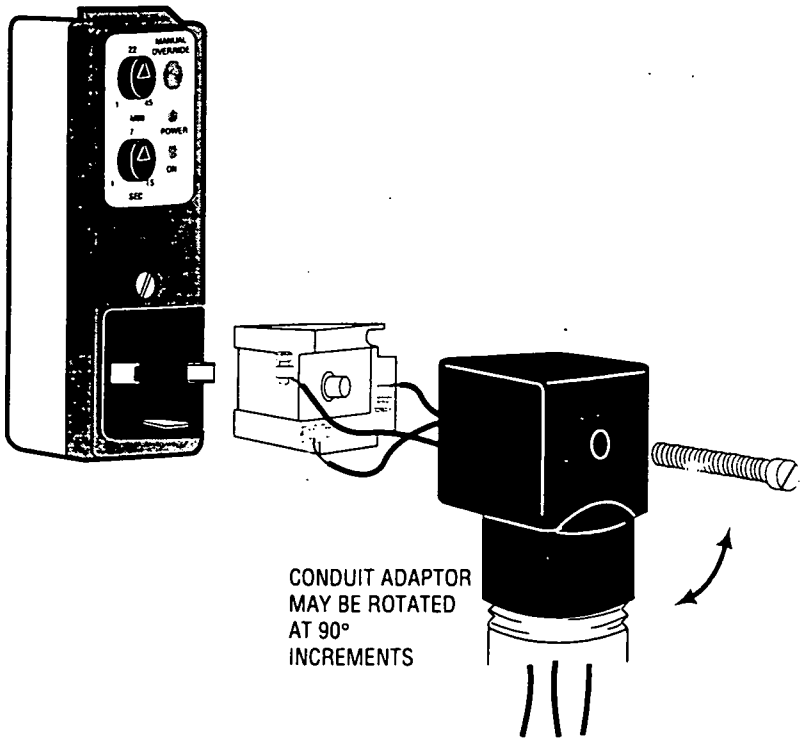
c. Optional conduit adapter: Conduit adapter may be used in place of power cord. To use:

1) Remove screw holding cord set to timer and remove.

2) Access terminal connections in conduit adapter by removing inner socket assembly from adapter housing.

3) After wiring and attaching conduit, reinstall socket assembly to adapter housing.

4) Attach conduit adapter to timer.



III. Operation

1. Timer

a. Adjusting time settings

1) Valve open time: Using knob marked "sec", turn knob until triangle on knob aligns with desired time. Use Table 1 to determine length of time valve needs to remain open to discharge the collected liquid. Amount of liquid discharged per period of time is based on line pressure ahead of valve.

Note: If you are not able to estimate the amount of liquid that collects while the valve is off, observe the drain when discharging to see if all the liquid present has been removed. This is evident if some air escapes after the liquid has been discharged and before the valve closes. If liquid is still present when valve closes, increase "on time".

If excessive air flows after liquid has been discharged, decrease "on time".

Note also that the amount of liquid present can change as operating conditions change (compressed air and ambient temperatures, flow rates, ambient relative humidity). Observe drain periodically to make certain that drain is remaining open long enough to discharge collected liquids.

2) Valve closed time:

Using knob marked "min", turn knob until triangle on knob aligns with desired time.

Note: If all liquid cannot be removed during time valve is open, increase valve "on time". If this is not possible, decrease "off time" so that less liquid collects between operations.

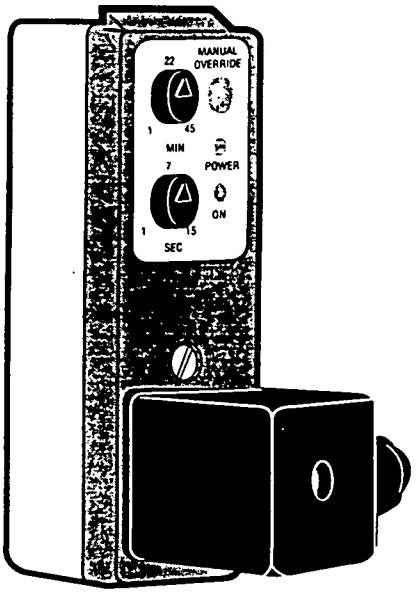
b. Manual Override - Manual override allows manual operation of the valve. To open valve, depress manual override switch.

Note: After depressing manual overide, valve will remain open for the period of time indicated by "sec" knob.

c. Status lights

1) "Power" light - light illuminates when timer is energized. If light is not illuminated, check that there is power to the drain and electrical connections are sound.

2) "On" light - light illuminates when output to solenoid coil is energized. Valve should be open when this light illuminates; if valve doesn't open, service is required.



2. Solenoid temperature

Note: Coil is designed for continuous duty service, however, when solenoid is energized for a long period, the coil enclosure becomes hot and can be touched with the hand for only an instant. This is a safe operating temperature.

3. Models 532-04-200S and 300S

Make certain that isolation valve is in open position during operation.

LIQUID DISCHARGE, LITERS/GALLONS PER OPERATION (Drains with 1/2" orifice only)

DISCHARGE TIME SECONDS	LINE PRESSURE WHEN DISCHARGING TO ATMOSPHERE					
	3.5 bar / 50 psig	7 bar / 100 psig	10.3 bar / 150 psig	14 bar / 200 psig	17.2 bar / 250 psig	21 bar / 300 psig
1	0.8 / 0.2	1.2 / 0.3	1.5 / 0.4	1.7 / 0.45	1.9 / 0.5	2.1 / 0.6
5	4.2 / 1.1	5.6 / 1.5	7.3 / 1.9	8.5 / 2.2	9.5 / 2.5	10.4 / 2.7
10	8.5 / 2.2	12.0 / 3.2	14.7 / 3.9	16.9 / 4.5	19.0 / 5.0	20.7 / 5.5
15	12.7 / 3.4	18.0 / 4.8	22.0 / 5.8	25.4 / 6.7	28.4 / 7.5	31.2 / 8.2

IV. Maintenance

CAUTION

Drain is a pressurized device. Depressurize before servicing.

Drain operates on electricity. Turn off electrical supply before servicing.

1. Models with integral isolation valve/strainer.

Periodically clean strainer.

a. Isolate strainer and valve by closing isolation valve.

b. Depressurize strainer and valve by depressing manual override.

c. Unscrew strainer cap; remove and clean strainer; reassemble

d. Open isolation valve.

2. Internally piloted valves -

Periodic cleaning is desirable. The time between cleanings varies depending on the level of contamination in the condensate.

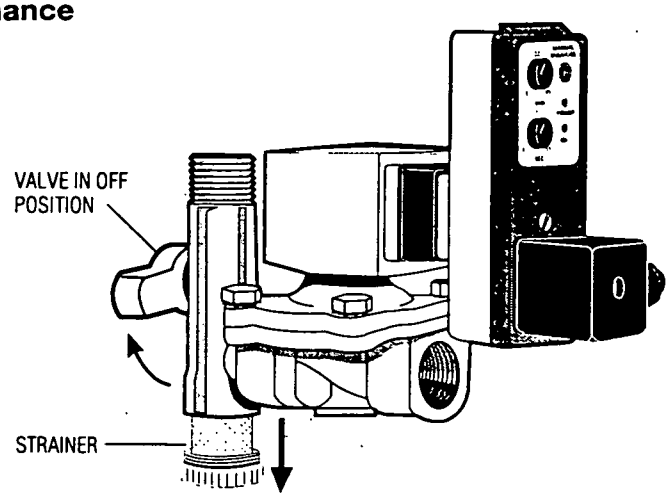
In general if the voltage to the coil is correct, sluggish valve operation, excessive leakage, or noise will indicate that cleaning is required.

Note: It is not necessary to remove valve body from the pipe line for cleaning.

Note: Internally piloted valves have small holes in the valve diaphragm which may plug in severely contaminated systems. When cleaning these valves make certain that pilot holes are open.

3. Valves may be rebuilt.

Contact factory or an ASCO dealer for repair parts.



MODELS 532-04-200S and 532-04-300S

4. Preventive maintenance

a. Keep condensate flowing through valve as free from dirt and foreign material as possible.

b. While in service, operate the valve at least once a month to ensure proper opening and closing.

c. Periodic inspection of internal valve parts for damage or excessive wear is recommended. Thoroughly clean all parts. Replace any parts that are worn or damaged.

SPECIFICATIONS

MODEL	MIN/MAX WORKING PRESSURE		MAXIMUM OPERATING TEMPERATURE	ELECTRICAL SPECS	VALVE TYPE	ORIFICE SIZE		CONN. NPT/BSP	DIMENSIONS						WEIGHT	
									HEIGHT		WIDTH		DEPTH			
	bar	psig				mm	in		mm	in	mm	in	mm	in	kg	lb
532-04-200S	0.3/14	5/200	49°C/120°F	115-60/100-50 or 230-60/200-50 NEMA 4	INTERNAL PILOT	16	5/8	1/2"	130	5.1/4	50	2.25	200	7-7/8	1.8	4
532-04-300S	0.3/21	5/300	49°C/120°F			16	5/8	1/2"	141	5.3/4	50	2.25	200	7-7/8	1.4	3
533-04-300	0.3/21	5/300	49°C/120°F		EXTERNAL PILOT	13	1/2	1/2"	140	5-1/2	50	2	127	5	0.9	2
533-04-300F	0.3/21	5/300	49°C/120°F			13	1/2	1/2"	159	6-1/4	50	2	178	7	1.4	3
532-02-1500	0.3/103	5/1500	49°C/120°F		DIRECT ACTING	1	3/64	1/4"	111	4-3/8	43	1.75	124	4-7/8	0.9	2

WARRANTY

The manufacturer warrants the product manufactured by it, when properly installed, operated, applied, and maintained in accordance with procedures and recommendations outlined in manufacturer's instruction manuals, to be free from defects in material or workmanship for a period of one (1) year from the date of shipment to the buyer by the manufacturer or manufacturer's authorized distributor, or eighteen months from the date of shipment from the factory, whichever occurs first, provided such defect is discovered and brought to the manufacturer's attention within the aforesaid warranty period. The manufacturer will repair or replace any product or part determined to be defective by the manufacturer within the warranty period, provided such defect occurred in normal service and not as a result of misuse, abuse, neglect or accident.

The warranty covers parts and labor for the warranty period. Repair or replacement shall be made at the factory or the installation site, at the sole option of the manufacturer. Any service performed on the product by anyone other than the manufacturer must first be authorized by the manufacturer. Normal maintenance items requiring routine replacement are not warranted. Unauthorized service voids the warranty and any resulting charge or subsequent claim will not be paid. Products repaired or replaced under warranty shall be warranted for the unexpired portion of the warranty applying to the original product. The foregoing is the exclusive remedy of any buyer of the manufacturer's product. The maximum damages liability of the manufacturer is the original purchase price of the product or part.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, WHETHER WRITTEN, ORAL, OR STATUTORY, **AND IS EXPRESSED IN LIEU OF THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE.** THE MANUFACTURER SHALL NOT BE LIABLE FOR LOSS OR DAMAGE BY REASON OF STRICT LIABILITY IN TORT OR ITS NEGLIGENCE IN WHATEVER MANNER INCLUDING DESIGN, MANUFACTURE OR INSPECTION OF THE EQUIPMENT OR ITS FAILURE TO DISCOVER, REPORT, REPAIR, OR MODIFY LATENT DEFECTS INHERENT THEREIN. THE MANUFACTURER, HIS REPRESENTATIVE OR DISTRIBUTOR SHALL NOT BE LIABLE FOR LOSS OF USE OF THE PRODUCT OR OTHER INCIDENTAL OR CONSEQUENTIAL COSTS, EXPENSES, OR DAMAGES INCURRED BY THE BUYER, WHETHER ARISING FROM BREACH OF WARRANTY, NEGLIGENCE OR STRICT LIABILITY IN TORT.

The manufacturer does not warrant any product, part, material, component, or accessory manufactured by others and sold or supplied in connection with the sale of manufacturer's products.

01/01/93

AUTHORIZATION FROM THE SERVICE DEPARTMENT IS NECESSARY BEFORE MATERIAL IS RETURNED TO THE FACTORY OR IN-WARRANTY REPAIRS ARE MADE.

HANKiSON INTERNATIONAL
Division Of Hansen Inc.
Canonsburg, PA 15317-1700 U.S.A.
Tel 724-745-1555 Fax 724-745-6040
E-mail - service@hankisonintl.com

HANKISON®

Automatic Electric Timed Drains

532 SERIES

▶ Easy to install, operate, and maintain

HANKISON automatic condensate drains reliably discharge water, oil, and oil/water mixtures from separators, receiver tanks, dryers, filters, and drip legs.

Installing Hankison automatic condensate drains reduces operating costs by saving:

- Man hours spent manually draining compressed air lines and equipment
- Compressed air wasted when valves are left open to bleed off condensate
- Downtime when unattended air lines fill with liquid and flood the air system

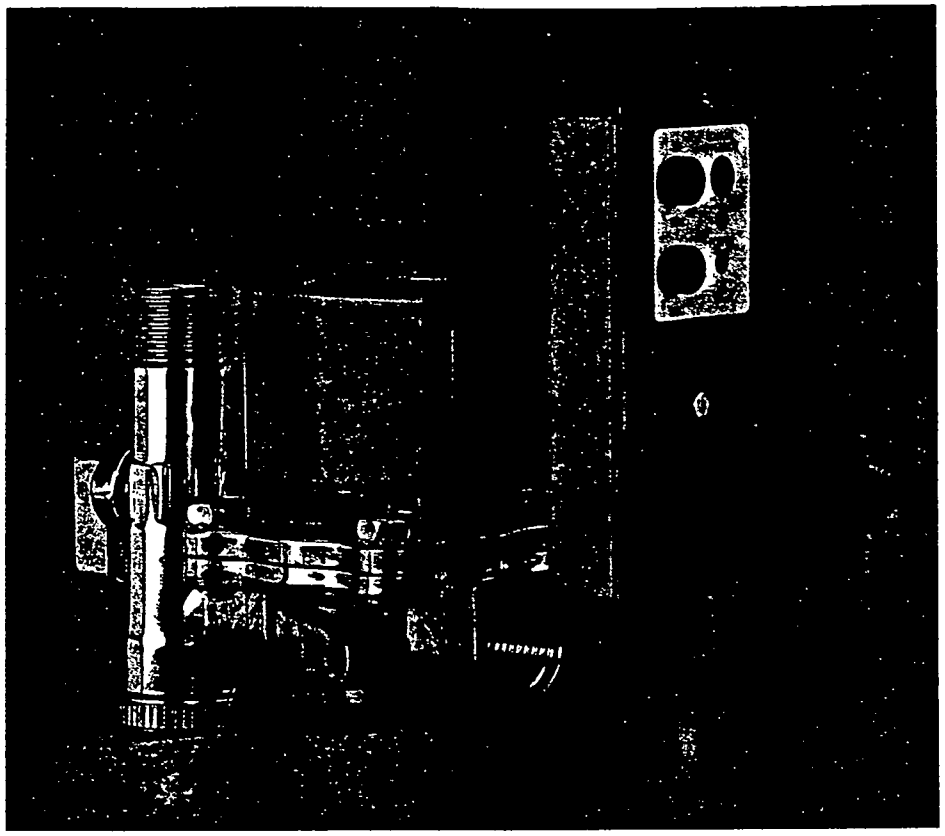
532 SERIES DRAINS FEATURE:

Solid state timer for accurate control of cycle times

- Allows accurate setting of both valve open and valve closed time periods
- Drain open time adjustable from 1 to 15 seconds ...allows close matching of valve open time to condensate load... minimizes air loss during discharge
- Time between drain openings adjustable from 1 to 45 minutes... allows maximum use of available condensate storage area

Rugged ASCO brand solenoid valves for reliable performance

- Models 532-04-200S and 532-04-300S utilize pilot operated diaphragm valves with large 13 mm; *1/2 inch* orifice
  - ... allows discharge of heavy liquid loads
  - ... resists clogging
  - Pressure is introduced above valve closure for leakproof shutoff
  - Softseat valve closure eliminates valve noise
  - Moveable plugnut/caged core construction minimizes impact of core on plugnut for maximum service life
  - Parts subject to wear are easily replaced without removing valve from line...replacement parts available worldwide
  - Heavy duty class F coil runs cooler than coils housed in metal enclosures
  - Choice of 14 and 21 bar, *200 and 300 psig* maximum working pressures
- Model 532-02-1500 with a maximum working pressure of 105 bar, *1500 psig* utilizes a direct acting valve



Model 532-04-200S with combination isolation valve/strainer

Compact modular design for ease of installation

- Six foot, three wire, grounded power cord included (adapter for 1/2 inch conduit available)
- Cord set, timer and valve plug together...may be reassembled in a variety of positions
- Combination isolation valve/strainer standard on models 532-04-200S and 532-04-300S
- Rugged, non-corrosive NEMA 4 construction

Easy to use

- External adjustment knobs for easy setting of valve open and closed times
- Manual override switch verifies valve operation
- Status lights for:
  - Power on - indicates that timer is energized
  - Valve energized - indicates that valve circuit is energized

Combination isolation valve/strainer (standard on models 532-04-200S and 532-04-300S)

- Protects valves from contaminants
- Allows for easy maintenance
  - Strainer or drain can be serviced while system remains pressurized
  - To clean strainer, close the isolation valve and depressurize valve using the manual override switch

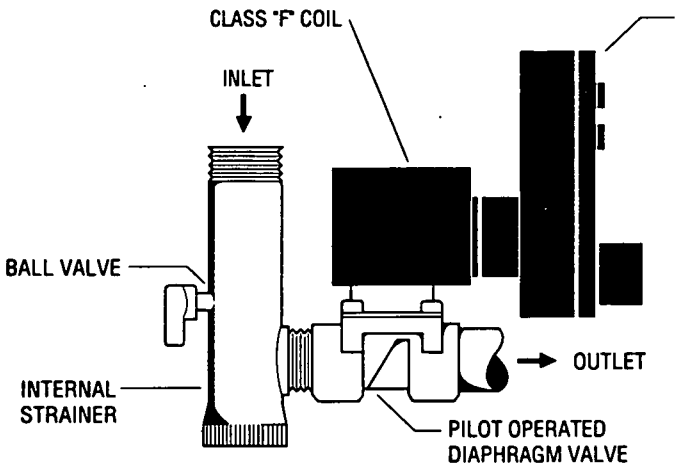
HANKISON INTERNATIONAL

SPECIFICATIONS

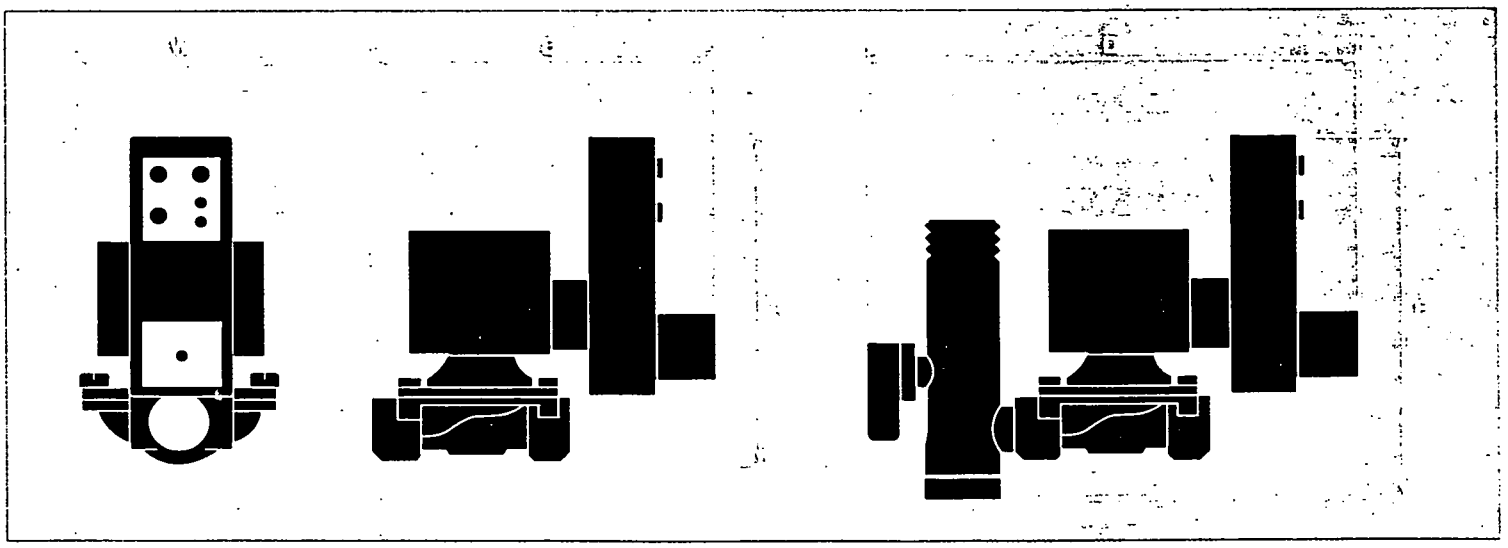
MODEL	MIN/MAX WORKING PRESSURE bar	psig	MAXIMUM OPERATING TEMPERATURE	ELECTRICAL SPECS	VALVE TYPE	ORIFICE SIZE mm	in	CONN. NPT/BSP	DIMENSIONS HEIGHT mm	in	WIDTH mm	in	DEPTH mm	in	WEIGHT kg	lb
532-04-200S	0.3/14	5/200	49°C/120°F	115-60/100-50 or 230-60/200-50 NEMA 4	INTERNALLY PILOT OPERATED DIAPHRAGM	16	5/8	1/2"	130	5.25	50	2.25	200	6	1.8	4
532-04-300S	0.3/21	5/300	49°C/120°F			16	5/8	1/2"	141	5.75	50	2.25	200	7 7/8	1.4	3
532-02-1500	0.3/103	5/1500	49°C/120°F		DIRECT ACTING	1	3/64	1/4"	111	4.38	43	1.75	124	4.875	0.9	2

LIQUID DISCHARGE, LITERS/GALLONS PER OPERATION (200 & 300 psig MWP models with 1/2"orifice only)

DISCHARGE TIME SECONDS	LINE PRESSURE WHEN DISCHARGING TO ATMOSPHERE					
	3.5 bar / 50psig	7 bar / 100 psig	10.3 bar / 150 psig	14 bar / 200 psig	17.2 bar / 250 psig	21 bar / 300 psig
1	0.8 / 0.2	1.2 / 0.3	1.5 / 0.4	1.7 / 0.45	1.9 / 0.5	2.1 / 0.6
5	4.2 / 1.1	5.6 / 1.5	7.3 / 1.9	8.5 / 2.2	9.5 / 2.5	10.4 / 2.7
10	8.5 / 2.2	12.0 / 3.2	14.7 / 3.9	16.9 / 4.5	19.0 / 5.0	20.7 / 5.5
15	12.7 / 3.4	18.0 / 4.8	22.0 / 5.8	25.4 / 6.7	28.4 / 7.5	31.2 / 8.2



MODELS 532-04-200S and 532-04-300S



MODEL 532-04-1500

MODELS 532-04-200S and 532-04-300S

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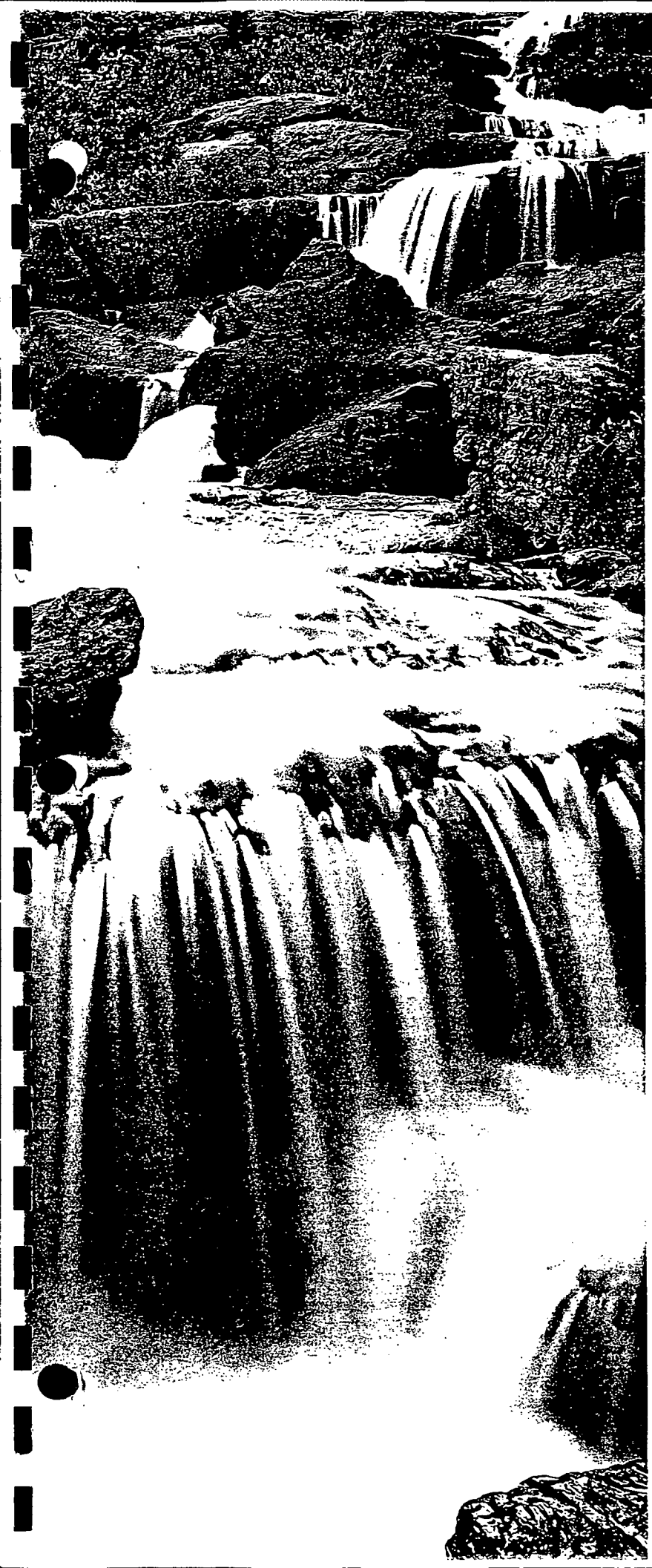
CANONSBURG, PA 15317-1700 U.S.A.
TEL (412) 745-1555 • FAX (412) 745- 6040



HANKiSON

HF SERIES

COMPRESSED AIR

FILTERS

Let Hankison Give You the Compressed Air Quality You Require

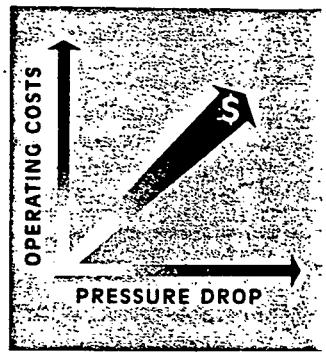
A typical compressed air system is contaminated with...abrasive solid particles such as dust, dirt, rust and scale...compressor lubricants (mineral or synthetic)...condensed water droplets and acidic condensates...and oil and hydrocarbon vapors.

If not removed, these contaminants increase pneumatic equipment maintenance costs, lead to instrument and control failure, contribute to poor product fit and finish and contaminate processes.

The right Hankison filter or filter system will remove these contaminants allowing your compressed air system to deliver the quality of air required by your application... whether it's plant air, instrument air, or medical air...helping to ensure consistent output quality while minimizing operating costs.

Cut the Cost of Compressed Air

Hankison filters remove more contaminants with less pressure drop. Compare the operating pressure drop of competitive brands and remember that for every extra 2 psi of pressure drop, power input needs to be increased by 1%.



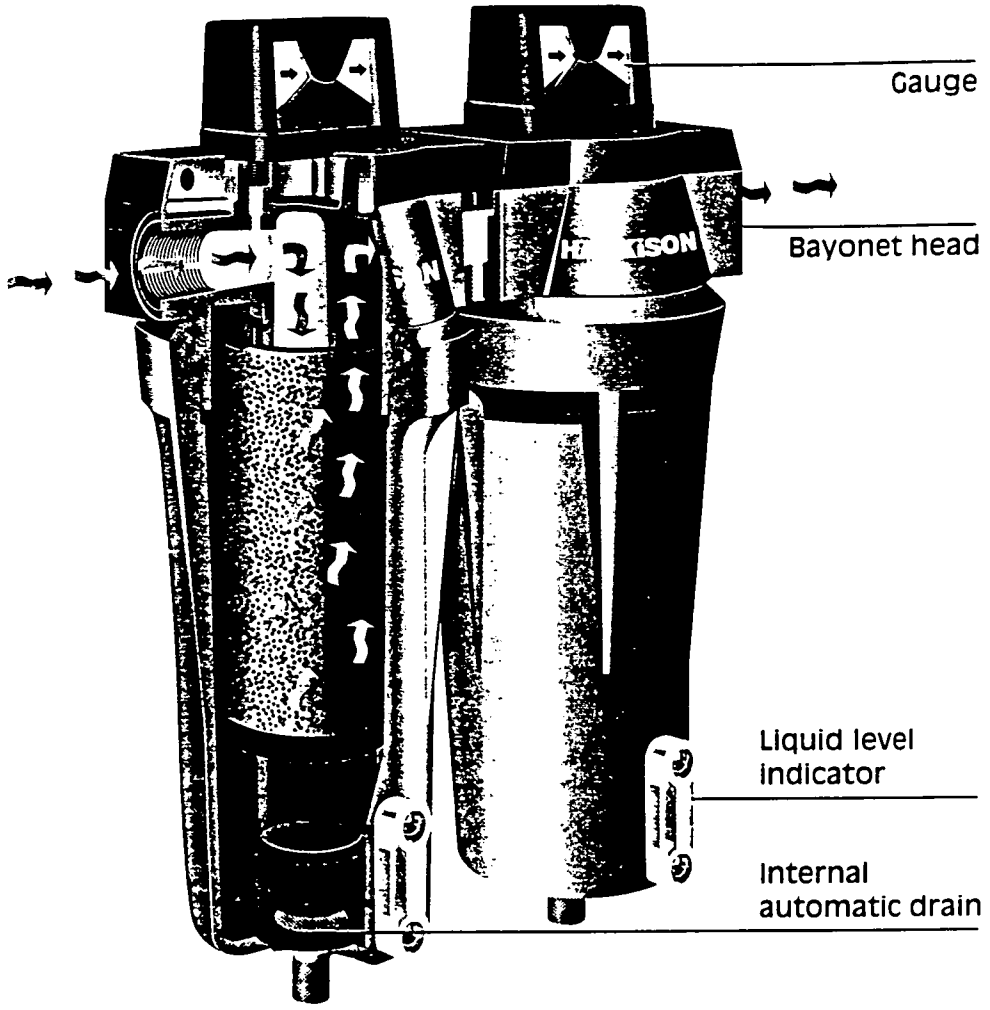
From the Leader in Compressed Air Treatment...

Since Hankison first developed their coalescing filters in the 1970s, they have been a leader in filtration design. Now, as the result of a development effort involving extensive testing of the latest state-of-the-art materials, Hankison is able to offer a totally new line of filtration products. New filter elements have been designed utilizing the latest media innovations and manufacturing techniques... resulting in increased performance, reduced size and lower operating pressure drop. Housings have been redesigned with larger flow areas to lower pressure drops and to allow easier installation, operation, and maintenance. A systems approach has been used to allow for convenient matching of filter types to achieve the air quality you desire, while comprehensive third party testing guarantees performance to CAGI, ISO, and PNEUROP* standards.

With a greater selection of filter grades, more models to choose from, and worldwide technical and service support, Hankison offers a new systemized solution for your compressed air quality needs.

* CAGI-Compressed Air and Gas Institute
* ISO-International Standards Organization
* PNEUROP-European Committee of Manufacturers of Compressors, Vacuum Pumps and Pneumatic Tools

Advanced Filter Housings Make Life a Little Easier



New Modular Housings for Flows through 780 scfm

- Enlarged flow paths reduce pressure drop
- Manufactured from top quality aluminum, zinc, and steel
- Chromated and epoxy powder painted (interior and exterior) for added durability and corrosion resistance
- 300 psig [21 kgf/cm²] maximum working pressure (tested to a 5:1 safety factor)

Easy to Install

- Modular connections - allow housings to be connected in series easily, while saving space
- Wall mounting bracket optional
- Can be mounted for left or right entry
- New space saving design reduces service clearances

Easy to Operate

New differential pressure indicators

Indicates optimum time for element change-maximizing your element investment while minimizing pressure drop

Slide indicator

Economical-changes color when filter element requires replacement

Gauge

- Large easy to read gauge face
- Dual gauge faces allow housings to be mounted in any flow direction
- Can be mounted remotely
- Switch for remote indication available

Liquid level indicator

- Allows visual monitoring of liquid level and signals the need for preventative maintenance to avoid downstream contamination
- Manufactured from thermoset polyurethane, compatible with synthetic lubricants

Internal automatic drains

- Pilot operated, pneumatically actuated...reliably discharges collected liquids
- Viton seals...totally compatible with synthetic lubricants
- Inlet screen for additional protection
- Discharge fitting threaded to facilitate drain line connection

Easy to Maintain

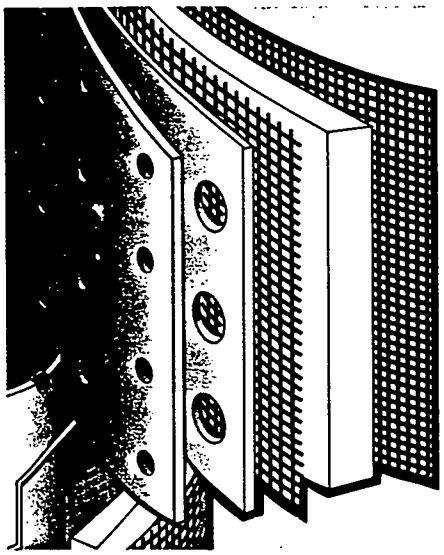
- ⅛ turn, self locking bayonet head to bowl connections (through 1")
- Push on elements make element replacement quick and easy
- If housing is not depressurized before disassembly, escaping air gives audible warning
- Captive o-ring
- Ribbed bowls allow use of C spanner
- Color coded elements for easy identification

Hankison Elements Offer Enhanced Performance and Low Pressure Drop

A choice of five elements allows you to design a system that delivers the air quality you require

- Push-on elements make element replacement easy
- Piston type element to housing seal keeps unfiltered air from by-passing element
- Corrosion resistant cores
  - Stainless steel for added structural integrity
  - Low resistance to flow
  - Seam welded for extra strength
- New "matrix blended fiber" media
  - Large, effective surface area - improves capture rate - ensures high efficiencies
  - Large open area minimizes pressure drop
- Coated, closed cell foam sleeve
  - Resists chemical attack from oils and acids
  - Ensures high efficiencies by preventing re-entrainment of coalesced liquids
- Chemically resistant end caps bound to media with specially formulated adhesive
- Silicone free
- Withstands temperatures to 150°F (66°C)

Grade 9



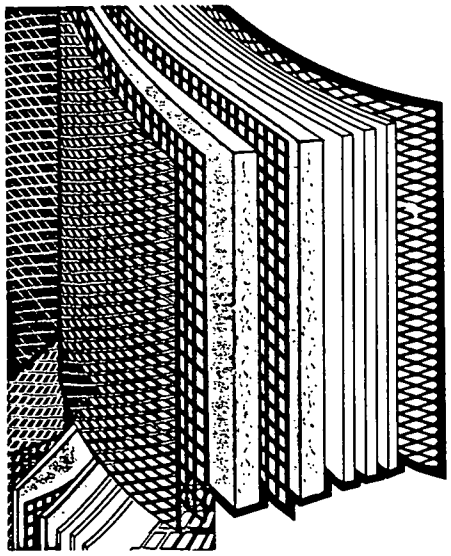
Separator/Filter

for bulk liquid removal plus a 3 micron coalescer (5ppm w/w maximum remaining oil content)[1]

Two-stage filtration

- **First stage** - two stainless steel orifice tubes provide 10 micron mechanical separation
- **Second stage** - in-depth fiber media captures solid and liquid particles to 3 microns

Grade 7E



General purpose air line filter

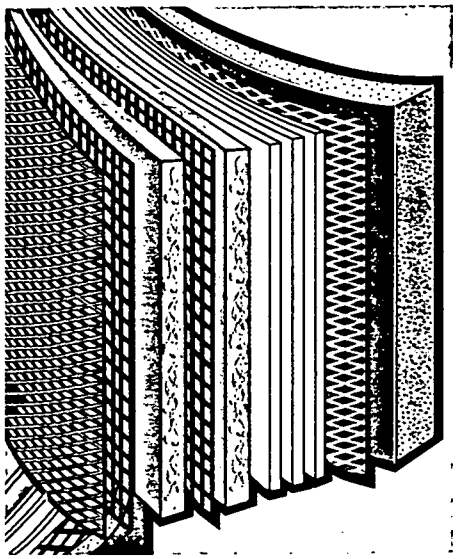
for removal of liquid water and oil; removes solid particles to 1 micron (1.0 ppm w/w maximum remaining oil content)[1]

- Corrosion resistant inner and outer cores

Two stage filtration

- **First stage** - captures larger particles with alternate layers of fiber media and media screen
- **Second stage** - coalesces aerosols and captures solid particles with multiple layers of epoxy bonded, blended fiber media

Grade 5



High efficiency oil removal filter

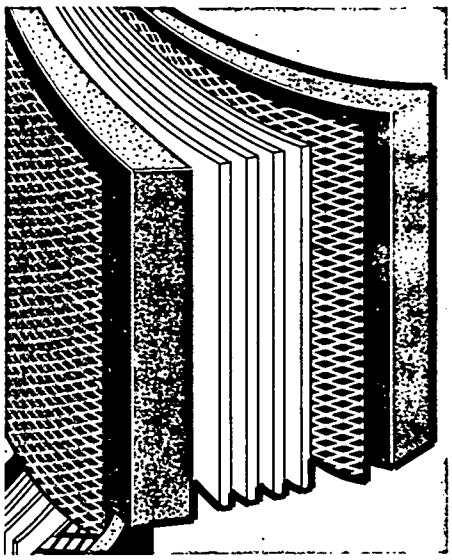
for coalescing fine water and oil aerosols; removes solid particles to 0.01 micron (0.01 ppm w/w maximum remaining oil content)[1]

- Corrosion resistant inner and outer cores

Two stage filtration

- **First stage** - multiple layers of fiber media and media screen remove larger particles, pre-filtering the air for the second stage
- **Second stage** - multiple layers of bonded, blended fiber media for fine coalescence
- Outer coated, closed cell foam sleeve

Grade 3



Ultra high efficiency oil removal filter

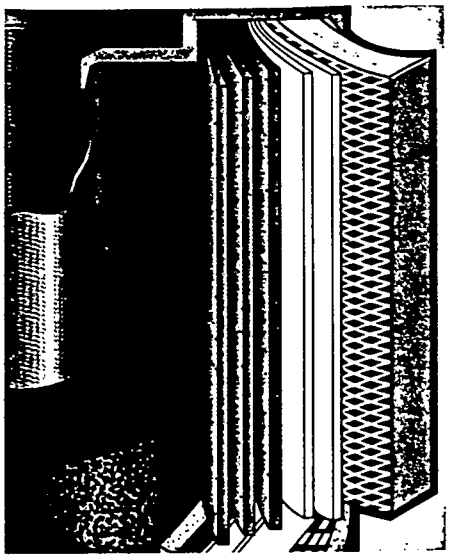
for coalescing ultra-fine oil aerosols; removes solid particles to 0.01 micron (0.001 ppm w/w maximum remaining oil content)[1]

- Corrosion resistant inner and outer cores

Two stage filtration

- **First stage** - coated, closed cell foam sleeve acts as prefilter and flow disperser
- **Second stage** - multiple layers of matrix blended fiber media for ultra-fine coalescence
- Outer coated, closed cell foam sleeve

Grade 1



Oil vapor removal filter

for removal of oil and hydrocarbon vapors normally adsorbable by activated carbon; removes solid particles to 0.01 micron (0.003 ppm w/w maximum remaining oil content)[2]

- Corrosion resistant inner and outer cores

Two stage filtration

- **First stage** - a stabilized bed of finely divided carbon particles removes the majority of the oil vapor
- **Second stage** - multiple layers of fiber media with bonded microfine carbon particles remove the remaining oil vapor
- Multiple layers of fine media prevent particle migration
- Outer coated, closed cell foam sleeve prevents fiber migration
- Designed for 1000 hour life at rated conditions

[1] Filter efficiencies have been established in accordance with CAGI standard ADF400 and are based on 100°F (38°C) inlet temperature.

[2] Filter efficiency has been established in accordance with CAGI standard ADF500 and is based on 100°F (38°C) inlet temperature.

