

Bristol-Myers Squibb Company

# **HIGH VACUUM EXTRACTION PILOT TEST WORK PLAN – REVISED**

Site #C734138

BMS Syracuse North Campus Restoration Area  
Thompson Road, East Syracuse,  
New York

July 2019, Revised October 2019

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# HIGH VACUUM EXTRACTION PILOT TEST WORK PLAN – REVISED



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Site #C734138  
BMS Syracuse North Campus  
Restoration Area  
Thompson Road, East Syracuse,  
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## ACRONYMS AND ABBREVIATIONS

AGC	Annual Guideline Concentrations
Arcadis	Arcadis U.S., Inc.
BDA	Brownfield Development Area
bgs	below ground surface
BMS	Bristol-Myers Squibb
CO <sub>2</sub>	carbon dioxide
COC	constituent-of-concern
DOT	Department of Transportation
DUSR	Data Usability Summary Report
eV	electron volt
FSAP	Field Sampling and Analysis Plan
HASP	Health and Safety Plan
LEL	lower explosive limit
MeCl	methylene chloride
n,n-DMA	n,n-dimethylaniline
NYSDEC	New York State Department of Environmental Conservation
O <sub>2</sub>	oxygen
PID	photoionization detector
PPE	personal protective equipment
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
SGC	Short-Term Guideline Concentrations
TCE	trichloroethene
TIC	tentatively identified compound(s)
µg/L	micrograms per liter
µg/m <sup>3</sup>	micrograms per cubic meter
VGAC	vapor-phase granular activated carbon
VOC	volatile organic compound(s)
Work Plan	<i>High Vacuum Extraction Pilot Test Work Plan</i>

## 1 INTRODUCTION

This *High Vacuum Extraction Pilot Test Work Plan* (Work Plan) has been developed for the Bristol-Myers Squibb (BMS) Syracuse North Campus Restoration Area (New York State Department of Environmental Conservation [NYSDEC] Brownfield Development Area [BDA] Site No. C734138) that is part of the BMS Facility located at 6000 Thompson Road in East Syracuse, New York (site). This Work Plan incorporates revisions to address preliminary comments provided by NYSDEC on the previous version of this Work Plan which was submitted to facilitate BMS's ability to implement certain initial tasks associated with this pilot test to accelerate the schedule. The tasks implemented included the Field Preparations and Pilot Test Well Installation Tasks, as detailed in Sections 2.1 and 2.2 of this Work Plan.

The pilot test will be performed in the BDA-10 well cluster area to achieve the following objectives:

- Evaluate whether high vacuum extraction is a viable technology to address methylene chloride (MeCl) impacts present in the glacial till beneath this area of the site.

### 1.1 Site Description

The BMS Facility is an approximately 90-acre biologic drug substance manufacturing facility located within a mixed industrial/residential area in an urban setting (Figure 1). Most of the BMS Facility is covered with buildings, paved parking lots, mowed lawns, and access roads. The BDA occupies approximately 24 acres of the BMS Facility. A site transformation project was implemented in the BDA, resulting in the demolition of numerous buildings and the conversion of much of the BDA to green space. Former site features, existing site features, and site monitoring wells are shown on Figure 2.

The overall topography of the BMS Facility slopes downward to the east-northeast, toward the local valley, which is drained by the South Branch of Ley Creek (referred to herein as Ley Creek). Ley Creek originates off-site to the south, runs along the eastern perimeter of the BMS operating facility, passes through a culvert beneath the adjacent CSX railroad tracks, and continues to the northwest. An open channel drainage ditch (known as Headson's Brook) intermittently flows parallel to the railroad tracks and discharges to Ley Creek adjacent to the BMS property.

The BDA-10 well cluster area, within the footprint of former Building 62, was selected for the pilot study because MeCl is detected at elevated concentrations in the till and in the groundwater within the underlying shallow bedrock at this location. This area is also located to the west of a former tunnel, east of the tank vault and away from other former subsurface facilities that are potential obstructions to drilling.

### 1.2 Hydrogeology

Based on drilling logs for the installation of wells in cluster BDA-10, the site stratigraphy for the pilot test area is summarized in Table A (below). Please note, hydraulic conductivity values presented in Table A are general site-wide estimates and are not specific to the pilot test area.