Application Guide

Filter Type	Description	CAGI, PNEUROP, and ISO Performance Data	Where Used
Grade 9 ***Separator/filter***	Mechanical separator and 3 micron coalescer removes • Bulk liquid • Large particles	Removes: Solids and liquids 3 microns and larger Remaining oil content 5 ppm w/w ISO 8573.1 Quality Class - Solids: Class 3, Oil Content: Class 5 Maximum inlet liquid load: 25.000 ppm w/w	Downstream of aftercoolers At point-of-use if no aftercooler/separator used upstream
Grade 7 ■ ***Air Line Filter***	General Purpose 1 micron coalescer for shop air operating • Tools • Motors • Cylinders	Removes: Solids and liquids 1 micron and larger Remaining oil content 1 ppm w/w ISO 8573.1 Quality Class - Solids: Class 2, Oil Content: Class 4 Maximum inlet liquid load: 2.000 ppm w/w	Upstream of ultra high efficiency oil removal filters Downstream of pressure-swing (heatless) desiccant dryers At point-of-use if aftercooler/ separator installed upstream
Grade 5 ■ ***High Efficiency Oil Removal Filter***	Fine coalescer for oil free air for industrial use • Painting • Injection molding • Instruments • Control valves	Removes: Solids and liquids 0.01 micron and larger 99.99+% of oil aerosols; remaining oil content 0.01 ppm w/w ISO 8573.1 Quality Class - Solids: Class 1, Oil Content: Class 2 Maximum inlet liquid load: 1.000 ppm w/w	Upstream of desiccant or membrane dryers Downstream of refrigerated dryers Downstream of pressure-swing desiccant dryers for fine particulate removal At point-of-use (may be used if light liquid load is present)
Grade 3 ■ ***Ultra High Efficiency Oil Removal Filter***	Ultra fine coalescer for oil free air for critical applications • Where air contacts product • Conveying • Agitating • Electronics manufacturing • Nitrogen replacement	Removes: Solids and liquids 0.01 micron and larger 99.999+% of oil aerosols; remaining oil content 0.001 ppm w/w ISO 8573.1 Quality Class - Solids: Class 1, Oil Content: Class 1 Maximum inlet liquid load: 100 ppm w/w	Upstream of desiccant or membrane dryers; use a Grade 7 as a prefilter if heavy liquid loads are present Downstream of refrigerated dryers
Grade 1 ■ ***Oil Vapor Removal Filter***	Activated carbon filter for odor free air for • Food and drug manufacturing • Breathing air • Gas processing	Removes: Oil vapor: remaining oil content 0.003 ppm w/w (as a vapor) Solids 0.01 micron and larger ISO 8573.1 Quality Class - Solids: Class 1, Oil Content: Class 1 No liquid should be present at filter inlet - use a high efficiency oil removal filter upstream of Grade 1 filters to prevent liquid oil contamination	Downstream of high efficiency oil removal filters

Air Quality/Pressure Drop Table

Grade	Solid Particles Down to	Remaining Oil Content	Pressure Drop at Rated Conditions psid *[kgf/cm²]*	
	micron	*ppm by weight*	Dry	Wet
9	3	5	1 *[0.07]*	1.5 *[0.11]*
• 7	1	1	1 *[0.07]*	2 *[0.14]*
• 5	0.01	0.01	1 *[0.07]*	3 *[0.21]*
• 3	0.01	0.001	2 *[0.14]*	6 *[0.42]*
• 1	0.01	0.003	1 *[0.07]*	N.A.

ISO 8573.1 Quality Classes

Quality Classes	Solid Contaminants (maximum particle size in microns)	Maximum Pressure Dew Point °F *[°C]*	Maximum Oil Content (droplets, aerosols and vapor) ppm w/w *[mg/m³]*
1	0.1	-94 *[-70]*	0.008 *[0.01]*
2	1	-40 *[-40]*	0.08 *[0.1]*
3	5	-4 *[-20]*	0.8 *[1]*
4	15	37.4 *[3]*	4 *[5]*
5	40	44.6 *[7]*	21 *[25]*
6	–	50 *[10]*	–

Model Number Configuration

HF **(1)** - **(2)** - **(3)** - **(4)**

Filter Grade
9 - Separator/filter
7 - Air Line Filter
5 - High Efficiency Oil Removal Filter
3 - Ultra High Efficiency Oil Removal Filter
1 - Oil Vapor Removal Filter

Step 1: Specify **Filter Grade** in space (1).
Step 2: Specify **Housing Number** in space (2). Select housing that has sufficient flow capacity for your application.
Step 3: Specify **Connection Size** in space (3).
Step 4: Refer to chart below for Standard Features. If corrosion proof stainless steel cores are needed, indicate an **S** in space (4). Corrosion resistant stainless steel cores are standard.
Example: A Grade 5 high efficiency oil removal filter with a capacity of 100 scfm and $^3/_4$" NPTF connections would be configured as: **HF5-24-6-DGL.**

Housing Number	Capacity scfm *[m^3/min] @ 100 psig, 7 kgf/cm^2*		Connections	
12	20	*[0.57]*	**3** - 3/8" NPTF or	**3B** - 3/8" BSP or
16	35	*[1.00]*	**4** - 1/2" NPTF	**4B** - 1/2" BSP
20	60	*[1.72]*		
24	100	*[2.9]*	**6** - 3/4" NPTF or	**6B** - 3/4" BSP or
28	170	*[4.9]*	**8** - 1" NPTF	**8B** - 1 BSP
32	250	*[7.2]*	**8** - 1" NPTF or	**8B** - 1 BSP or
36	375	*[11]*	**10** - 1-1/4" NPTF or	**10B** - 1-1/4" BSP or
			12 - 1-1/2" NPTF	**12B** - 1-1/2" BSP
40	485	*[14]*	**16** - 2" NPTF or	**16B** - 2" BSP or
			20 - 2-1/2" NPTF	**20B** - 2-1/2" BS
44	625	*[18]*	**20** - 2-1/2" NPTF	**20B** - 2-1/2" BSP
48	780	*[22]*		
52	625	*[18]*	**24** - 3" NPTM	**80** - DN 80 Flange
54	1000	*[29]*	**24** - 3" NPTM	**80** - DN 80 Flange
56	1250	*[36]*		
60	1875	*[54]*	**24** - 3" NPTM	**80** - DN 80 Flange
64	2500	*[72]*	**4F** - 4" ANSI Flange	**100** - DN 100 Flange
68	3125	*[89]*		
72	5000	*[143]*	**6F** - 6" ANSI Flange	**150** - DN 150 Flange
76	6875	*[197]*	**6F** - 6" ANSI Flange	**150** - DN 150 Flange
80	8750	*[250]*		
84	11875	*[340]*	**8F** - 8" ANSI Flange	**200** - DN 200 Flange
88	16250	*[465]*	**8F** - 8" ANSI Flange	**200** - DN 200 Flange
92	21250	*[608]*	**10F** - 10" ANSI Flange	**250** - DN 250 Flange

Features
D - Internal Drain
P - Slide Indicator
G - Differential Pressure Gauge
L - Liquid Level Indicator
S - Corrosion Proof Stainless Steel Cores

Standard Models

Model	Housing Number	Connection Sizes Available	Standard Features Grades 9	Standard Features Grades 7, 5, 3	Standard Features Grades 1	Maximum Pressure and Temperature Manual Drain	Maximum Pressure and Temperature with D or L	Height in *[mm]*	Width in *[mm]*	Weight lb *[kg]*	Replacement Element No.	Qty Reqd
Modular Type Housings												
HF**[Grade]**-12-**[Conn.]**-**[Features]**	12	3, 3B, 4, 4B	D	D	NONE	300 psig *21 kgf/cm^2* 150°F *66°C*	250 psig *17.6 kgf/cm^2* 150°F *66°C*	11.05 *[281]*	4.13 *[105]*	7.9 *[3.6]*	E **[Grade]**-12	
HF**[Grade]**-16-**[Conn.]**-**[Features]**	16		P	P				11.05 *[281]*	4.13 *[105]*	8.1 *[3.7]*	E **[Grade]**-16	
HF**[Grade]**-20-**[Conn.]**-**[Features]**	20		L	L				13.40 *[340]*	4.13 *[105]*	8.5 *[3.9]*	E **[Grade]**-20	
HF**[Grade]**-24-**[Conn.]**-**[Features]**	24	6, 6B, 8, 8B	D G	D G				15.32 *[389]*	5.25 *[133]*	9.6 *[4.4]*	E **[Grade]**-24	1
HF**[Grade]**-28-**[Conn.]**-**[Features]**	28		L	L				19.57 *[497]*	5.25 *[133]*	10.5 *[4.8]*	E **[Grade]**-28	
HF**[Grade]**-32-**[Conn.]**-**[Features]**	32	8, 8B, 10, 10B, 12, 12B	G	G				22.80 *[579]*	6.44 *[164]*	10.2 *[4.6]*	E **[Grade]**-32	
HF**[Grade]**-36-**[Conn.]**-**[Features]**	36		L (1)	L				27.29 *[693]*	6.44 *[164]*	11.3 *[5.1]*	E **[Grade]**-36	
HF**[Grade]**-40-**[Conn.]**-**[Features]**	40	16, 16B, 20, 20B	G (1)	D G				31.08 *[789]*	7.63 *[194]*	28 *[12.7]*	E **[Grade]**-40	
HF**[Grade]**-44-**[Conn.]**-**[Features]**	44	20, 20B						36.83 *[935]*	7.63 *[194]*	33 *[15.0]*	E **[Grade]**-44	
HF**[Grade]**-48-**[Conn.]**-**[Features]**	48							42.96 *[1091]*	7.63 *[194]*	38 *[17.2]*	E **[Grade]**-48	
Pressure Vessel												
HF**[Grade]**-52-**[Conn.]**-**[Features]**	52	24, 80	D G	D G		300 psig *21 kgf/cm^2*	300 psig *21 kgf/cm^2*	40.88 *[1038]*	10.25 *[260]*	36 *[16.3]*	E **[Grade]**-PV	1
HF**[Grade]**-54-**[Conn.]**-**[Features]**	54	24, 80	G (1)	G (1)	NONE	225 psig *15.8 kgf/cm^2* 150°F *66°C*	225 psig *15.8 kgf/cm^2* 150°F *66°C*	48.00 *[1219]*	16.00 *[406]*	91 *[41.3]*	E **[Grade]**-54	2
HF**[Grade]**-56-**[Conn.]**-**[Features]**	56							48.00 *[1219]*	16.00 *[406]*	91 *[41.3]*	E **[Grade]**-PV	2
HF**[Grade]**-60-**[Conn.]**-**[Features]**	60	24, 80						49.00 *[1245]*	16.25 *[413]*	120 *[54.4]*	E **[Grade]**-PV	3
HF**[Grade]**-64-**[Conn.]**-**[Features]**	64	4F, 100						52.25 *[1327]*	20.00 *[508]*	179 *[81.2]*	E **[Grade]**-PV	4
HF**[Grade]**-68-**[Conn.]**-**[Features]**	68							52.25 *[1327]*	20.00 *[508]*	182 *[82.6]*	E **[Grade]**-PV	5
HF**[Grade]**-72-**[Conn.]**-**[Features]**	72	6F, 150						54.63 *[1387]*	24.00 *[610]*	271 *[123]*	E **[Grade]**-PV	8
HF**[Grade]**-76-**[Conn.]**-**[Features]**	76	6F, 150						62.56 *[1589]*	28.00 *[711]*	518 *[235]*	E **[Grade]**-PV	11
HF**[Grade]**-80-**[Conn.]**-**[Features]**	80							62.56 *[1589]*	28.00 *[711]*	527 *[239]*	E **[Grade]**-PV	14
HF**[Grade]**-84-**[Conn.]**-**[Features]**	84	8F, 200						69.13 *[1756]*	33.00 *[838]*	709 *[322]*	E **[Grade]**-PV	19
HF**[Grade]**-88-**[Conn.]**-**[Features]**	88	8F, 200						67.94 *[1726]*	39.00 *[991]*	918 *[416]*	E **[Grade]**-PV	26
HF**[Grade]**-92-**[Conn.]**-**[Features]**	92	10F, 250						70.94 *[1802]*	45.88 *[1165]*	1412 *[640]*	E **[Grade]**-PV	34

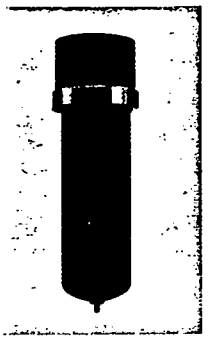
(1) Drain plugs standard. Externally mounted auto drains available.

Sizing

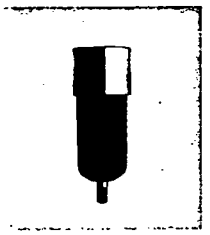
To find the maximum flow at pressures other than 100 psig *[7 kgf/cm^2]*, multiply the flow (from table above) by the Correction Factor corresponding to the minimum pressure at the inlet of the filter. Do not select filters by pipe size; use flow rate and operating pressure.

Minimum Inlet Pressure	psig	20	30	40	60	80	100	120	150	200	250	300
	kgf/cm^2	1.4	2.1	2.8	4.2	5.6	7.0	8.4	10.6	14.1	17.6	21.1
Correction Factor		0.30	0.39	0.48	0.65	0.82	1	1.17	1.43	1.87	2.31	2.74

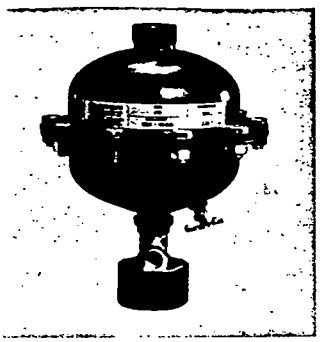
Pressure Vessel Style Housings - for flows through 21,000 scfm



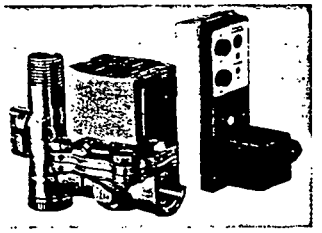
High Temperature Afterfilters - 1 micron particulate filters



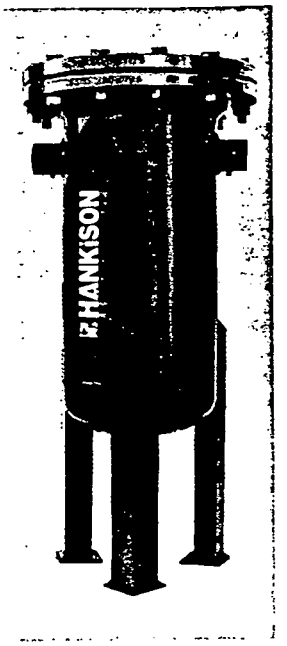
Mini Filters - for flows to 5 scfm



Pneumatically Actuated Automatic Condenstate Drains



Electrically Actuated Automatic Condensate Drains



Mist Eliminators - for flows through 3,000 scfm

HANKISON INTERNATIONAL

Division Of Hansen Inc.
Canonsburg, PA 15317-1700 U.S.A.
Tel 724-745-1555 Fax 724-745-6040
E-mail-inquiry@hankisonintl.com
Internet-www.hankisonintl.com

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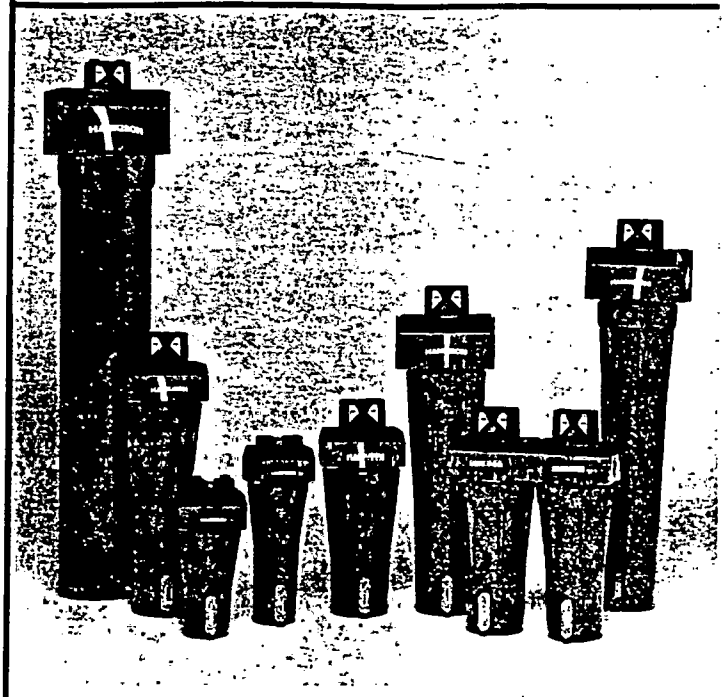
INSTRUCTION MANUAL

Models HF(grade)-12 through HF(grade)-48

HANKISON®



COMPRESSED AIR FILTERS

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MODEL NUMBER CONFIGURATION 2
1.0 INSTALLATION 3
2.0 OPERATION 5
3.0 MAINTENANCE 6
DIMENSIONS AND WEIGHTS 7
WARRANTY 8

General Safety Information

1. Pressurized devices

   WARNING

   - Do not exceed maximum operating pressure indicated on serial number tag.
   - Make certain filter is fully depressurized before servicing.

2. Breathing Air

   - Air treated by this equipment may not be suitable for breathing without further purification. Refer to OSHA standard 1910.134 for breathing air requirements.

3. Flammable gases

   WARNING

   While the materials of construction are compatible with many flammable gases, the following application limitations must be considered:

   - Housing materials are slightly porous. The product must be used in a well ventilated area in the absence of sparks or ignition sources. Do not use in Class 1, Division 1, Group D environments.
   - The type of area - forced exhaust system used (i.e., high or low level) would be dependent on the gas involved.
   - Each application (other than for air or inert gas) must be reviewed to minimize fire or explosion hazard.

SERVICE DEPARTMENT: (724) 746-1100

Model Number Configuration

HF (1) - (2) - (3) (4)

Filter Grade
9 - Separator/filter
7 - Air Line Filter
5 - High Efficiency Oil Removal Filter
3 - Ultra High Efficiency Oil Removal Filter
1 - Oil Vapor Removal Filter

Housing Number	Capacity scfm *[m³/min]* @ 100 psig [7 kgf/cm²]	Connection Sizes	
12 **16** **20**	20 *[0.57]* 35 *[1.00]* 60 *[1.72]*	**3** - 3/8" NPTF or **4** - 1/2" NPTF	**3B** - 3/8" BSP or **4B** - 1/2" BSP
24 **28**	100 *[2.9]* 170 *[4.9]*	**6** - 3/4" NPTF or **8** - 1" NPTF	**6B** - 3/4" BSP or **8B** - 1 BSP
32 **36**	250 *[7.2]* 375 *[11]*	**8** - 1" NPTF or **10** - 1-1/4" NPTF or **12** - 1-1/2" NPTF	**8B** - 1 BSP or **10B** - 1-1/4" BSP or **12B** - 1-1/2" BSP
40	485 *[14]*	**16** - 2" NPTF or **20** - 2-1/2" NPTF	**16B** - 2" BSP or **20B** - 2-1/2" BSP
44 **48**	625 *[18]* 780 *[22]*	**20** - 2-1/2" NPTF	**20B** - 2-1/2" BSP

1. **Filter Grade** is indicated in space (1).

2. **Housing Number** is indicated in space (2).

3. **Connection Size** is indicated in space (3)

4. **Features**
   D = Internal Automatic Drain Mechanism
   P = Differential Pressure Slide Indicator
   G = Differential Pressure Gauge Indicator
   L = Liquid Level Indicator
   S = Corrosion Proof Stainless Steel Element

Example: A Grade 5 high efficiency oil removal filter with a capacity of 100 scfm and 3/4" NPTF connections would be configured as: **HF 5-24-6DGL**

Grade Identification

Filter grade can be identified by the third digit of the model number. In addition, elements with a foam outer sleeve can be identified by color

Grade	Description	Type	Outer foam color
9	Separator/filter	Mechanical separator and 3 micron coalescer	none
7	General purpose air line filter	1 micron coalescer	none
5	High efficiency oil removal filter	High efficiency (99.99+%) coalescer	Red
3	Ultra high efficiency oil removal filter	Ultra high efficiency (99.999+%) coalescer	Blue
1	Oil vapor removal filter	Activated carbon adsorber	Green

1.0 Installation

A. Where Used/Air Quality After Filtration

Grade	Where used	Solid particle removal (maximum size in microns)	Liquid removal efficiency (at rated conditions)	Maximum inlet liquid loading ppm w/w	Remaining oil content ppm w/w
9	Separator - downstream of an aftercooler Point-of-use - where no aftercooler is installed upstream	3	99+% of water	25,000	5 aerosols
7	Prefilter - • Alone ahead of desiccant dryers if no oil is present • Ahead of Grade 3 Afterfilter - downstream of pressure-swing (heatless) desiccant dryers Point-of-use - where aftercooler is installed upstream	1	100% of water	2,000	1 aerosols
5	Prefilter - alone ahead of desiccant and membrane dryers if oil is present Afterfilter • Downstream of refrigerated dryer • Downstream of pressure-swing (heatless) desiccant dryers for finer solid particle removal	0.01	99.99+% of oil	1,000	0.01 aerosols
3	Prefilter - ahead of desiccant and membrane dryers if oil is present (use after Grade 7 to reduce liquid and solids load, prolong element life and ensure filtration efficiency) Afterfilter - downstream of refrigerated dryer	0.01	99.999+% of oil	100	0.001 aerosols
1	Use a Grade 7 or Grade 5 ahead of Grade 1 to remove any liquid present	0.01	Removes vapors only	No liquid should be present	0.003 vapor

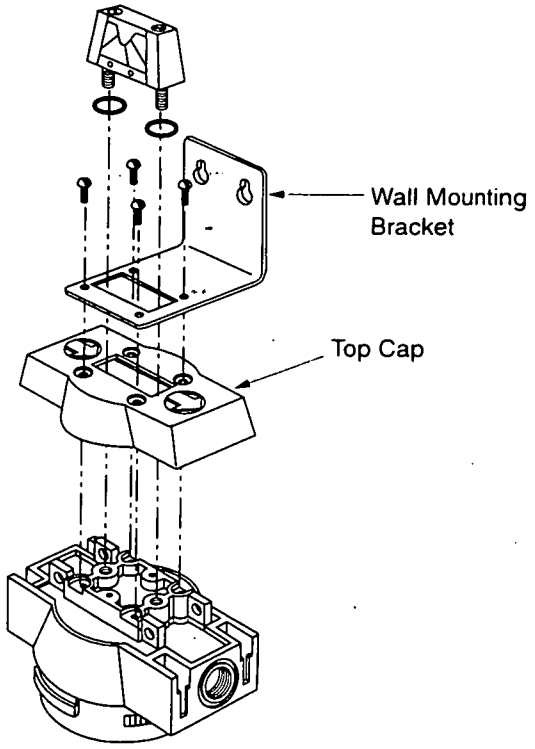
B. Mounting

1. Wall mounting brackets - Mount bracket to filter head:

   (1) remove four (4) screws holding black plastic top cap to filter head

   (2) place bracket on head over plastic cap

   (3) install screws supplied with bracket.



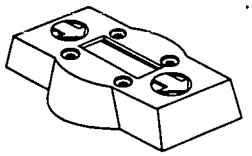
C. Piping

1. Before installing, blow out pipe line to remove scale and other foreign matter.

2. This unit has DRYSEAL pipe threads; use pipe compound or tape sparingly to male threads only.

3. Mounting (Grades 9,7,5,3) - mount so that inlet and outlet connections are horizontal (filter bowl vertical) to ensure proper liquid drainage.

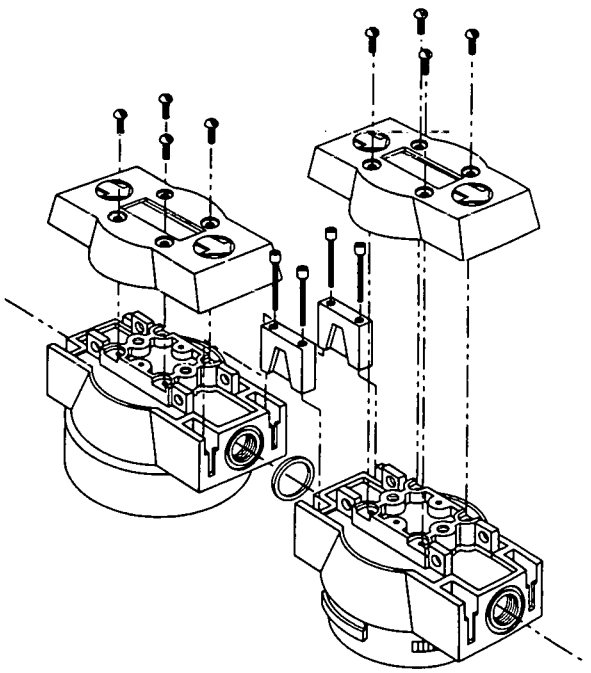
4. Flow Direction - install so that the air flow is in the direction of arrows on the filter head. Flow through the element is inside out.



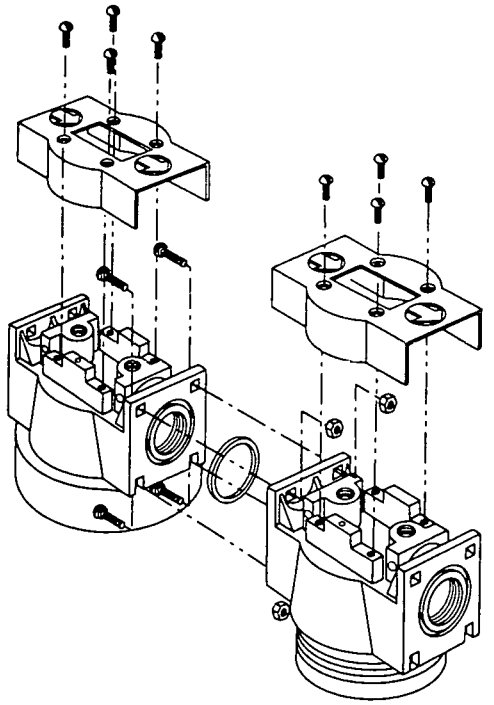
5. Direct filter-to-filter (modular) connection - Filter heads may be joined without using a pipe nipple

   a. Bayonet type heads - Use two (2) modular connectors, o-ring, and four (4) socket head cap screws (sold as kit)

   Remove black plastic top cap, apply generous amount of lubricant to o-ring, install o-ring in groove, and insert connectors. Screw connectors to head using socket head cap screws.



   b. Threaded heads
   Use four carriage bolts, nuts and o-ring (sold as kit). Remove black plastic top caps, apply generous amount of lubricant to o-ring, install o-ring in groove, and install bolts and nuts.



NOTE: Make certain flow direction through filters is correct (pin holes used for aligning top caps should be in the same position on all filters; when hole is in the front, inlet is to the left).

NOTE: Lubricate o-ring with generous amount of lubricant before installation.

6. Isolation valves and by-pass piping - For ease of service, isolation and by-pass valves are desirable. In critical applications, two filters installed in parallel may be necessary to avoid interruption of air supply.

D. Drain provisions

1. Internal Automatic Drains - Drain line
   The bottom of internal automatic drains are provided with 1/8" (inside threads) for connection of a drain line if desired.

2. External Auto Drains - External auto drains may be added as follows:

   Models with housings 12 through 28 - remove internal drain and install adapter (available from factory). Adapter outlet connection is 1/8" (inside threads).

   Models with housings 32 and 36 - remove adaptor fitting from bottom of bowl; 1/2" (inside threads) port is available for external drain connection

   Models with housings 40 through 48 - remove pipe plug; 1/2" (inside thread) port is available for external drain connection

2.0 Operation

WARNING: Do not operate filter at pressures in excess of Maximum Working Pressure indicated on Serial Number Tag.

NOTE: Maximum Operating Temperature - 150°F, 66°C. Liquid filtration above 120°F, 49°C is not recommended since there is typically oil present in a vapor state which passes through the filter and condenses downstream.

NOTE: Grade 1 - If operated above 100°F, 38°C may experience less than 1000 hours of life because of greater oil vapor content.

A. Liquid Draining - Grades 9, 7, 5, 3

NOTE: Collected liquids must be removed to ensure proper operation.

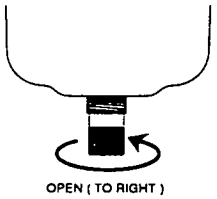
NOTE: Depressurize slowly, to avoid filter element damage.

1. Manual Drain - Turn to your right (clockwise) to open and to your left (counterclockwise) to close.

2. Automatic Drain - Liquids will automatically discharge when sufficient accumulation occurs.

   a. Internal Auto Drains - These drains may be manually drained by turning to your right (clockwise) to open and to your left (counterclockwise) to close.

NOTE: Manually drain internal auto drains daily to verify drain function.



B. Operational Checkpoints

Grades 9,7,5,3

1. Check pressure drop across the filter

   a. Pressure differential in excess of 10 psi (0.7 kgf/cm²) - pressure indicator in red area - indicates that the filter sleeve or element should be replaced.

NOTE: Element should be changed annually or when indicator changes to red, whichever occurs first.

NOTE: Pressure drop should never exceed 50 psi (3.5 kgf/cm²).

   b: Check for sudden reduction in pressure drop. This might indicate:

      (1) Possible leak across element o-ring seal

      (2) Leak through the element due to physical damage

2. Check flow, pressure, and temperature to make certain filter is being operated within design conditions.

3. Check to see that filter is installed level to insure proper drainage.

4. Check that manual drains are drained periodically or that automatic drains are functioning.

NOTE: On models with Liquid Level Sight glass - Check that orange ball is below top of Sight glass.

Grade 1

1. Check for an oily smell by opening the manual valve. If an oily smell exists, the following should be checked:

   a. Filter element adsorption capacity exhausted

   b. Leak across element o-ring seal

   c. Leak through element due to physical damage

   d. Presence of liquids because of lack of or failure of prefilters

   e. Flow, pressure and temperatures outside design conditions

   f. Presence of gaseous impurities which cannot be adsorbed

CAUTION: Methane, carbon monoxide, carbon dioxide and various inorganic gases cannot be removed by a Grade 1 filter.

C. Flow Capacity

Maximum air flow for the various filters at 100 psig (7 kgf/cm²) is indicated in Table 1. To determine maximum air flows at inlet pressures other than 100 psig (7 kgf/cm²), multiply flow from Table 1 by air flow correction factor from Table 2 that corresponds to the minimum operating pressure at the inlet of the filter.

NOTE: Filters should not be selected by pipe size. Select using flow rate and operating pressure only.

Table 1 - Maximum Flow @100 psig [7 kgf/cm²]

Housing	scfm *[m³/min]*
12	20 *[0.57]*
16	35 *[1.00]*
20	60 *[1.72]*
24	100 *[2.9]*
28	170 *[4.9]*
32	250 *[7.2]*
36	375 *[11]*
40	485 *[14]*
44	625 *[18]*
48	780 *[22]*

Table 2 - Air Flow Correction Factor

Minimum Inlet Pressure	psig	20	30	40	60	80	100	120	150	200	250	300
	kgf/cm²	1.4	2.1	2.8	4.2	5.6	7.0	8.4	10.6	14.1	17.6	21.1
Correction Factor		0.30	0.39	0.48	0.65	0.82	1.00	1.17	1.43	1.87	2.31	2.74

3.0 Maintenance

A. When to Replace Filter Element

NOTE: Grades 7,5,3,1 - complete element is replaced; Grade 9 - unless separator core is damaged outer sleeve only is replaced.

1. Grades 9,7,5,3
   a. Initial (dry) pressure drop: 1 psi (0.07 kgf/cm²) to 2 psi (0.14 kgf/cm²)

   b. Operating pressure drop: As filter becomes liquid loaded (wetted), pressure drop will increase to 2 to 6 psi (0.14 to 0.42 kgf/cm²). Further pressure drop occurs as element loads with solid particles.

FOR MAXIMUM FILTRATION EFFICIENCY, REPLACE ELEMENT WHEN PRESSURE DROP REACHES 10 PSI (0.7 KGF/CM²) (INDICATOR IN RED AREA) OR ANNUALLY, WHICHEVER OCCURS FIRST.

NOTE: Pressure drop may temporarily increase when flow is resumed after flow stoppage. Pressure drop should return to normal within one hour.

NOTE: Grades 5 and 3 - During normal operation bottom of foam sleeve will have a band of oil. Spotting above the band indicates that liquids are accumulating faster than they can be drained and that prefiltration is required.

2. Grade 1

   a. Adsorption capacity - 1000 hours at rated capacity. Element life is exhausted when odor can be detected downstream of the filter.

B. Procedure for Element Replacement

WARNING: THIS FILTER IS A PRESSURE CONTAINING DEVICE. DEPRESSURIZE BEFORE SERVICING. If filter has not been depressurized before disassembly, an audible alarm will sound when the bowl begins to be removed from the head. If this occurs, stop disassembly, isolate and completely depressurize filter before proceeding.

1. Isolate filter (close inlet and outlet valves if installed) or shut off air supply.

2. Depressurize filter by slowly opening manual drain valve.

3. Remove bowl

   a. For models 12 through 28 - bayonet mount - push bowl up, turn bowl 1/8th turn to your left, and pull bowl straight down

   b. For models 32 through 48 - threaded bowls - unscrew bowl from head using hand, strap wrench or C spanner.

4. Clean filter bowl

5. Replace element

   a. Replacing complete element

      1) Pull off old element and discard

      2) Make certain o-ring inside top of replacement element is in place and push element onto filter head.

NOTE: Grades 5, 3, and 1 - Do not handle elements by outside foam cover. Handle by bottom end cap only.

   b. Grade 9 - replacing sleeve only

      1) Pull element straight down to remove.

      2) Remove bolt and bottom cap and remove disposable filter sleeve.

      3) Clean separator core with soap and water if necessary.

      4) Slide new filter sleeve over separator core and replace bottom cap and hand tighten bolt.

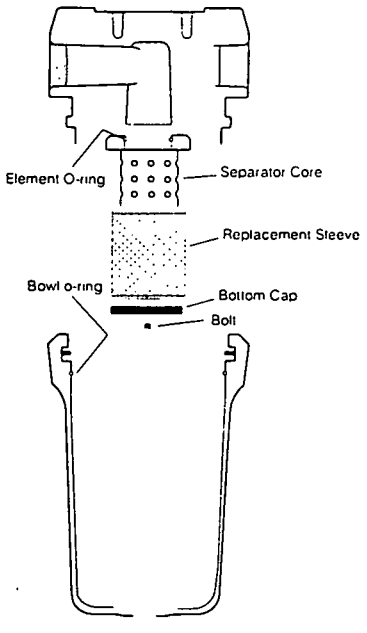
      5) Make certain o-ring inside top of element is in place and push element onto filter head.

6. After making certain that o-ring inside top of bowl (and on bayonet mount heads, wave spring) are in place, reassemble bowl to head.

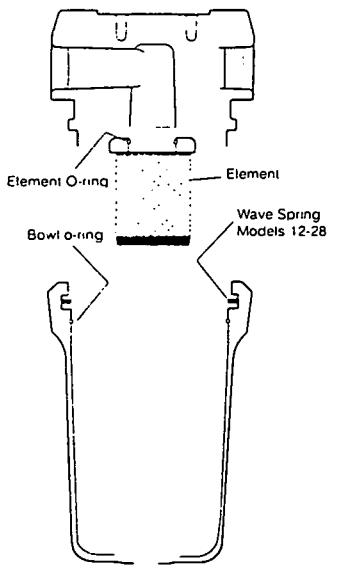
NOTE: Make certain o-ring is generously lubricated.

NOTE: Wave spring ends should be pointed down to prevent the wave spring from interfering with reassembly.

NOTE: Threaded bowl to head connection, generously lubricate threads with a high grade/temperate lubricate 150°F, 66°C.



Grade 9 - Sleeve Replacement



All Grades - Element Replacement

C. Auto Drain Mechanism

It is recommended that drain mechanism be replaced annually.

REPAIR KITS (Continued)

Name of Part	Qty.	Part No.
PERIODIC OVERHAUL KIT (SSP AIR END) (Includes next nine items)		302SSP6013
GASKET KIT (SEE BELOW)	1	303SSP6013
OIL SEAL KIT (SEE BELOW)	1	300SSP6013
ROLLER BEARING	1	12BA105
ROLLER BEARING	1	12BA106
ROLLER BEARING	1	12BA104
ROLLER BEARING	1	12BA103
ROLLER BEARING	2	12BA51
SPRING	1	78W50
SPRING	1	78W52
GASKET KIT (SSP AIR END) (Includes next eight items)		303SSP6013
PERIODIC MAINTENANCE KIT (SEE ABOVE)	1	302SSM6013
SHIM SET (SHAFT)	1	77H63
SHIM SET	1	77H62
GASKET RING	2	25C603N
PACKING RING	4	60AM46
FASTENER SEAL	4	60DD65
GASKET	4	25C138N
GASKET ELIMINATOR	1	25BC222
OIL SEAL KIT (SSP AIR ENDS) (Includes next seven items)		300SSP6013
WEAR SLEEVE	1	200SSP1458
OIL SEAL	1	60DD692
OIL SEAL	1	60DD693
O–RING	1	8502140
O–RING	1	25BC380
GASKET ELIMINATOR	1	25BC222
CHECK VALVE	1	90AR923
WEAR SLEEVE INSTALLATION / REMOVAL KIT (SSP Air Ends) (Includes next seven items)		200SSP4017
PULLER	1	200SSP219
PLATE–PULLER	1	200SSP340
SCREW	1	75LM192
SCREW	1	655ED120
SCREW	2	75D177
GUIDE	1	200SSP450
TOOL	1	200SSP074
AIR COOLED FIELD INSTALLED ENCLOSURE KIT	1	282ECM4017
AIR COOLED FIELD INSTALLED ENCLOSURE KIT	1	283ECM4017

Gardner Denver

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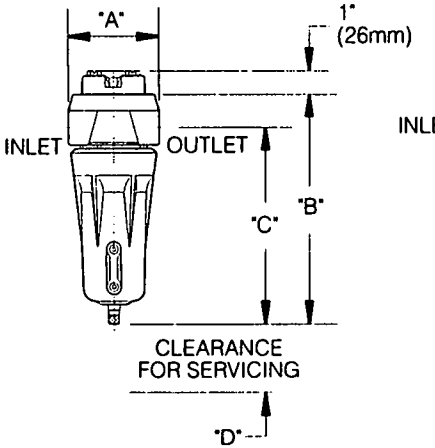
http://www.gardnerdenver.com **mktg@gardnerdenver.com**

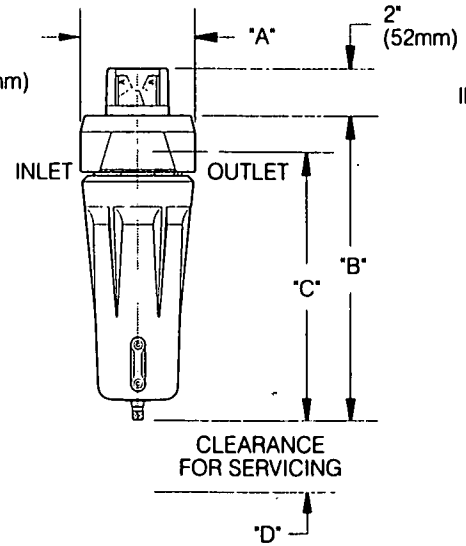
Filter Type ***HF(Grade)-***	12	16	20	24	28	32	36	40	44	48
Replacement Element ***E(Grade)-***	12	16	20	24	28	32	36	40	44	48
Nominal Air Flow scfm @100 psig (m^3_n/min @ 7.0 bar)	20 (.57)	35 (1.00)	60 (1.72)	100 (2.9)	170 (4.9)	250 (7.2)	375 (11)	485 (14)	625 (18)	780 (22)
In/Out Connection ***NPT or BSP***	3/8, 1/2	3/8, 1/2	3/8, 1/2	3/4, 1	3/4, 1	1, 1-1/4, 1-1/2	1, 1-1/4, 1-1/2	2, 2-1/2	2-1/2	2-1/2
"A"	4.13 (105)	4.13 (105)	4.13 (105)	5.25 (133)	5.25 (133)	6.44 (164)	6.44 (164)	7.63 (194)	7.63 (194)	7.63 (194)
"B"	10.05 (255)	10.05 (255)	12.40 (316)	13.32 (338)	17.57 (446)	20.80 (528)	25.29 (642)	29.08 (739)	34.83 (885)	40.96 (1040)
"C"	8.59 (224)	8.59 (224)	10.97 (285)	11.74 (298)	15.99 (406)	18.98 (482)	23.47 (596)	26.83 (681)	32.58 (827)	38.71 (983)
"D"	3.00 (76)	3.00 (76)	3.00 (76)	3.50 (89)	3.50 (89)	4.00 (102)	4.00 (102)	4.00 (102)	4.00 (102)	4.00 (102)
Weight	7.9 (3.58)	8.1 (3.67)	8.5 (3.86)	9.6 (4.35)	10.5 (4.76)	10.2 (4.63)	11.3 (5.13)	28 (12.70)	33 (14.97)	38 (17.24)
Maximum Working Pressure	300 psig, 21 bar (1)					300 psig, 21 bar (1)				
Maximum Operating Temperature	150°F, 66°C					150°F, 66°C				
Head Material	Zinc					Aluminum				
Bowl Material	Zinc			Aluminum		Aluminum		Steel		
Liquid Level Indicator Material	Isoplast					Isoplast		------		

NOTES

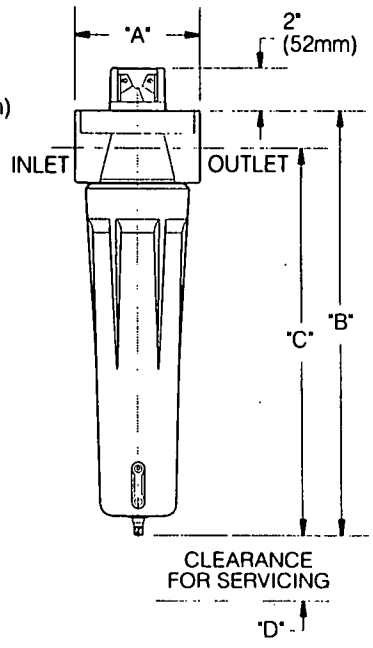
(1) Filter assemblies with a Liquid Level Indicator or an Automatic Float Drain installed will have a maximum working pressure of 250 psi (17 bar)



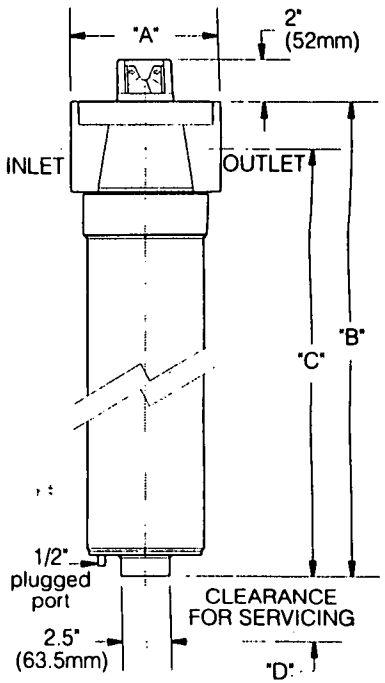
Sizes HF(Grade)-12, 16, 20



Sizes HF(Grade)-24, 28



Sizes HF(Grade) 32, 36



Sizes HF(Grade) 40, 44, 48

WARRANTY

The manufacturer warrants the product manufactured by it, when properly installed, operated, applied, and maintained in accordance with procedures and recommendations outlined in manufacturer's instruction manuals, to be free from defects in material and workmanship for a period of one (1) year from date shipment to the buyer by the manufacturer or manufacturer's authorized distributor provided such defect is discovered and brought to the manufacturer's attention within the aforesaid warranty period.

The manufacturer will repair or replace any product or part determined to be defective by the manufacturer within the warranty period, provided such defect occurred in normal service and not as a result of misuse, abuse, neglect or accident. Normal maintenance items requiring routine replacement are not warranted. The warranty covers parts and labor for the warranty period. Repair or replacement shall be made at the factory or the installation site, at the sole option of the manufacturer. Any service performed on the product by anyone other than the manufacturer must first be authorized by the manufacturer.

Unauthorized service voids the warranty and any resulting charge or subsequent claim will not be paid.

Products repaired or replaced under warranty shall be warranted for the unexpired portion of the warranty applying to the original product.

The foregoing is the exclusive remedy of any buyer of the manufacturer's product. The maximum damages liability of the manufacturer is the original purchase price of the product or part.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, WHETHER WRITTEN, ORAL, OR STATUTORY, AND IS EXPRESSED IN LIEU OF THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. THE MANUFACTURER SHALL NOT BE LIABLE FOR LOSS OR DAMAGE BY REASON OF STRICT LIABILITY IN TORT OR ITS NEGLIGENCE IN WHATEVER MANNER INCLUDING DESIGN, MANUFACTURE OR INSPECTION OF THE EQUIPMENT OR ITS FAILURE TO DISCOVER, REPORT, REPAIR, OR MODIFY LATENT DEFECTS INHERENT THEREIN.

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The manufacturer does not warrant any product, part, material, component, or accessory manufactured by others and sold or supplied in connection with the sale of manufacturer's products. 1/96

AUTHORIZATION FROM THE SERVICE DEPARTMENT IS NECESSARY BEFORE MATERIAL IS RETURNED TO THE FACTORY OR IN-WARRANTY REPAIRS ARE MADE.

SERVICE DEPARTMENT: (724) 746-1100

HANKISON INTERNATIONAL

Division Of Hansen Inc.
Canonsburg, PA 15317-1700 U.S.A.
Tel 724-745-1555 Fax 724-745-6040
E-mail - service@hankisonintl.com

NIP-233
March, 1983
Supersedes July, 1982

DESIGNER™ SERIES HIGH PERFORMANCE REGULATORS

TYPES R40 R41

OPERATION – R40 CONVENTIONAL REGULATOR

The R40 conventional regulator can be used as a pilot regulator to control a pilot operated (slave) regulator, or it can be used to regulate air pressure in low flow applications.

Outlet pressure is controlled by the adjusting knob (1). Clockwise rotation increases and counterclockwise rotation decreases outlet pressure. When the knob (1) is rotated fully counterclockwise, no force is applied to the regulating spring (2), and the valve (3) is held closed by the valve spring (4). Clockwise rotation of the knob (1) compresses the regulating spring (2) which applies a downward force on top of the diaphragm (5). The diaphragm (5) and valve tube (6) move downward forcing valve (3) off its seat which allows air to flow through the regulator to the downstream system.

Outlet pressure increases in the downstream system and sensing chamber (7) and applies an upward force on bottom of the diaphragm (5). The diaphragm, valve tube, and valve (5, 6, 3) move upward, compressing the regulating spring (2). Upward movement stops when the forces below the diaphragm balance the forces above the diaphragm. When there is no downstream flow demand, the balance of forces occurs with the valve (3) closed. When there is downstream flow demand, the balance of forces occurs when the valve opens sufficiently to compensate for demand, thus maintaining the desired outlet pressure.

RELIEVING FEATURE. The relieving feature allows the reduction of outlet pressure even though the system is dead-ended. When the knob (1) is turned counterclockwise, the force on the regulating spring (2) is reduced, and air pressure in the sensing chamber (7) moves the diaphragm (5) and valve tube (6) upward. This upward movement lifts the valve tube (6) off the valve (3) and allows air to escape from the outlet side of the regulator through the tube (6) and vent (8) to atmosphere. As the outlet pressure decreases to the reduced pressure setting, the diaphragm and valve tube move downward, closing the relief passage.

The diaphragm will likewise move upward in response to an increase in outlet pressure above the regulator setting allowing air to escape to the atmosphere as described above. However the flow capacity of the relief passage is limited, and depending upon the source of the over pressure condition, the outlet pressure might increase to a point significantly higher than the regulator setting. For this reason, the relief feature of a regulator must not be relied upon as an overpressure safety device. See WARNING note below.

CONSTANT BLEED FEATURE. The constant bleed feature helps to minimize outlet pressure drop when a flow demand is initially placed on the regulator. A very small amount of outlet air flows continuously through bleed hole (9) in the valve tube and escapes to atmosphere through vent (8). This keeps the valve slightly open to replace the air lost to atmosphere through the constant bleed. Since the valve is always partially open, the pressure drop is minimized when demand is initially increased from no flow to some higher flow. This constant escape of air from the regulator vent is normal and does not indicate a faulty regulator. Nonbleed models are not equipped with bleed hole (9).

OPERATION – R41 FEEDBACK REGULATOR

The R41 feedback regulator, which has a port marked "FDBK" located next to the "IN" port, can only be used as a pilot regulator to control Norgren R18 and 11-042 pilot operated (slave) regulators. Operation of the feedback R41 is the same as the conventional R40 except that outlet pressure of the slave regulator is sensed (thru the feedback line) under the R41 diaphragm (5), causing valve (3) to close when the desired outlet pressure of the slave regulator is achieved. See Installation NOTES on next page.

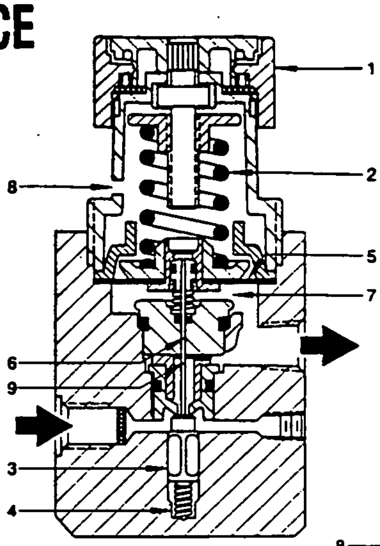
WARNING

THESE REGULATORS ARE INTENDED FOR USE IN INDUSTRIAL COMPRESSED AIR SYSTEMS ONLY. DO NOT USE THESE REGULATORS WHERE PRESSURE OR TEMPERATURE CAN EXCEED RATED OPERATING CONDITIONS. SEE SPECIFICATIONS.

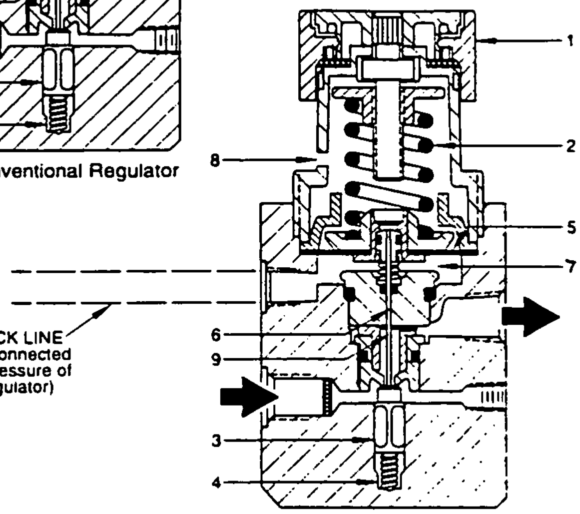
IF OUTLET PRESSURE IN EXCESS OF THE REGULATOR PRESSURE SETTING COULD CAUSE DOWNSTREAM EQUIPMENT TO RUPTURE OR MALFUNCTION, INSTALL A PRESSURE RELIEF DEVICE DOWNSTREAM OF THE REGULATOR. THE RELIEF PRESSURE AND FLOW CAPACITY OF THE RELIEF DEVICE MUST SATISFY SYSTEM REQUIREMENTS

THE ACCURACY OF THE INDICATION OF PRESSURE GAUGES CAN CHANGE, BOTH DURING SHIPMENT (DESPITE CARE IN PACKAGING) AND DURING THE SERVICE LIFE. IF A PRESSURE GAUGE IS TO BE USED WITH THESE PRODUCTS AND IF INACCURATE INDICATIONS MAY BE HAZARDOUS TO PERSONNEL OR PROPERTY, THE GAUGE SHOULD BE CALIBRATED BEFORE INITIAL INSTALLATION AND AT REGULAR INTERVALS DURING USE. FOR GAUGE STANDARDS REFER TO ANSI B40.1.

BEFORE USING WITH FLUIDS OTHER THAN AIR, FOR NON-INDUSTRIAL APPLICATIONS, OR FOR LIFE-SUPPORT SYSTEMS CONSULT NORGREN.



R40 Conventional Regulator



R41 Feedback Regulator

1'/2" Pilot Stg

WARNING

FEEDBACK LINE BETWEEN R41 AND SLAVE REGULATOR OUTLET PRESSURE MUST BE CONNECTED BEFORE TURNING ON AIR PRESSURE. IF THE FEEDBACK LINE IS NOT CONNECTED, SLAVE REGULATOR OUTLET PRESSURE WILL RAPIDLY INCREASE TO INLET PRESSURE WHEN THE R41 ADJUSTING KNOB IS TURNED CLOCKWISE. NEVER USE THE R41 FEEDBACK REGULATOR AS A CONVENTIONAL REGULATOR.

SPECIFICATIONS

See NC-233 for description of model number.

RATED OPERATING CONDITIONS –
Inlet Pressure: 10 to 450 psig (0.7 to 31 bar)
Temperature: 0° to 175°F (–18° to 79°C) with dewpoint less than air temperature below 35°F (2°C).

FLUID: Compressed Air

MAIN PORTS –
Standard: 1/4" PTF
Optional: G 1/4 ISO

R41 FEEDBACK PORT –
Standard: 1/8" PTF
Optional: G 1/8 ISO

R40 TYPE: Conventional; Relieving Diaphragm; Constant Bleed (Non-Bleed Optional)

R41 TYPE: Feedback; Relieving Diaphragm; Constant Bleed (Non-Bleed Optional)

OUTLET PRESSURE ADJUSTMENT RANGES* –
Standard: 5 to 125 psig (.3 to 8.6 bar)
Optional: 2 to 50 psig (.1 to 3.5 bar)
Optional: 10 to 250 psig (.7 to 17.2 bar)

MATERIALS OF CONSTRUCTION –
Body, Bonnet, Valve Seat: Aluminum
Valve: Teflon
Elastomers: Buna-N

*Outlet pressure adjustment ranges are not minimum or maximum outlet pressure limits. Regulators can be adjusted to zero psig outlet pressure and, generally, to pressures in excess of those specified. The use of these regulators to control pressures outside of the specified ranges is not recommended.

INSTALLATION

NOTE

- ***IF THE R40 OR R41 WILL BE USED AS A PILOT REGULATOR FOR THE R18 SLAVE REGULATOR, SEE NIP-230 FOR INSTALLATION.***
- ***IF THE R40 OR R41 WILL BE USED AS A PILOT REGULATOR FOR THE 11-042 SLAVE REGULATOR, SEE NIP-234 FOR INSTALLATION.***

1. Install regulator as close as possible to the device being serviced. Regulator can be installed at an angle.
2. In systems with a cyclic demand, install regulator upstream of cycling control valves.
3. System piping should be same size as regulator ports.
4. Connect piping to proper ports using pipe thread sealant on male threads only. Do not allow sealant to enter interior of regulator. The "IN" and "OUT" ports are marked on the regulator body.
5. Install a filter upstream of the regulator.

ADJUSTMENT

1. Before turning on system pressure, turn regulator adjustment counterclockwise until all load is removed from regulating spring.
2. Turn on system pressure.
3. Turn regulator adjustment clockwise until the desired outlet pressure is reached.
4. To avoid minor readjustment after making a change in pressure setting, always approach the desired pressure from a lower pressure. When reducing from a higher to a lower setting, first reduce to some pressure less than that desired, then bring up to the desired pressure.
5. Push lockring on adjusting knob downward to lock pressure setting. To release, pull lockring upward.

DISASSEMBLY

1. Shut off inlet pressure and reduce pressure in inlet and outlet lines to zero.
2. Turn adjusting knob counterclockwise until all load is removed from spring (3).
3. Disassemble the regulator in accordance with the exploded view. Use a 7/8" socket to remove guide plug (9). When items 1 thru 11 have been removed, cover bonnet bore in body (16) with a clean cloth, then direct a jet of air into the "IN" port to force valve seat (12), valve (14) and spring (15) out of body. Catch seat, valve, and spring in cloth placed over bonnet bore in body.

CLEANING

1. Clean parts using warm water and soap. Do not submerge bonnet (2) in cleaning solution as lubricant will be removed.
2. Rinse all parts and dry thoroughly.
3. Inspect all parts.
4. Replace worn or damaged parts.

REASSEMBLY

1. Prior to reassembly, lubricate the following items:

Item	Lubricant
6, 7, 10, 13 (O-rings and outer surface of tube)	Generous coat of Dow Corning 44 grease (or equivalent).
2, 9 (threads on bonnet and guide plug)	Small, even amount of Armite Laboratories Led-Plate 250 (or equivalent).

2. Assemble the regulator as shown in the exploded view. Torque guide plug (9) to 30-to-50 inch-pounds. Torque bonnet (2) to 34-to-40 foot-pounds.

REPAIR PARTS

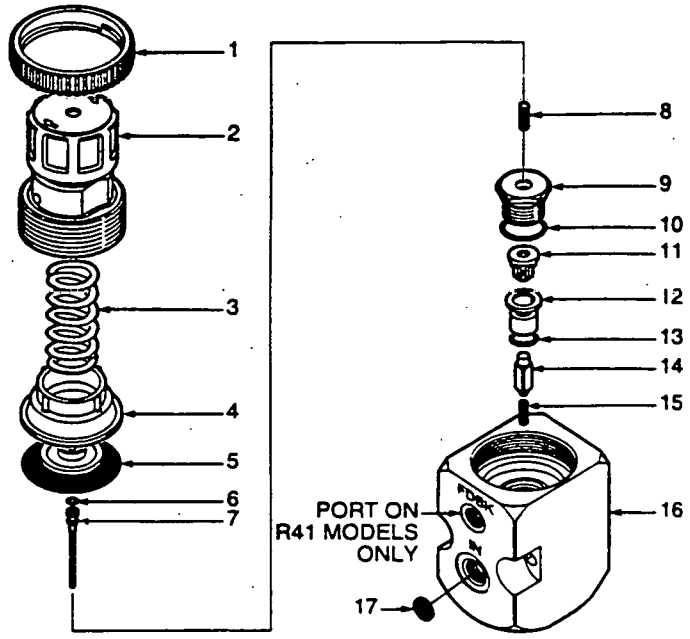
Diaphragm (Item 5)	5909-50
Valve Tube, Constant Bleed (Item 7)	5907-50
Valve Tube, Non-Bleed (Item 7)	5907-51
Valve Seat (Item 12)	5906-01
Valve (Item 14)	5905-01
Regulating Spring (Item 3)	
2 to 50 psig	5302-02
5 to 125 psig	5354-02
10 to 250 psig	5195-01

ACCESSORIES

Panel Mounting Nut (Item 1)	5191-89
Wall Mounting Bracket	5203-05
Integral Mounting Kit (Mounts the R40 or R41 to the R18)	
PTF Threads	5945-42
ISO G Threads	5945-43

REPAIR KITS

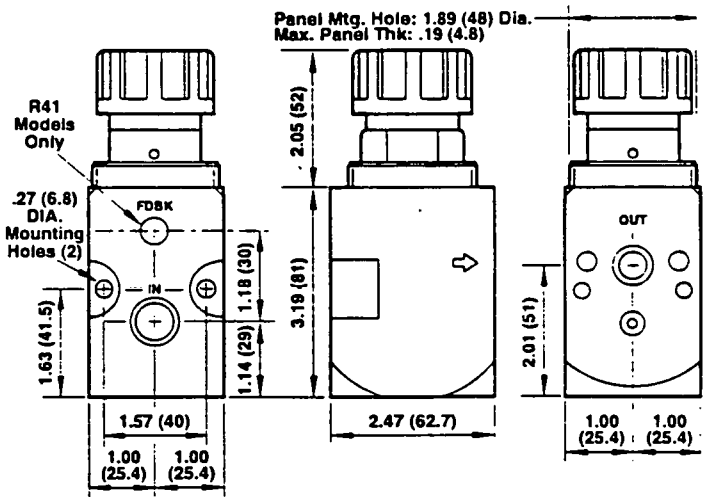
Includes items 5, 6, 8, 9, 10, 11, 13, 14, 15, 17	5945-41

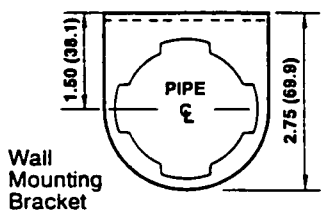


1. Panel Mounting Nut (Optional)
2. Bonnet
3. Regulating Spring
4. Slip Ring
5. Diaphragm
6. O-ring
7. Tube
8. Valve Spring
9. Guide Plug
10. O-ring
11. Guide Bushing
12. Valve Seat
13. O-ring
14. Valve
15. Valve Spring (same as 8)
16. Body
17. Screen

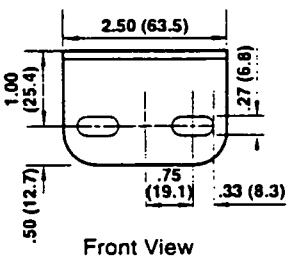
DIMENSIONS

All dimensions in inches (mm).





Top View



Front View

NIP-233/3-83

Trerice

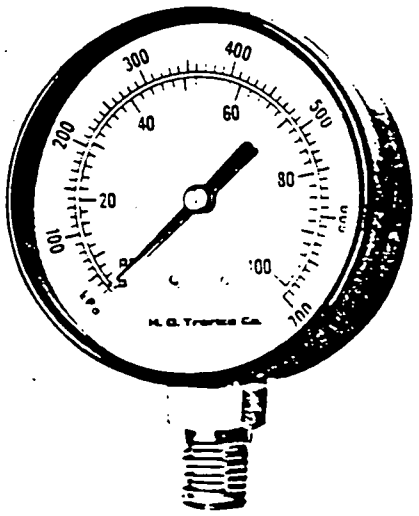
PRESSURE GAUGES
NO. 800 & 800LF SERIES
2½", 3½" & 4½" SIZES · DRY
2½", 3½" SIZES · LIQUID FILLED

NO. 800 SERIES — 2½", 3½" & 4½" SIZES

The No. 800 Series TRERICE Pressure Gauges are very desirable for use where inexpensive light weight gauges are preferred for indicating pressures on steam, air, water, oil or any pressure medium that does not attack brass. They are also recommended for applications where severe pulsations do not exist. These gauges are furnished standard in 2½", 3½" & 4½" sizes in drawn steel cases & rings. Bottom outlet is standard. Back outlet can be supplied on the 2½" and on special order the 3½" size. Panel mounted front flange and U-clamp styles are also available on special order. Also, brass or brass chrome plated drawn cases can be supplied on special order.

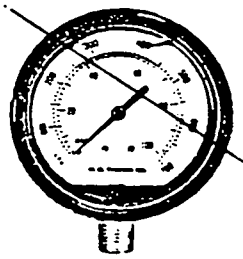
STANDARD SPECIFICATIONS

CASE: Drawn steel — black finished.
RING: Friction type — black finished.
DIAL: Steel with white background and dual scale with PSI and Kpa. Black markings on the outer scale & blue markings on the inner scale.
WINDOW: Clear glass; 600 psi & above — plastic.
POINTER: Aluminum — black finished.
MOVEMENT: Brass.
BOURDON TUBE: Above 15 psi to 1000 psi — phosphor bronze. 15 psi and below and above 1000 psi — beryllium copper.
SOCKET: Brass — ¼" NPT.
ACCURACY: ANSI B40.1 Grade B. 2% over middle half of scale range. 3% over remainder.
HOW TO ORDER: State — quantity, catalog number, range, size and bottom tom or back outlet.



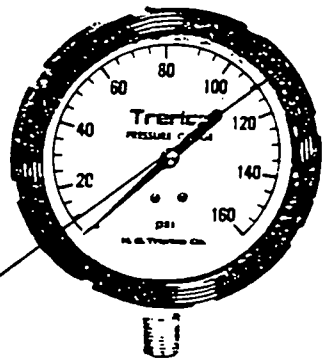
NO. 800

NOTE: For correct use and application of pressure gauges, see PRESSURE GAUGE STANDARD ANSI B40.1.



No. 800LF · 2½"
STANDARD SPECIFICATIONS

CASE: Black Rynite ®.
RING & WINDOW: One piece moulded acrylic.
DIAL: White with black outer scale markings, blue inner scale markings.
POINTER: Plain — black finish.
MOVEMENT: Brass.
BOURDON TUBE: Above 15 psi to 1000 psi — phosphor bronze. 15 psi and below and above 1000 psi — beryllium copper.
SOCKET: Brass — ¼" NPT.
ACCURACY: ANSI B40.1 Grade B. 2% over middle half of scale range. 3% over remainder.
LIQUID FILLS: 0 to 150°F — Glycerin, −60 to 150°F — Silicone.
RANGES: Vacuum to 5000 psig.
HOW TO ORDER: State Quantity, catalog number, size, range and type of fill.



No. 800LF · 3½"
STANDARD SPECIFICATIONS

CASE: Black nylon.
RING: Threaded black nylon.
WINDOW: Acrylic plastic.
DIAL: White with black scale markings.
POINTER: Plain — black finish.
MOVEMENT: Brass.
BOURDON TUBE: Above 15 psi to 1000 psi — phosphor bronze. 15 psi and below and above 1000 psi — beryllium copper.
SOCKET: Brass — ¼" NPT.
ACCURACY: ANSI B40.1 Grade B. 2% over middle half of scale range. 3% over remainder.
LIQUID FILLS: 0 to 150°F — Glycerin, −60 to 150°F — Silicone.
RANGES: Vacuum to 5000 psig.
HOW TO ORDER: State Quantity, catalog number, size, range and type of fill.

NOTE: For requirements on 4½" liquid filled gauges, see page 140-4 for the 450LF Series.

Trerice

PRESSURE GAUGES
NO. 800 & NO. 800LF SERIES
RANGES

STANDARD PRESSURE, COMPOUND & VACUUM RANGES FOR NO. 800 AND NO. 800LF GAUGES

DIAL RANGE		2½" SIZE				4½" SIZE			
		FIGURE INTERVALS		MINOR GRADUATIONS		FIGURE INTERVALS		MINOR GRADUATIONS	
VACUUM	PRESSURE	VACUUM	PRESSURE	VACUUM	PRESSURE	VACUUM	PRESSURE	VACUUM	PRESSURE
30" Hg. – 100 kPa	0 psi 0 kPa	5" Hg. 10 kPa	– – – – – –	1" Hg. 2 kPa	– – – – – –	5" Hg. 10 kPa	– – – – – –	0.5" Hg. 1 kPa	– – – – – –
30 Hg. – 100 kPa	15 psi 100 kPa	10" Hg. 20 kPa	5 psi 20 kPa	2" Hg. 5 kPa	1 psi 5 kPa	10" Hg. 20 kPa	5 psi 20 kPa	2" Hg. 5 kPa	1 psi 5 kPa
30" Hg. – 100 kPa	30 psi 200 kPa	10" Hg. 25 kPa	5 psi 25 kPa	2" Hg. 5 kPa	1 psi 5 kPa	10" Hg. 25 kPa	5 psi 25 kPa	1" Hg. 5 kPa	1 psi 5 kPa
30" Hg. – 100 kPa	60 psi 400 kPa	10" Hg. 50 kPa	10 psi 50 kPa	2" Hg. 5 kPa	2 psi 5 kPa	10" Hg. 50 kPa	10 psi 50 kPa	2" Hg. 5 kPa	2 psi 5 kPa
30" Hg. – 100 kPa	100 psi 700 kPa	30" Hg. 100 kPa	20 psi 100 kPa	2" Hg. 10 kPa	2 psi 10 kPa	30" Hg. 100 kPa	20 psi 100 kPa	2" Hg. 10 kPa	2 psi 10 kPa
30" Hg. – 100 kPa	150 psi 1000 kPa	30" Hg. 100 kPa	30 psi 200 kPa	5" Hg. 20 kPa	5 psi 20 kPa	30" Hg. 100 kPa	30 psi 100 kPa	5" Hg. 10 kPa	2 psi 10 kPa
30" Hg. – 100 kPa	300 psi 2000 kPa	30" Hg. 100 kPa	50 psi 200 kPa	10" Hg. 50 kPa	10 psi 50 kPa	30" Hg. 100 kPa	50 psi 200 kPa	5 Hg. 20 kPa	5 psi 20 kPa
0 psi 0 kPa	15 psi 100 kPa	– – – – – –	3 psi 10 kPa	– – – – – –	.5 psi 2 kPa	– – – – – –	3 psi 10 kPa	– – – – – –	.2 psi 1 kPa
0 psi 0 kPa	30 psi 200 kPa	– – – – – –	5 psi 20 kPa	– – – – – –	1 psi 5 kPa	– – – – – –	5 psi 20 kPa	– – – – – –	.5 psi 2 kPa
0 psi 0 kPa	60 psi 400 kPa	– – – – – –	10 psi 50 kPa	– – – – – –	2 psi 10 kPa	– – – – – –	10 psi 50 kPa	– – – – – –	1 psi 5 kPa
0 psi 0 kPa	100 psi 700 kPa	– – – – – –	20 psi 100 kPa	– – – – – –	2 psi 10 kPa	– – – – – –	20 psi 100 kPa	– – – – – –	2 psi 10 kPa
0 psi 0 kPa	160 psi 1100 kPa	– – – – – –	20 psi 200 kPa	– – – – – –	5 psi 20 kPa	– – – – – –	20 psi 200 kPa	– – – – – –	2 psi 10 kpa
0 psi 0 kPa	200 psi 1400 kPa	– – – – – –	40 psi 200 kPa	– – – – – –	5 psi 20 kPa	– – – – – –	40 psi 200 kPa	– – – – – –	5 psi 20 kPa
0 psi 0 kPa	300 psi 2000 kPa	– – – – – –	50 psi 400 kPa	– – – – – –	10 psi 50 kPa	– – – – – –	50 psi 400 kPa	– – – – – –	5 psi 20 kPa
0 psi 0 kPa	*400 psi 2800 kPa	– – – – – –	50 psi 400 kPa	– – – – – –	10 psi 50 kPa	– – – – – –	50 psi 400 kPa	– – – – – –	10 psi 50 kPa
0 psi 0 kPa	600 psi 4000 kPa	– – – – – –	100 psi 500 kPa	– – – – – –	10 psi 100 kPa	– – – – – –	100 psi 500 kPa	– – – – – –	10 psi 50 kPa
0 psi 0 kPa	1000 psi 7000 kPa	– – – – – –	200 psi 1000 kPa	– – – – – –	20 psi 100 kPa	– – – – – –	200 psi 1000 kPa	– – – – – –	20 psi 100 kPa
0 psi 0 kPa	1500 psi 10000 kPa	– – – – – –	300 psi 2000 kPa	– – – – – –	50 psi 200 kPa	– – – – – –	300 psi 2000 kPa	– – – – – –	20 psi 100 kPa
0 psi 0 kPa	2000 psi 14000 kPa	– – – – – –	400 psi 2000 kPa	– – – – – –	50 psi 200 kPa	– – – – – –	400 psi 2000 kPa	– – – – – –	50 psi 200 kPa
0 psi 0 kPa	3000 psi 20000 kPa	– – – – – –	500 psi 4000 kPa	– – – – – –	100 psi 500 kPa	– – – – – –	500 psi 4000 kPa	– – – – – –	50 psi 200 kPa
0 psi 0 kPa	5000 psi 35000 kPa	– – – – – –	1000 psi 5000 kPa	– – – – – –	100 psi 500 kPa	– – – – – –	1000 psi 5000 kPa	– – – – – –	50 psi 500 kPa

*Not available in back connected model.

Dual scales (PSI & Kpa) are standard and are carried in stock. Single scale available on special order.

NOTE: For correct use and application of pressure gauges. see PRESSURE GAUGE STANDARD ANSI B40.1.

ITEM 6

Multistage Diffuser

Ancillaries

Blower Fan
Flow Switch
Level Switch

CARBTROL®
CORPORATION

51 Riverside Avenue
Westport, Connecticut 06880
1-800-242-1150 • Fax. # (203) 226-5322
Web Address: http://www.carbtrol.com

INSTALLATION AND OPERATING INSTRUCTIONS
CARBTROL® GROUNDWATER TREATMENT SYSTEM

INSTALLATION

The Carbtrol Groundwater Treatment System consists of a Multistage Diffuser (MSD-6-100) with a Low Air Flow Switch, a High Level , a reinforced lid and a motor starter.

Position the MSD-6-100 skid on a level surface not subject to flooding. The mounting pallets are designed for forklift entry for ease of field installation.

Note: The MSD tank must be placed on a level surface so as to fully support and evenly distribute the load of a full tank.

The system is provided with a cover and vent stack connection to minimize local buildup of volatile concentrations around the area of the unit. If the Multistage Diffuser System is to be installed indoors, the stack should be vented to the outside.

If the system is to be operated in cold climates, it should be located indoors.

Remove any shipping tape and packing material. Inspect the pallets, equipment, and piping. Check all threaded and flexible coupling piping connections and all bolt assemblies as these connections may come loose during shipment.

Reference Composite Dimensions Drawing No. 1894/12.

FIELD PIPING CONNECTIONS

Connect the MSD blower discharge piping to the blower outlet using the flange assembly provided and to the air inlet of the diffuser tank using the flexible coupling provided.

Connect the owner's piping to the 3/4"Ø bottom drain valve for disposal as required.

Note: If additional blower suction piping is required, use one pipe size larger than the blower inlet and avoid using pipe elbows in the blower suction line. The addition of blower suction piping will affect fan performance and may require an adjustment to the position of the inlet slide gate valve.

Connect the discharge of the owner's raw water feed pump(s) to the inlet of the MSD using the 4"Ø flexible coupling provided.

Connect minimum 6"Ø piping (furnished by others) from the MSD discharge to the treated water discharge pipe, sump, or trench. ARRANGE OUTLET PIPING FOR GRAVITY DISCHARGE.

Insert an 8"Ø vent stack as required into the 8" x 10" lid vent connection. If the stack is more than 5' 0" long, provide guy wires to prevent stack swaying and supports to bear stack weight.

CAUTION: The MSD lid is designed for a maximum of 5" w.c. steady backpressure. Intermittent or pulsating backpressure may cause premature failure of the lid. Backpressure in excess of 5" w.c. may cause the unit to leak at the lid gasket.

Note: It is recommended that a demister be installed on the MSD air exhaust if the the MSD air is to exhaust through carbon units.

FIELD ELECTRICAL CONNECTIONS

Connect the owner's 260V, 3Ø, 60 Hz. power to the motor starter.

The following switches are supplied with the unit and should be wired in series with the owner's raw water feed pump(s):

- MSD Low Air Flow Switch
- MSD High Level Switch

If the Low Air Flow Switch should close or the High Level Switch should open, the raw water feed pump(s) should be de-energized. This will prevent the discharge of inadequately treated water and/or flooding at the site.

The MSD blower should not be automatically started and stopped upon alarm conditions, but should run continuously.

If desired, provide a bypass switch to enable the owner's raw water feed pump(s) to start up in the MSD low air flow condition during initial filling of the MSD tank.

Field installation should be in accordance with all local ordinances and the National Electrical Code.

OPERATION

Close the drain valve in the MSD tank.

Check blower for proper rotation.

WARNING: DO NOT start the MSD blower until the MSD tank is filled.

The MSD diffuser tank may be filled with clean water for startup via a garden hose, or it may be filled by turning on the owner's raw water feed pump(s) with operators in attendance, only until the diffuser tank is filled. At this time the pump(s) should be turned to off.

Once the diffuser tank is filled, start the MSD blower. Turn off the bypass switch, if any, to the MSD blower Low Air Flow Switch.

The slide gate valve at the MSD blower suction has been factory preset and scribed to deliver proper air flow for operation of the system. The MSD blower discharge gauge should read 19" w.c. during operation.

The system air flow was factory set on clean equipment. Higher blower discharge pressures at the original slide gate valve setting may indicate sediment buildup, resulting in reduced air flow. Inspect the unit and clean as necessary.

If the blower discharge pressure is less than 21" w.c. at the original slide gate valve setting, consult Carbtrol.

Note: The MSD was tested with no backpressure on the unit. The addition of carbon will change the reading on the MSD blower discharge gauge.

The MSD should be inspected at least once per shift while in operation.

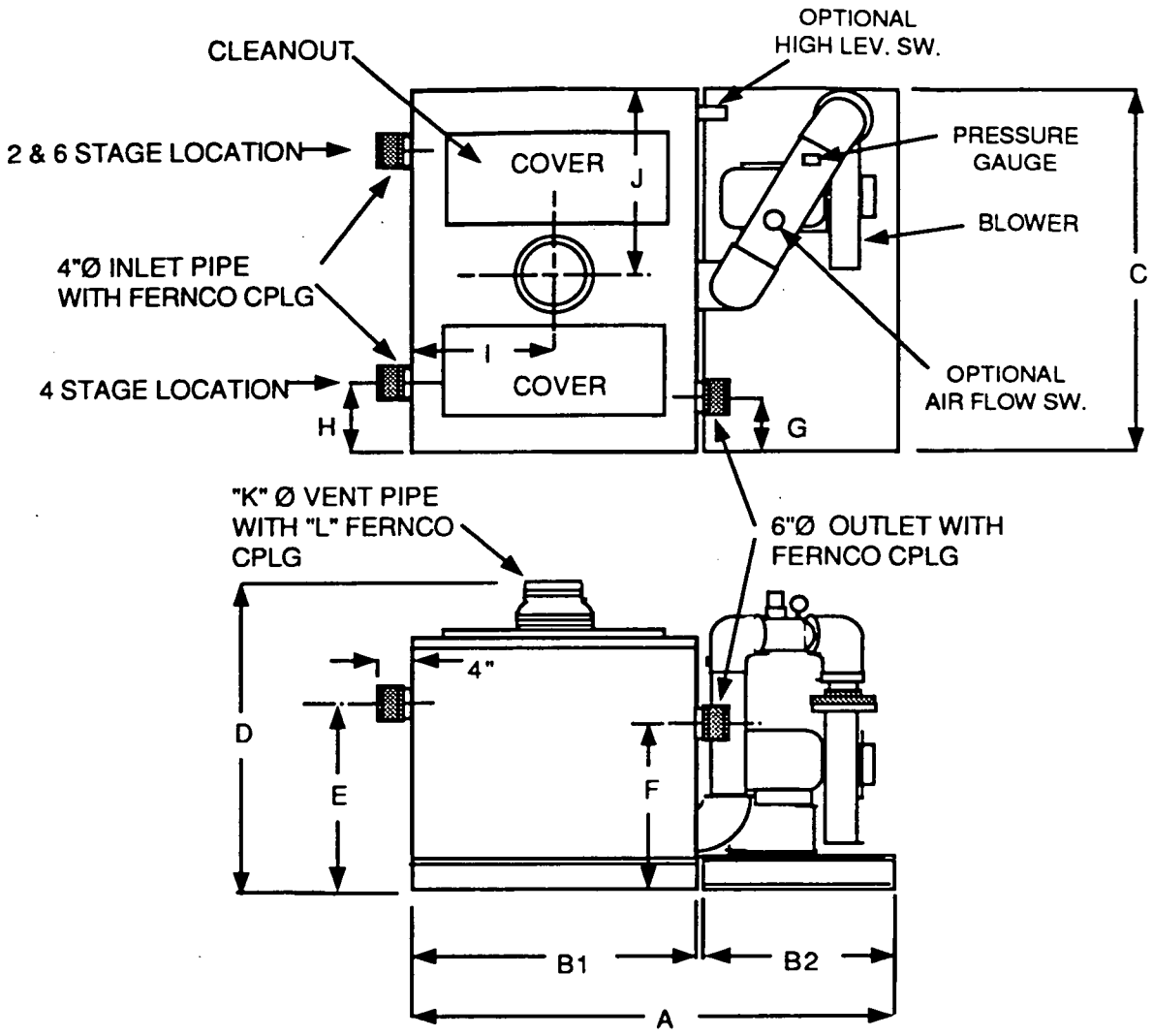
To stop operation of the system, first stop the owner's raw water feed pump(s). Next, turn the MSD blower off. If this shutdown is to be for an extended period, the MSD diffuser tank should be drained back to the head of the system or the water disposed of in an environmentally safe manner using the 3/4"Ø bottom drain valve provided.

MAINTENANCE

If the MSD Low Air Flow Switch is activated, check the MSD blower for proper operation and the diffuser pipes for fouling. Also check the blower inlet and air discharge line for blockage or restrictions.

If the MSD High Level Switch is activated, check the MSD outlet pipe for blockage.

The MSD air diffuser pipes are threaded for easy removal for cleaning. Drain the tank per the above instructions, remove the diffuser pipes and clear the holes of any blockage. Hose down the tanks to remove any sediment buildup.



	DIMENSIONS IN INCHES AT BASE FRAME													
MODEL	A	B1	B2	C	D	E	F	G	H	I	J	K	L	COVERS
MSD2	45 1/4	21	24	48	36 5/8	23 1/4	19 1/2	10 1/2	10 1/2	10 1/2	24	8	6 x 8	12 x 12
MSD4	64 1/4	40	24	48	36 5/8	23 1/4	19 1/2	10 1/2	10 1/2	20	24	10	8 x 10	12 x 28
MSD6	83 1/4	59	24	48	39 3/8	23 1/4	19 1/2	10 1/2	10 1/2	29 1/2	24	10	8 x 10	12 x 46

CARBTROL®
CORPORATION
51 RIVERSIDE AVENUE
WESTPORT CONN. 06880
(203) 226-5642

SCALE ____ | BY WH

DATE 6-21-93 | *wah* | REV 3-20-98

2,4 & 6 STAGE, MULTI-STAGE DIFFUSER

STANDARD AND HIGH AIR FLOW MODELS

COMPOSITE DIMENSIONS | S | DWG 1894/12

LEVEL SWITCH

Model NKP

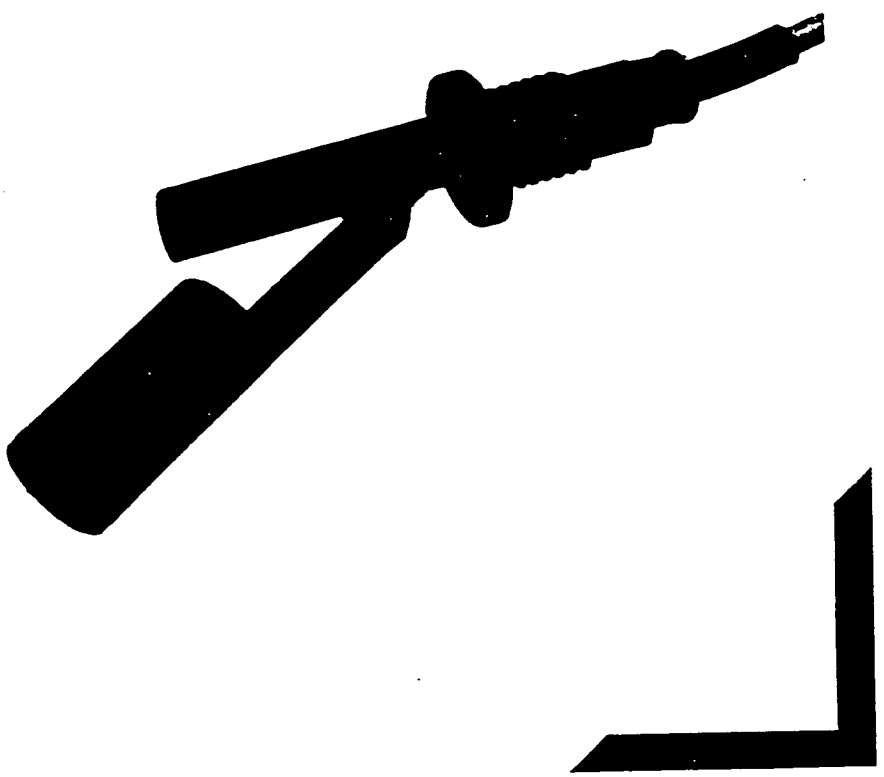
Features

- Excellent Chemical Resistance
- Small Size-Easy Installation
- N/O or N/C User Selectable
- Gas Encapsulated Reed Switch
- NEMA 6 Protection
- Cost Effective
- Ideal for Tanks with Inaccessible Tops or Bottoms

LEVEL SWITCH

Features

- Excellent Chemical Resistance
- Small Size-Easy Installation
- N/O or N/C User Selectable
- Gas Encapsulated Reed Switch
- NEMA 6 Protection
- Cost Effective
- Ideal for Tanks with Inaccessible Tops or Bottoms
- Virtually Maintenance-Free

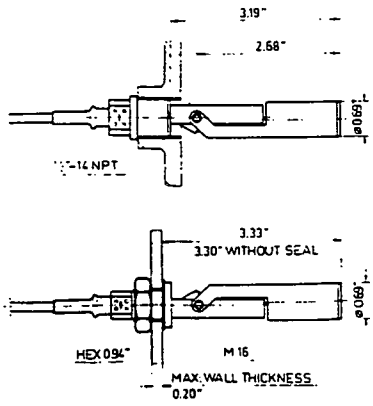


Kobold's NKP is a highly cost effective level switch. The unit is available in either polypropylene or PVDF construction for maximum compatibility with aggressive fluids. The NKP is distingulshed by its instant response, small footprint and high capacity reed switch.