Table A. Pilot Test Area Stratigraphy

Lithologic Unit	Description	Thickness (feet)	Hydraulic Conductivity (feet per day) <sup>1</sup>
Fill	Gravel with variable debris, sand, silt, and clay	5 to 7	Range: 0.12 to 27 Geometric Mean: 1.1
Till	Very dense silt with variable gravel, sand, and clay	27 to 31	Range: 0.025 to 6.7 Geometric Mean: 0.14
Weathered Bedrock	Very dense silty clay with angular pieces of shale and intervals of competent shale several feet thick	2.5 to 3	Range: 0.037 to 13 Geometric Mean: 0.32
Competent Bedrock	Vernon Shale – Sparsely fractured shale with thin beds and veins of selenite (gypsum) and dolomite	NA	Range: 0.034 to 0.97 Geometric Mean: 0.16

As discussed in footnote 1, site monitoring data indicate that the till unit has a very low permeability beneath the pilot test area, with groundwater production rates from this unit expected to be very low as well. The hydraulic gradient at the site is to the east-northeast, toward Ley Creek. The water table within this area of the BDA occurs in the overburden near the fill/till interface and is recharged principally by infiltration of precipitation on and upgradient of the site. Groundwater flow in the overburden is interpreted to be principally horizontal due to the lower hydraulic conductivity of underlying units. However, there is a downward hydraulic gradient through the till into the bedrock across most of the site. Groundwater movement in the weathered and competent bedrock is focused along discrete, interconnected zones of relatively higher hydraulic conductivity associated with relict fractures in weathered bedrock and transmissive fractures in competent bedrock.

### 1.3 Nature and Extent of Constituents-of-Concern within the Pilot Test Area

Results from previous site investigations, which included installation of the BDA-10 monitoring well cluster (BDA-10DT, BDA-10-MT, and BDA-10RX) and monitoring well CHP43RX, indicate methylene chloride (MeCl) is the primary constituent-of-concern (COC) present in soil and groundwater beneath the pilot test area. Other COC detected at lower concentrations within the pilot test area include trichloroethene (TCE) and n,n-Dimethylaniline (n,n-DMA).

Concentrations of MeCl in soil within the till unit exceed the Protection of Groundwater Soil Cleanup Objective (6NYCRR Part 375). The highest concentration of MeCl (110 milligrams per kilogram) was observed in the till unit at a depth of approximately 20 feet below ground surface (bgs). MeCl concentrations appear to decrease in soil at depths below 20 feet bgs.

MeCl, n,n-DMA and TCE are all detected at concentrations above NYSDEC Technical and Operational Guidance Series 1.1.1 criteria in groundwater within the till and/or weathered bedrock units beneath the

<sup>1</sup> Hydraulic conductivity estimated based on drawdown observed in monitoring wells during low-flow sampling. A subset of monitoring wells screened in the till and competent bedrock did not achieve steady state drawdown during sampling or had insufficient recharge for low-flow sampling. Thus, the actual hydraulic conductivity of these units is inferred to be considerably lower than the calculated geometric mean values presented here.

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pilot test area. Dissolved phase MeCl concentrations range from 78 micrograms per liter ( $\mu\text{g/L}$ ) at the base of the till unit to 18,000  $\mu\text{g/L}$  within the underlying weathered bedrock. Dissolved-phase n-n-DMA concentrations also range from 1.2  $\mu\text{g/L}$  at the base of the till unit to 2.6  $\mu\text{g/L}$  within the weathered bedrock. TCE was detected at a concentration of 18  $\mu\text{g/L}$  within the till but was not detected in the underlying weather bedrock. MeCl, n-n-DMA and TCE were not detected in groundwater within the deeper, competent bedrock.

The MeCl detections in the till are the primary focus of this pilot test.

## 2 PILOT TEST IMPLEMENTATION

Arcadis of New York, Inc. (Arcadis) has implemented field activities including pilot test well installation and development, sampling of groundwater and soil vapor from the pilot test extraction well and will implement the high vacuum pilot test upon approval of this Work Plan by the NYSDEC.