Operation

The NKP is installed into the sidewalls of tanks. The plastic float contains a magnet which moves as the fluid level rises above or drops below the switch installation point. This movement brings the magnet into close proximity with an encapsulated reed contact, causing it to switch. The contact function may be selected as either normally open or normally closed by rotating the switch 180° about its axis. This simple design makes the NKP virtually maintenance free.

Dimensions



Ordering Data		
Fittings	PP	PVDF
½" NPT	NKP-2401	NKP-2501
Bulkhead	NKP-6401	NKP-6501

Specifications

Composition:
Float: Polypropylene, PVDF
Housing: Polypropylene, PVDF
Fittings: ½" NPT or bulkhead
Orientation: Horizontal ± 30°
Max. Temperature:
Polypropylene: 175° F
PVDF: 212° F
Max. Pressure: 145 PSIG
Min. Fluid Density:
Polypropylene: 0.6 g/ml
PVDF: 0.95 g/ml
Reed Switch:
Max. Voltage: 250 VAC
Max. Current: 1.5 A
Max. Power: 50 watts
Cabling: 3 ft, PVC clad, AWG 20/2
Protection: NEMA 6

OPERATING & MAINTENANCE INSTRUCTIONS AND PARTS LIST

for
HDBI - Backward Inclined Blowers
RBE - Radial Blade Exhausters
HP - High Pressure Blowers

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XI	Assembly Drawings	Page 7-12

⚠ DANGER

ALL FANS AND BLOWERS SHOWN HAVE ROTATING PARTS AND PINCH POINTS. SEVERE PERSONAL INJURY CAN RESULT IF OPERATED WITHOUT GUARDS. STAY AWAY FROM ROTATING EQUIPMENT UNLESS IT IS DISCONNECTED FROM ITS POWER SOURCE AND ALL ROTATING PARTS HAVE STOPPED MOVING.

READ ALL OPERATING INSTRUCTIONS CONTAINED HEREIN BEFORE INSTALLING EQUIPMENT.

⚠ DANGER

NO GUARANTEE OF ANY LEVEL OF SPARK RESISTANCE IS IMPLIED BY SPARK RESISTANT CONSTRUCTION. IT HAS BEEN DEMONSTRATED THAT ALUMINUM IMPELLERS RUBBING ON RUSTY STEEL MAY CAUSE HIGH INTENSITY SPARKS. AIR STREAM MATERIAL AND DEBRIS OR OTHER SYSTEM FACTORS MAY ALSO CAUSE SPARKS.

cincinnati fan

PART # 01001
CATALOG # PMK-1293
SUPERSEDES: PMK-992

I GENERAL SAFETY NOTES

1. Rotating parts including shaft and V-belt drives must be properly guarded to prevent personal injury.

2. Electrical wiring must be accomplished by a qualified electrician in accordance with all applicable codes.

3. Care should be taken:
   - Not to run fan above its safe speed (See Performance Tables in Sales Catalog or call CFV sales office).
   - Not to operate in excessive temperatures (See limitations in Sales Catalog or call CFV sales office).
   - Not to operate in dangerous environments.
   - Read all instructions carefully.

II RECEIVING

Receiving Inspection

When unit is received, inspect immediately for damaged or missing parts. Even though all units are carefully inspected and prepared for shipment at the factory, rough handling enroute may cause concealed damage or cause nuts, set screws, bolts or locking collars to work loose. Be certain all fasteners are tightened securely. Rotate wheel by hand to verify that it rotates freely and that there are no obstructions.

Table #1

TORQUE VALUES FOR TAPERED BUSHINGS		
	MINIMUM RECOMMENDED TORQUE (INCH-LBS)	
Bushing Size	Steel Parts	Alum. Parts
H	95	60
B & P	192	80
Q & R	348	155

Inspect all shipments carefully for damage. THE RECEIVER MUST NOTE ANY DAMAGE ON THE CARRIER'S BILL OR LADING AND FILE A CLAIM IMMEDIATELY WITH THE FREIGHT COMPANY IN THE CASE OF ANY DAMAGE. Keep a record of all equipment received, including inspection details and date of receipt because of the possibility of partial shipments.

III HANDLING

Handle your equipment with care. Some fans are provided with lifting lugs or holes for easy handling. Others must be handled using nylon straps or well-padded chains and cables which protect the fan's coating and housing. Spreader bars should be used when lifting large parts.

Centrifugal fans are best lifted using one strap under the fan's scroll and another strap around the bearing base. DO NOT LIFT CENTRIFUGAL FANS BY THE FAN SHAFT, WHEEL, FLANGES OR INLET SUPPORT.

IV GENERAL INSTALLATION INSTRUCTIONS

Foundations

Fan foundation must be flat, level and rigid. Where foundation is not completely flat, shims must be placed under fan support at each anchor bolt as required. Bolting fan to an uneven foundation distorts alignment and causes vibration.

Structural steel foundations should be heavily cross-braced for load support.

Table #2

SET SCREW TORQUE VALUES			
SET SCREW SIZE		MINIMUM REQUIRED TORQUE (INCH-LBS)	
Diameter & No. of Threads/Inch	Hex Size Across Flats (Allen Wrench)	Steel Set Screw Into Steel Threads	Steel Set Screw Into Alum. Threads or Stainless Steel Set Into Stainless Steel Threads
1/4-20	1/8"	92	65
5/16-18	5/32"	165	100
3/8-16	3/16"	228	155
7/16-14	7/32"	348	230
1/2-13	1/4"	504	330
5/8-11	5/16"	1104	700

NOTE: If wheel set screws are loosened and/or wheel is removed from shaft, set screws must be replaced. Set screws cannot be used more than once. Use knurled, cup point set screws with a locking patch.

OPERATION

Before Connecting Power

1. Inspect all fasteners and retighten if necessary:
   a. Foundation bolts.
   b. Set screws in fan and wheel and V-belt drive (See Tables #1 & #2 on preceding page).
   c. Housing, bearing and motor mounting.

2. Inspection doors should be tight and sealed.

3. Bearings should be checked for alignment and lubrication (See Fan Bearing Maintenance, page 5).

4. Turn rotating assembly by hand to insure that it does not strike housing. If the wheel strikes the housing, the wheel may have moved on the shaft or the bearings may have shifted in transit. Correction must be made prior to start up.

5. Check motor to insure proper speed and electrical characteristics.

6. Check V-belt drive for alignment and correct belt tension.

7. After wiring, energize motor for 1 second to check for proper rotation.

V GENERAL MAINTENANCE

CAUTION

Before any maintenance or service is performed, assure that unit is disconnected from power source to prevent accidental starting.

The key to good fan maintenance is a regular and systematic inspection of all fan parts. Severity of the application should determine frequency of inspection. The components requiring service are generally the moving parts which include bearings, fan wheel, belts, sheaves and motor.

Cast Aluminum & Metal Parts

Cast aluminum and steel parts usually do not require maintenance during the life of the unit except painted metal surfaces that may require periodic repainting. In a severe, dirty operation, the wheel should be cleaned with a wire brush to prevent an accumulation of foreign matter that could result in fan unbalance. After cleaning wheel, inspect for possible cracks or excessive wear, which can cause unbalance. DO NOT operate a wheel that is cracked, chipped, has broken blades or excessive wear. NOTE: If wheel set screws are loosened and/or wheel is removed from shaft, set screws must be replaced. Set screws cannot be used more than once. Belts on V-belt drive units require periodic inspection and replacement when worn. For multiple belt drives, belts should be replaced with matched sets.

Motor Maintenance

1. Disconnect power to motor.

2. Removing dust and dirt: Blow out open type motor windings with low pressure air to remove dust or dirt. Air pressure above 50 P.S.I. should not be used as high pressure may damage insulation and blow dirt under loosened tape. Dust accumulation can cause excessive insulation temperatures.

3. Lubrication: The motor bearings and the fan bearings on the belt drive fans should be greased at regular intervals. Motor manufacturers' greasing instructions and recommendations should be followed closely. Avoid the use of a pressure greasing system which tends to fill the bearing chamber completely. Do not overgrease. Use only 1 or 2 shots with a hand gun in most cases. Maximum hand gun rating 40 P.S.I. Rotate bearings during lubrication where good safety practice permits. NOTE: On motors with non-regreasable sealed bearings, no lubrication is required for the life of the bearings.

To prevent rusting of bearing parts, the rotor must be rotated at regular intervals (30 days) to assure these parts are will covered with oil or grease.

VI V-BELT DRIVES

Care should be taken not to over tighten V-belt drive. Excessive belt tension overloads fan and motor bearings. It is much less expensive to replace belts worn from slippage than to replace bearings damaged from excessive loading.

Fans shipped completely assembled have had V-belt drive aligned at the factory. Alignment should be rechecked before operation as a precaution due to handling during shipment.

A WORD OF CAUTION

ABOUT MOTORS

Using your hand to test the running temperature of a motor can be a very painful experience:

Normal body temperature	98.6° F
Threshold of pain caused by heat	120.0° F
Average temperature of hottap water	140.0° F
Average temperature of hot coffee	180.0° F
Normal operating temperature of a fully loaded electric motor, open type, 70° F ambient temperature	174.0° F

1. Be sure sheaves are locked in position.

2. Key should be seated firmly in keyway.

3. Place straight edge or taut cord across faces of driving and driven sheaves to check alignment. The motor and fan shafts must be parallel with V-belts and at right angles to the shafts.

4. Start the fan. Check for proper rotation. Run fan at full speed. A slight bow should appear on slack side of belt. Disconnect power and adjust belt tension by adjusting motor on its sliding base. All belts must have some slack on one side.

5. If belts squeal at start up, they may be too loose.

6. When belts have had time to seat in the sheave grooves, then readjust belt tension.

V-belt drive assembly can be mounted as follows:

1. Clean motor and fan shafts. Be sure they are free from corrosive material. Clean bore of sheaves and coat with heavy oil for ease of shaft entry. Remove oil, grease, rust or burrs from sheaves.

2. Place fan sheave on fan shaft and motor sheave on its shaft. **Do not pound sheaves on** as this may damage bearings. Tighten sheaves per Table # 1 on page 2.

Table #3 (See Fan Bearing Maintenance, page 5.)

Conditions Around Bearing	**Operating Temperature of Fan**	****Greasing Intervals**
Fairly Clean	up to 120 °F	6 -12 months
	120°-160°F	2-3 months
	160°-200°F plus*	1-2 months
Moderate to Extremely Dirty	up to 160°F	1-2 months
	160°-200°F plus*	2-4 weeks
Cold Storage Room		every defrosting period or no more than 4 months

* For fan applications over 200°F: greasing intervals should be from several days to 2 weeks, depending on the temperature.

**For vertical installations, greasing intervals should be twice as frequent as table values.

The following greases, or one that is equivalent to the general description, are recommended for the following temperatures or excessive moisture applications.

Operating Conditions	**Use Grease Equivalent to these Grades**
Temperatures -65°F to 0°F	Esso-Beacon #325 (-65°F) Mobil Grease #28 (-65°F) Shell Oil Aeroshell No. 7 (-100°F)

General Description: Versatile multipurpose microgel thickened synthetic hydrocarbon grease with corrosion inhibitors, anti-oxidant additives, water resistance tendencies and EP characteristics.

Temperature 0°F to 200° F inclusive (Also use for heavy condensation or direct splash of water)	Mobil Oil - Mobilux EP #2 Shell Oil - Shell Alvania EP #2 Chevron - Chevron SRI #2

General Description: Multipurpose NLGI#2 grease from lithium soap with EP characteristics, rust inhibitors, anti-oxidant additives and good water resistance tendencies.

Temperatures over 200°F	Dow Corning-DC44 (400°F) (Not compatible with non-silicon based greases)

General Description: Versatile multipurpose microgel thickened synthetic hydrocarbon grease with corrosion inhibitors, anti-oxidant additives, water resistance tendencies and EP characteristics.

3. Move motor on slide base so belts can be placed in grooves of both sheaves without forcing. Do not roll belts or use a tool to force belts over the grooves.

4. Align fan and motor shafts so they are parallel. The belts should be at right angles to the shafts. A straight edge or taut cord placed across the face of the sheaves will aid in alignment.

5. Tighten belts by adjusting motor base. Correct tension gives the best drive efficiency. Excessive tension causes undue bearing pressure.

6. Start the fan and run it at full speed. Adjust belt tension until only a slight bow appears on the slack side of the belts. If slippage occurs, a squeal will be heard at start-up. Eliminate this squeal by **disconnecting power** and tightening up the belts.

7. Give belts a few days running time to become seated in sheave grooves, then readjust belt tension.

If the shafts become scratched or marked, carefully remove sharp edges and high spots such as burrs with fine emery cloth or honing stone. Avoid getting emery dust in the bearings.

Do not apply any belt dressing unless it is recommended by the drive manufacturer. V-belts are designed for frictional contact between the grooves and sides of the belts. Dressing will reduce this friction.

Belt tension on an adjustable pitch drive is obtained by moving the motor, not by changing the pitch diameter of the adjustable sheave.

VII FAN BEARING MAINTENANCE

Sealed Bearings

Sealed for life bearings are pre-lubricated with the correct amount of manufacturer approved ball bearing grease, and are designed for application where relubrication is not required.

Relubricatable Bearings

The motor bearings and fan bearings on belt drive fans should be greased at regular intervals. Motor manufacturers greasing instructions and recommendations should be followed closely. Avoid the use of a pressure greasing system which tends to fill the bearing chamber completely. Do not over grease.

NOTE: On motors with non-regreasable, sealed bearings, no lubrication is required for the life of the bearing.

Table #3 (page 4) lists the time intervals between fan greasing to insure proper lubrication in adverse conditions of heat and dust. Use only 1 or 2 shots with a hand gun in most cases. Maximum handgun rating 40 P.S.I.

VIII WARRANTY

Cincinnati Fan & Ventilator Company warrants products of its own manufacture against defects of material and workmanship under normal use and service for a period of eighteen (18) months from date of shipment or twelve (12) months from date of installation, whichever occurs first.

This warranty does not cover ordinary wear and tear, abuse, misuse, overloading, negligence, alteration or systems and/or materials not of Seller's manufacture. Expenses incurred by Buyer(s) in repairing or replacing any defective product will not be allowed except where authorized in writing and signed by an officer of the Seller.

The obligation of Seller under this warranty shall be limited to repairing or replacing F.O.B. Seller's plant, or allowing credit at Seller's option. This warranty is expressly in lieu of all other warranties expressed or implied including the warranties of merchantability and fitness for use and of all other obligations and liabilities of the Seller. The Buyer acknowledges that no other representations were made to him or relied upon him with respect to the quality or function of the products herein sold.

On equipment furnished by the Seller, but manufactured by others, such as motors, Seller extends the same warranty as Seller receives from the manufacturer thereof. Repairs for motors should be obtained from nearest authorized motor service station for the make of motor furnished. All motors used are products of well-known manufacturers with nationwide service facilities. Check the yellow pages of your telephone directory for the location of the nearest service shop.

Cincinnati Fan & Ventilator Company assumes no responsibility for material returned to our plant without our prior written permission.

IX ORDERING REPLACEMENT PARTS

Replacement or spare parts may be ordered through your local Cincinnati Fan representative. (Refer to drawings that begin on page 7.)
The following information should accompany parts orders:

1. Motor horsepower, frame size, motor speed, voltage, phase, cycle and enclosure. Motor manufacturer's model number from motor nameplate.
2. Fan Speed (if V-belt driven).
3. Fan serial **and** model numbers from the **fan** nameplate and a complete description of the part.

An adequate stock of repair parts is maintained where possible. If your fan is vital to production or to plant operation, it is advisable to have all spare parts on hand to minimize the possibility of downtime.

X FAN TROUBLE SHOOTING

In the event that trouble is experienced in the field, the following are the most common fan difficulties. These points should be checked in order to prevent needless delay and expense.

1. CAPACITY OR PRESSURE BELOW RATING

a. Incorrect direction of wheel rotation.
b. Speed too slow.
c. Dampers not properly adjusted.
d. Poor fan inlet or outlet conditions (elbows, restrictions).
e. Air leaks in system.
f. Damaged wheel.
g. Total resistance of system higher than anticipated.
h. Wheel mounted backwards on shaft.
i. Fan not properly selected for a high temperature and/or high altitude application.

2. VIBRATION AND NOISE

a. Misalignment of bearings, coupling, wheel or V-belt drive.
b. Unstable foundation or supports.
c. Foreign material in fan causing unbalance.
d. Worn bearings.
e. Damaged wheel or motor.
f. Broken or loose bolts and set screws.
g. Bent shaft.
h. Worn coupling.
i. Fan wheel or drive unbalanced.
j. 120 cycle magnetic hum due to electrical input. Check for high or unbalanced voltage.
k. Fan delivering more than rated capacity.
l. Loose dampers.
m. Speed too high or fan rotating in wrong direction.
n. Vibration transmitted to fan from some other source.

3. OVERHEATED BEARINGS

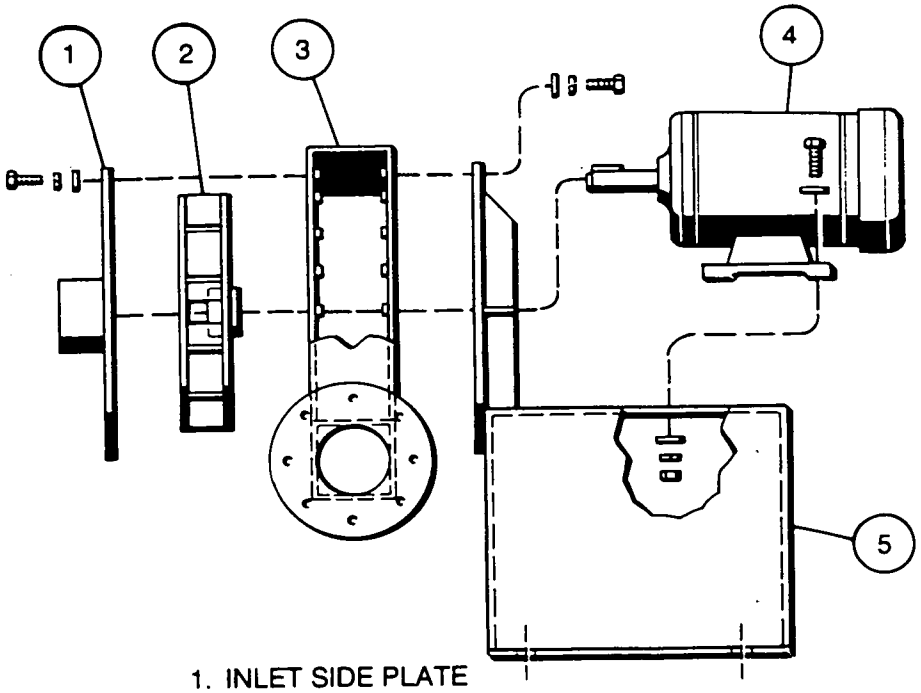
a. Check bearing lubrication.
b. Poor alignment.
c. Damaged wheel or drive.
d. Bent shaft.
e. Abnormal end thrust.
f. Dirt in bearings.
g. Excessive belt tension.

4. OVERLOAD ON MOTOR

a. Speed too high.
b. Fan over capacity due to existing system resistance being lower than original rating.
c. Specific gravity or density of gas above design value.
d. Wrong direction of wheel rotation.
e. Shaft bent.
f. Poor alignment.
g. Wheel wedging or binding on fan housing.
h. Bearings improperly lubricated.
i. Motor improperly wired.
j. Defective motor. Motor must be tested by motor manufacturer's authorized repair shop.

MODEL HP

ARRANGEMENT 4

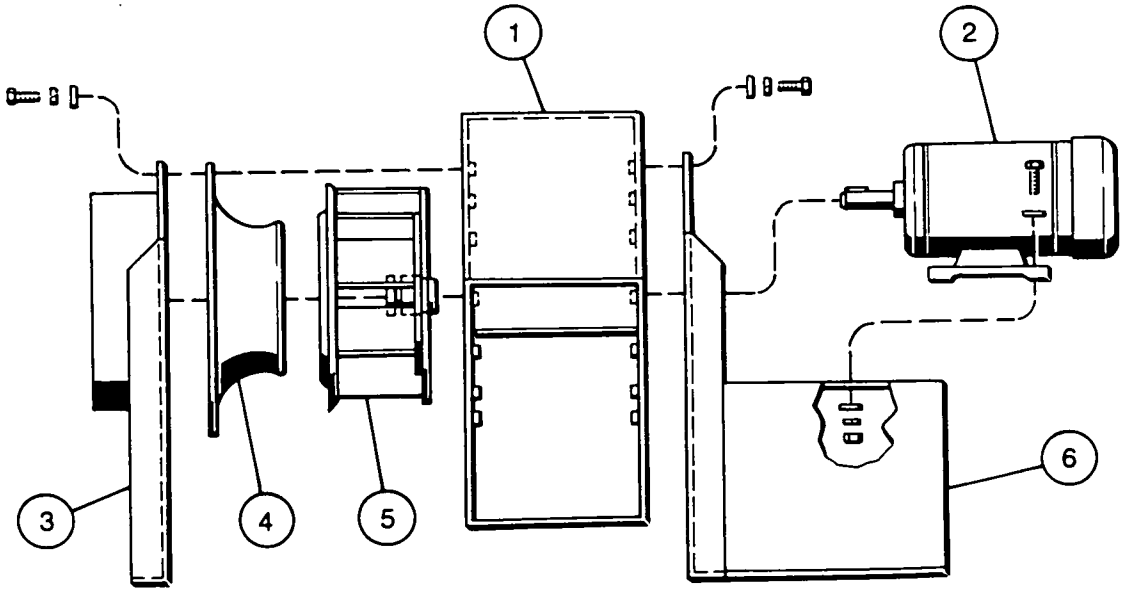


1. INLET SIDE PLATE
2. WHEEL
3. HOUSING
4. MOTOR
5. BASE

NOTE: SHAFT SEAL IS NOT SHOWN.

MODELS HDBI & RBE

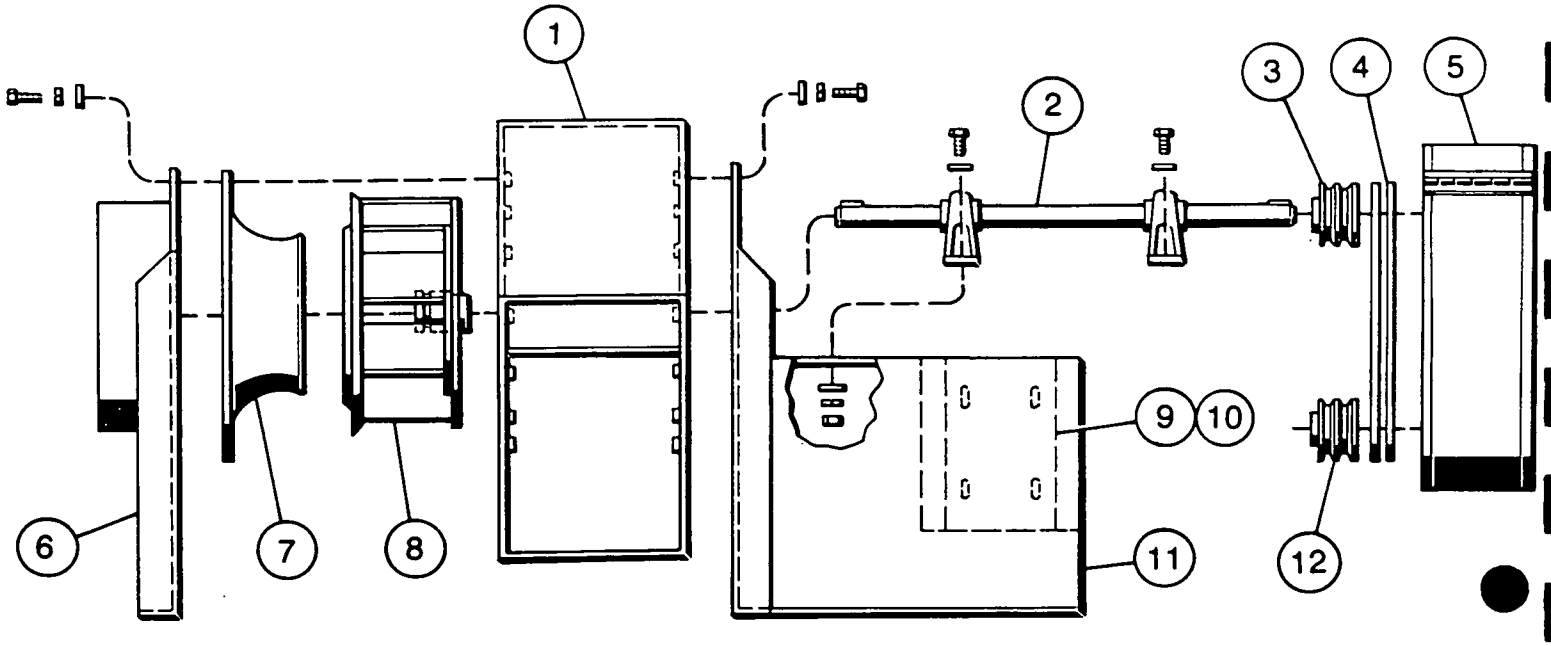
ARRANGEMENT 4



1. HOUSING
2. MOTOR
3. INLET SIDE PLATE
4. INLET BELL (ON MODEL HDBI ONLY)
5. WHEEL (HDBI WHEEL SHOWN)
6. BASE

MODELS HDBI & RBE

ARRANGEMENT 1 AND 9

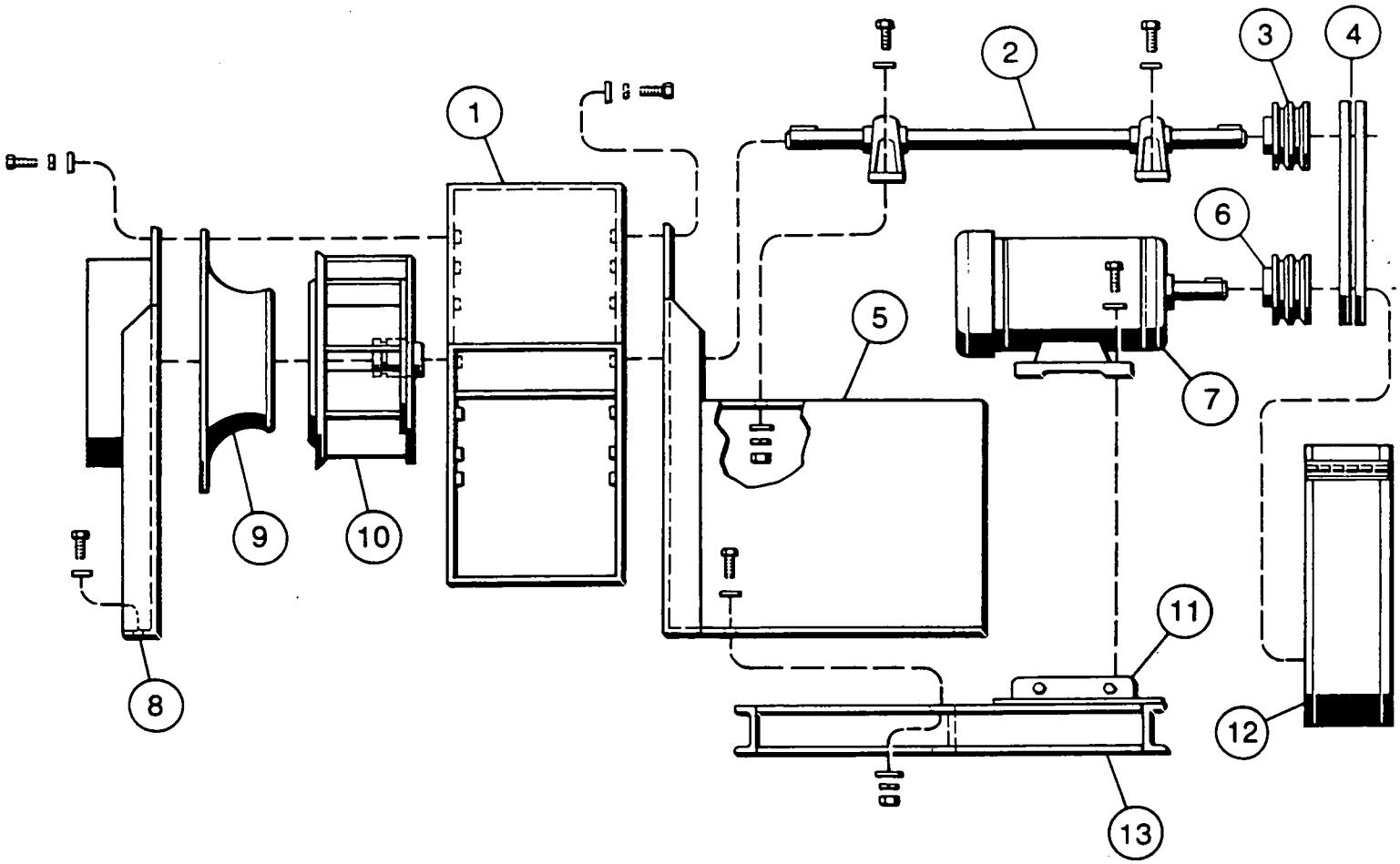


1. HOUSING
2. SHAFT AND BEARING ASSEMBLY
3. FAN SHAFT PULLEY (ARR. 9 ONLY)
4. BELT(S) (ARR. 9 ONLY)
5. BELT GUARD (ARR. 9 ONLY)
6. INLET SIDE PLATE
7. INLET BELL (ON MODEL HDBI ONLY)
8. WHEEL (HDBI WHEEL SHOWN)
9. MOTOR SLIDE BASE (ARR. 9 ONLY)
10. MOTOR (ARR. 9 ONLY) *
11. BASE, FAN
12. MOTOR SHAFT PULLEY (ARR. 9 ONLY)

* MOTOR NOT SHOWN IN FIGURE

MODELS HDBI & RBE

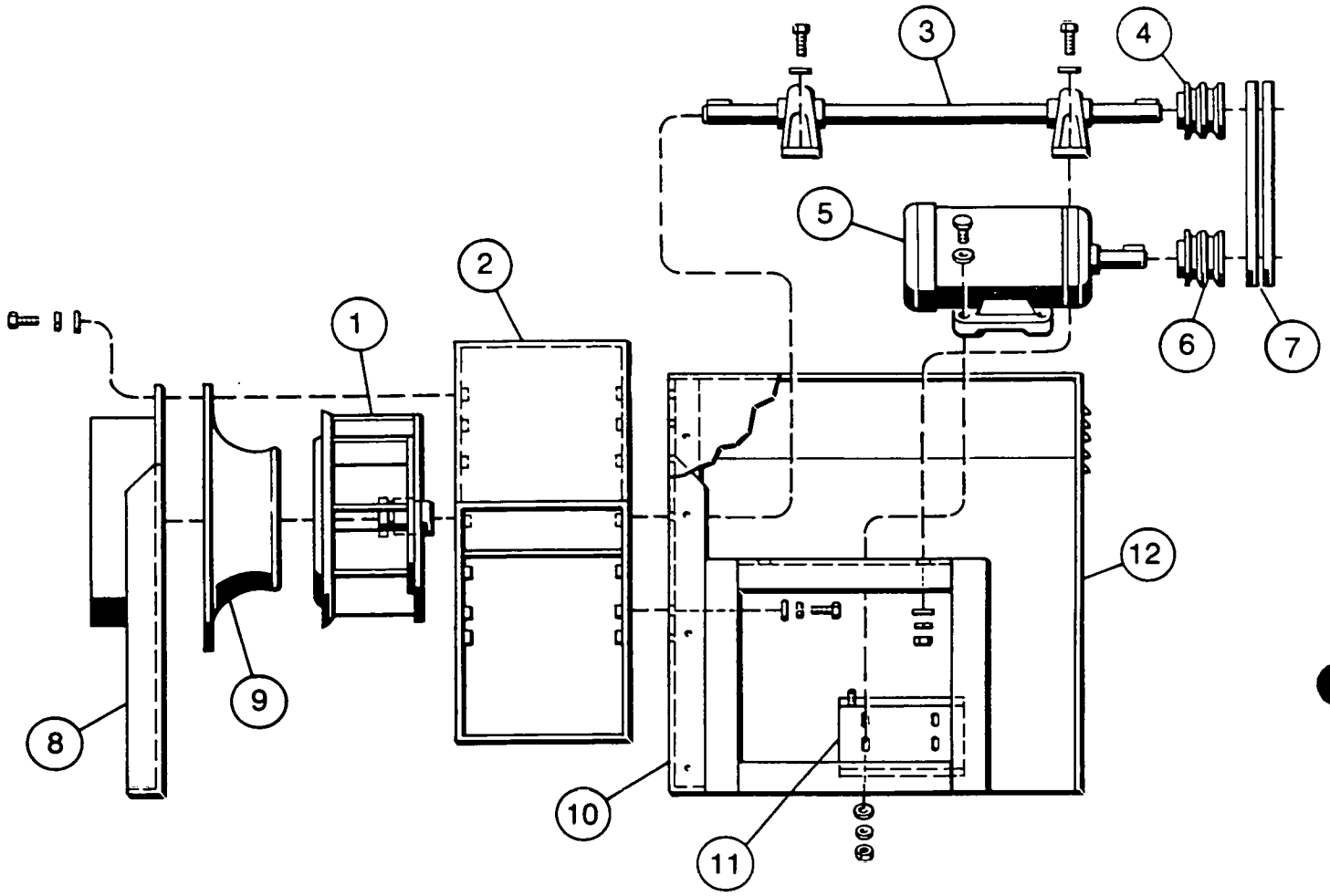
ARRANGEMENT 9CB CHANNEL BASE



1. HOUSING
2. SHAFT AND BEARING ASSEMBLY
3. FAN SHAFT PULLEY
4. BELT(S)
5. BASE, FAN
6. MOTOR SHAFT PULLEY
7. MOTOR
8. INLET SIDE PLATE
9. INLET BELL (ON MODEL HDBI ONLY)
10. WHEEL (HDBI WHEEL SHOWN)
11. MOTOR SLIDE BASE
12. BELT GUARD
13. BASE, CHANNEL

MODELS HDBI & RBE

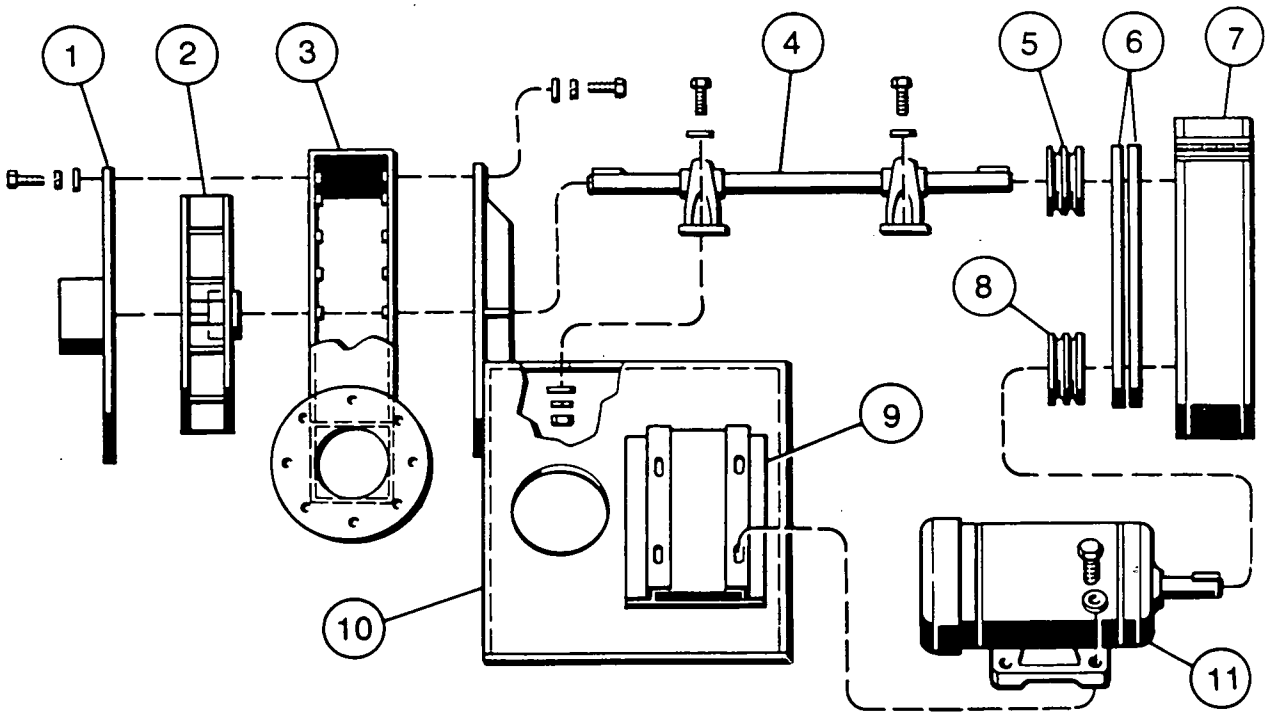
ARRANGEMENT 10



1. WHEEL (HDBI WHEEL SHOWN)
2. HOUSING
3. SHAFT AND BEARING ASSEMBLY
4. FAN SHAFT PULLEY
5. MOTOR
6. MOTOR SHAFT PULLEY
7. BELT(S)
8. INLET SIDE PLATE
9. INLET BELL (ON MODEL HDBI ONLY)
10. BASE
11. MOTOR BASE
12. WEATHER COVER

MODEL HP

ARRANGEMENT 1 AND 9

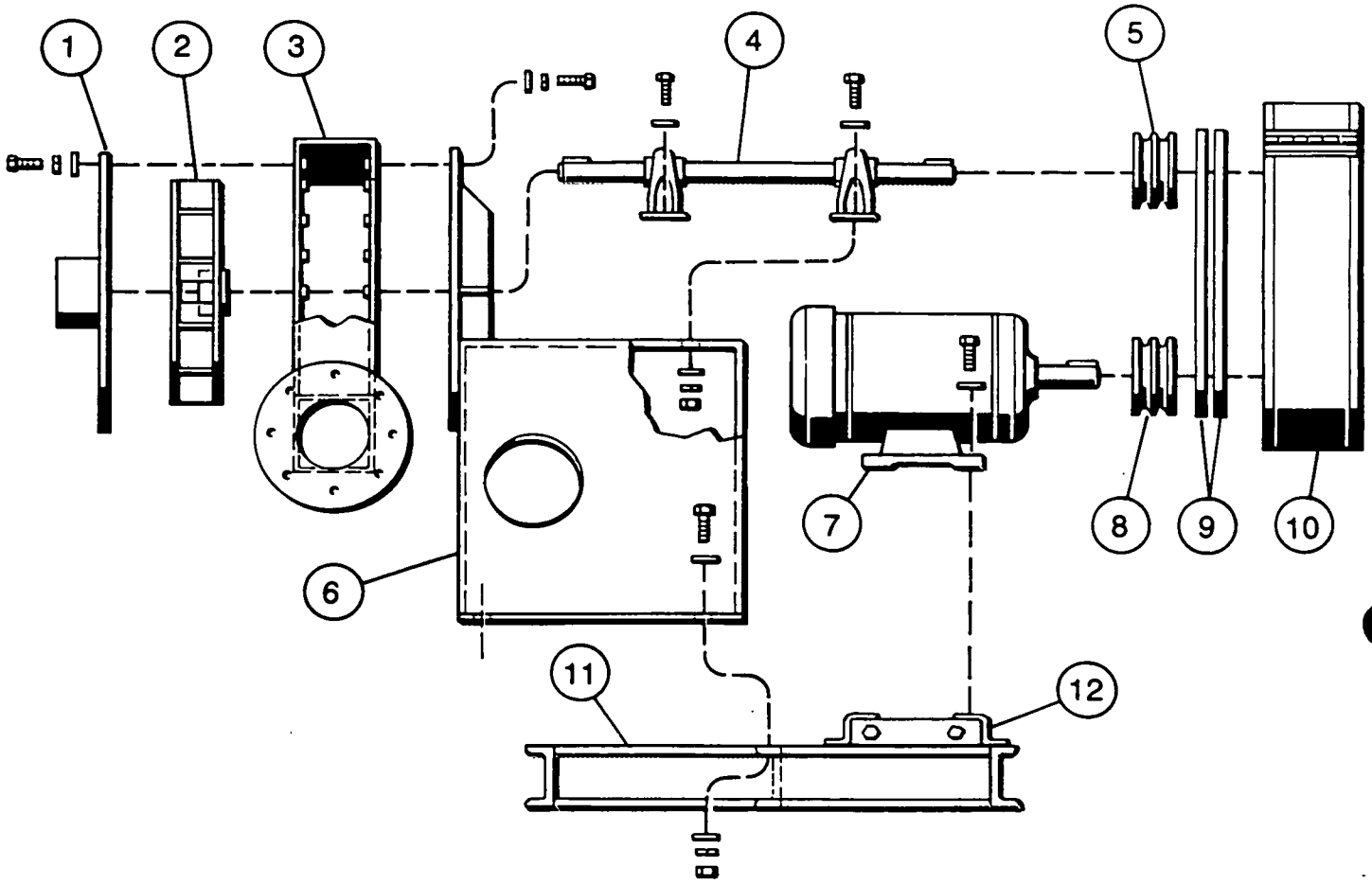


1. INLET SIDE PLATE
2. WHEEL
3. HOUSING
4. SHAFT AND BEARING ASSEMBLY
5. FAN SHAFT PULLEY (ARR. 9 ONLY)
6. BELT(S) (ARR. 9 ONLY)
7. BELT GUARD (ARR. 9 ONLY)
8. MOTOR SHAFT PULLEY (ARR. 9 ONLY)
9. MOTOR SLIDE BASE (ARR. 9 ONLY)
10. BASE, FAN
11. MOTOR (ARR. 9 ONLY)

NOTE: SHAFT SEAL IS NOT SHOWN.

MODEL HP

ARRANGEMENT 9CB CHANNEL BASE



1. INLET SIDE PLATE
2. WHEEL
3. HOUSING
4. SHAFT AND BEARING ASSEMBLY
5. FAN SHAFT PULLEY
6. BASE, FAN
7. MOTOR
8. MOTOR SHAFT PULLEY
9. BELT(S)
10. BELT GUARD
11. BASE, CHANNEL
12. MOTOR SLIDE BASE

NOTE: SHAFT SEAL IS NOT SHOWN.

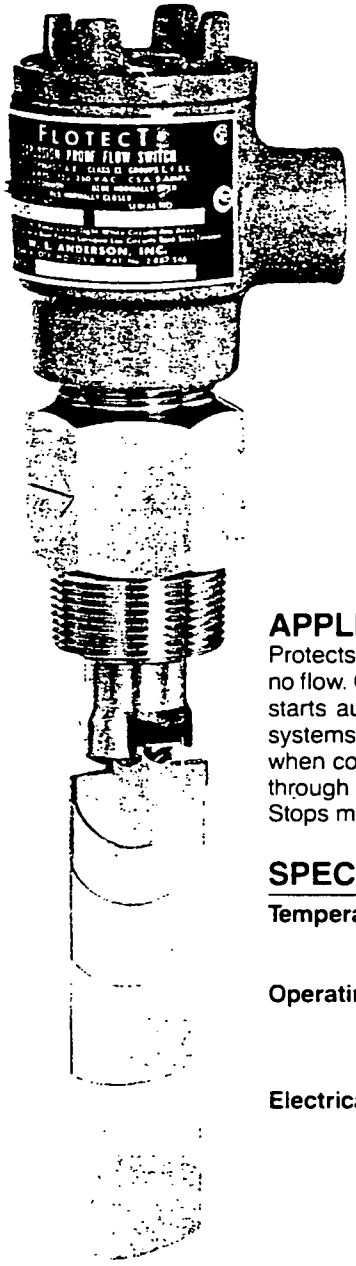
FLOTECT. Vane Operated Flow Switch

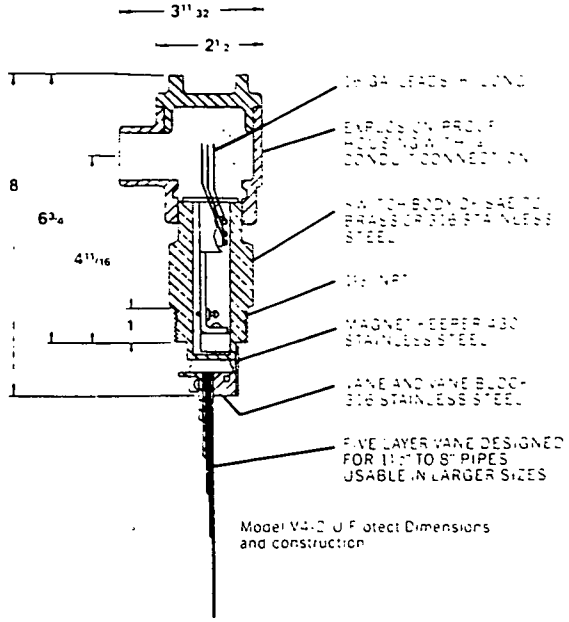
INSTALLATION AND OPERATING INSTRUCTIONS

Explosion-Proof; U.L. and C.S.A. listed – Class I, Groups C, D; Class II, Groups E, F, G.
CENELEC: EExd 11B T6.

Dependable protection against flow variation or stopping in pipelines for fluids, gasses and flowing solids.

Supplied with custom or universal multi-layer vanes for field installation in pipes from 1½".

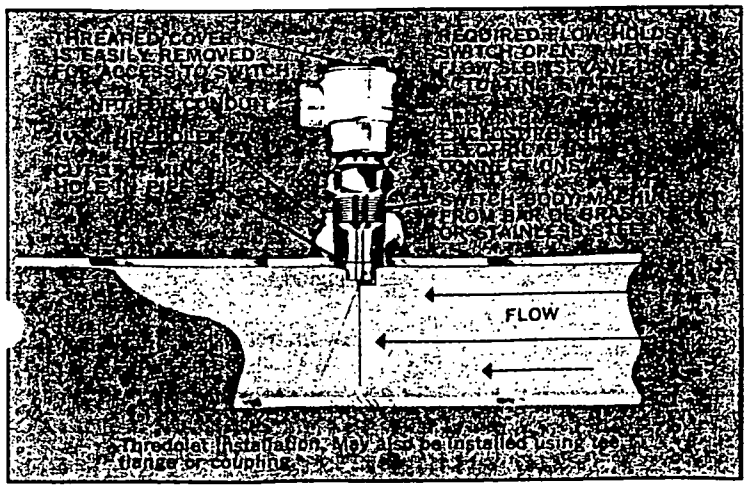




Model V4-C U.L. Flotect Dimensions and construction

Compact and reliable, the Flotect V4 Flow switch operates automatically to protect equipment and pipeline systems against damage from reduction or loss of flow. Installed in thousands of pipelines and processing plants around the world, this unique magnetically actuated switching design gives superior performance. Universal multi-layer vane accommodates pipe sizes from 1½" up. Custom vanes are available with factory calibration. There are no bellows, springs, or seals to fail. Instead, the free-swinging vane attracts a magnet within the solid metal switch body above, actuating a snap switch by means of a simple lever arm.

:atures include: Simplicity of design and a leak-proof switch body, machined from bar stock for pressures to 2000 psig, (138 bar), it eliminates the possibility of process fluid entering the switch compartment. The threaded conduit enclosure cover permits easy inspection or replacement of electrical assembly without shutting down the process, or removing electrical conduit. Power must be disconnected. The unit fits directly into pipeline with tee, thredolet or flange for easy installation. Pendulum-like vane action responds accurately to fluid flow rate. The custom vane or multi-layer vane is sensitive to low velocity flows, yet it is rugged enough to withstand high flow surges. If desired, a delay timer can be wired into the installation. All units are explosion-proof and listed with U.L. and C.S.A. for Class I, Groups C and D, Class II, Groups E, F, and G or are flame-proof to CENELEC EExd IIB T6.



*Thredolet installation (1) also be installed using tee flange or coupling.

APPLICATIONS

Protects motors, pumps and other equipment against low flow and no flow. Controls sequential operation of pumps, etc. Automatically starts auxiliary pumps and engines or actuates alarm and signal systems. Stops water cooled engines, machines and processes when coolant flow is interrupted. Shuts down burner when air flow through heating coil fails. Controls dampers according to flow. Stops machines if cooling oil flow ceases.

SPECIFICATIONS

Temperature limits:	Standard 275°F (135°C). High temperature option (not U.L., C.S.A. or CENELEC), 400°F (205°C) max.
Operating Pressure:	Brass 1000psig (69bar) 316S.S. 2000psig(138bar) Ratings to 5000psig(345bar) available (SPDT only).
Electrical Rating:	U.L. and CENELEC: 10A@ 125/250 Vac C.S.A.; 5A@ 125/250 Vac, 5A resistive 3A inductive@ 30Vdc Optional ratings (not UL, CSA or CENELEC); MV option; Gold contacts, 1.0A@ 125 Vac MT option: 400°F (205°C), 5A@125/250Vac
Wiring:	U.L./C.S.A. unit; 16 gauge copper wire, 6" long, mechanically and solder bonded to switch. CENELEC unit: Terminal board.
Switch body:	One piece milled and bored Brass or 316 SS. Other materials on request.
Vane:	316 SS 1 9/16" (40mm) wide. Std. trim includes 430 SS and silver solder. Other materials on request.
Piping Connection:	1½" NPT std for mounting in 1½" thredolet. For other mounting see back page. Thredolet fittings available.
Installation:	Within 5° of vertical for proper operation. Units for horizontal installation (vertical pipes) on request.
Weight:	4lb.-5oz. (1.96Kg)
Options:	All 316SS wetted parts. Teflon coated wetted parts. DPDT circuits. Cartridge heater to melt paraffin, etc. Time delay relay.

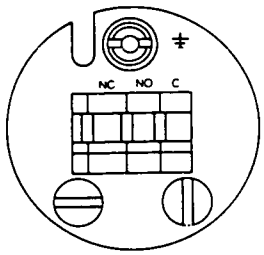
INSTALLATION

1. Remove packing material from switch body-cap and remove tape from magnet keeper. Adjust vane length if necessary on multi-layer vanes only. Install switch in thredolet previously welded to line. In some cases, it may be necessary to install the switch in a flange or tee. Note: extreme care must be excercised in welding the fitting to the line so that it is plumb and level.

2. The arrow on the side of the switch must point in the direction of flow.

3. **U.L. and C.S.A. units only:** Thread connecting wires through conduit and connect.
   Black – Common
   Blue – N.O.
   Red – N.C.
Note: Double pole, double throw switches have dual black, blue and red leads. These are connected in the same manner as single pole, double throw switches, as described above.

CENELEC units only: Wire in accordance with local electrical codes. Cable should enter enclosure housing through an approved Ex cable gland (not supplied). Stripped and tinned leads are simply pushed into wire entry of terminal block. Depress spring release with small screwdriver when inserting or removing fine stranded leads. Be sure strands do not bridge across terminal spacing. Double pole, double throw switches have dual terminal blocks.



TERMINAL CONNECTIONS

Note: The switch is deactivated and contacts are in normal condition when there is no flow in the line.

4. Make sure conduit or cable are properly sealed. Electrical components must be kept free of moisture, including condensation, at all times. **CAUTION:** To prevent ignition of hazardous atmosphere, disconnect the device from the supply circuit before opening. Keep assembly tightly closed when in operation.

5. Inspect and clean wetted parts at regular intervals.

6. **CENELEC units only:** The "T" class is dependent upon the ambient temperature of the media. The approved ratings are: T6 at 75°C, T5 at 90°C; T4 at 125°C; T3 at 135°C.

7. Custom vane units have been calibrated at factory to meet requirements. Do not change.

ADJUSTMENT OF MULTI-LAYER VANE

Remove only those layers which are too long. Leave the smaller layers to reinforce the vane. The longest vane fits 6" (150mm) or larger pipe, the second longest vane fits 4" (100mm) pipe, etc. Actuation-Deactuation rates are shown in the charts on the next page.
To remove vane layers, proceed as follows:

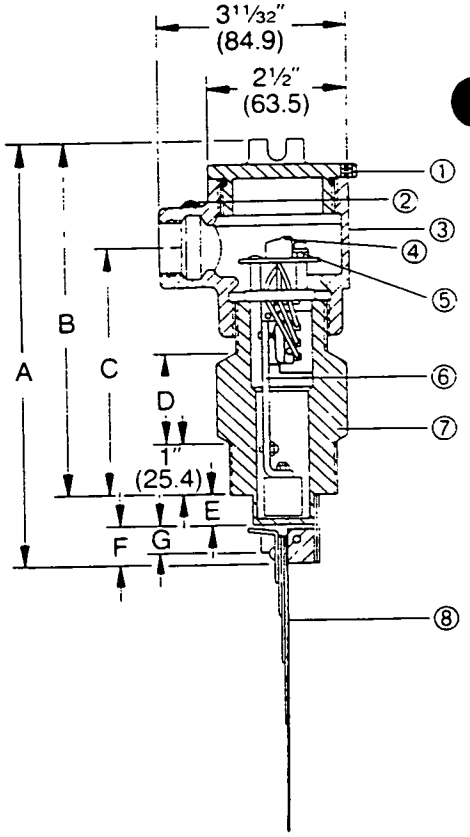
1. Remove the two screws and lockwashers holding the layers together. Do not lose these special corrosion resistant type 316 stainless steel screws and lockwashers.

2. Remove the unwanted layers.

3. Resecure the vane with the original two screws and lockwashers.

4. With a hammer, lightly peen the ends of the screws so that they can't back out.

5. If you lose the screws or lockwashers, don't replace with other parts which may corrode and break. That would void the warrantee and might cause severe damage to equipment located downstream of the switch.



CENELEC unit shown, for U.L./C.S.A. unit see first page.

DIM.	V4		V4-2	
	IN.	MM	IN.	MM
A	8 3/16	208	8	203
B	6	152	6 3/4	171
C	4 1/16	119	3 15/16	100
D	1	25.4	1 3/4	44
E	1 5/16	33	9/16	14
F	7/8	22	1 1/16	17
G	1 1/16	17	1/2	13

PARTS LIST

1. Cover lock. (CENELEC unit only).
2. External ground. (CENELEC unit only).
3. Enclosure housing and cover.
4. Terminal block. (CENELEC unit only, UL/CSA unit has 6" leads).
5. Internal ground.
* 6. Magnet arm and switch assembly.
7. Switch body.
* 8. Vane assembly.

*Approved replacement parts.

APPROXIMATE ACTUATION-DEACTUATION FLOW RATES FOR COLD WATER

UPPER FIGURES IN GPM. LOWER FIGURES IN M3/HR.

VANE AYERS	1.5" PIPE	2" PIPE	3" PIPE	4" PIPE	6" PIPE	8" PIPE	10" PIPE	12" PIPE	14" PIPE	16" PIPE	18" PIPE	20" PIPE
1	7- 3 1.6-0.7	15- 8 3.4-1.8	45-22 10- 5	95-40 22- 9	210-120 48- 27	375-175 85- 40	600-300 136- 68	900-450 204-102	1200-600 273-136	1400-800 318-182	2000-1000 454- 227	2400-1200 545- 273
1&2		7- 4 1.6-0.9	23- 14 5.2-3.2	50- 35 11.4-7.9	130-90 30-20	230-150 52- 34	450-250 102- 57	650-350 148- 79	900-500 204-114	1200-650 273-148	1450-800 329-182	1800-1000 409- 227
1. 2&3			11- 7 2.5-1.6	27- 19 6.1-4.3	80-60 18-14	160-115 36- 26	300-180 68- 41	450-275 102- 62	600-350 136- 79	750-450 170-102	1000-600 227-136	1200-700 273-159
1. 2. 3&4				17- 12 3.9-2.7	60-45 14-10	120-90 27-20	230-150 52- 34	310-200 70- 45	430-280 98- 64	550-360 125- 82	700-450 159-102	850-550 193-125
1. 2. 3. 4&5					40- 30 9.1-6.8	80-65 18-15	135-100 31- 23	200-140 45- 32	290-200 66- 45	360-250 82- 57	460-325 104- 74	575-400 131- 91

Actuation rates are based on cold water at a specific gravity of 1.0. For fluids of different specific gravity, actuation rates may be approximated by dividing the rate shown by the square root of the specific gravity.

APPROXIMATE ACTUATION-DEACTUATION FLOW RATES FOR AIR

UPPER FIGURES IN SCFM. LOWER FIGURES IN NM3/S.

VANE LAYERS	1.5" PIPE	2" PIPE	3" PIPE	4" PIPE	6" PIPE	8" PIPE	10" PIPE	12" PIPE	14" PIPE	16" PIPE	18" PIPE	20" PIPE
1	32- 17 0.02-0.008	65- 32 0.03-0.02	210- 105 0.10-0.05	400- 200 0.19-0.09	950- 475 0.45-0.22	1550- 850 0.73-0.40	2400-1300 1.1- 0.6	3450-1900 1.6- 0.9	4700-2600 2.2- 1.2	6400-3500 3.0- 1.7	8000-4400 3.8- 2.1	10000-5500 4.7- 2.6
1&2		23- 13 0.01-0.006	120- 70 0.06-0.03	195- 140 0.09-0.07	550- 375 0.26-0.18	1100- 700 0.52-0.33	1850-1200 0.87- 0.57	2700-1750 1.3- 0.8	3400-2200 1.6- 1.0	4800-3100 2.3- 1.5	6000-3900 2.8- 1.8	7400-4800 3.5- 2.3
1, 2&3			60- 48 0.03-0.02	135- 100 0.06-0.05	375- 265 0.18-0.13	725- 500 0.34-0.24	1200- 850 0.57-0.40	1850-1300 0.87- 0.61	2600-1800 1.2- 0.8	3350-2350 1.6- 1.1	4300-3000 2.0- 1.4	5300-3700 2.5 1.7
1, 2, 3&4				65- 50 0.03-0.02	260- 200 0.12-0.09	500- 400 0.24-0.19	875- 700 0.41-0.33	1250-1000 0.59- 0.47	1900-1500 0.90- 0.71	2500-2000 1.2- 0.9	3100-2500 1.5- 1.2	3900-3100 1.8- 1.5
1, 2, 3, 4&5					130- 100 0.06-0.05	310- 250 0.15-0.12	650- 525 0.31-0.25	1000- 800 0.47-0.38	1600-1250 0.76- 0.59	2200-1750 1.04- 0.83	2800-2250 1.3- 1.1	3550-2850 1.7- 1.3

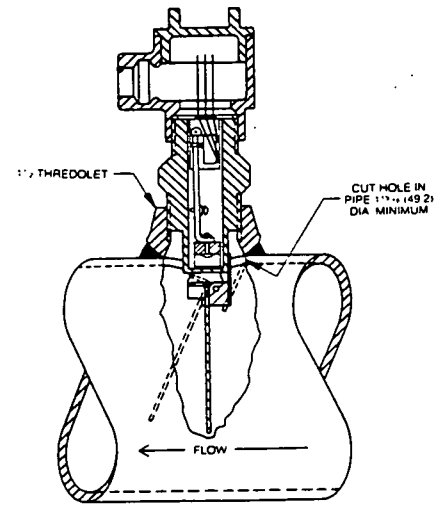
Values shown in both charts are nominal. If normal flows exceed actuation rates by less than 10%, custom vanes are recommended. Figures are based on standard vertical installation in a 1½" thredolet in a horizontal run of pipe.

Limited Warranty: The Seller warrants all Dwyer instruments and equipment to be free from defects in workmanship or material under normal use and service for a period of one year from date of shipment. Liability under this warranty is limited to repair or replacement F.O.B. factory of any parts which prove to be defective within that time or repayment of the purchase price at the Seller's option provided the instruments have been returned, transportation prepaid, within one year from the date of purchase. All technical advice, recommendations and services are based on technical data and information which the Seller believes to be reliable and are intended for use by persons having skill and knowledge of the business, at their own discretion. In no case is Seller liable beyond replacement of equipment F.O.B. factory or the full purchase price. This warranty does not apply if the maximum ratings label is removed or if the instrument or equipment is abused, altered, used at ratings above the maximum specified, or otherwise misused in any way.

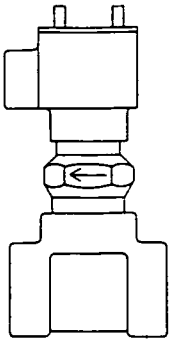
THIS EXPRESS LIMITED WARRANTY IS IN LIEU OF AND EXCLUDES ALL OTHER REPRESENTATIONS MADE BY ADVERTISEMENTS OR BY AGENTS AND ALL OTHER WARRANTIES, BOTH EXPRESS AND IMPLIED. THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE FOR GOODS COVERED HEREUNDER.

Buyers Remedies: THE BUYER'S EXCLUSIVE AND SOLE REMEDY ON ACCOUNT OF OR IN RESPECT TO THE FURNISHING OF NONCONFORMING OR DEFECTIVE MATERIAL SHALL BE TO SECURE REPLACEMENT THEREOF AS AFORESAID. THE SELLER SHALL NOT IN ANY EVENT BE LIABLE FOR THE COST OF ANY LABOR EXPENDED ON ANY SUCH MATERIAL OR FOR ANY SPECIAL, DIRECT, INDIRECT OR CONSEQUENTIAL DAMAGES TO ANYONE BY REASON OF THE FACT THAT IT SHALL HAVE BEEN NON-CONFORMING OR DEFECTIVE.

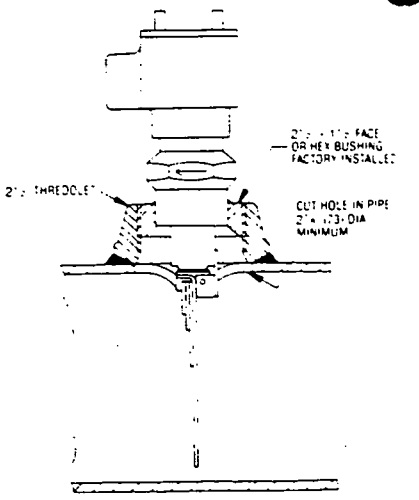
APPLICATION DRAWINGS FOR FLOTECT®
AUTOMATIC FLOW SWITCHES



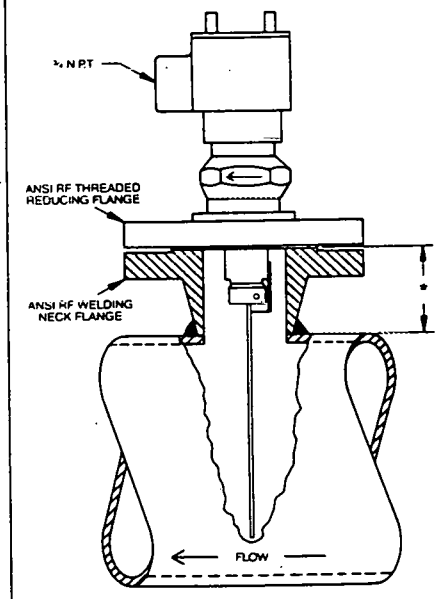
STANDARD INSTALLATION



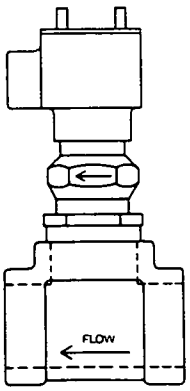
1½" × 1½" × 1½"
TEE INSTALLATION



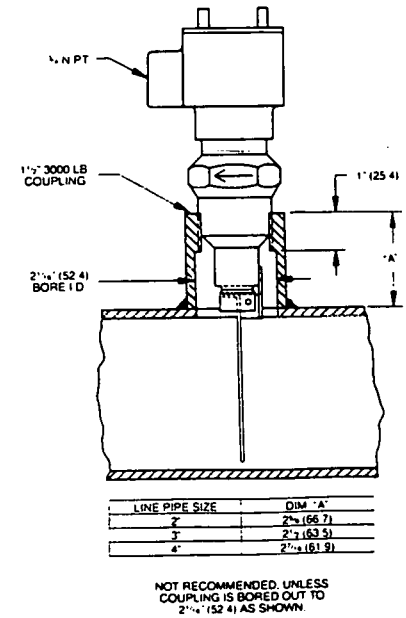
2½" THREDOLET INSTALLATION



FLANGE INSTALLATION



2" × 2" × 2" TEE
INSTALLATION



W. E. ANDERSON DIV., DWYER INSTRUMENTS, INC.
P.O. Box 358
Michigan City, IN 46360
Phone: 219/879-8000 Telex: 25916
Fax: 219/872-9057

LITHO IN U.S.A. 2/92
FR 82-440629-00

ATTACHMENT 2

Inspection and Maintenance Report Forms

Site Inspection/Maintenance List
Leica, Inc.

DURING EVERY VISIT, PLEASE CHECK THE FOLLOWING AND CONDUCT MAINTENANCE ACTIVITIES AS NEEDED

Compressor:

1. Check auto sentry controller on the compressor to determine
   - If air filter needs to be changed
   - If oil separator needs to be changed
   - If oil filter element needs to be changed
   - If compressor lubricant needs to be changed
2. Check reservoir oil level
3. Check for proper load/unload
4. Check discharge pressure/temperature
5. Check dirt accumulation on cooler and clean if needed

Air Inlet:

6. Inspect the Air Inlet and remove any obstructions

Blower:

7. Grease Shaft Bearings – do not over grease
8. Check oil and add as needed

MONTHLY Site Inspection/Maintenance Checklist
Leica, Inc.

Inspector: _____ Date: _____

Section I: Complete Monthly		**Attention**
Blower:	**Checked**	**Needed?**
Check belts on skid and adjust as needed	Y/N	Y/N
Compressor:		
Change oil filter element	Y/N	Y/N
Pumps:		
Check mechanical seal for leakage and replace if needed	Y/N	Y/N

Section II: Complete Every 6 Months		**Attention**
Blower:	**Checked**	**Needed?**
Change oil	Y/N	Y/N
Grease the blower motor	Y/N	Y/N
Compressor:		
Lubricate motor	Y/N	Y/N
Pumps:		
Lubricate motor	Y/N	Y/N

Section III: Complete Every 12 Months		**Attention**
Compressor:	**Checked**	**Needed?**
Change lubricant	Y/N	Y/N
Check relief valve	Y/N	Y/N
Replace air filter	Y/N	Y/N

ATTACHMENT 3

Monitoring Well Logs

BOREHOLE LOG

PROJECT: 90-821

BOREHOLE: MW1

PHASE II SUBSOIL INVESTIGATION
CHEEKTOWAGA, NEW YORK
FOR: Leica Inc.

DATE: 23 November 1990
GEOLOGIST TEJ

REFERENCE POINT (Top of Riser) 662.38
GROUND SURFACE 662.53

DEPTH (ft)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % RQD	COMMENTS
0.4		**ASPHALT**		1		GS					
1.0		**SUB-BASE** Grey sandy gravel.		2		SS	7		0		NO RECOVERY DURING THIS INTERVAL
		SILTY CLAY TILL Grey silty clay, trace fine sand, DTPL, stiff. -Interlaminated with red silty seams throughout.									
				3		SS	10		60		OVA rdg.= NIL
8.5		**SILTY SAND** Brownish grey silty fine sand, trace fine gravel, saturated, loose.		4		SS	9		25		OVA rdg.= NIL
		-Occasional limestone fragments encountered at bottom of hole.		5		SS	50/1in.				OVA rdg.= NIL
12.6		Borehole terminated at 12.6 ft in silty sand.									AUGER REFUSAL AT 12.6 FT.

NOTE: ELEVATION RESURVEYED MARCH 1994.

Gartner Lee Inc.

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-64)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-1A
(Page 1 of 5)
DATE COMPLETED: MARCH 31, 1994
DRILLING METHOD: 6 5/8" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	663.48					
	GROUND SURFACE	664.0					
	Augered through asphalt and gravel		ROAD BOX				
1.0	SP-SAND(FILL), some fine to medium gravel, little silt, brown and gray, moist to wet	663.0	CONCRETE SEAL				
2.0				1SS		11	0
	ML-SILT(NATIVE), little to some clay, little sand, trace fine subrounded gravel, stiff, red brown, dry to moist	661.6					
3.0							
4.0			4" ø STEEL CASING	2SS		40	0
5.0							
6.0			10" ø BOREHOLE	GS 3SS		34	0
7.0							
8.0			CEMENT/ BENTONITE GROUT	4SS		15	0.1
9.0	SM-SAND, fine to medium grained, brown to gray, moist to wet	655.2					
10.0				GS 5SS		24	0.1
11.0							
12.0				6SS		42	0
	SP-SAND(TILL), some fine to medium subround to subangular gravel, dense, gray, dry to moist	651.7					
13.0				GS 7SS		>50	0.1

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
GRAIN SIZE ANALYSIS GS
CHEMICAL ANALYSIS (○) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-64)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-1A

DATE COMPLETED: MARCH 31, 1994
DRILLING METHOD: 6 5/8" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
		650.7	10"ø BOREHOLE; 4"ø STEEL CASING; 6"ø BOREHOLE; CEMENT/ BENTONITE GROUT; 3"ø NX COREHOLE				
14.0	BEDROCK – wet rotary to 14.3 ft BGS						
	END OF OVERBURDEN HOLE @ 14.3 FT BGS	649.7					
15.0	NOTES: 1. At completion a 4" steel casing was installed to 14.3 ft. BGS for bedrock drilling. 2. Bulk soil samples collected from 5.0 to 7.0, 9.0 to 11.0 and 12.5 to 13.3 ft BGS for grain size analysis. 3. Soil sample retained for chemical analysis of TCL VOCs.						
16.0							
17.0							
18.0							
19.0							
20.0							
21.0							
22.0							
23.0							
24.0							
25.0							
26.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
GRAIN SIZE ANALYSIS GS
CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-65)

PROJECT NAME: LEICA INC, RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-1A (Page 3 of 5)
DATE COMPLETED: MARCH 31, 1994
DRILLING METHOD: 6 5/8" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIENDTRERORCVKAL	RNUUNMBER	CROECOVERY	RQD	WRAETTEURRN
ft BGS		ft. AMSL				%	%	%
	Overburden	650.7	10" BOREHOLE					
	LIMESTONE(Onondaga Formation, Moorehouse Member): light gray, fine to coarse grained, slightly to heavily weathered, trace vertical fractures, massively bedded, trace coral, some chert, stylolites, some carbonaceous partings		4" STEEL CASING		WR			
14.0			6" BOREHOLE					
			CEMENT/ BENTONITE GROUT					
15.0	– moderately weathered carbonaceous parting (@ 15.2 and 15.5 ft BGS) – dark chert (15.2 to 15.7 ft BGS)							
16.0	– carbonaceous parting (@ 15.9, 16.0, 16.2, 16.8 and 17.0 ft BGS)							
17.0	– brachiopod (@ 17.1 ft BGS)		3" NX COREHOLE					
18.0	– weathered joint (@ 18.0 ft BGS) – carbonaceous parting (@ 18.4, 19.4 and 19.7 ft BGS)				1	100	69.0	80
19.0								
20.0	– moderately weathered zone, vertical fracture (19.7 to 20.5 ft BGS)							
21.0	– moderately weathered break (20.7 and 22.1 ft BGS)							
22.0	– small closed fracture, small crystal lined vug (@ 22.3 ft BGS) – dark chert zone (22.6 to 22.7 and 23.1 to 23.3 ft BGS)							
23.0								
24.0	– slightly weathered vertical fracture (23.6 to 24.2 ft BGS) – dark chert layers interspersed with limestone (24.2 to 25.4 ft BGS) – rubble zone, moderately weathered (24.6 to 24.9 ft BGS)				2	100	71.0	0
25.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-65)

PROJECT NAME: LEICA INC, RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-1A
(Page 4 of 5)
DATE COMPLETED: MARCH 31, 1994
DRILLING METHOD: 6 5/8" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIT/CORE/CVKL	RUN NUMBER	CORE RECOVERY	ROD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
26.0	– coral (25.5 to 25.6 ft BGS) – stylolite (@ 25.6 ft BGS) – dark chert (25.6 to 25.8 ft BGS)							
27.0	– trace coral and solution pitting (26.3 to 26.5 ft BGS) – small calcite mass (@ 26.5 ft BGS) – dark chert zone (26.9 to 27.1 and 27.3 to 27.6 ft BGS)							
28.0	– coral between moderately weathered breaks (27.7 to 27.8 ft BGS) – closed vertical fracture (28.2 to 28.5 ft BGS)				2	100	71.0	0
29.0								
30.0	– gray and buff colored chert (28.7 to to 29.6 ft BGS) – rugose coral outline (29.8 to 29.9 ft BGS) – weathered break (@ 30.5 ft BGS)		3"ø NX COREHOLE					
31.0	– buff colored chert (30.5 to 31.0 ft BGS) – weathered coral (31.4 to 31.8 ft BGS)							
32.0								
33.0	– dark chert (32.7 to 33.5 ft BGS)							
34.0	– slightly weathered carbonaceous parting (@ 33.5 ft BGS) – abundant light gray and buff colored chert (34.0 to 38.7 ft BGS)							
35.0					3	100	86.0	0
36.0								
37.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG
(BEDROCK)

(L-65)

PROJECT NAME: LEICA INC, RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-1A
(Page 5 of 5)
DATE COMPLETED: MARCH 31, 1994
DRILLING METHOD: 6 5/8" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIENDTRERORCVKAL	RNUUNMBER	CRORECOVERY	RQD	WRAETTEURRN
ft BGS		ft. AMSL				%	%	%
38.0	– brachiopod (@ 37.4 ft BGS) – moderately weathered break (@ 37.5 ft BGS)		3"ø NX COREHOLE		3	100	86.0	0
39.0	– carbonaceous parting (@ 39.0 and 39.4 ft BGS)							
	END OF HOLE @ 39.4 FT. BGS	624.6						
40.0								
41.0								
42.0								
43.0								
44.0								
45.0								
46.0								
47.0								
48.0								
49.0								

BOREHOLE LOG

PROJECT: 90-821

BOREHOLE: MW2

PHASE II SUBSOIL INVESTIGATION
CHEEKTOWAGA, NEW YORK
FOR: Leica Inc.

DATE: 23 November 1990
GEOLOGIST TEJ

DEPTH (ft)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % RQD	COMMENTS
		REFERENCE POINT (Top of Riser) 657.01 GROUND SURFACE 657.45									
0.5		**TOPSOIL** Dark brown silty clay with rootlets and organic matter, moist.				SS	6		80		NO READINGS TAKEN
1											
2.0		**SILTY CLAY TILL** Brown silty clay, trace fine sand, DTPL, firm.									
2		**SILTY SAND** Brown silty fine sand, trace fine gravel, moist becoming saturated below about 6.0 ft, compact.									
3											
4		-Trace orange colored staining observed between about 4.0 and 5.0 ft.				SS	14		75		
5											
6.0											
6		-Becoming a sand and gravel below about 6.0 ft.				SS	50/ 1in.		16		
7											
8		-Occasional limestone and chert fragments observed at bottom of hole.									
8.5		Borehole terminated at 8.5 ft in sand and gravel.									AUGER REFUSAL AT 8.5 FT.
		NOTE: ELEVATION RESURVEYED MARCH 1994.									

Gartner Lee Inc.

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-66)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-2A
(Page 1 of 3)
DATE COMPLETED: NOVEMBER 30, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	657.02					
	GROUND SURFACE	657.1					
	SM/ML-SAND and SILT(FILL), little vegetation, topsoil, loose, dark brown, moist	656.6	ROAD BOX				
1.0	ML-SILT(NATIVE), little sand and clay, stiff, red brown, moist		CONCRETE SEAL	1SS		8	0
2.0			4"ø STEEL CASING				
3.0	– very stiff, mottled, gray, buff, brown and red brown, dry			2SS		29	0
4.0			10"ø BOREHOLE				
		652.4					
5.0	SM/ML-SAND and SILT, trace fine rounded gravel, dense, brown, dry		CEMENT/ BENTONITE GROUT	3SS		50	0
6.0							
7.0	GP-GRAVEL, some sand, shaly, dense, fine, dry	650.1		4SS		62	0
	SM/ML-SAND and SILT, trace fine rounded gravel, medium dense, brown, wet	649.8					
8.0		649.0		5SS		>100	0
	BEDROCK-spoon refusal at 8.1 ft BGS, auger refusal at 8.4 ft BGS	648.7	6"ø BOREHOLE				
9.0	END OF OVERBURDEN HOLE @ 8.4 FT BGS		3"ø NX COREHOLE				
	NOTES: 1. At completion a 4" steel casing was installed to 8.4 ft. BGS for bedrock drilling. 2. Soil samples retained for geologic record.						
10.0							
11.0							
12.0							
13.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(BEDROCK)

(L-67)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-2A

DATE COMPLETED: NOVEMBER 30, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIENDTRERORCVKAL	RUNNUMBER	CORE RECOVERY	RQD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
	Overburden		10"ø BOREHOLE; 4"ø STEEL CASING; CEMENT/ BENTONITE GROUT; 6"ø BOREHOLE					
8.0	LIMESTONE(Onondaga Formation, Moorehouse Member): light gray to dark gray, fine to medium grained, very thin to medium bedded, carbonaceous, trace coral, sparsley fossiliferous, little chert	649.0			WR			
9.0	– numerous moderately weathered fractures (9.0 to 10.1 ft BGS)							
10.0								
	– moderately weathered carbonaceous parting (@ 10.5 and 11.1 ft BGS)				1	100	67.0	80
11.0								
12.0	– very light gray, finer grained (11.9 to 14.3 and 15.9 to 18.0 ft BGS)		3"ø NX COREHOLE					
13.0								
14.0								
15.0					2	96	44.0	60
16.0								
17.0								
	– moderately to heavily weathered interval (17.5 to 18.3 ft BGS)							
18.0								
					3	100	53.0	50
19.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-67)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-2A (Page 3 of 3)
DATE COMPLETED: NOVEMBER 30, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIT/CORE/KAL	RUN NUMBER	CORE RECOVERY	RQD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
	– abundant carbonaceous partings (19.3 to 20.3 ft BGS)							
20.0	– light gray fine grained, weathered (20.2 to 22.3 ft BGS)							
21.0								
22.0	– detrital, coarser grained, infrequent small coral (22.3 to 26.0 ft BGS)				4	98	65.0	50
23.0								
24.0								
25.0			3"ø NX COREHOLE					
26.0								
	– coral (26.7 to 26.9 ft BGS)							
27.0	– rugose coral (27.2 to 27.4 ft BGS)							
28.0	– brown gray chert nodule, fine grained, hard (27.9 to 28.5 ft BGS)				5	100	61.0	<50
	– 1/2" thick shaly band (@ 28.6 ft BGS)							
29.0								
30.0	END OF HOLE @ 29.9 FT. BGS	627.1						
31.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

BOREHOLE LOG

PROJECT: 90-821

BOREHOLE: MW3

PHASE II SUBSOIL INVESTIGATION
CHEEKTOWAGA, NEW YORK
FOR: Leica Inc.

DATE: 22 November 1990
GEOLOGIST TEJ

DEPTH (ft)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % RQD	COMMENTS
		REFERENCE POINT (Top of Riser) 655.94 GROUND SURFACE 656.20									
0.4		**ASPHALT**		1		GS					NO READINGS TAKEN
1.0		**SUB-BASE** Grey sand and gravel.		2		SS	10		50		
1		**SILTY CLAY TILL** Brown silty clay, numerous fractures, trace fine sand, DTPL, stiff to very stiff. -Grey colored alteration observed along vertical fractures between about 1.0 and 3.0 ft.									
2											
3											
4											
5				3		SS	20		0		NO RECOVERY DURING THIS INTERVAL
6											
7											
7.5		**SILTY SAND** Brown silty fine sand, trace fine gravel, moist, loose.									
8											
9		-Saturated below about 9.0 ft.		4		SS	5		71		
10											
11.0	11	**Borehole terminated at 11.0 ft in silty sand.**									AUGER REFUSAL AT 11.0 FT.

NOTE: ELEVATION RESURVEYED MARCH 1994.

Gartner Lee Inc.

BOREHOLE LOG

PROJECT: 90-821

BOREHOLE: MW4

PHASE II SUBSOIL INVESTIGATION
CHEEKTOWAGA, NEW YORK
FOR: Leica Inc.

DATE: 20 November 1990
GEOLOGIST TEJ

DEPTH (ft)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % RQD	COMMENTS
		REFERENCE POINT (Top of Riser) 655.57 GROUND SURFACE 656.00									
		FILL Dark brown to black silty clay, some sand and fine to medium gravel, firm. -Brick fragments and black colored staining observed.		1		GS					AUGERED DIRECTLY TO 1.0 FT.
1				2		SS	6		45		OVA rdg.= 2-4
2											
3.0 3		**SILTY CLAY TILL** Red brown silty clay, trace fi d and gravel, APL, very stiff.									
4											
5				3		SS	16		83		OVA rdg.= 60 OVA rdg.= 400 IN AUGERS
6											
7											
8.0 8		**SILTY SAND**(inferred) Brown silty fine sand, trace fine gravel, saturated.									
9				4		SS	46		24		NO RECOVERY DUE TO CASING INSTALLATION
10											
11.0 11		-Becoming a sand and gravel below about 11.0 ft.									
12		-Occasional limestone fragments observed at bottom of hole.									
12.8				5		SS	50/1in.				AUGER REFUSAL AT 12.8 FT.
		Borehole terminated at 11.0 ft in sand and gravel. NOTE: Stratigraphy inferred from surrounding boreholes from about 7.0 to 11.0 ft.									
		NOTE: ELEVATION RESURVEYED MARCH 1994.									

Gartner Lee Inc.

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-01)

PROJECT NAME: LEICA
PROJECT NO.: 3967
CLIENT: LEICA
LOCATION: CHEEKTOWAGA, N.Y.

HOLE DESIGNATION: MW-5
DATE COMPLETED: JULY 1, 1991
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL
	REFERENCE POINT (Top of Riser)	654.80
	GROUND SURFACE	655.24
	Augered through asphalt to 0.5 ft BGS	-0.5
	Gray fine to medium SAND, little fine to medium angular gravel, moist, FILL	
2.5	Same, except dry to moist	-2.9
	Red brown CLAY, some silt, little sand, trace fine round gravel, hard, dense, dry to moist, NATIVE	
5.0		
		-6.4
7.5	Red brown SILT, some fine to medium sand, little clay, moist	
	Interbedded silt, fine sand and clay lenses, (7.4 to 7.6 ft BGS)	-8.0 -8.4
	Red brown CLAY, little silt, soft, moist	-8.9
10.0	Gray CLAY, soft, moist	
	Gray fine to medium SAND, moist to wet	
	Same, with some silt	
12.5	Gray fine to coarse SAND, little fine round gravel, moist to wet	-11.9
	Same, except hard, dry	
	END OF HOLE @ 11.9 FT. BGS	
15.0	NOTES:	
	1. No soil samples taken for chemical analysis. Geologic record samples were collected.	
17.5	2. At completion a monitoring well was installed to 11.9 ft BGS.	
20.0		
22.5		
25.0		
27.5		
30.0		
32.5		

MONITOR INSTALLATION

SCREEN DETAILS:
Screened Interval:
9.4 to 11.5' BGS
Length -2.1'
Diameter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval:
7.5 to 11.9' BGS
Material -# 4 Sand

SAMPLE NUMBER	STATE	N VALUE	HNU (ppm)
1SS	X	11	0.9
2SS	X	14	1.2
3SS	X	24	1.9
4SS	X	15	2.8
5SS	X	8	1.2
6SS	X	12	1

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-68)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-5A

DATE COMPLETED: DECEMBER 1, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	654.84					
	GROUND SURFACE	655.3					
	Asphalt pavement	654.8	ROAD BOX				
1.0	GW-GRAVEL(FILL), fine to medium, angular, dry	654.3					
	CL-CLAY, little sand and gravel, soft, brown to red brown, dry to moist		CONCRETE SEAL	1SS		14	10
2.0		653.4					
	SM/ML-SAND and SILT, little gravel, medium stiff, dry to moist						
3.0							
				3SS		8	0.7
4.0			4"ø STEEL CASING				
	CL-CLAY(NATIVE), some silt, soft, red brown, moist	650.9					
5.0	Augered to 8.0 ft BGS						
6.0							
7.0			CEMENT/ BENTONITE GROUT				
8.0		647.3					
	SM-SAND, some silt, trace fine rounded gravel, medium dense, moist to wet, no sheen or odor						
9.0			12"ø BOREHOLE	4SS		25	18
10.0							
11.0				5SS		34	7.5
	BEDROCK - wet rotary to 12.6 ft BGS						
	END OF OVERBURDEN HOLE @ 12.6 FT BGS	643.5					
12.0	NOTES:		6"ø BOREHOLE				
	1. At completion a 4" steel casing was installed for bedrock drilling to 12.6 ft BGS	642.7					
	2. Soil samples collected for chemical analysis from 1.0 to 4.5 ft BGS and 8.0 to 11.8 BGS for TCL VOCs, TAL Metals and TPH.						
13.0	3. Soil samples retained for geologic record.		3"ø NX COREHOLE				
	4. For statigraphy from 4.5 to 8.0 ft BGS see MW-5.						