### 2.1 Field Preparations

The site-specific Health and Safety Plan (HASP) has been updated to incorporate health and safety measures for personal protective equipment (PPE) drilling work and high vacuum pilot test system equipment. The existing project Field Sampling and Analysis Plan (FSAP) (OBG 2013a) and Quality Assurance Project Plan (QAPP) (OBG 2013b) have been reviewed and a brief supplement has been assembled for the QAPP (Attachment 1) to ensure they appropriately address procedures for the pilot test and associated sampling.

In addition, Arcadis has completed an air dispersion modeling analysis following the DAR-1 procedures to demonstrate that pilot test emissions, with the proposed effluent controls, will comply with New York State Short-Term Guideline Concentrations (SGC) which are applicable for a short-duration pilot test such as this. Initially, the model was run using the emission rate derived from estimated vapor-phase concentrations based on soil and groundwater data collected from the pilot test area. Following installation and sampling of soil vapor from the extraction well, the potential emissions determined from the results of the soil vapor sample were used to run the air dispersion model a second time. The uncontrolled emission rate for methylene chloride calculated from the estimated vapor-phase concentrations is relatively low at 0.11 lbs/hr, and the DAR-1 modeling indicates that predicted ambient impacts for uncontrolled discharge will be approximately 41  $\mu\text{g}/\text{m}^3$ , which is well below the SGC threshold for methylene chloride of 14,000  $\mu\text{g}/\text{m}^3$ . However, the planned vapor effluent treatment has still been conservatively designed to ensure compliance with New York State SGC criteria, and ambient impacts predicted by the model for the controlled emissions scenario is only 2  $\mu\text{g}/\text{m}^3$ . A memo summarizing the results of the DAR-1 modeling is included as Attachment 2.

### 2.2 Pilot Test Well Installation

#### 2.2.1 Utility Clearance

Before performing intrusive work at the site, Arcadis contacted Dig Safely New York to mark buried public utilities entering the property, obtained excavation permits from the BMS facility engineering department, reviewed known utility mapping provided by BMS, and conducted a utility survey of the proposed boring locations. Arcadis also used ground penetrating radar and electro-magnetic induction to identify and mark buried utilities in the vicinity of the proposed pilot test wells. Well locations were adjusted based on the findings of the utility survey to the location identified on Figure 3.

#### 2.2.2 Community Air Monitoring

Community air monitoring was performed during drilling of the pilot test wells. Consistent with prior BDA drilling activities, worker breathing zone air was monitored for dust and volatile organic compounds

(VOC), and ambient air around the perimeter of the work area was monitored for VOC only. Dust was monitored using a particulate monitor and VOC were monitored using a photoionization detector (PID) equipped with an 11.7 electron volt (eV) lamp. As an extra precaution, industrial fans were operated along the upwind perimeter of the work zone to induce a consistent flow of fresh air across the work area when drilling was performed. Perimeter air was measured at dedicated upwind and downwind stations, based on prevailing wind direction. This approach was consistent with the Community Air Monitoring Plan (OBG 2013c) for the project, with dust monitoring modification previously approved by the NYSDEC based on the lack of perimeter dust exceedances during site transformation activities, and the limited extent of intrusive activities to be conducted. Community air monitoring was not required during well development or vapor/groundwater sampling activities associated with the Work Plan.

### 2.2.3 Pilot Tests Well Layout and Installation

One new extraction well (HVP-EW-1) and eight new observation wells (HVP-OW-1S/1D, HVP-OW-2S/2D, HVP-OW-3S/3D, and HVP-OW-4S/4D) were installed for the pilot test at the approximate locations shown on Figure 3. Wells were installed by a track-mounted roto-sonic drill rig. Drilling work was supervised by an Arcadis field geologist.

Soil cores were collected continuously from each boring during drilling. Lithology of these soil cores was logged in the field, and representative soil samples were collected and screened in the field for total VOC using the sample bag headspace method and a PID equipped with an 11.7 eV lamp, as described in Section 5.2 of the FSAP (OBG 2013a).