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-69)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-5A (Page 2 of 4)
DATE COMPLETED: DECEMBER 1, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIENDTRERORCVKAL	RNUUNMBER	CRORECOVERY	RQD	WRAETTURRN
ft BGS		ft. AMSL				%	%	%
	Overburden	643.7	12"ø BOREHOLE CEMENT/ BENTONITE GROUT; 4"ø STEEL CASING; 6"ø BOREHOLE					
12.0	LIMESTONE(Onondaga Formation, Moorehouse Member): light gray to gray, thin to medium bedded, fine to medium grained, little coral and fossils, carbonaceous, little chert, stylolites, slightly to moderately weathered – rubble, heavily weathered (12.6 to 12.8 ft BGS) – small closed slightly weathered vertical 60° fracture (14.3 to 14.7 ft BGS) – brown to dark brown chert nodule (14.6 to 14.8 ft BGS) – slightly weathered break (@ 15.1 ft BGS) (17.5 to 18.3 ft BGS)							
13.0								
14.0								
15.0					1	91	52.0	90
16.0			3"ø NX COREHOLE					
	– dark gray chert nodule (16.6 to 17.3 ft BGS)							
17.0	– light gray (17.3 to 19.3 ft BGS)							
18.0								
19.0	– dark gray, detrital layer, fossil fragments, little chert (19.3 to 20.0 ft BGS)				2	93	70.0	90
20.0	– brown chert (20.3 to 20.4 ft BGS)							
21.0								
22.0	– coral (20.6 to 20.7, 21.6 to 21.8, 22.2 to 22.3 ft BGS) – numerous slightly weathered fractures, occasional coral (22.0 to 25.8 ft BGS)				3	98	55.0	90
23.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-69)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-5A (Page 3 of 4)
DATE COMPLETED: DECEMBER 1, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	DESCRIPTION OF STRATA	ELEVATION ft. AMSL				INTERVAL	RUN NUMBER	CORE RECOVERY %	RQD %	WATER RETURN %
24.0							3	98	55.0	90
25.0										
26.0	– buff to light brown chert (25.8 to 27.8 ft BGS)									
27.0										
28.0	– gray detrital layer, medium to coarse grained, numerous small coral and fossil fragments (27.8 to 29.9 ft BGS)				3"ø NX COREHOLE					
29.0							4	100	88.0	90
30.0	– dark gray chert (29.9 to 30.6, 30.8 to 32.1, 32.5 to 33.2, 33.3 to 33.4 and 33.5 to 34.0 ft BGS)									
31.0										
32.0										
33.0										
34.0							5	100	85.0	90
35.0	– buff to light brown chert (34.5 to 34.8, 35.0 to 35.2, 36.0 to 36.2, 37.1 to 37.2, 37.3 to 37.7, 38.4 to 38.6, 39.2 to 40.0 and 40.5 to 41.6 ft BGS)									

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-69)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-5A (Page 4 of 4)
DATE COMPLETED: DECEMBER 1, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	DESCRIPTION OF STRATA	ELEVATION ft. AMSL	MONITOR INSTALLATION	BEDROCK INTERVAL	RUN NUMBER	CORE RECOVERY %	RQD %	WATER RETURN %
36.0								
37.0								
38.0					5	100	85.0	90
39.0			3"ø NX COREHOLE					
40.0								
41.0								
42.0	END OF HOLE @ 42 FT. BGS	612.8						
43.0								
44.0								
45.0								
46.0								
47.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

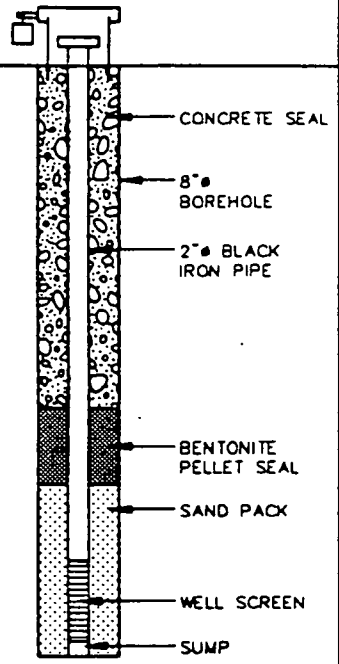
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: LEICA
PROJECT NO.: 3967
CLIENT: LEICA
LOCATION: CHEEKTOWAGA, N.Y.

HOLE DESIGNATION: MW-6
DATE COMPLETED: JULY 1, 1991
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL
	REFERENCE POINT (Top of Riser)	660.84
	GROUND SURFACE	661.16
2.5	Dark brown fine SAND, some silt, trace coal, glass and vegetation, dry, FILL	
	Same, except brown, little fine to medium concrete	-2.0
	Black with white fine SAND, some fine coal, dry	
	Black SLAG, some coal and sand, moist	-4.5
5.0	Red brown SILT, little fine sand, some clay, dry, NATIVE	-4.8
	Gray fine SAND, little silt, trace clay, dry to moist, some black discoloration	-6.8
7.5	Same, except moist	
	Red brown CLAY, some silt, little fine sand and fine round gravel, dry, TILL	
10.0	Same, except little fine to medium rounded to subrounded gravel	
		-11.2
	Red brown, gray and brown SILT, some fine sand, little clay, laminated, dry to moist	
12.5	Same, except gray and pink	-12.7
	Gray fine SAND, little silt and clay, stiff, moist	
15.0	Gray fine to medium SAND, trace fine round gravel, soft, moist to wet	-15.5
	END OF HOLE @ 15.5 FT. BGS	
17.5	NOTES:	
	1. No soil samples taken for chemical analysis. Geologic record samples were collected.	
20.0	2. At completion a monitoring well was installed to 15.5 ft BGS.	
22.5		
25.0		
27.5		
30.0		
32.5		

MONITOR INSTALLATION



SCREEN DETAILS:
Screened Interval:
13.0 to 15.1' BGS
Length -2.1'
Diameter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval:
11.0 to 15.5' BGS
Material -# 4 Sand

SAMPLE NUMBER	STATE	N VALUE	HNU (ppm)
1SS		16	0.4
2SS		4	0.8
3SS		7	0.6
4SS		11	0.8
5SS		18	0.4
6SS		18	0.4
7SS		6	0.4
8SS		>100	1.8

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-70)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-6A (Page 1 of 4)
DATE COMPLETED: DECEMBER 17, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	659.38					
	GROUND SURFACE	659.8					
	For overburden stratigraphy see MW-6		ROAD BOX				
1.0			CONCRETE SEAL				
2.0							
3.0							
4.0			4"ø STEEL CASING				
5.0							
6.0			12"ø BOREHOLE				
7.0							
8.0			CEMENT/ BENTONITE GROUT				
9.0							
10.0							
11.0							
12.0							
13.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ⧖ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-70)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAG, NEW YORK

HOLE DESIGNATION: MW-6A

DATE COMPLETED: DECEMBER 17, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
14.0	BEDROCK – wet rotary to 14.9 ft BGS	646.2	12" ø BOREHOLE; CEMENT/ BENTONITE GROUT; 6" ø BOREHOLE; 4" ø STEEL CASING; 3" ø NX COREHOLE				
15.0	END OF OVERBURDEN HOLE @ 14.9 FT BGS	644.9					
	NOTES: 1. At completion a 4" steel casing was installed for bedrock drilling to 14.9 ft BGS						
16.0							
17.0							
18.0							
19.0							
20.0							
21.0							
22.0							
23.0							
24.0							
25.0							
26.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

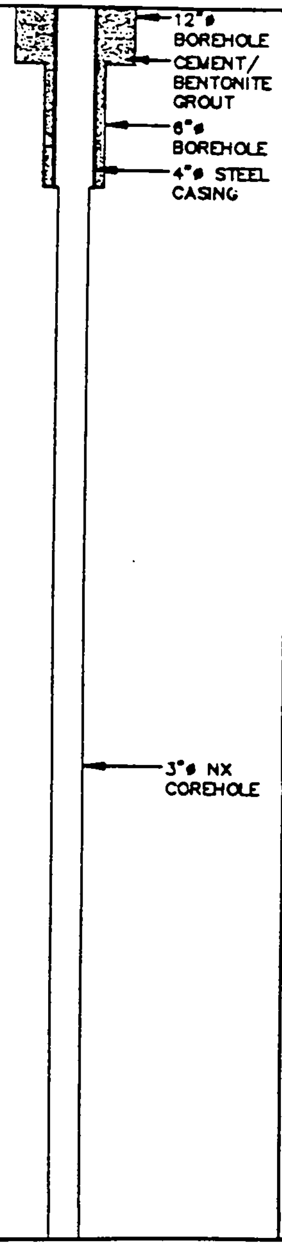
CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-71)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-6A (Page 3 of 4)
DATE COMPLETED: DECEMBER 17, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	DESCRIPTION OF STRATA	ELEVATION ft. AMSL	MONITOR INSTALLATION	BEDROCK INTERVAL	RUN NUMBER	CORE RECOVERY %	RQD %	WATER RETURN %
	Overburden							
14.0	LIMESTONE(Onondaga Formation, Moorehouse Member): light gray, fine to medium grained, thinly bedded, carbonaceous, little chert, ocassional fossils and coral, numerous stylolites	646.2						
15.0								
16.0	– slightly weathered carbonaceous parting (@ 15.9 and 16.0 FT BGS)							
17.0								
18.0	– slighlty weathered 80° vertical fracture (18.3 to 18.7 ft BGS)							
19.0	– small coral (@ 18.9 and 19.0 ft BGS)							
20.0	– numerous slightly weathered carbonaceous partings (@ 20.2 to 20.6 ft BGS) – moderately weathered carbonaceous partings (@ 20.6, 20.9, 22.0, 22.4, 23.6 and 24.9 ft BGS)				1	98	64.0	60
21.0								
22.0								
23.0								
24.0	– brachiopod fragments, coral fragments, moderately weathered break (@ 24.5 ft BGS)							
25.0	– rugose coral outline (@ 25.0 ft BGS) – brachiopod (@ 25.2 ft BGS)				2	100	88.0	0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND   ▼ STATIC WATER LEVEL   NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-71)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-6A (Page 4 of 4)
DATE COMPLETED: DECEMBER 17, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIENDTRERORCVKAL	RUNNUMBER	CORE RECOVERY	ROD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
26.0	– brachiopod and coral fragments, coarser grained matrix (@ 25.7 ft BGS)							
	– slightly to moderately weathered carbonaceous parting (@ 25.9, 26.6 and 29.9 ft BGS)							
27.0	– coral, slight petroleum oil odor, fossil fragments in matrix (25.9 to 26.1 ft BGS)							
	– several small rugose coral outlines (27.0 to 27.2 ft BGS)							
28.0	– medium to dark gray mottled, some limestone remineralization (27.4 to 27.9 ft BGS)							
	– brachiopod fossil (@ 27.8 ft BGS)				2	100	88.0	0
29.0								
	– small gypsum mass and gypsum filled veinlets (@ 29.3 ft BGS)							
30.0	– coral, coral fragments, detrital layer, coarser grained (30.0 to 30.1, 30.3 to 32.1, 34.2 to 34.4 ft BGS)		3"ø NX COREHOLE					
	– finer grained (30.1 to 30.3 ft BGS)							
31.0								
32.0	– brown gray chert nodules, slight HCl reaction, fine grained, hard (32.1 to 32.8, 33.5 to 34.0, 34.1 to 34.2 and 34.4 to 36.0 ft BGS)							
33.0	– small coral, open veins (32.8 to 32.9 ft BGS)							
34.0					3	100	100.0	0
35.0								
36.0	END OF HOLE @ 36.0 FT. BGS	623.8						
37.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

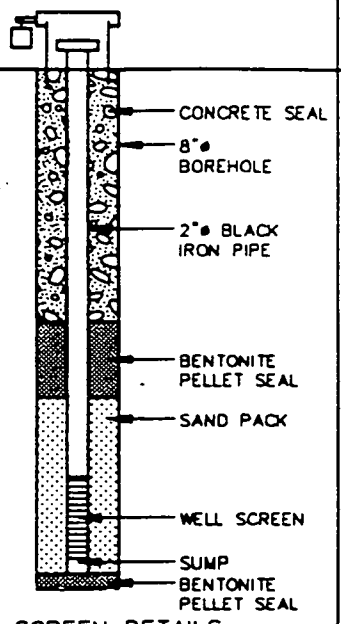
(L-03)

PROJECT NAME: LEICA
PROJECT NO.: 3967
CLIENT: LEICA
LOCATION: CHEEKTOWAGA, N.Y.

HOLE DESIGNATION: MW-7
DATE COMPLETED: JULY 2, 1991
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL
	REFERENCE POINT (Top of Riser)	658.21
	GROUND SURFACE	658.51
	Augered through asphalt to 0.5 ft BGS	-0.5
	Gray medium SAND, some medium gravel and asphalt, dry to moist, FILL	-1.1 / -1.4
2.5	Black fine COAL, some silt and sand, moist, some brown discoloration	
	Red brown CLAY, little silt and fine sand, trace gravel, moist, some black discoloration, fuel oil and gasoline odor	-3.8
5.0	Same, with trace wood, gasoline odor	-5.1
	Black SILT, some clay, little fine sand, moist gasoline and septic odor	
7.5	Same, except grading to gray	
	Red brown CLAY, some silt, moist, NATIVE	-8.6
	Same, except little silt, hard, dense, dry to moist	
10.0	Red brown and gray SILT and CLAY, some sand, laminated	-10.6
12.5	Gray medium SAND, trace fine to medium gravel, moist to wet	-13.0
	Brown to red brown SILT, some clay, little fine to medium sand, hard, dense, dry to moist	-13.6
15.0	END OF HOLE @ 13.6 FT. BGS	
	NOTES: 1. No soil samples taken for chemical analysis. Geologic record samples were collected. 2. At completion a monitoring well was installed to 13.2 ft BGS.	
17.5		
20.0		
22.5		
25.0		
27.5		
30.0		
32.5		

MONITOR INSTALLATION



SCREEN DETAILS:
Screened Interval:
10.7 to 12.8' BGS
Length -2.1'
Diameter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval:
8.6 to 13.2' BGS
Material -# 4 Sand

SAMPLE NUMBER	STATE	N VALUE	HNU (ppm)
1SS	X	14	2.2
2SS	X	5	55
3SS	X	14	35
4SS	X	30	55
5SS	X	27	10-12
6SS	X	26	7.5
7SS	X	>50	1.5

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS (○) WATER FOUND ▽ STATIC WATER LEVEL ▼

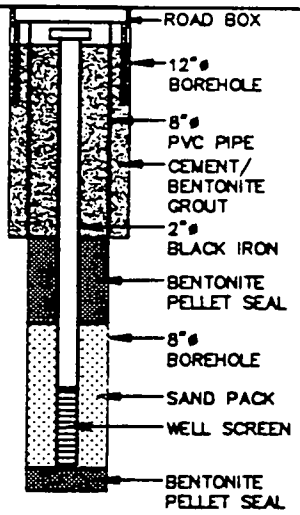
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

(L-05)

PROJECT NAME: LEICA
PROJECT NO.: 3967
CLIENT: LEICA
LOCATION: CHEEKTOWAGA

HOLE DESIGNATION: BH-A / MW-8
DATE COMPLETED: JANUARY 22, 1992
DRILLING METHOD: 8 1/4" ID HSA / 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE N VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	656.11					
	GROUND SURFACE	656.43					
	Black and brown ASPHALT, some gravel, dry, FILL	-0.5		1SS		23	3.6
2.5	Dark gray CINDERS, some brick, clay and gravel, moist, fuel oil odor	-2.0					
	Dark gray CLAY, some coal, some white fibrous waste, red discoloration, moist, fuel oil / petroleum odor	-3.2		2SS		15	32.9
5.0	Gray SAND, some silt and clay, moist	-4.8		3SS		22	4.2 23.3
	Same, except dry to moist	-6.0					
	Red brown SILT, some sand, little clay, dry to moist, sour odor, NATIVE	-7.0		4SS		13	24 32
7.5	Red brown CLAY, little silt and fine round gravel, dry to moist, sour odor	-7.8					
	Gray and brown SILT, some clay, little interbedded sand lenses, moist, sour odor	-9.2		5SS		9	39 51
10.0	Gray CLAY, some silt, dry to moist, sour odor	-11.5		6SS		39	54 38
12.5	Gray SAND, little silt and clay, moist	-12.6		7SS		>50	44
	Same, except fine to medium grained, trace to little fine round gravel, moist to wet, sour odor						
	Same, with clay lens, some sheen						
15.0	NAPL (@ 11.5 to 11.8 ft BGS)						
	Gray fine SAND, some fine gravel, hard, dense, dry to moist, petroleum odor						
17.5	END OF HOLE @ 12.6 FT. BGS						
	NOTES:						
	1. At completion a monitoring well was installed to 11.9 ft BGS.						
20.0	2. Soil samples were collected for chemical analysis from 11.5 to 12.0 ft BGS for VOCs and TPH.						
22.5							
25.0							
27.5							
30.0							
32.5							



SCREEN DETAILS:
Screened Interval:
9.9 to 11.9' BGS
Length -2.0'
Diameter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval:
8.2 to 12.0' BGS
Material -# 2 QROC

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (○) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

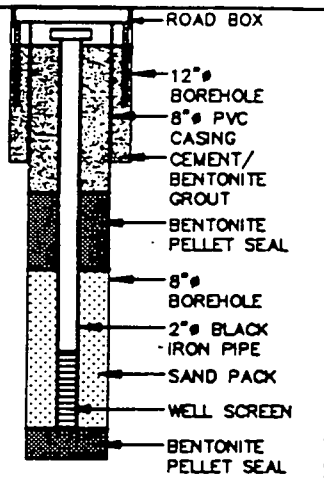
(L-06)

PROJECT NAME: LEICA
PROJECT NO.: 3967
CLIENT: LEICA
LOCATION: CHEEKTOWAGA

HOLE DESIGNATION: BH-B / MW-9
DATE COMPLETED: JANUARY 22, 1992
DRILLING METHOD: 8 1/4" ID HSA / 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL
	REFERENCE POINT (Top of Riser)	654.99
	GROUND SURFACE	655.36
	Black and gray ASPHALT, some gravel, dry to moist, FILL	-0.5
	Red brown SAND, some silt, little gravel, dry to moist	-1.7
2.5		-2.8
	Dark brown and gray CLAY, some gravel, moist to wet, slight petroleum odor	-3.1
		-4.0
	Red brown and gray CLAY, some silt, little sand, dry to moist, NATIVE	-5.0
5.0		
	Red brown and gray SAND, some silt, little fine gravel, trace clay, dry to moist, dense, slight sour odor	
7.5		-7.3
	Red brown SILT, some clay, little sand and fine gravel, dry to moist, no odor	-8.3
	Red brown CLAY, some silt, trace fine to medium gravel and sand, dry to moist, no odor	-9.4
10.0		
	Same, except little sand in lenses	-11.1
	Same, except gray, little silt and fine sand	-11.8
12.5	Gray SAND, little silt and clay, moist, no odor	
	Same, with trace fine rounded gravel, moist to wet	
15.0	Gray CLAY, little sand seams (1/8" or less), trace fine rounded gravel, moist, no odor	
	Gray fine to medium SAND, trace silt and clay, moist to wet, no odor	
17.5	Gray fine SAND, some silt, trace gravel, dense, dry to moist, no odor	
	END OF HOLE @ 11.8 FT. BGS	
20.0	NOTES:	
	1. At completion a monitoring well was installed to 11.0 ft BGS.	
22.5		
25.0		
27.5		
30.0		
32.5		

MONITOR INSTALLATION



SCREEN DETAILS:
Screened Interval:
9.0 to 11.0' BGS
Length -2.0'
Diameter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval:
6.8 to 11.0' BGS
Material -#2 QROC

SAMPLE NUMBER	STATE	N VALUE	PID (ppm)
1SS		11	0
2SS		18	0
3SS		19	2.2 2.0
4SS		14	2.4 2.8
5SS		5	2.2 2.6
6SS		58	2.7 2.7

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

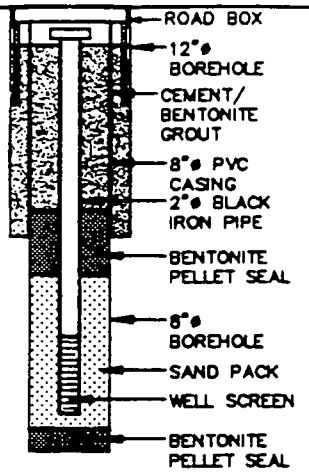
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

(L-07)

PROJECT NAME: LEICA
PROJECT NO.: 3967
CLIENT: LEICA
LOCATION: CHEEKTOWAGA

HOLE DESIGNATION: BH-C / MW-10
DATE COMPLETED: JANUARY 22, 1992
DRILLING METHOD: 8 1/4" ID HSA / 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	655.48					
	GROUND SURFACE	655.82					
2.5	Dark brown and red brown SILT, some clay and sand, trace coal, brick, slag, concrete and plastic, dry to moist, no odor, FILL Red brown SILT, some clay, little sand and gravel, dry to moist	-3.0		1SS		6	0
	Black and dark gray SILT, some sand and organic matter, moist, NATIVE	-3.8		2SS		7	4 19.3
5.0	Black and dark gray fine to medium SAND, little silt, moist, gasoline odor	-4.3		3SS		24	23 9.2
	Red brown SILT, some clay and sand, dry to moist	-6.0		4SS		15	46 79.2
7.5	Red brown CLAY, some silt, little sand, trace gravel, dry to moist, slight odor						
	Same, except little sand in interbedded lenses, some odor	-8.7		5SS		12	23.9 14.9
10.0	Same, with some gravel, musty odor	-10.5		6SS		69	39.7 14
	Gray SAND, little silt and clay, trace round gravel, moist	-11.6					
12.5	Same, except medium grained, poorly graded, wet						
	Gray fine SAND, some fine gravel, hard, dense, dry to moist						
15.0	END OF HOLE @ 11.6 FT. BGS						
	NOTES: 1. At completion a monitoring well was installed to 11.9 ft BGS. 2. Soil sample submitted for chemical analysis for TPH from 3.8 to 4.1 ft BGS.						
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							
32.5							



SCREEN DETAILS:
Screened Interval:
8.6 to 10.6' BGS
Length -2.0'
Dia'eter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval:
7.0 to 11.0' BGS
Material -#2 QROC

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (oval) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

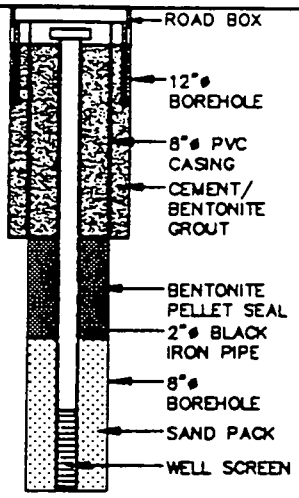
(L-08)

PROJECT NAME: LEICA
PROJECT NO.: 3967
CLIENT: LEICA
LOCATION: CHEEKTOWAGA

HOLE DESIGNATION: BH-D / MW-11
DATE COMPLETED: JANUARY 23, 1992
DRILLING METHOD: 8 1/4" ID HSA / 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL
	REFERENCE POINT (Top of Riser)	656.08
	GROUND SURFACE	656.58
	Black and gray ASPHALT, some sand and gravel, dry to moist, FILL	-0.5
2.5	Red brown SAND, some silt, little clay, trace gravel, dry	
	Dark brown and red brown CLAY, dry to moist	-3.0
		-3.8
	Gray fine to medium SAND, little silt, moist, slight odor, NATIVE	-4.3
5.0	Red brown SILT, some clay, little sand and gravel, dry to moist, sour odor	-6.0
7.5	Red brown CLAY, some silt, little sand, trace gravel, dry to moist, slight sour odor Same, except gray, some sand in alternating layers	
10.0	Gray SAND, little silt and clay, well graded, moist, slight petroleum odor	-9.8
	Same, with some fine to medium gravel, little silt, no clay	-11.2
12.5	Gray fine SAND, trace fine gravel, dense, moist, gravel content increases with depth, slight odor	-12.6
15.0	END OF HOLE @ 12.6 FT. BGS	
	NOTES: 1. At completion a monitoring well was installed to 12.5 ft BGS. 2. Soil samples were collected for chemical analysis from 4.0 to 6.0 ft and from 10.8 to 11.4 ft BGS for VOCs and TPH. A sample containing a dark brown NAPL mixed into the soil was collected for chemical analysis from the auger plug after augering from 12.0 to 12.5 ft BGS.	
17.5		
20.0		
22.5		
25.0		
27.5		
30.0		
32.5		

MONITOR INSTALLATION



SCREEN DETAILS:
Screened Interval:
10.5 to 12.5' BGS
Length -2.0'
Dia'eter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval:
8.6 to 12.6' BGS
Material -#2 QROC

SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
1SS		24	0
2SS		7	0
3SS		21	14 20
4SS		32	46.1
5SS		11	100 42.6
6SS		14	260 293
7SS		>50	169

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (oval) WATER FOUND ▽ STATIC WATER LEVEL ▼

Project: LEICA

Project No: 3947

Date: 7/12/99

Client: Leica Microsystems Inc.

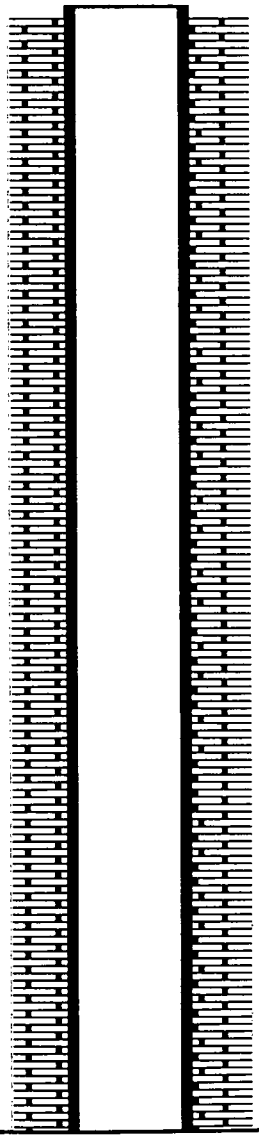
Location: 203 Eggert Road, Cheektowaga, NY

Well #: MW-11A

Geologist: Joe Glista

SUBSURFACE PROFILE

Depth	Description	Remarks	Well Construction Data	Remarks
0	Ground Surface			
1	Fill			
2				
3				
4				
5	Red Clay			
6				Sand Pack to 10.5' BG
7				
8				
9				
10				Grouted Casing to 15' BG
11				
12				
13				
14	Limestone Bedrock			
15				



Maxim Technologies Drill Rig Operator: Phil Bence

Drilling Method: Rotary Cone

Drilling Date: 7/12/99

Well Diameter: 8"

Project: LEICA

Project No: 3947

Date: 7/12/99

Client: Leica Microsystems Inc.

Location: 203 Eggert Road, Cheektowaga, NY

Well #: MW-11A

Geologist: Joe Glista

SUBSURFACE PROFILE

Depth	Description	Remarks	Well Construction Data	Remarks
16				Well Screen to 16.2' BG
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Maxim Technologies Drill Rig Operator: Phil Bence

Drilling Method: Rotary Cone

Drilling Date: 7/12/99

Well Diameter: 8"

Project: LEICA

Project No: 3947

Date: 7/12/99

Client: Leica Microsystems Inc.

Location: 203 Eggert Road, Cheektowaga, NY

Well #: MW-11A

Geologist: Joe Glista

SUBSURFACE PROFILE

Depth	Description	Remarks	Well Construction Data	Remarks
31				
32				
33				
34				
35				Void and Fractures
36				Depth of Well 36.2' BG
37	End of Boring			
38				
39				
40	End of Borehole			
41				
42				
43				
44				
45				

Maxim Technologies Drill Rig Operator: Phil Bence

Drilling Method: Rotary Cone

Drilling Date: 7/12/99

Well Diameter: 8"

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-09)

PROJECT NAME: LEICA
PROJECT NO.: 3967
CLIENT: LEICA
LOCATION: CHEEKTOWAGA

HOLE DESIGNATION: MW-12
DATE COMPLETED: JANUARY 29, 1992
DRILLING METHOD: 8 1/4" ID HSA / 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE HNu (ppm)
	REFERENCE POINT (Top of Riser)	656.93					
	GROUND SURFACE	657.30					
2.5	Augered to 6.0 ft BGS		ROAD BOX; 12"ø BOREHOLE; CEMENT/ BENTONITE GROUT; BENTONITE PELLET SEAL; 2"ø BLACK IRON PIPE; 8"ø BOREHOLE; SAND PACK; WELL SCREEN				
5.0							
7.5	Red brown SILT, some clay, little sand and fine gravel, dry to moist, no odor, NATIVE	-6.0		1SS		34	0
10.0	Brown and gray with red brown CLAY, some silt and interbedded sand lenses, dry to moist, no odor	-8.9		2SS		18	0
	Same, except little sand	-10.2		3SS		11	0
12.5	Gray SAND, some silt, little fine gravel, moist to wet, slight petroleum odor			4SS		>50	42 0
15.0	END OF HOLE @ 13.4 FT. BGS	-13.4					
17.5	NOTES: 1. At completion a monitoring well was installed to 13.2 ft BGS. 2. Soil samples were collected for chemical analysis from 10.0 to 12.0 ft BGS for VOCs and TPH.						
20.0							
22.5							
25.0							
27.5							
30.0							
32.5							

SCREEN DETAILS:
Screened Interval:
8.2 to 13.2' BGS
Length -5.0'
Diameter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval:
6.8 to 13.4' BGS
Material -#2 QROC

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (oval) WATER FOUND ▽ STATIC WATER LEVEL ▼

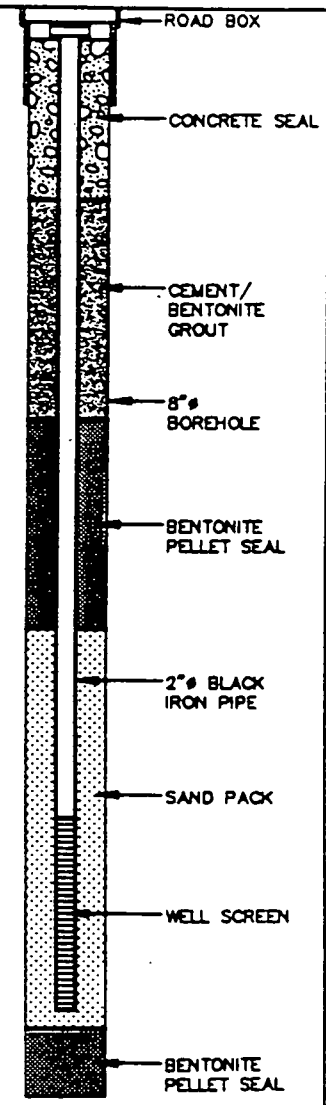
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

(L-72)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-13
DATE COMPLETED: DECEMBER 8, 1993
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL
	REFERENCE POINT (Top of Riser)	654.66
	GROUND SURFACE	654.9
1.0	ML-SILT(FILL), some clay, little sand, dark brown, moist, no odor, no sheen	
		653.5
2.0	ML-SILT(NATIVE), some clay, little sand, trace gravel and rootlets, stiff to very stiff, laminated, red brown, dry to moist	
3.0		
4.0		
5.0		
6.0		
		648.1
7.0	SM-SAND, little silt, trace fine round gravel, trace intermittant clay, fine to medium grained, gray with brown, moist to wet	
8.0		
9.0		
10.0		
11.0	SP-SAND(TILL), little to some subrounded gravel, trace silt, dense, fine grained, gray, moist	643.9
		643.5
12.0	END OF HOLE @ 11.4 FT. BGS	
	NOTES:	
	1. At completion a 2" monitoring well was installed to 10.5 ft BGS.	
	2. Soil samples collected for chemical analysis from 2.0 to 4.0 ft BGS and 8.0 to 11.0 ft BGS for TCL VOCs, TAL Metals and TPH.	
13.0	3. Shelby tube sample collected from adjacent borehole from 3.5 to 5.5 ft BGS for grain size, permeability, porosity, atterberg limits	



SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
1SS		4	2
2SS		14	4
3SS		22	0.6
4SS		24	1
5SS		25	0
6SS		>60	0

SCREEN DETAILS:
Screened Interval: 8.5 to 10.5' BGS
Length -2.0'
Diameter -2.0"
Slot # 10
Material -Stainless Steel

Sand pack interval: 6.5 to 10.7' BGS
Material -# 0 Morey

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (oval) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-73)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-13A
(Page 1 of 4)
DATE COMPLETED: DECEMBER 9, 1993
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	655.13					
	GROUND SURFACE	655.4					
	For overburden stratigraphy see MW-13		ROAD BOX				
1.0			CONCRETE SEAL				
2.0							
3.0							
4.0			4"ø STEEL CASING				
5.0							
6.0							
7.0			CEMENT/ BENTONITE GROUT				
8.0							
9.0							
10.0			12"ø BOREHOLE				
11.0							
12.0	BEDROCK – wet rotary to 12.9 ft BGS	643.5	6"ø BOREHOLE				
13.0	END OF OVERBURDEN HOLE @ 12.9 FT BGS	642.5	3"ø NX COREHOLE				

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-74)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-13A (Page 2 of 4)
DATE COMPLETED: DECEMBER 9, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR	BIENTRERORCVKAL	RNUUNMBER	CORE RECOVERY	ROD	WRATERURN
ft BGS		ft. AMSL				%	%	%
	Overburden		12"ø BOREHOLE; CEMENT/BENTONITE GROUT					
12.0	LIMESTONE(Onondaga Formation, Moorehouse Member): light gray, fine grained, slightly to moderately weathered, trace vertical fractures, massively bedded, trace coral, some chert, stylolites, some carbonaceous partings	643.5	8"ø BOREHOLE; 4"ø STEEL CASING		WR			
13.0	– heavily weathered rubble (12.9 to 13.3 ft BGS)							
14.0	– moderately weathered break (● 13.7 ft BGS) – slightly weathered vertical break (14.0 to 14.3 ft BGS)				1	95	19.0	90
15.0	– moderately weathered break (● 14.5, 14.7 and 16.4 ft BGS)							
16.0			3"ø NX COREHOLE					
17.0								
	– 40° inclined moderately weathered break (● 17.5 ft BGS)							
18.0	– stylolite (● 17.7 ft BGS)							
	– small coral (● 18.6 ft BGS)							
19.0	– stylolite break, slightly weathered (● 19.1 ft BGS) – abundant small coral, pitting due to coral erosion (19.1 to 20.0 ft BGS)							
20.0	– coral (20.0 to 20.2 and 20.3 to 20.5 ft BGS)				2	99	98.0	80
	– massive coral, open veined, brown stained, fuel oil odor (20.6 to 21.1 ft BGS)							
21.0	– black carbon depoits in openings of coral, 1/4" layer (● 21.1 ft BGS) – abundant small coral (21.1 to 21.7 ft BGS)							
22.0	– no staining (below 21.7 ft. BGS) – abundant small coral, mostly small rugose and fan (● 21.7 to 45.0 ft BGS)							
23.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-74)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-13A (Page 3 of 4)
DATE COMPLETED: DECEMBER 9, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR	BIENDTRERORCVKAL	RNUUNMBER	CRECOREOVERY	RQD	WRETURN
ft BGS		ft. AMSL				%	%	%
24.0	– fans coral (23.7 to 23.9 ft BGS)				2	99	98.0	80
25.0	– large rugose coral (25.1 to 25.2 ft BGS)							
26.0	– moderately weathered break (● 26.4 ft BGS)							
27.0								
28.0	– open veined fan coral (27.6 to 27.8 ft BGS) – small brachiopod fossils (● 27.9 ft BGS) – coral (28.3 to 28.4 ft BGS)		3"ø NX COREHOLE					
29.0	– rugose coral (29.2 to 29.3 ft BGS)							
30.0					3	100	100.0	70
31.0								
32.0	– moderately weathered coral zone, abundant coral (31.6 to 33.2 ft BGS)							
33.0								
34.0	– stylolytic zone, finer grained, no coral (33.5 to 33.8 ft BGS) – massive coral zone, heavily weathered, yellow brown color, slight odor (34.2 to 34.6 ft BGS)							
35.0	– weathered break (● 35.0, 35.8 and 37.0 ft BGS)				4	100	100.0	80

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-74)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-13A (Page 4 of 4)
DATE COMPLETED: DECEMBER 9, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR	BEDROCK INTERVAL	RUN NUMBER	CORE RECOVERY	RQD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
	– lighter gray, abundant small coral (35.3 to 37.9 ft BGS)							
36.0								
37.0								
38.0	– darker gray, coarser grained, slight odor (38.0 to 40.6 ft BGS)							
39.0	– large rugose coral (@ 39.0 to 39.2 ft BGS)							
40.0			3"ø NX COREHOLE		4	100	100.0	80
	– lighter gray, less coral, no staining, finer grained stylolites (40.6 to 44.5 ft BGS)							
41.0								
42.0								
43.0								
44.0	– large stylolites (44.5 ft BGS)							
	– abundant fan coral, darker gray matrix, brown staining, slight odor (44.5 to 45.0 ft BGS)							
45.0	END OF HOLE @ 45.0 FT. BGS	610.4						
46.0								
47.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

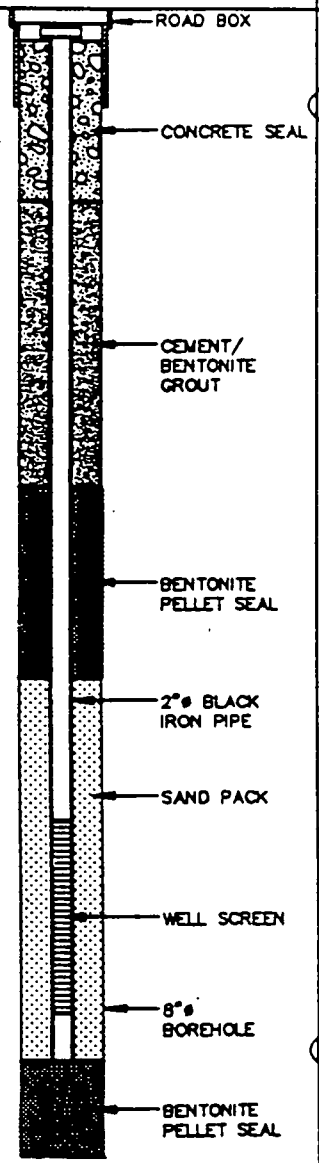
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-75)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-14
DATE COMPLETED: DECEMBER 6, 1993
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL
	REFERENCE POINT (Top of Riser)	653.38
	GROUND SURFACE	653.7
1.0	ML-SILT(FILL), some clay, little sand, trace vegetation, medium stiff, red brown, dry to moist	652.7
2.0	ML-SILT(NATIVE), little sand, trace clay, roots, loose, loamy, dark brown, moist - some sand, little clay, soft, red brown, moist	
3.0		
4.0	CL-CLAY, little silt, trace fine to medium subrounded gravel, laminated, stiff to very stiff, red brown, dry to moist	649.9
5.0		
6.0		
7.0	- soft, red brown and gray	
8.0	SM-SAND, trace clay and silt, trace fine subrounded gravel, medium dense, gray, moist	646.0
9.0		
10.0		
11.0	SP-SAND(TILL), little to some fine subrounded gravel, dense, gray	642.9
	Spoon refusal @ 11.8 ft BGS, auger refusal @ 12.0 ft BGS)	641.9
12.0	END OF HOLE @ 12.0 FT. BGS	641.7
13.0	NOTES: 1. At completion a 2" monitoring well was installed to 11.0 ft BGS. 2. Soil samples collected for chemical analysis from 0.0 to 2.0 ft BGS and 10.0 to 11.0 ft BGS for TCL/TCLP Metals, BNAs, VOCs and TOC, TPH AND 310.13.	



SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
1SS		7	6.4
2SS		13	6
3SS		33	40
4SS		10	31
5SS		21	37
6SS		40	24

SCREEN DETAILS:
Screened Interval: 8.5 to 10.5' BGS
Length -2.0'
Diameter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval: 7.0 to 11.0' BGS
Material -# 0 Morey

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (oval) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-76)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-14A
(Page 1 of 3)
DATE COMPLETED: DECEMBER 7, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	653.70					
	GROUND SURFACE	654.0					
	For overburden stratigraphy see MW-14		ROAD BOX				
1.0			CONCRETE SEAL				
2.0							
3.0							
4.0							
5.0							
6.0			CEMENT/ BENTONITE GROUT				
7.0							
8.0			12"ø BOREHOLE				
9.0							
10.0			4"ø STEEL CASING				
11.0							
12.0	BEDROCK – wet rotary to 12.9 ft BGS	642.1	6"ø BOREHOLE				
13.0	END OF OVERBURDEN HOLE @ 12.9 FT BGS	641.1	3"ø NX COREHOLE				

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-77)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-14A (Page 2 of 3)
DATE COMPLETED: DECEMBER 7, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	DESCRIPTION OF STRATA	ELEVATION ft. AMSL	MONITOR	BIENTRERORCVKAL	RUNNUMBER	CORE RECOVERY %	RQD %	WATER RETURN %
	Overburden	642.1	12"ø BOREHOLE; CEMENT/BENTONITE GROUT; 8"ø BOREHOLE; 4"ø STEEL CASING					
12.0	LIMESTONE(Onondaga Formation, Moorehouse Member): light gray, fine grained, slightly to moderately weathered, trace vertical fractures, massively bedded, trace coral, some chert, stylolites, some carbonaceous partings				WR			
13.0	– slightly weathered break (@ 13.0 ft BGS)							
14.0	– weathered zone, dark chert (13.4 to 13.6 ft BGS)				1	90	52.0	90
	– brachiopod fossil (@ 14.0 ft BGS)							
	– coral (14.4 to 14.5 ft BGS)							
15.0	– medium grained, buff, pink and gray, trace coral (15.0 to 15.4 ft BGS)							
	– dark chert nodule (15.7 to 15.9 and 16.4 to 16.7 ft BGS)							
16.0			3"ø NX COREHOLE					
	– small crystal filled vug (@ 16.8 ft BGS)							
17.0	– shale layer, banding (@ 17.0 ft BGS)							
18.0								
	– stylolite parting (@ 18.4 ft BGS)							
	– coral (18.8 to 18.9 ft BGS)							
19.0	– stylolite parting (@ 19.2 ft BGS)							
	– dark detrital layer between two stylolites (19.7 to 19.9 ft BGS)				2	100	74.0	40
20.0								
	– moderately weathered break (@ 20.7 ft BGS)							
21.0								
	– slightly weathered break (@ 21.7 ft BGS)							
22.0	– fan coral (22.1 to 22.4 ft BGS)							
23.0	– heavily weathered zone, rubble (23.2 to 23.4 and 23.6 to 23.8 ft BGS)							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-77)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-14A (Page 3 of 3)
DATE COMPLETED: DECEMBER 7, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR	BIENDTRERORCVKAL	RNUUNMBER	CROERCOVERY	RQD	WRAETTEURRN
ft BGS		ft. AMSL				%	%	%
24.0					2	100	74.0	40
25.0								
26.0	– slightly weathered break (● 25.7 and 25.9 ft BGS)							
	– moderately weathered break (● 26.5 ft BGS)							
27.0	– rugose coral (26.8 to 27.0 ft BGS)							
	– slightly weathered break (● 27.6 ft BGS)							
28.0								
	– solution pitting (28.4 to 28.5 ft BGS)		3"ø NX COREHOLE					
29.0	– small coral (● 29.0 ft BGS)							
	– slightly weathered break (● 29.5, 29.6, 30.3 ft BGS)							
30.0	– coral (29.8 to 30.0 ft BGS)				3	101	95.0	5
31.0	– massive fan coral, open veins, weathered, stained, fuel oil odor (31.1 to 32.0 ft BGS)							
32.0								
33.0	– coral break, moderately weathered, open veins, fuel oil odor (● 32.7 ft BGS)							
	– frequent small coral, open veins, slight fuel oil odor (33.4 to 35.0 ft BGS)							
34.0								
35.0	END OF HOLE ● 35.0 FT. BGS	619.0						

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

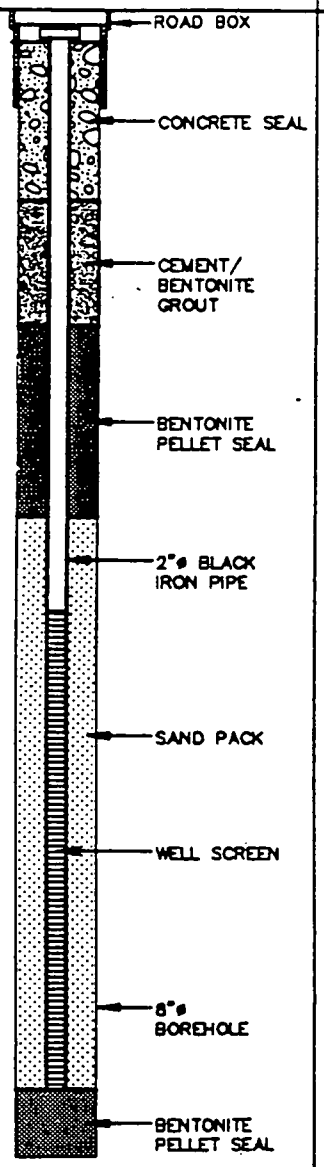
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-78)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-15
DATE COMPLETED: DECEMBER 14, 1993
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL
	REFERENCE POINT (Top of Riser)	658.35
	GROUND SURFACE	658.7
	Augered through asphalt and pavement	658.2
1.0	SP-SAND(FILL), some gravel, brown, moist	
		657.0
2.0	ML-SILT, little sand and clay, brown, moist	656.7
	ML-SILT(NATIVE), little to some clay, little sand, trace fine subrounded gravel, very stiff, laminated, red brown, dry to moist	
3.0		
4.0		
5.0		
6.0		
7.0	- softer	
		651.1
8.0	SM-SAND, little silt, trace fine rounded gravel, fine to medium grained, gray, moist to wet, no sheen, no odor	
9.0		
10.0		
11.0		
		647.4
	SM-SAND(TILL), some silt, little gra[illegible]very dense, brown, dry	
12.0		646.7
	END OF HOLE @ 12.0 FT. BGS	
13.0	NOTES: 1. At completion a 2" monitoring well was installed to 11.3 ft BGS. 2. Soil samples retained for geologic record.	



SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
1SS		9	0
2SS		21	0
3SS		22	0.6
4SS		23	0
5SS		6	0
6SS		52	0

SCREEN DETAILS:
Screened Interval: 6.3 to 11.3' BGS
Length -5.0'
Diameter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval: 5.3 to 11.3' BGS
Material -# 0 Morey

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-79)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-15A (Page 1 of 4)
DATE COMPLETED: DECEMBER 16, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	658.51					
	GROUND SURFACE	658.8					
	For overburden stratigraphy see MW-15		ROAD BOX				
1.0			CONCRETE SEAL				
2.0							
3.0							
4.0			4"ø STEEL CASING				
5.0							
6.0							
7.0			CEMENT/ BENTONITE GROUT				
8.0							
9.0							
10.0			12"ø BOREHOLE				
11.0							
12.0							
13.0	BEDROCK – wet rotary to 14.4 ft BGS	646.0	8"ø BOREHOLE				

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-79)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-15A

DATE COMPLETED: DECEMBER 16, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
14.0	END OF OVERBURDEN HOLE @ 14.4 FT BGS	644.4	6"ø BOREHOLE; 4"ø STEEL CASING; 3"ø NX COREHOLE				
15.0							
16.0							
17.0							
18.0							
19.0							
20.0							
21.0							
22.0							
23.0							
24.0							
25.0							
26.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (○) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(BEDROCK)

(L-80)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-15A (Page 3 of 4)
DATE COMPLETED: DECEMBER 6, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIENDTRERORCVKAL	RUNNUMBER	CORE RECOVERY	RQD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
	Overburden	646.0	6"ø BOREHOLE; CEMENT/BENTONITE GROUT; 4"ø STEEL CASING					
14.0	LIMESTONE(Onondaga Formation, Moorehouse Member): light gray, fine grained, slightly to moderately weathered, trace vertical fractures, massively bedded, trace coral, some chert, stylolites, some carbonaceous partings				WR			
15.0	– moderately weathered, some rubble, trace coral (14.4 to 15.0 ft BGS)							
	– moderately weathered fracture (@ 15.8 and 17.9 ft BGS)							
16.0	– detrital layers, medium grained, little fossil/coral fragments (15.8 to 16.0, 16.4 to 16.6 and 16.8 to 17.6 ft BGS)							
	– large brachiopod (@ 16.6 ft BGS)							
17.0	– moderately weathered caronaceous parting (@ 16.8 ft BGS)							
	– slightly weathered carbonaceous parting (@ 17.6 ft BGS)							
18.0	– brown chert nodule, calcite veinlets (17.8 to 18.6 ft BGS)				1	78	78.0	60
	– light gray, medium grained, frequent coral fragments (17.9 to 20.2 ft BGS)							
19.0	– moderately weathered carbonaceous parting (@ 18.1 and 18.2 ft BGS)							
	– heavily weathered fracture (@ 18.5 ft BGS)							
	– brown and white calcite (18.6 to 18.8 ft BGS)							
20.0	– coral, open veins, white (18.8 to 19.0 ft BGS)							
	– rugose coral (19.0 to 19.1 ft BGS)							
	– brachiopods (@ 19.2 ft BGS)		3"ø NX COREHOLE					
21.0	– rugose coral outline, open pores, crescent shaped (19.3 to 19.4 ft BGS)							
	– coral (19.9 to 20.2 ft BGS)							
	– weathered fracture, rubble (@ 21.1 ft BGS)							
22.0	– heavily weathered zone (21.1 to 22.0 ft BGS)							
	– lighter colored, medium grained, detrital, trace small coral (22.0 to 26.0 ft BGS)							
23.0	– moderately weathered carbonaceous parting (@ 24.0 to 24.3 ft BGS)							
24.0					2	100	69.0	0
25.0	– coral, slight yellow discoloration, weathered (24.8 to 25.0 ft BGS)							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-80)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-15A (Page 4 of 4)
DATE COMPLETED: DECEMBER 6, 1993
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIENDTRERORCVKAL	RUNNUMBER	CORE RECOVERY	RQD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
	– darker gray, medium grained, detrital layers, occasional coral, fossil fragments, numerous slightly weathered breaks (25.6 to 28.5 ft BGS)				2	100	69.0	0
26.0								
27.0	– vertical fractures, slightly weathered (27.3 to 27.7 ft BGS)							
28.0					3	100	71.0	0
29.0								
30.0	– slightly weathered fracture(● 29.9 ft BGS) – light brown to buff chert, fine grained, several calcite filled veinlets (29.9 to 30.7 ft BGS)		3"ø NX COREHOLE					
31.0	– medium gray, trace stylolites, light to dark gray mottling (30.7 to 34.3 ft BGS)							
32.0	– 35 to 45° inclined carbonaceous partings and bedding (● 31.8, 32.3 and 32.4 ft BGS)							
33.0					4	100	94.0	0
34.0	– brown chert nodule (34.3 to 34.6 ft BGS)							
35.0	– buff chert nodules (35.2 to 36.0 ft BGS)							
36.0	END OF HOLE ● 36.0 FT. BGS	622.8						
37.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-81)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-16

DATE COMPLETED: DECEMBER 15, 1993
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	659.89					
	GROUND SURFACE	660.2					
	SM-SAND(FILL), some silt, little gravel, dry to moist, no odor		ROAD BOX				
1.0			CONCRETE SEAL	1SS		67	8.1
	- gray cement, weathered						
2.0	ML-SILT(NATIVE), some clay, little sand and fine round gravel, red brown, dry to moist, slightly musty odor	658.2					
3.0				2SS		24	6.2
			CEMENT/ BENTONITE GROUT				
4.0							
5.0				3SS		30	6
6.0			BENTONITE PELLET SEAL				
		653.5					
7.0	SM-SAND, little silt and clay, brown, moist	653.1		4SS		20	6
	SW-SAND, fine to medium grained, brown, moist to wet, slight to some odor						
8.0			2"ø BLACK IRON PIPE				
9.0				5SS		76	55
			SAND PACK				
10.0							
				6SS		>100	60
11.0		649.3	WELL SCREEN				
	SP-SAND(TILL), some fine subrounded gravel, very stiff, dry to moist, sharp odor						
12.0							
				7SS		>100	22
13.0			8"ø BOREHOLE				
	END OF HOLE @ 13.3 FT. BGS	646.9					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (oval) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-81)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-16

DATE COMPLETED: DECEMBER 16, 1993
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
14.0	NOTES: 1. At completion a 2" monitoring well was installed to 12.0 ft BGS. 2. Soil samples retained for geologic record. Chemical analysis sample collected from BH-EDW1-93, 16.0 ft northwest.		SCREEN DETAILS: Screened Interval: 10.0 to 12.0' BGS Length -2.0' Diameter -2.0" Slot # 10 Material -Stainless Steel Sand pack interval: 7.0 to 13.3' BGS Material -# 0 Morey				
15.0							
16.0							
17.0							
18.0							
19.0							
20.0							
21.0							
22.0							
23.0							
24.0							
25.0							
26.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

Project: LEICA

Project No: 3947

Date: 5/25/00

Client: Leica Microsystems Inc.

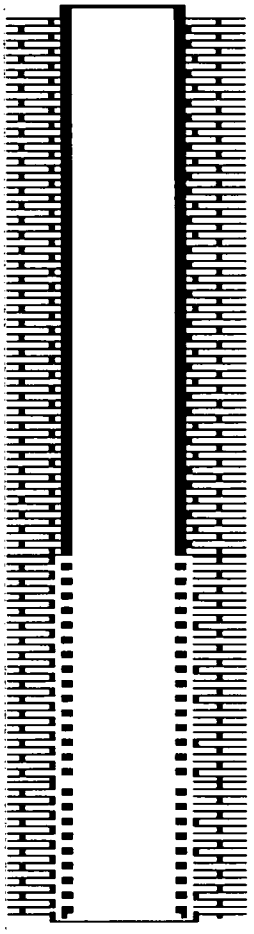
Location: 203 Eggert Road, Cheektowaga, NY

Well #: MW-16R

Geologist: Joe Glista

SUBSURFACE PROFILE

Depth	Description	Remarks	Well Construction Data	Remarks
0	Ground Surface			
	Bitumin			
2	Red/Brown CLAY	Dry, no odor		Native Backfill
3				Solid Riser
4				Top of Bentonite
6	Red/Grey/Brown CLAY some Silt	Slightly damp Odor, 84.4 ppm PID		Top of Sand Pack
7				.020 slot Screen
8	Grey/Brown SILT and CLAY	Slightly damp Odor, 93.8 ppm PID		
9	Grey SILT some Clay, little fine Sand and Limestone Gravel	Damp Odor, 41.7 ppm PID		
10		88.9 ppm PID		
11		Sample Obtained 62 ppm PID		
12				
	End of Borehole			
13				
14				
15				



Maxim Technologies Drill Rig Operator: Scott

Drilling Method: HSA

Drilling Date: 5/25/00

Well Diameter: 2"

Sheet: 1 of 1

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-82)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-16A (Page 1 of 4)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE N VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	659.95					
	GROUND SURFACE	660.3					
	For overburden stratigraphy see MW-16		ROAD BOX				
1.0			CONCRETE SEAL				
2.0							
3.0							
4.0			12"ø BOREHOLE				
5.0							
6.0			6"ø STEEL CASING				
7.0							
8.0			CEMENT/ BENTONITE GROUT				
9.0							
10.0							
	BEDROCK – wet rotary to 12.58 BGS	649.7					
11.0							
12.0							
	END OF OVERBURDEN HOLE @ 12.5 FT BGS	647.8	6"ø BOREHOLE				
13.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-83)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-16A (Page 2 of 4)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 8 1/4" ID HSA/ WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIENDTRERORCVKAL	RUNNUMBER	CORE RECOVERY	RQD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
	Overburden	649.7	12"ø BOREHOLE					
12.0	LIMESTONE(Onondaga Formation, Moorehouse Member): light gray, fine grained, slightly to moderately weathered, trace vertical fractures, massively bedded, trace coral, some chert, stylolites, some carbonaceous partings		CEMENT/ BENTONITE GROUT		WR			
13.0	– heavily weathered zone, rubble (12.5 to 17.0 ft BGS)		6"ø STEEL CASING					
14.0								
15.0								
16.0			6"ø BOREHOLE					
17.0	– rock more intact, good RQD (17.0 to 20.8 ft BGS)				1	59	39.0	50
18.0	– buff colored chert (17.9 to 18.4 ft BGS)							
19.0								
20.0								
21.0	– heavily weathered zone, rubble, little dark chert, mud zone (20.8 to 22.0 ft BGS)							
22.0	– rubble zone, heavily weathered, trace to little dark chert (22.0 to 24.0 ft BGS)							
23.0					2	85	0.0	0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-83)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-16A (Page 3 of 4)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 8 1/4" ID HSA/ WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIENDTRERORCVKAL	RUNNUMBER	CORE RECOVERY	RQD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
	– mud filled vertical fracture, chemical odor (23.5 to 23.7 ft BGS)				2	85	0.0	0
24.0	– rubble zone, heavily weathered, trace coral, little dark chert (24.0 to 25.3 ft BGS)							
25.0	– dark chert (25.3 to 25.9 ft BGS)							
26.0	– light gray chert (25.9 to 26.3 ft BGS)							
	– trace clacite and coral (@ 26.7 ft BGS)							
27.0	– brachiopod (@ 27.4 ft BGS)							
	– dark chert (27.4 to 28.6 ft BGS)							
28.0			6" ø BOREHOLE		3	89	71.0	0
	– rugose coral, solitary, closed vein, detrital layer (28.6 to 29.2 ft BGS)							
29.0	– dark to buff chert, carbonaceous partings (29.2 to 29.8 ft BGS)							
30.0	– coral (30.4 to 30.5 ft BGS)							
	– buff colored chert (30.8 to 32.0 ft BGS)							
31.0								
32.0	– medium gray chert (32.0 to 33.0 ft BGS)							
	– chert, light to medium gray (32.0 to 33.5 ft BGS)							
33.0	– carbonaceous parting (@ 33.3 ft BGS)							
	– coral, open veins (33.9 to 34.0 ft BGS)				4	106	87.0	0
34.0								
35.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-83)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-16A (Page 4 of 4)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 8 1/4" ID HSA/ WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIT ENDT RERORCVKAL	RUN NUMBER	CORE RECOVERY	RQD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
36.0	– buff colored chert (35.5 to 40.0 ft BGS)							
37.0			6"ø BOREHOLE		4	106	87.0	0
38.0								
39.0								
40.0	END OF HOLE @ 40.0 FT. BGS	620.3						
41.0								
42.0								
43.0								
44.0								
45.0								
46.0								
47.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-84)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-17A (Page 1 of 5)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	659.18					
	GROUND SURFACE	659.5					
	Auger through two asphalt layers		ROAD BOX				
1.0	SM-SAND(FILL), some silt and gravel, dark brown, dry to moist	658.5	CONCRETE SEAL				
	ML-SILT(NATIVE), some clay, little sand and fine gravel, very stiff, red brown, dry	657.9					
2.0				1SS		14	0
3.0							
4.0				2SS		31	0
			4"ø STEEL CASING				
5.0	SP-SAND, trace fine rounded gravel, fine to medium grained, gray and brown, moist to wet	654.7					
6.0				3SS		36	0
	- wet						
7.0			12"ø BOREHOLE				
8.0			CEMENT/ BENTONITE GROUT	4SS		49	0
9.0							
10.0				5SS		85	0
11.0							
12.0				6SS		34	0
13.0							
				7SS		48	0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-84)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-17A (Page 2 of 5)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 8 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
14.0	CL-CLAY, some silt, very stiff, gray, moist	646.1	12" ø BOREHOLE	7SS		48	0
	SM-SAND(TILL), some silt, little fine gravel, very dense, brown and gray, dry to moist	645.9	CEMENT/ BENTONITE GROUT				
15.0	BEDROCK - wet rotary to 15.6 ft BGS	645.0	4" ø STEEL CASING				
			8" ø BOREHOLE				
16.0	END OF OVERBURDEN HOLE @ 15.6 FT BGS	643.9					
	NOTES: 1. Soil samples retained for geologic record. 2. Bulk samples collected for grain size analysis form 9.0 to 13.0 ft BGS. 3. At completion a 4" thick steel casing was installed to 15.2 ft BGS for bedrock drilling.		3" ø NX COREHOLE				
17.0							
18.0							
19.0							
20.0							
21.0							
22.0							
23.0							
24.0							
25.0							
26.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-85)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-17A (Page 3 of 5)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIT TYPE	RUN NUMBER	CORE RECOVERY	ROD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
	Overburden	643.9	12" ø BOREHOLE 4" ø STEEL CASING 6" ø BOREHOLE CEMENT/ BENTONITE GROUT					
15.0	LIMESTONE(Onondaga Formation, Moorehouse Member): light gray, fine grained, slightly to moderately weathered, trace vertical fractures, massively bedded, trace coral, some chert, stylolites, some carbonaceous partings – coral fossil, rugose (16.1 ft BGS) – brachiopod (@ 16.6 ft BGS) – moderately weathered zone, vertical fracture (16.6 to 17.4 ft BGS) – carbonaceous parting (@ 17.9, 18.5 and 19.3 ft BGS)				WR			
16.0								
17.0								
18.0								
19.0			3" ø NX COREHOLE		1	100	67.0	80
20.0								
21.0	– coral (20.7 to 20.9 ft BGS) – frequent small coral (21.0 to 21.7 ft BGS)							
22.0	– carbonaceous parting (21.8, 22.2, 22.4, @ 22.8 ft BGS) – dark chert (22.2 to 22.4 and 23.8 to 24.0 ft BGS)							
23.0								
24.0	– carbonaceous parting (24.3, 24.8, 25.8, 26.2 and 26.7 ft BGS)							
25.0								
26.0	– dark chert (25.8 to 26.0, 26.2 to 26.3, 26.7 to 27.2 and 27.8 to 28.0 ft BGS)				2	100	86.0	90

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-85)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-17A (Page 4 of 5)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH	DESCRIPTION OF STRATA	ELEVATION	MONITOR INSTALLATION	BIT/CORE	RUN NUMBER	CORE RECOVERY	RQD	WATER RETURN
ft BGS		ft. AMSL				%	%	%
27.0								
28.0					2	100	86.0	90
29.0	– carbonaceous parting (@ 28.7 ft BGS) – dark chert (28.8 to 28.9 ft BGS) – small vug (@ 29.0 ft BGS) – dark chert (29.1 to 29.4 ft BGS) – coral (29.7 to 29.9 ft BGS)							
30.0								
31.0	– dark chert (30.6 to 30.9 ft BGS) – carbonaceous parting (@ 30.6, 32.2, 32.5, 32.7, 32.9 and 33.0 ft BGS) – carbonaceous partings (@ 33.6, 34.1, 34.5, 34.8, 35.3, 35.8, 36.0, 37.2 and 40.0 ft BGS)		3"ø NX COREHOLE					
32.0								
33.0								
34.0	– darker bands (33.9 to 34.0, 34.1 to to 34.5, 34.7 to 35.1, and 35.3 to 35.6)							
35.0					3	99	87.0	90
36.0								
37.0	– abundant light gray to buff colored chert (36.7 to 40.0 ft BGS)							
38.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

(L-85)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-17A (Page 5 of 5)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 8 1/4" ID HSA / WET ROTARY
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	DESCRIPTION OF STRATA	ELEVATION ft. AMSL	MONITOR INSTALLATION	BEDROCK INTERVAL	RUN NUMBER	CORE RECOVERY %	RQD %	WATER RETURN %
39.0			3"ø NX COREHOLE					
40.0	END OF HOLE @ 40 FT. BGS	619.5						
41.0								
42.0								
43.0								
44.0								
45.0								
46.0								
47.0								
48.0								
49.0								
50.0								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

▽ WATER FOUND ▼ STATIC WATER LEVEL NM – NOT MEASURED

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-86)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-18 (Page 1 of 2)
DATE COMPLETED: MARCH 30, 1994
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: J. WILLIAMS

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	662.51	ROAD BOX				
	GROUND SURFACE	663.1	CONCRETE SEAL				
1.0	ML-SILT(FILL), some angular gravel, some medium to coarse sand, trace clay, stiff, dark brown and gray			1SS		24	0
2.0							
3.0			2" ø BLACK IRON PIPE	2SS		14	0
4.0	CL-CLAY(NATIVE), some silt, trace rootlets, trace large gravel, soft to firm, gray and brown, moist	659.1					
5.0				3SS		10	0
6.0			CEMENT/ BENTONITE GROUT				
7.0			8" ø BOREHOLE	4SS		42	0
8.0	ML-SILT, some clay, some fine sand, brown and gray, moist	655.0					
9.0				5SS		26	0
10.0	CL-CLAY, little silt, very stiff, red brown, moist	653.1	BENTONITE PELLET SEAL				
11.0	SM-SAND, little silt and subrounded gravel, fine to medium grained, brown and gray, wet	652.0	SAND PACK	6SS		13	0
12.0			WELL SCREEN				
13.0				(7SS)		4	0
			BENTONITE PELLET SEAL				

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (oval) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

(L-86)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-18

DATE COMPLETED: MARCH 30, 1994
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: J. WILLIAMS

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
14.0			8" ø BOREHOLE; BENTONITE PELLET SEAL	8SS		>100	0
15.0	END OF HOLE @ 14.8 FT. BGS NOTES: 1. At completion a 2" monitoring well was installed to 13.4 ft BGS. 2. Soil samples collected for chemical analysis from 13.5 to 14.3 ft BGS for TCL VOCs.	648.3	SCREEN DETAILS: Screened Interval: 11.4 to 13.4' BGS Length -2.0' Diameter -2.0" Slot # 10 Material -Stainless Steel Sand pack interval: 10.7 to 13.4' BGS Material -# 0 Morey				
16.0							
17.0							
18.0							
19.0							
20.0							
21.0							
22.0							
23.0							
24.0							
25.0							
26.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-87)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-19

DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	660.84					
	GROUND SURFACE	661.3					
	Auger though asphalt		ROAD BOX				
	GP-GRAVEL(FILL), some coarse sand, black, wet	660.8					
1.0		660.2	CONCRETE SEAL				
	SM-SAND(FILL), some silt, little fine to medium subrounded gravel, red brown to buff, dry to moist			1SS		15	0
2.0	- red brown and gray						
3.0			2" ø BLACK IRON PIPE	2SS		5	0
4.0							
5.0	OH-SILT(NATIVE), some loam, rootlets, dark gray, moist	656.4	CEMENT/ BENTONITE GROUT	3SS		10	0.2
6.0							
	ML-SILT, some clay, little sand and fine gravel, very stiff, laminated, red brown, dry	655.1					
7.0			8" ø BOREHOLE	4SS		32	0
8.0							
9.0			BENTONITE PELLET SEAL				
	- some sand, little clay, very stiff, gray and brown, dry			5SS		31	0
10.0							
11.0							
		649.7		6SS		23	0
	SM-SAND, little silt, little fine rounded gravel, gray, moist to wet		SAND PACK				
12.0							
13.0			WELL SCREEN				
				(7SS)		>60	0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

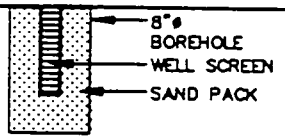
CHEMICAL ANALYSIS (7SS) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-87)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-19 (Page 2 of 2)
DATE COMPLETED: APRIL 7, 1994
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
14.0	Spoon refusal @ 13.7, auger refusal @ 14.3 ft BGS	647.0		7SS		>60	0
	END OF HOLE @ 14.3 FT. BGS						
	NOTES: 1. At completion a 2" monitoring well was installed to 13.9 ft BGS. 2. Soil samples collected for chemical analysis from 12.5 to 13.7 ft BGS for TCL VOCs and TPH.		SCREEN DETAILS: Screened Interval: 11.9 to 13.9' BGS Length -2.0' Diameter -2.0" Slot # 10 Material -Stainless Steel Sand pack interval: 9.5 to 14.3' BGS Material -# 0 Morey				
15.0							
16.0							
17.0							
18.0							
19.0							
20.0							
21.0							
22.0							
23.0							
24.0							
25.0							
26.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (◯) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-88)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-20
DATE COMPLETED: APRIL 5, 1994
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: J. WILLIAMS

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	659.12 659.4					
1.0	ML-SILT(FILL), little clay and roots, brown, moist		ROAD BOX CONCRETE SEAL	1SS		6	0.1
2.0							
3.0				2SS		10	0.4
4.0	CL-CLAY(NATIVE), some silt, trace subangular to subrounded gravel, very stiff, red brown, dry to moist	655.7	CEMENT/ BENTONITE GROUT				
5.0			2"ø BLACK IRON PIPE	3SS		25	0.2
6.0			8"ø BOREHOLE				
7.0	SCREEN DETAILS: Screened Interval: 10.2 to 12.2' BGS Length -2.0' Diameter -2.0" Slot # 10 Material -Stainless Steel Sand pack interval: 8.5 to 12.2' BGS Material -# 0 Morey		BENTONITE PELLET SEAL	4SS		29	1
8.0							
9.0				5SS		14	0.4
10.0							
	SP-SAND, some rounded gravel, gray, wet	649.0	SAND PACK				
11.0			WELL SCREEN	(6SS)		7	0.5
12.0							
	END OF HOLE @ 12.6 FT. BGS	.8	BENTONITE PELLET SEAL	7SS		>100	0.5
13.0	NOTES: 1. At completion a 2" monitoring well was installed to 12.2 ft BGS. 2. Soil samples collected for chemical analysis from 11.0 to 12.0 ft BGS for TCL VOCs.						

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (oval) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-89)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-21

DATE COMPLETED: APRIL 4, 1994
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	657.72					
	GROUND SURFACE	658.0					
	Auger through asphalt pavement		ROAD BOX				
	GP—GRAVEL(FILL), some fine to medium sand, fine angular gravel, gray, moist	657.5	CONCRETE SEAL				
1.0				1SS		18	0
	ML—SILT(NATIVE), little clay, trace fine sand, gray and brown, moist	656.5					
2.0							
3.0	— some clay, trace sand and fine round gravel, very stiff, red brown, dry to moist		2"ø BLACK IRON PIPE	3SS		11	0
4.0			CEMENT/ BENTONITE GROUT				
5.0				3SS		27	0
6.0			8"ø BOREHOLE				
7.0				4SS		35	0
8.0			BENTONITE PELLET SEAL				
9.0	— little sand and clay, trace fine gravel, medium stiff, soft, gray and brown, dry to moist			5SS		24	0.1
	CH—CLAY, little silt, little sand, soft, gray, brown, moist	648.3					
10.0							
11.0	SM—SAND, little silt, and fine subrounded gravel, gray, moist to wet	647.1	SAND PACK	6SS		9	0.1
12.0			WELL SCREEN				
				7SS		>100	0.1
13.0	END OF HOLE @ 12.8 FT. BGS	645.2	BENTONITE PELLET SEAL				

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (◯) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-89)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-21 (Page 2 of 2)
DATE COMPLETED: APRIL 4, 1994
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
14.0	NOTES: 1. At completion a 2" monitoring well was installed to 12.7 ft BGS. 2. Soil samples collected for chemical analysis from 11.0 to 12.0 ft BGS for TCL VOCS.		SCREEN DETAILS: Screened Interval: 10.7 to 12.7' BGS Length -2.0' Diameter -2.0" Slot # 10 Material -Stainless Steel Sand pack interval: 9.0 to 12.7' BGS Material -# 0 Morey				
15.0							
16.0							
17.0							
18.0							
19.0							
20.0							
21.0							
22.0							
23.0							
24.0							
25.0							
26.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS ⬭ WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

(L-90)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-22
DATE COMPLETED: MARCH 29, 1994
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE N VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	652.51					
	GROUND SURFACE	652.9					
1.0	ML-SILT(FILL), some sand, little clay, loose brown, moist		ROAD BOX; CONCRETE SEAL	1SS		3	0.2
2.0	ML-SILT(NATIVE), some clay, trace sand, very dense, red brown, dry to moist	651.1					
3.0			2" ø BLACK IRON PIPE	2SS		14	-
4.0			BENTONITE PELLET SEAL				
5.0				3SS		18	-
6.0	SM-SAND, little silt and clay, trace fine round gravel, gray, moist to wet	647.3	8" ø BOREHOLE				
7.0				4SS		9	-
8.0			SAND PACK				
9.0	- soft, wet, no sheen, no odor			5SS		40	-
10.0	SP-SAND(TILL), some fine round gravel, very stiff, gray, dry to moist, no odor	643.6	WELL SCREEN	6SS		>100	-
11.0	END OF HOLE ● 10.7 FT. BGS	642.2	BENTONITE PELLET SEAL				
12.0							
13.0							

NOTES:
1. At completion a 2" monitoring well was installed to 10.5 ft BGS.
2. Soil samples collected for chemical analysis from 8.5 to 9.5 ft BGS for TCL VOCS.
3. Bulk soil samples collected from 2.0 to 4.0 ft BGS and 7.0 to 9.0 ft BGS, for grain size analysis.
4. PID not operative due to wet snow/rain.

SCREEN DETAILS:
Screened Interval:
8.5 to 10.5' BGS
Length -2.0'
Diameter -2.0"
Slot # 10
Material -Stainless Steel
Sand pack interval:
5.6 to 10.6' BGS
Material -# 0 Morey

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (○) WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(L-91)

PROJECT NAME: LEICA INC. RI/FS
PROJECT NO.: 3967
CLIENT: LEICA INC.
LOCATION: CHEEKTOWAGA, NEW YORK

HOLE DESIGNATION: MW-23 (Page 2 of 2)
DATE COMPLETED: MARCH 30, 1994
DRILLING METHOD: 4 1/4" ID HSA
CRA SUPERVISOR: K. LYNCH

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
14.0			8" ø BOREHOLE	7SS		63	NA
15.0			BENTONITE PELLET SEAL	8SS		58	NA
16.0	END OF HOLE @ 16.0 FT. BGS NOTES: 1. At completion a 2" monitoring well was installed to 13.5 ft BGS. 2. Soil samples collected for chemical analysis from 12.5 to 13.5 ft BGS for VOCS.	640.5	SCREEN DETAILS: Screened Interval: 11.5 to 13.5' BGS Length -2.0' Diameter -2.0" Slot # 10 Material -Stainless Steel Sand pack interval: 9.3 to 13.5' BGS Material -# 0 Morey				
17.0							
18.0							
19.0							
20.0							
21.0							
22.0							
23.0							
24.0							
25.0							
26.0							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

CHEMICAL ANALYSIS (oval) WATER FOUND ▽ STATIC WATER LEVEL ▼

ATTACHMENT 4

Monitoring Records

LEICA, Inc.

GROUNDWATER SAMPLING RECORD: Sampling During System Operation

Date _____

WELL NO.	SAMPLE I.D.	BOTTOM DEPTH TOC (FT.)	GW ELEV. TOC (FT.)	AMOUNT OF H_2O (FT.)	WATER PURGED (GAL.)	TIME SAMPLED (DAY/HRS.)	COMMENTS/ OBSERVATIONS
MW-1	N/A				N/A	N/A	
MW-3	N/A				N/A	N/A	
MW-4	N/A				N/A	N/A	
MW-5	N/A				N/A	N/A	
MW-6							
MW-7							
MW-8	N/A				N/A	N/A	
MW-9	N/A				N/A	N/A	
MW-10*							
MW-11							
MW-12	N/A				N/A	N/A	
MW-13	N/A				N/A	N/A	
MW-14							
MW-15	N/A				N/A	N/A	
MW-16							
MW-18	N/A				N/A	N/A	
MW-19	N/A				N/A	N/A	

LEICA, Inc.
GROUNDWATER SAMPLING RECORD: Sampling During System Operation
Date _____

WELL NO.	SAMPLE I.D.	BOTTOM DEPTH TOC (FT.)	GW ELEV. TOC (FT.)	AMOUNT OF H_2O (FT.)	WATER PURGED (GAL.)	TIME SAMPLED (DAY/HRS.)	COMMENTS/ OBSERVATIONS
MW-20	N/A				N/A	N/A	
MW-21	N/A				N/A	N/A	
MW-22*							
MW-23	N/A				N/A	N/A	
MW-1A	N/A				N/A	N/A	
MW-2A	N/A				N/A	N/A	
MW-5A	N/A				N/A	N/A	
MW-6A*							
MW-11A							
MW-13A	N/A				N/A	N/A	
MW-14A*							
MW-15A*							
MW-16A							
MW-17A	N/A				N/A	N/A	

Notes: Samples denoted with an asterisk (*) are sampled every other quarterly sampling event (i.e., semiannually).
N/A indicates that this is not applicable for the well. No samples are collected from these wells, information is gathered regarding groundwater elevation only.

LEICA, Inc.

GROUNDWATER SAMPLING RECORD: Annual Sampling Upon Completion of Remediation

Date _____

WELL NO.	SAMPLE I.D.	BOTTOM DEPTH TOC (FT.)	GW ELEV. TOC (FT.)	AMOUNT OF H_2O (FT.)	WATER PURGED (GAL.)	TIME SAMPLED (DAY/HRS.)	COMMENTS/ OBSERVATIONS
MW-1	N/A				N/A	N/A	
MW-3	N/A				N/A	N/A	
MW-4	N/A				N/A	N/A	
MW-5	N/A				N/A	N/A	
MW-6							
MW-7							
MW-8	N/A				N/A	N/A	
MW-9	N/A				N/A	N/A	
MW-10							
MW-11							
MW-12	N/A				N/A	N/A	
MW-13	N/A				N/A	N/A	
MW-14							
MW-15							
MW-16							
MW-18	N/A				N/A	N/A	
MW-19	N/A				N/A	N/A	

LEICA, Inc.
GROUNDWATER SAMPLING RECORD: Annual Sampling Upon Completion of Remediation
Date _____

WELL NO.	SAMPLE I.D.	BOTTOM DEPTH TOC (FT.)	GW ELEV. TOC (FT.)	AMOUNT OF H_2O (FT.)	WATER PURGED (GAL.)	TIME SAMPLED (DAY/HRS.)	COMMENTS/ OBSERVATIONS
MW-20	N/A				N/A	N/A	
MW-21	N/A				N/A	N/A	
MW-22							
MW-23	N/A				N/A	N/A	
MW-1A	N/A				N/A	N/A	
MW-2A	N/A				N/A	N/A	
MW-5A	N/A				N/A	N/A	
MW-6A							
MW-11A							
MW-13A	N/A				N/A	N/A	
MW-14A							
MW-15A							
MW-16A							
MW-17A	N/A				N/A	N/A	

Notes: N/A indicates that this is not applicable for the well. No samples are collected from these wells, information is gathered regarding groundwater elevation only.

LEICA, Inc.
AIR SCREENING RECORD: Quarterly Monitoring
Date _____
Page 1 of 1

SAMPLE LOCATION	PID Response	Sample Collected (Y/N)	Sample Number	COMMENTS/ OBSERVATIONS
Horizontal Unit Before Carbon				
Horizontal Unit After Carbon				
Vertical Unit Before Carbon				
Horizontal Unit After Carbon				
Groundwater Unit Before Carbon				
Groundwater Unit After Carbon				

ATTACHMENT 4

Monitoring Records

LEICA, Inc.
GROUNDWATER SAMPLING RECORD: Sampling During System Operation
Date _____

WELL NO.	SAMPLE I.D.	BOTTOM DEPTH TOC (FT.)	GW ELEV. TOC (FT.)	AMOUNT OF H_2O (FT.)	WATER PURGED (GAL.)	TIME SAMPLED (DAY/HRS.)	COMMENTS/ OBSERVATIONS
MW-1	N/A				N/A	N/A	
MW-3	N/A				N/A	N/A	
MW-4	N/A				N/A	N/A	
MW-5	N/A				N/A	N/A	
MW-6							
MW-7							
MW-8	N/A				N/A	N/A	
MW-9	N/A				N/A	N/A	
MW-10							
MW-11							
MW-12	N/A				N/A	N/A	
MW-13	N/A				N/A	N/A	
MW-14							
MW-15	N/A				N/A	N/A	
MW-16							
MW-18	N/A				N/A	N/A	
MW-19	N/A				N/A	N/A	

LEICA, Inc.
GROUNDWATER SAMPLING RECORD: Sampling During System Operation
Date _____

WELL NO.	SAMPLE I.D.	BOTTOM DEPTH TOC (FT.)	GW ELEV. TOC (FT.)	AMOUNT OF H_2O (FT.)	WATER PURGED (GAL.)	TIME SAMPLED (DAY/HRS.)	COMMENTS/ OBSERVATIONS
MW-20	N/A				N/A	N/A	
MW-21	N/A				N/A	N/A	
MW-22							
MW-23	N/A				N/A	N/A	
MW-1A	N/A				N/A	N/A	
MW-2A	N/A				N/A	N/A	
MW-5A	N/A				N/A	N/A	
MW-6A							
MW-11A							
MW-13A	N/A				N/A	N/A	
MW-14A							
MW-15A							
MW-16A							
MW-17A	N/A				N/A	N/A	

Notes: N/A indicates that this is not applicable for the well. No samples are collected from these wells, information is gathered regarding groundwater elevation only.

LEICA, Inc.
GROUNDWATER SAMPLING RECORD: Annual Sampling Upon Completion of Remediation
Date _____

WELL NO.	SAMPLE I.D.	BOTTOM DEPTH TOC (FT.)	GW ELEV. TOC (FT.)	AMOUNT OF H_2O (FT.)	WATER PURGED (GAL.)	TIME SAMPLED (DAY/HRS.)	COMMENTS/ OBSERVATIONS
MW-1	N/A				N/A	N/A	
MW-3	N/A				N/A	N/A	
MW-4	N/A				N/A	N/A	
MW-5	N/A				N/A	N/A	
MW-6							
MW-7							
MW-8	N/A				N/A	N/A	
MW-9	N/A				N/A	N/A	
MW-10							
MW-11							
MW-12	N/A				N/A	N/A	
MW-13	N/A				N/A	N/A	
MW-14							
MW-15							
MW-16							
MW-18	N/A				N/A	N/A	
MW-19	N/A				N/A	N/A	

LEICA, Inc.
GROUNDWATER SAMPLING RECORD: Annual Sampling Upon Completion of Remediation
Date _____

WELL NO.	SAMPLE I.D.	BOTTOM DEPTH TOC (FT.)	GW ELEV. TOC (FT.)	AMOUNT OF H_2O (FT.)	WATER PURGED (GAL.)	TIME SAMPLED (DAY/HRS.)	COMMENTS/ OBSERVATIONS
MW-20	N/A				N/A	N/A	
MW-21	N/A				N/A	N/A	
MW-22							
MW-23	N/A				N/A	N/A	
MW-1A	N/A				N/A	N/A	
MW-2A	N/A				N/A	N/A	
MW-5A	N/A				N/A	N/A	
MW-6A							
MW-11A							
MW-13A	N/A				N/A	N/A	
MW-14A							
MW-15A							
MW-16A							
MW-17A	N/A				N/A	N/A	

Notes: N/A indicates that this is not applicable for the well. No samples are collected from these wells, information is gathered regarding groundwater elevation only.