- The eight observation wells were installed as nested shallow/deep well clusters in the same borehole. As illustrated on Figure 3, the four observation well clusters were installed at an approximately 90-degree spacing around the extraction well. Two of the well pairs were installed at distances of approximately 5 feet (HVP-OW-1S/1D) and 15 feet (HVP-OW-4S/4D) from the observation well, and the other two well pairs (HVP-OW-2S/2D and HVP-OW-3S/3D) were installed approximately 10 feet from the extraction well. Pilot test well screen intervals and basic construction details are summarized below. Additional construction details are provided on Figure 4. Extraction well HVP-EW-1 – 4-inch-diameter, stainless steel, with a 10-foot-long, 20-slot screen installed from approximately 21 to 31 feet bgs.
- Shallow observation wells OW-1S, OW-3S, and OW-4S – 2-inch diameter, stainless steel, with a 5-foot-long, 10-slot screen installed from approximately 10 to 15 feet bgs, completely below the fill/till interface.
- Shallow observation well OW-2S – 2-inch-diameter, stainless steel, with a 10-foot-long, 10-slot screen installed from approximately 5 to 15 feet bgs, such that the screen extends a minimum of 1-foot above the static water table elevation and approximately 2.5 feet above the till into fill, to allow monitoring for vacuum influence that might develop within that unit.
- Deep observation wells HVP-OW-1D, HVP-OW-2D, HVP-OW-3D, and HVP-OW-4D – 2-inch-diameter, stainless steel, with a 10-foot-long, 20-slot screen installed from approximately 21 to 31 feet bgs, across the same subsurface interval as the extraction well.

For the nested observation wells, hydrated bentonite pellets were used to seal the annular space in the borehole between the two screened intervals, as well as above the shallow screened interval. Similarly, a

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2-foot hydrated bentonite seal was installed above the screened interval of the extraction well. The remainder of the annular space above the bentonite seal in the extraction well and the upper bentonite seal in the nested observation wells was sealed with neat non-shrinking cement.

The extraction well screen interval was selected to intersect the zone of highest apparent soil impacts within the till, as indicated by PID readings, recorded at a depth of approximately 24 to 28 feet during installation of the BDA-10 cluster wells. Because permeability of the till unit is very low, a 10-foot extraction well screen has been selected instead of a 5-foot screen, as a longer screen is more likely to intersect lenses of more permeable coarser grained sediment within the till matrix where residual MeCl mass may reside. A longer screen will also allow for a pneumatic pump to be operated in the extraction well during the pilot test in the event the groundwater recovery rate is higher than expected.

The pilot extraction and observation wells were developed by Arcadis personnel following installation to the extent that it was possible/practical given the slow groundwater recharge rate expected for the till unit. Well development was conducted in accordance with the procedures in Section 6.2 of the FSAP (OBG 2013a).

The top of the inner casings and ground surface at each well will be marked and surveyed to the nearest 0.01 foot, and the elevation will be determined relative to North American Vertical Datum of 1988 and North American Datum. The measuring point on all wells will be a mark on the innermost well casing. All surveying work will be performed by a New York State-licensed surveyor.

### 2.2.4 Soil Sampling

During installation of the extraction well, two soil samples were collected for laboratory analysis where the highest PID readings were recorded in the till during drilling. One sample was collected from the 23- to 25-foot depth interval and the second was collected at the 27- to 29-foot depth interval. A duplicate sample was also collected for analysis from the 27- to 29-foot depth interval. Soil samples were submitted to Eurofins Lancaster Environmental Laboratory for the following analyses in accordance with the QAPP (OBG 2013b) and the following United States Environmental Protection Agency (USEPA) SW-846 Methods.

- VOC (including top 10 tentatively identified compounds [TIC]) – 8260C
- Semi-volatile organic compounds (including top 20 TIC) – 8270D
- Glycols and alcohols – 8015C/8015D
- Formaldehyde, glutaraldehyde, and acetaldehyde – 8315A

### 2.2.5 Vapor Headspace/Groundwater Sampling

Arcadis collected one vapor sample from approximately 1 foot above the measured groundwater surface elevation within the extraction well headspace to provide additional data to confirm selection/design of off-gas treatment controls for the pilot test. The sample was collected in a Summa® Cannister directly from the well head, which was sealed to prevent inflow of atmospheric air into the casing during sampling. The sample was sent to Eurofins Air Toxics, Inc. laboratories in Folsom, CA to be analysed for the attached location-specific VOC compound list in accordance with USEPA Method TO-15 analysis. As discussed

above, the headspace vapor sample results was used to update the DAR-1 air dispersion model for the pilot test and confirm the selected off-gas treatment is appropriate.