LEICA, Inc.
AIR SCREENING RECORD: Quarterly Monitoring
Date _____
Page 1 of 1

SAMPLE LOCATION	PID Response	Sample Collected (Y/N)	Sample Number	COMMENTS/ OBSERVATIONS
Horizontal Unit Before Carbon				
Horizontal Unit After Carbon				
Vertical Unit Before Carbon				
Vertical Unit After Carbon				
Groundwater Treatment Unit Before Carbon				
Groundwater Treatment Unit After Carbon				

LEICA, Inc.
GROUNDWATER SAMPLING RECORD: Annual Sampling Upon Completion of Remediation
Date _____

WELL NO.	SAMPLE I.D.	BOTTOM DEPTH TOC (FT.)	GW ELEV. TOC (FT.)	AMOUNT OF H_2O (FT.)	WATER PURGED (GAL.)	TIME SAMPLED (DAY/HRS.)	COMMENTS/ OBSERVATIONS
MW-20	N/A				N/A	N/A	
MW-21	N/A				N/A	N/A	
MW-22							
MW-23	N/A				N/A	N/A	
MW-1A	N/A				N/A	N/A	
MW-2A	N/A				N/A	N/A	
MW-5A	N/A				N/A	N/A	
MW-6A							
MW-11A							
MW-13A	N/A				N/A	N/A	
MW-14A							
MW-15A							
MW-16A							
MW-17A	N/A				N/A	N/A	

Notes: N/A indicates that this is not applicable for the well. No groundwater samples are collected from these wells, information is gathered regarding groundwater elevation only. *Collect groundwater sample from MW-4 if MW-11 does not contain any collectable liquid or is inaccessible.

ATTACHMENT 5

Sample Containerization and Holding Times

Sample Containerization and Holding Times
Leica, Inc.

Groundwater Samples

Analysis	Bottle Type	Preservation	Holding Time
VOCs by EPA Method 8260	**VOA vial**	**Hydrochloric Acid to pH<2, cool to 4° C**	**14 days**

Air Samples

Analysis	Bottle Type	Preservation	Holding Time
VOCs by EPA Method TO-14 modified	**Tedlar bag**	**None, do not cool**	**3 days**

ATTACHMENT 6

Sampling Equipment

Sampling Equipment
Leica, Inc.

Groundwater Sampling Equipment

- Personal safety equipment (eye protection, safety shoes, etc.);
- A copy of the sampling and analysis program;
- Sample bottles sufficient for planned samples with spares;
- Polyethylene ground cloth;
- Disposable latex gloves;
- Paper towels;
- New Teflon bailer;
- New Nylon rope (individual lengths for each well).

Air Sampling Equipment

- Personal safety equipment (eye protection, safety shoes, etc.);
- A copy of the sampling and analysis program;
- Tedlar bags with spares;
- Disposable latex gloves;
- Plastic Tubing that fits pump and stopcock on Tedlar bags (individual lengths for each unit if needed).

Shipping and Packaging Equipment

- Shipping labels;
- Packing materials to prevent glass sample containers from bumping together and breaking or to prevent puncture of Tedlar bags;
- Ice (for groundwater samples only);
- Ice chests with sufficient volume to hold sample bottles, packing material and ice (for groundwater samples); and
- Coolers or boxes with sufficient volume to hold Tedlar bags and packing material (for air samples).

Documentation Equipment

- Groundwater Sampling Record;
- Air Screening Record;
- Chain of custody forms;
- Waterproof pens; and
- Field Notebook.

ATTACHMENT 7

SOP: Decontamination of Field Equipment

ENVIRONMENTAL SERVICES
STANDARD OPERATING PROCEDURE

DECONTAMINATION OF FIELD EQUIPMENT

Project Number: NES/Generic	Copy No.	Assigned To:

APPROVALS

TITLE / DEPT. - SIGNATURE - DATE

REV NO.	PREPARED BY	DOCUMENT REVIEW	PROJECT MANAGER	DEPARTMENT MANAGER	VICE PRESIDENT/ GENERAL MANAGER
0					
1					
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12					

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish the guidelines for decontamination of all field equipment potentially exposed to contamination during drilling, soil sampling, and water sampling activities. The objective of decontamination is to ensure that all drilling and soil-sampling and water-sampling equipment is decontaminated (i.e., free of potential contaminants): 1) prior to being brought onsite to avoid the introduction of potential contaminants to the site; 2) between drilling and sampling events and activities onsite to eliminate the potential for cross contamination between boreholes and wells; and 3) prior to the removal of equipment from the site to prevent the transportation of potentially contaminated equipment offsite.

The following SOP is stringent in that it is largely adapted from the New Jersey Department of Environmental Protection and Energy's (NJDEPE) *Field Sampling Procedures Manual, May 1992.* However, in determining decontamination procedures on a site-specific basis, state and Federal regulatory and agency requirements and guidance must be considered. Decontamination procedures must be in compliance with state and/or Federal protocols in order that regulatory agency scrutiny of the procedures and data collected do not result in non-acceptance (invalidation) of the work undertaken and data collected.

2.0 DECONTAMINATION OF HEAVY EQUIPMENT

Items such as drill rigs, well casing, auger flights, augers, rods, samplers, tools, backhoes and any piece of equipment that can potentially come in contact (directly or indirectly) with the sampling matrix should be decontaminated prior to and after each usage during a site investigation (i.e. use only decontaminated equipment) Drilling rigs and associated items mentioned previously should be properly decontaminated by the contractor before arrival on site. Heavy equipment can be steam cleaned or manually scrubbed.

2.1 Steam generators and power washers use potable water to provide a high pressure medium to remove visible debris. They are also efficient in terms of ease of handling and well generate low volumes of wash solutions. Potential disadvantages include the need for a fixed or portable power source and water supply and they may not be practical for use on small pieces of equipment or for one day sampling events.

2.2 Manual scrubbing involves using a non-phosphate, laboratory-grade glassware detergent solution, followed by a thorough water rinse. This method can be as effective as a steam generator but is labor intensive and generates large volumes of wash and rinse solutions.

2.3 Drilling equipment utilized in the presence of thick sticky oils (e.g., PCBs) may need special decontamination procedures before actual steam cleaning or scrubbing.

2.4 The wash solutions may have to be contained, sampled and disposed of in a proper manner depending on the type of contaminants encountered and Federal, state and local procedures.

3.0 PROCEDURE FOR NON-AQUEOUS SAMPLING EQUIPMENT

3.1 All equipment should be decontaminated prior to beginning sampling events and after each individual sample is collected.

3.2 A location for a decontamination station should be selected. It should be located away from any potential sources of cross contamination. The decontamination station must in no way contaminate an otherwise

clean area. Decontamination should be performed over a container and the residual liquid material must be properly disposed.

3.3 Wear disposable gloves while cleaning equipment to avoid cross contamination and change gloves as needed.

3.4 Disassemble sampling devices and scrub with a brush in a non-phosphate, laboratory-grade detergent and tap water solution to remove visual or gross contamination.

3.5 Rinse with generous amounts of tap water.

3.6 Rinse with distilled or de-ionized water.

3.7 Place clean equipment on a clean plastic sheet to dry (e.g., polyethylene).

3.8 Reassemble the cleaned equipment as necessary.

3.9 If metal samples are to be collected, an acid rinse (10% nitric acid) followed by a distilled and deionized water rinse is needed. If analysis of metals is required and carbon steel sampling devices are used instead of stainless steel, it may be necessary to reduce the nitric acid rinse from 10% to 1% to reduce the leaching of metals from the sampler to the sample. It is then necessary to use a 1% nitric acid rinse after the tap water rinse (step 3.5).

3.10 If analysis of organics will be conducted, then a rinse of acetone (pesticide grade) followed by a rinse with distilled and deionized water will be necessary.

4.0 PROCEDURE FOR AQUEOUS SAMPLING EQUIPMENT

Wherever possible, disposable bailers or laboratory-decontaminated stainless-steel bailers will be used for sampling. (The use of laboratory-cleaned, packaged and dedicated bailers for collecting groundwater samples is required in the State of New Jersey.) This is advantageous because bailer decontamination takes place in a controlled environment and reduces the risk of cross contamination of the wells to be sampled. However, if the need arises, the following steps will be taken to decontaminate aqueous sampling equipment prior to beginning sampling events and after each individual sample is collected:

4.1 laboratory grade glassware detergent plus tap water wash;
4.2 tap water rinse;
4.3 distilled and de-ionized water rinse;
4.4 10% nitric acid (trace metal or higher grade) rinse * diluted with distilled or de-ionized water;
4.5 distilled or de-ionized water rinse;
4.6 acetone (pesticide grade) rinse**;
4.7 distilled or de-ionized water rinse; and
4.8 air dry.

* Skip this step unless sample is being analyzed for metals
** Skip this step unless sample is being analyzed for organics

5.0 DECONTAMINATION OF SUBMERSIBLE PUMPS

Submersible pumps and wire leads must be cleaned and flushed prior to and between each use according to the following protocol.

5.1 Wash pump casing, hose and cable using an external laboratory-grade glassware detergent plus tap water;
5.2 tap water rinse;
5.3 flush 10-20 gallon of potable water through the pump*;
5.4 distilled or de-ionized water rinse;
5.5 for a two-inch diameter submersible pump, the recessed screw at the bottom of the pump must be removed and the cavity should be rinsed out with distilled or de-ionized water and then filled with distilled or de-ionized water **;
5.6 pump and wires should be placed on clean polyethylene sheeting.

* For submersible pumps smaller than four inches in diameter, the number of gallons to be flushed can be proportionately reduced (i.e., three inches -- 15 gallons, two inches -- 10 gallons).

**NES maintains two Grundfos^{TM}, two-inch diameter submersible pumps. The recessed screw mentioned in step 5.5 may not be pertinent to other brands or sizes of submersible pumps.

6.0 DECONTAMINATION FLUIDS

It may be necessary in some cases to forego chemical decontamination in the field and pursue non-chemical means (i.e., without using solvent rinses such as acetone, methanol or nitric acid). This may be preferable because it eliminates the chance of introducing potentially hazardous chemicals at the site which: 1) may be deleterious to the environment; 2) cause unnecessary exposure of the field personnel to hazardous substances; 3) confuse interpretation of chemical analytical data; and 4) require off site disposal of wash waters which otherwise could be discharged on-site. Any necessary agency approval must be obtained prior to using non-chemical decontamination methods in the field.

ATTACHMENT 8

Chain of Custody

Columbia Analytical Services, Inc.
An Employee-Owned Company
www.caslab.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

One Mustard St., Suite 250 • Rochester, NY 14609-0859 • (716) 288-5380 • 800-695-7222 x11 • FAX (716) 288-8475 PAGE _____ OF _____

SR #

CAS Contact

Project Name	Project Number
Project Manager	Report CC
Company/Address	
Phone #	FAX#
Sampler's Signature	Sampler's Printed Name

ANALYSIS REQUESTED *(Include Method Number and Container Preservative)*

PRESERVATIVE

NUMBER OF CONTAINERS

GC/MS VOA's ☐ 8260 ☐ 624 ☐ CLP
GC/MS SVOA's ☐ 8270 ☐ 625 ☐ CLP
GC VOA's ☐ 8021 ☐ 601/602
PESTICIDES/ PCB's ☐ 8081 ☐ 608 ☐ CLP ☐ 8082
STAR'S LIST 8021 VOA's ☐ TOTAL ☐ TCLP
STAR'S LIST 8270 SVOA's ☐ TOTAL ☐ TCLP
TCLP ☐ VOA's ☐ METALS
WASTE CHARACTERIZATION ☐ SVOA's ☐ H/P ☐ Reactivity ☐ Corrosivity ☐ Ignitability
METALS, TOTAL (List in comments below)
METALS, DISSOLVED (List in comments below)

Preservative Key
0. NONE
1. HCL
2. HNO_3
3. H_2SO_4
4. NaOH
5. Zn. Acetate
6. MeOH
7. $NaHSO_4$
8. Other _____

REMARKS/ ALTERNATE DESCRIPTION

CLIENT SAMPLE ID	FOR OFFICE USE ONLY LAB ID	SAMPLING DATE	SAMPLING TIME	MATRIX

SPECIAL INSTRUCTIONS/COMMENTS
Metals

See QAPP ☐

TURNAROUND REQUIREMENTS

_____ RUSH (SURCHARGES APPLY)

_____ 24 hr _____ 48 hr _____ 5 day

_____ STANDARD

REQUESTED FAX DATE

_____

REQUESTED REPORT DATE

_____

REPORT REQUIREMENTS

_____ I. Results Only

_____ II. Results + QC Summaries (LCS, DUP, MB/MBD as required)

_____ III. Results + QC and Calibration Summaries

_____ IV. Data Validation Report with Raw Data

_____ V. Specialized Forms / Custom Report

Edata _____ Yes _____ No

INVOICE INFORMATION

PO#

BILL TO:

SUBMISSION #:

SAMPLE RECEIPT: CONDITION/COOLER TEMP: _____ CUSTODY SEALS: Y N

RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY
Signature	Signature	Signature	Signature	Signature	Signature
Printed Name	Printed Name	Printed Name	Printed Name	Printed Name	Printed Name
Firm	Firm	Firm	Firm	Firm	Firm
Date/Time	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time

Distribution: White - Return to Originator; Yellow - Lab Copy; Pink - Retained by Client

SCOC-0101-08

ATTACHMENT 9

SOP: Collection of Quality Control Samples

ENVIRONMENTAL SERVICES
STANDARD OPERATING PROCEDURE

COLLECTION OF QUALITY CONTROL SAMPLES

Project Number: NES/Generic	Copy No.	Assigned To:

APPROVALS

TITLE / DEPT. - SIGNATURE - DATE

REV NO.	PREPARED BY	DOCUMENT REVIEW	PROJECT MANAGER	DEPARTMENT MANAGER	VICE PRESIDENT/ GENERAL MANAGER
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1.0 PURPOSE

The purpose of this standard operating procedure is to establish guidelines for the collection of quality control (QC) samples and to explain the measures taken to ensure the integrity of each sample collected. The objective of any QC program is to ensure that the data generated are of known and reliable quality. The acceptance of sampling data by regulatory agencies and in litigation-support investigations can depend heavily on the proper QC program to justify the results presented.

The QC sampling requirements must be determined based upon the data quality objectives for the project. In some instances, regulatory agencies, such as the USEPA, may specify or provide guidance concerning QC sampling on a project. All QC requirements should be clearly defined in the work plan developed for the project, including types of samples to be collected, sample collection methods, and frequency of sampling.

2.0 QUALITY CONTROL SAMPLES

QC Samples are used to prove sampling activities and laboratory performance during an environmental investigation or routine monitoring at a site. Types of QC samples may include field blanks (a.k.a., equipment or rinseate blanks), trip blanks (a.k.a., travel blanks), replicates (a.k.a., duplicates or split samples), matrix spike/matrix, spike duplicates, and performance evaluation samples. A discussion pertaining to each QC sample type is provided below.

2.1 Field Blanks

Description - A field equipment blank (field blank) is collected to check on the sampling equipment handling, preparation, storage and shipment procedures implemented in the field. A field blank is performed by exposing demonstrated analyte-free water (e.g., distilled/deionized water) to the sampling process (i.e., the water must pass through or over the actual sampling equipment) Preferably, the analyte free water should be provided by the laboratory performing the sample analysis. At a selected field location documented in the field book, the water is poured from the full set of bottles through the dedicated field sampling device that has been decontaminated for sample collection (e.g., auger flight, split-spoon sampler or bailer) and into the empty set of laboratory-supplied sample bottles. It is important that the blank be exposed to the entire sampling process, e.g., a field blank for metals should be filtered if the samples were also filtered. Field blanks are generally not required for potable well sampling events or when a sample is collected directly from a source into a sampling container without the aid of any tools. The need for field blanks as a check on the cleanliness of dedicated or disposable sampling equipment (e.g., disposable polyethylene bailers or dedicated bladder pumps) is dependent upon the scope and duration of a project and should be specified in the work plan. Field blanks are usually preserved in the same manner and analyzed for the same suite of parameters as the other samples collected during the sampling event. In some situations it may be advantageous to require equipment blanks for each type of sampling procedure (e.g., split-spoon, bailer, pump).

Field blanks may also be used to detect potential interference or cross contamination from ambient air during sampling events, especially if known sources of contamination are within close proximity or monitoring instruments indicate the presence of contamination above background levels. This field blank is a sample bottle that is filled and sealed with demonstrated analyte free water, and is opened in the field and exposed to the air at a location to check for potential

atmospheric interferences. The blank is then resealed and shipped back to the laboratory for analysis.

Frequency - For short-duration sampling events, the rate of one field blank per day is usually sufficient. For sampling events lasting more than a few days, field blanks are generally performed at the rate of between 5% to 10% of the total number samples collected throughout the event.

2.2 Trip Blanks

Description - Trip blanks consist of a set of sample bottles filled at the laboratory with demonstrated analyte free water. These samples then accompany the bottles that are prepared at the laboratory into the field, and back to the laboratory along with the collected samples for analysis. **These bottles should never be opened in the field.** Trip blanks must return to the laboratory with the same set of bottles they accompanied to the field. Trip blanks are primarily used to check for "artificial" contamination of the samples during transport to the laboratory for analysis.

Frequency - Idealistically, one trip blank per cooler containing VOC samples, or test substance of other analytes of interest, should accompany each day's samples.

2.3 Replicate Samples

Description - Replicate samples are collected to check on the reproducibility of results either within a laboratory or between laboratories. A replicate sample is called a split sample when it is collected with or turned over to a second party (e.g., regulatory agency, litigant's consulting firm) for an independent analysis.

With the exception of VOCs, obtaining replicate samples in a soil or sediment matrix requires homogenization of the sample aliquot prior to filling sample containers. **Samples taken for VOC analysis however must always be taken from discrete locations or intervals without mixing.** Homogenization of the sample for remaining parameters is necessary to generate two equally representative samples. Note that enough sample must be collected at one time in order to fill all necessary containers. Samples should be thoroughly mixed using a decontaminated stainless-steel bowl and spoon. Once mixing is completed, the sample should be divided in half and containers should be filled by scooping samples alternately from each half.

Replicates of aqueous samples for VOC analysis should be filled from the same bailer or other sampling device whenever possible and be the first set of containers filled. Aqueous replicate samples for other parameters are either obtained from the same sampling device or by alternately filling sample containers from the same sampling device for each parameter.

Frequency - Replicates for determining the reproducibility of laboratory results are commonly collected at a rate of 5% (one for every twenty samples collected). Split samples are at the discretion of the second party and may include every sample collected.

2.4 Performance Evaluation Samples

Description - In certain instances when a laboratory's quality assurance performance is in question, splitting samples may not prove as useful as providing blind performance evaluation (PE) samples to a laboratory since analytical performance and accuracy differs from laboratory to laboratory. Performance evaluation samples provide information on a laboratory's performance based upon

analysis of that sample which contains parameters of a known and defined concentration. A PE sample can be used to pre-qualify a laboratory or, if submitted blind with a sample lot, may be used to evaluate the quality of the analytical data. PE samples consist of pre-measured, pre-determined samples of known origin and concentration which are submitted for analysis along with a sample shipment from the field. Deviations from known concentration may indicate improper calibration or other laboratory errors that may have influenced the results reported for those samples collected in the field.

Frequency - Performance evaluation samples are usually required by the governing agency for a project. Therefore, the frequency of submitting these samples to the laboratory is commonly at the discretion of the agency.

2.5 Matrix Spike/Matrix Spike Duplicates

Description -Spikes of compounds (e.g., standard compound, test substance, etc.) may be added to samples in the laboratory to determine if the matrix is interfering with constituent identification or quantification, as well as a check for systematic errors and lack of sensitivity of analytical equipment Samples for spikes are collected in the identical manner as for standard analysis and shipped to the laboratory for spiking. Matrix spike duplicate sample collection and laboratory spiking and analysis is done to check on the reproducibility of matrix spike results. Prior to sampling, check with the laboratory to determine if additional sample volumes are required for matrix spike/matrix spike duplicate (MS/MSD) samples.

Frequency - The rate for MS/MSDs is almost always one per sample delivery group. A sample delivery group can be defined as either:

- all field samples collected during a project;
- each set of twenty field samples collected during a project; or
- each fourteen calendar day period during which field samples for a project are received by the laboratory (said period beginning with the receipt of the first sample in the sample delivery group),which ever comes first.

3.0 PROCEDURE

3.1 Determine the type and number of QA/QC samples to be collected as specified in the work plan and implement the sampling as outlined above.

3.2 Ensure unbiased handling and analysis of performance evaluation, replicate and blank QC samples by concealing their identity by means of coding so that the analytical laboratory cannot determine which samples are included for QC purposes. Attempt to use a code that will not cause confusion if additional samples are collected in the future.

3.3 Label selected matrix spike samples so that the laboratory knows which samples are to be spiked. For projects when only a few samples are collected during a long interval of time, it may be advantageous not to select matrix spike samples until after the samples are received by the laboratory, thus limiting the number of MS/MSDs. In this instance, frequent communication must be maintained between the sampling crew and the laboratory to ensure that an appropriate number of MS/MSDs are analyzed.

3.4 Document the QC samples on the appropriate field forms and in the field notebook. On the chain of custody form, fortification, replicate and blank QC samples will be labeled using the codes discussed above and MS/MSDs will be identified as such.

3.5 Place QC samples in their assigned coolers with the investigatory samples. Refer to NES Document No. 82A8496 for sample handling and shipping procedures.

ATTACHMENT 10

Site Health and Safety Plan

REMEDIATION SYSTEM INSTALLATION
SITE HEALTH AND SAFETY PLAN

Leica, Inc. Site
Eggert and Sugar Roads
Town of Cheektowaga, Erie County, NY
Site ID Number: 915156

Prepared for

New York State Department of Environmental Conservation
Division of Hazardous Waste Remediation, Region 9
270 Michigan Avenue
Buffalo, New York 14203-2999

and

Leica Microsystems, Inc.
P.O. Box 123
Buffalo, New York 1420-0123

January 1999

REMEDIATION SYSTEM INSTALLATION
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January 1999

Project Application	**Prepared By**	**Date**
3947-100	**Jon Menti**	

Approvals

Title	**Signature**	**Date**
NES Health and Safety Officer		
NES Project Manager		
NES Senior Department Manager		

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1 SCOPE OF WORK

The remediation system installation involves the following activities:

- Trenching and installing piping;
- Well installation; and
- Installing air injection units.

The remediation system installation involves the installation of subsurface piping and equipment for the removal of Volatile Organic Compounds (VOCs) from the subsurface.

Support activities will include:

- Data analyses of samples;
- Mapping the area of contamination for remediation;
- Installation of an equipment storage building; and
- Installation of equipment into the building.

1.1 PHYSICAL DESCRIPTION

The Leica Optical Site is located at the southeast corner of the Eggert and Sugar Road intersection in Cheektowaga, New York. There are three separate areas of contamination consisting of the former drum storage area, the northeast source area, and the southeastern area. The areas are also known as Leica areas A, B, and C, respectively.

1.2 PROJECT PHASE OBJECTIVE

The overall objective of this phase of the project is to install and operate the remediation system and thereby remediate areas of VOC contaminated soils. This task will be accomplished without posing any acute or chronic health hazards to site workers or to the general public. Essential secondary objectives include a) keeping all soil and water samples free of cross-contamination and b) keeping any unnecessary environmental harm from taking place.

2 HEALTH AND SAFETY PERSONNEL

Name:	**Responsibility:**
Mark Cambra	Project Manager
Joseph Glista	Site Superintendent
Joseph Glista	Site Health and Safety Officer
Richard Moss	NES Safety Officer

The Site Health and Safety Officer (HSO), and Site Superintendent are responsible for ensuring that the policies and procedures detailed in this plan and the NES Health and Safety Plan (policies 82A8117 - 82A8125) are implemented.

Site workers are responsible for reporting suspected overexposures and other suspected unsafe or unhealthy conditions. This program is largely dependent on individual site worker participation and open communication.

Subcontractors may provide a Site Specific Health and Safety Plan (SHASP) for their employees addressing exposure to hazardous materials or other site hazards. (The subcontractor may also choose to use the NES SHASP). However, the subcontractor shall hold NES harmless from, and indemnify it against all liability in the event of an employee injury. NES, if requested, will review and approve the subcontractor's health and safety plan at any time or during any phase of this project.

2.1 EMERGENCY INFORMATION

The following information shall be posted near all site telephones.

Emergency Services

Name:	Location:	Number:
Fire: Medical:	Eggert and Sugar Road	**911**
Police:	Eggert and Sugar Road	**911**
Poison Control Center:	Children's Hospital (Buffalo)	716-878-7654

Agency Notifications

Organization:	Name:	Number:
NYDEC	Greg Sutton	716-851-7220
NYS Health Department	Cameron O'Conner	716-847-4507
Cheektowaga Emergency Services	Routine number	716-685-1238
Erie County Department of Health	John Kociela, Director	716-858-7677

Other Emergency Notification Numbers

Organization:	Name:	Number:
Leica Microsystems, Inc	Bruce Mallott	716-686-3140
NES Safety Officer	Richard Moss	203-796-5234
NES Project Manager	Mark Cambra	203-796-5305
NES Personnel Office	Bonnie Ianuzzi	203-796-5273

2.2 SITE SAFETY EQUIPMENT, SUPPLY AND INFORMATION

Site safety equipment and medical supplies will be kept inside the NES site office trailer. The following equipment and information will be posted within the office trailer:

- First aid kit;
- Eyewash station;

- 10 lbs. ABC rated portable fire extingusher;
- MSDS for any materials used by NES or it's sub-contractors; and
- Federal and New York State employees rights posting.

2.3 SITE CONTROL AND SECURITY

Site control and security encompasses every aspect of NES operations. This phase of the project involves activities within the fenced-in property of the site. Site control rules are intended to meet several objectives:

- Prevent unauthorized persons from inadvertently approaching work areas which may contain hazards;
- Protect private properties from inadvertent incursion or damage during construction or sampling activities;
- Prevent unauthorized vehicular traffic, which would possibly act to cross - contaminate public or private property, and
- Ensure the security of the Contractor's and Subcontractor's property and equipment.

3 GENERAL RULES AND PROCEDURES

All site workers will sign-in when starting the workday, and sign-out when leaving. A daily log has been established for this purpose. This log is not intended as a record of employment attendance, but only as a means of determining the presence of individuals in the sampling and construction areas for security reasons.

3.1 SITE SPECIFIC TRAINING

NES will provide and maintain on-site documentation for the following OSHA Health and Safety and Site - Specific training:

- Site Workers will document 40 hours of training and work on-site for 3 days under supervision to meet OSHA 29 CFR 1910.120(e)(3)(i) General Site Worker criteria.
- Site Workers will also meet the annual 8-hour refresher training requirements under 29 CFR 1910.120(e)(8).

The Site Supervisor and Site Health and Safety Officer shall each document 40 hour and supervised training in accordance with OSHA 29 CFR 1910.120(e)(3)(i) and an additional 8 hours of Site Supervisor training in accordance with OSHA CFR 1910.120(e)(4).

Upon initial mobilization at the site and prior to work activity, employees will be provided thorough documented instruction, regarding all aspects of the Health and Safety Plan, with emphasis upon:

- Site contaminants;

- Location of site control zones and restrictions;
- Location of safety equipment;
- Personal protective equipment required;
- Emergency procedures, and
- General safe work practices, site restrictions, policies and procedures.

Safety meetings will be conducted at least weekly with all site employees and representatives of Sub-contractors. Typical topics would include:

- Review of hazards associated with new work activity or specific work conditions;
- Compliance issues, such as temporarily restricted areas; and
- General safety training where deficiencies or difficulties with safe equipment operation are evident.

3.2 VISITORS

All visitors and agency representatives must report directly to the NES Site Supervisor prior to entering the work area. Visitors are not permitted within the work area unless accompanied by authorized site personnel. All visitors and agency representatives will sign-in and out on a visitor log administered by the Site Health and Safety Officer. The Site Health and Safety Officer will assign to visitors and agency representatives all necessary personal protective equipment and review with them the site policies and procedures. Visitors and agency representatives will comply with the NES HASP while on the premises.

3.3 VEHICLE OPERATIONS

Privately owned vehicles (POV) are not permitted beyond the designated parking areas which are reserved for site personnel and visitors. Only authorized NES vehicles are permitted beyond the parking area. Subcontractor vehicles will be permitted beyond the employee parking area only with the permission of the Site Superintendent or Site Health and Safety Officer.

4 SITE WORKER PROTECTION

4.1 SUB-SURFACE UTILITIES

Before any work activities take place, including boring, drilling and digging, all possible underground utilities must be marked and identified by the appropriate agency to ensure the safety of all site workers. This task is the responsibility of the Drilling Contractor and NES.

4.2 PETROLEUM HYDROCARBON EXPOSURE

Petroleum hydrocarbons, present as soil contamination and/or free product can pose significant flammability, toxicity, and mechanical hazards. Lighter fractions, although largely depleted through volatization and microbial action, may be present in isolated pockets. Potential anaerobic biodegradation at lower depths could result in methane pockets that can be released during excavation or sampling activities.

Site workers shall limit direct contact to petroleum hydrocarbon contamination to levels as low as reasonably achievable. The use of Tyvek coveralls with Level D personal protective equipment will be required.

The action level for Level C operations will be a 200 ppm airborne concentration, detected by the PID or by detector tube. Level C operations require workers to use an air purifying respirator. The establishment of an exclusion zone will need to be implemented if the action levels are met, to ensure that all workers within the work area are properly equipped with respiratory protection.

The ceiling level or maximum concentration that can be present with workers in the exclusion zone will be 300 ppm. High concentrations of mist or vapor may cause respiratory tract irritation, headache, dizziness, nausea, and vomiting. Prolonged skin contact may cause irritation or dermatitis. Ingestion may cause nausea, vomiting, and esophageal irritation, edema, with possible central nervous system depression. The emergence of any of these symptoms requires evacuation of workers from the exclusion zone, Safety Officer notification and medical attention, as appropriate, for the affected employee(s).

Although flammable airborne concentrations are not anticipated in the exclusion zones, the action level will be 10% of the lower explosive limit (LEL). Since a mixture of petroleum hydrocarbons is present, and the vapor constituents cannot be readily identified, an LEL of 1% volume to volume in air will be assumed. Therefore, a 1,000-ppm VOC concentration (10% of the assumed LEL) will be considered a potentially flammable atmosphere. The calibrant gas will be methane. The action level will require that all exclusion zone work be suspended and the exclusion zone evacuated at 10% of the LEL.

4.3 CHLORINATED SOLVENTS

Chlorinated solvents are organic liquids with a chloroform-like odor. They are used as solvents for removing grease from machined metal products. Site workers shall limit direct contact with solvents to levels as low as reasonably possible. Latex gloves shall be used when handling any liquid or soil samples and when decontaminating equipment.

The Action Level for Level C operations will be 10 ppm airborne concentration in the work area. (A reading taken *within* a monitoring well does not constitute the "work area"). Detector tubes or a photoionization detector (PID) shall be used to monitor for chlorinated solvents. Where concentrations exceed the action limit, workers in the area shall wear full-face air purifying respirators. Care is warranted as short term and long term inhalation exposures of >0.2 ppm could potentially cause adverse health effects to the liver, nervous system and circulatory system.

4.4 LIFTING HAZARDS

Care must be taken when loading and unloading equipment or supplies from elevated platforms, such as rack trucks and shipping containers. Workers must also exercise appropriate caution in moving drums and poly rolls. The Site Superintendent is responsible for ensuring that an adequate number of workers are assigned to each lifting task.

Employees are not required to lift any object under circumstances that they believe would be potentially injurious, due to the object's weight, dimensions, or ability of a container to retain contents during the lifting process.

4.5 ENVIRONMENTAL HAZARDS

4.5.1 NOISE

Site workers exposed to noise at or above 85 dB on an 8 hour time-weighted average are to wear hearing protection (earplugs or muffs). Engineering controls to limit high noise exposure, such as varying personnel assignments, should be instituted when feasible. Refer to the NES Health and Safety Plan, Worker Protection and safe Work Practices, NES Document 82A8118 for compliance information.

4.5.2 HYPERTHERMIA

Conditions in the work area during the summer months can be expected to occasionally exceed 90°F during the day, accompanied by high humidity. The ambient wet bulb globe temperature (WBGT) may be above 90°F at certain times. **These ambient conditions are greatly exacerbated by the protective equipment such as cotton coveralls, Tyvek or PVC coveralls, hard hats and gloves.**

These dangerous environmental conditions can have rapid deleterious affects on a worker's ability to safely perform basic tasks and recognize obvious hazards. It is essential that proper precautions, outlined below be consistently followed.

Heat related problems include **heat cramps, heat exhaustion, and heat stroke.** Refer to the NES Health and Safety Plan, Worker Protection and Safety Work Practices (82A8118) for a detailed explanation of the symptoms and first aid for each condition. This document is included with the Site Health and Safety Plan. **All workers MUST be familiarized with this information.**

Preventive measures, when conditions warrant, require establishing a designated rest area near each work area. This refuge area should offer a cooler environment, with water or a suitable "sport-ade" liquid available at all times. Workers are permitted to cease work activities and rest in a cooler refuge area any time that they deem necessary due to the effects of heat stress. **The designated initial refuge area is the NES Project Office.**

4.5.3 HYPOTHERMIA

Cold-related problems can arise in two forms, hypothermia and frostbite, which often occur together. Both hypothemia and frostbite are extremely serious and require immediate treatment. Hypothermia is a drop in internal body temperature due to the inability to retain sufficient metabolic body heat. This usually occurs in five stages: shivering, listlessness and sleepiness, unresponsiveness, freezing of the extremities, and death. Frostbite, which may start as "frost nip" and progress to superficial and deep frostbite, is the actual freezing of the skin and underlying tissues.

Conditions which warrant vigilance for hypothermia and frostbite are not necessarily extreme. *Individuals who work in wet conditions, have poor circulation, restrictive clothing, long periods of inactivity, or have taken certain prescription drugs may be susceptible at temperatures as high as 50°F.*

Under potential hypothermic environmental conditions, supervisors will provide frequent rest periods which include warm and dry refuge and warm fluids. The NES Project Office is the designated refuge area.

Workers showing signs of frostbite or hypothermia shall be placed in a warm, dry area and provided with warm fluids. Treatment shall be provided on a first aid basis by the Site Health and Safety Officer or other certified first aid provider. Emergency Medical Services will be requested as signs & symptoms warrant, including minor symptoms that persist for more than 10 minutes.

4.6 *TRENCHING*

Trenching operations will take place on the paved areas within the site. Trench cutting will be achieved with the use of a Ditch Trencher. Well piping will be installed within the trenches.

The trench cuts will be approximately 6" wide x 2-3' deep. This size trench is ***not*** a confined space hazard (29 CFR 1910.146). However, the trench may pose a trip and fall hazard and caution must be used when working in or around this area. If any trench area is to be left open

over night, the trench must be marked off with yellow barricade tape. The tape will read "CAUTION". Trenches are not to be left open over weekends or holidays.

4.7 PERSONAL PROTECTIVE EQUIPMENT (PPE)

During trench cutting, well drilling or the use of a direct push apparatus, hearing protection must be used at all times to reduce dB level exposure for NES employees working with or around this equipment. ANSI approved eye protection also must be worn when working with any machinery or cutting, drilling, and digging equipment. For the sampling phase of this project the minimum of level "D" protective equipment must be maintained by all Site Workers. Depending on site-specific conditions, the HSO may require upgrading of the PPE to a higher level. Specific personal protective equipment for each level of protection is as follows. Site workers are always given the option to upgrade personal protective equipment (PPE). Downgrading of PPE is permissible only under the expressed direction of the Site Health and Safety Officer.

LEVEL	PROTECTIVE EQUIPMENT
A	Not applicable
B	Not applicable
C	**All Level D PPE and:** Tyvek coveralls Latex gloves (under leather work gloves) Rubber over-boots Full face air purifying respirator (APR) with HEPA/VOC filter canister*
D	Hard Hats Leather work gloves with latex gloves Safety toe boots Impact eye protection Face Shield with hard hat for specified tasks Integral hearing protection with hard hat for specified tasks Splash protection for specified tasks Tyvek coveralls for specified tasks

*Respirator canisters determined by type of chemical hazard. All canisters will have HEPA filters.

5 ADDITIONAL SITE SAFETY PROCEDURES

5.1 SPILL RESPONSE PROCEDURES

The following materials may be present on site and may have the potential for release:

- Diesel fuel used to power equipment
- Gasoline used to power equipment
- Hydraulic fluid used in equipment hydraulic systems

- Other chemicals within the site area, such as chlorinated hydrocarbons extracted as contaminated media.

In the event there is a hydraulic line leak, fuel spill, or accidental spill of contaminated media (water or soil), the following procedures will be implemented:

1. All operations will cease and affected equipment will be shut off.
2. Absorbent materials will be applied to the spill area.
3. Upon containment, the absorbent materials will be collected in 5-gallon pails or 55-gallon drums, and held on-site. The waste will be disposed of as required by federal and New York state laws.
4. The Leica site representative will be notified of the release.
5. Any spill of petroleum products in excess of 5 gallons shall be reported to the NYSDEC within 2 hours of the release.

5.2 LOCKOUT/TAGOUT

Prior to maintenance or repair work on equipment, all electrical, hydraulic, pneumatic or steam pressurized sources of energy must be OFF or fully disconnected in accordance with NES Lockout/Tagout Procedures. Refer to NES Document 82A8124, Control of Hazardous Energy Sources for compliance information.

5.3 MEDICAL SURVEILLANCE

The NES Site Health and Safety Officer shall be notified of any onsite emergencies and be responsible for ensuring that the appropriate actions are taken.

NES intends to take all appropriate measures to ensure the health and safety of employees that may be at the risk of exposure to potentially harmful conditions during the course of this project.

- A medical surveillance program is promulgated by federal law. The OSHA 29 CFR 1910.120(f) HAZWOPER standard requires that employees participate in a medical surveillance program if they have work assignments that pose risk of exposure to hazardous substances.

Medical surveillance is an ongoing process that begins prior to the start of the employee's job assignment. The medical surveillance program will include the following examinations:

- Pre-employment medical examination.
- Periodic medical examination.
- Post-exposure examination, when necessary.
- Exit or termination medical examination.

Emergency medical examination and treatment.

NES will utilize Board Certified Physicians specializing in Occupational Medicine. The primary Medical Advisor is listed below. An alternate Medical Advisor may be assigned by the NES Safety Officer.

Corporate Health Care
Germantown Road
Danbury, CT. 06810
(203) 207 –3300

6 COMMUNITY AIR MONITORING PLAN

As recommended by the New York State Department of Health, real-time air monitoring, for volatile compounds and particulate levels at the perimeter of the work area is necessary when ground intrusive activities are occurring. The plan includes the following:

- Volatile organic compounds must be monitored at the downwind perimeter of the work area on a continuous basis. If total organic vapor levels exceed 5 ppm above background, work activities must be halted and monitoring continued under the provisions of a Vapor Emission Response Plan. All readings must be recorded and be available for State (DEC & DOH) personnel to review.

- Particulates should be continuously monitored upwind, downwind and within the work area at temporary particulate monitoring stations. If the downwind particulate level is 150 ug/m3 greater than the upwind particulate level, then dust suppression techniques must be employed. All reading must be recorded and be available for State (DEC & DOH) personnel to review.

6.1 VAPOR EMMISSION RESPONSE PLAN

If the ambient air concentration of organic vapors exceeds 5 ppm above background at the perimeter of the work area, activities will be halted and monitoring continued. If the organic vapor level decreases below 5 ppm above background, work activities can resume. If the organic vapor levels are greater than 5 ppm over background but less than 25 ppm over background at the perimeter of the work area, activities can resume provided:

- The organic vapor level 200 ft. downwind of the work area or half the distance to the nearest residential or commercial structure, whichever is less, is below 5 ppm over background.

If the organic vapor level is above 25 ppm at the perimeter of the work area, activities must be shutdown. When work shutdown occurs, downwind air monitoring as directed by the Safety Officer will be implemented to ensure that vapor emission does not impact the nearest residential or commercial structure at levels exceeding those specified in the Major Vapor Emission section.

6.2 MAJOR VAPOR EMISSION

If any organic levels greater than 5 ppm over background are identified 200 feet downwind from the work area or half the distance to the nearest residential or commercial property, whichever is less, all work activities must be halted.

If, following the cessation of the work activities, or as the result of an emergency, organic levels persist above 5 ppm above background 200 feet downwind or half the distance to the nearest residential or commercial property from the work area, then the air quality must be monitored within 20 feet of the perimeter of the nearest residential or commercial structure (20 Foot Zone).

If efforts to abate the emission source are unsuccessful and if the organic vapor levels of 5 ppm above background levels persist for more than 30 minutes in the 20 Foot Zone, then the Major Vapor Emission Response Plan shall automatically be placed into effect. However, the Major Vapor Emission Response Plan shall be immediately placed into effect if organic vapor levels are greater than 10 ppm above background.

6.3 MAJOR VAPOR EMISSION RESPONSE PLAN

Upon activation, the following activities will be undertaken:

1. All Emergency Response Contacts as listed in the Health and Safety Plan of the Work Plan will go into effect.

2. The local police will be contacted immediately by the Safety Officer and advised of the situation.

3. Air monitoring will be conducted at 30 minute intervals within the 20 Foot Zone. If two successive readings below action levels are measured, work activity may resume and air monitoring may be halted or modified by the Safety Officer.