Arcadis also sampled groundwater from the new extraction well. The sample was collected following low-flow sampling methodology in accordance with the FSAP (OBG 2013a). The groundwater sample, a field duplicate sample, and a trip blank were sent to Eurofins Lancaster Laboratories in Lancaster, Pennsylvania, to be analysed for VOCs in accordance with USEPA Method 8260C. The results supplement the data used to characterize the groundwater recovery stream and estimate dissolved-phase MeCl mass recovery during the pilot test.

Samples were analyzed on a 5-day rush turn-around, so the data were available to review and guide any final adjustments to pilot test procedures or off-gas treatment.

### 2.3 High Vacuum Pilot Test

#### 2.3.1 Pilot Test Set Up and Equipment

A mobile multi-phase extraction pilot system platform will be mobilized to the site to conduct pilot testing activities. The pilot test platform is mounted inside a box-truck and powered by the truck engine, like a vacuum truck; therefore, an electrical power drop or generator will not be required for the pilot test. The unit will operate in two-phase extraction mode in which groundwater and soil vapor are recovered under high vacuum applied through a drop tube inserted into the extraction well at the targeted depth interval. Vacuum will be applied to the well by a liquid ring pump capable of applying a maximum vacuum of approximately 29 inches of mercury (inHg). Recovered groundwater will be separated out from the vapor stream in a vapor liquid separator (knock-out) tank, then transferred into a holding tank within the pilot system. Groundwater will be transferred from the holding tank into 275-gallon Department of Transportation- (DOT-) approved plastic totes for storage, as necessary, during the pilot test. Exhaust from the liquid ring pump will be passed through an oil separator drum to remove any oil blow-through from the liquid ring pump, a heat exchanger, and then treated through two 175-pound vapor-phase granular activated carbon (VGAC) vessels arranged in series to remove MeCl and any other VOC prior to discharging to the atmosphere. A process flow diagram for the two-phase extraction pilot test is shown on Figure 5.

The pilot test platform is equipped with flow meters, vacuum gauges, sample ports, and necessary hoses to connect the system manifold to the extraction well. In the event the till formation is more permeable than expected and/or groundwater recovery rates are higher than expected, the mobile pilot test platform is also equipped with additional equipment that will allow the test to continue in dual-phase extraction mode. In this setup, a pneumatic pump would be used for groundwater extraction, and a rotary claw blower capable of operating across a lower vacuum range would be used to apply vacuum at the wellhead, similar to soil vapor extraction. A process flow diagram for a dual-phase extraction pilot test is shown on Figure 6.

Specifications for major equipment to be utilized during the pilot test are included in Attachment 3.



### 2.3.2 Pilot Test Procedure

The pilot test will last a maximum of 5 days as detailed below. The actual pilot test procedures and duration may vary from what is proposed in this work plan and is dependent on real-time data and the response of the formation observed during implementation of the pilot test. Any major changes to the proposed pilot test procedures will be communicated in advance to NYSDEC to obtain concurrence/approval. Examples of major procedural changes include modifications to major pilot system equipment (e.g., transitioning from two-phase to dual-phase configuration, or modifications to off-gas treatment); discontinuing pilot testing before the 5-day test period; eliminating pilot test phases (e.g., vacuum step testing); eliminating or modifying water/air sampling. Phone communications will be documented in a follow-up written notice sent to NYSDEC. If a response cannot be obtained from NYSDEC, or if a change is required during off-work hours, the proposed change(s) will be implemented such that the test can continue without excessive downtime, and an email documenting the change(s) will be sent to NYSDEC. The pilot test will be conducted in standard Modified level D PPE. Community air monitoring will not be required as no intrusive work is associated with operation of the pilot test and vapor-phase emissions will be treated prior to discharge.

#### 2.3.2.1 Baseline Monitoring

After the mobile system is set up and connected to the extraction wellhead, operation checks and safety-shut-off control devices will be tested to show equipment is properly working. Before initiating the pilot test, baseline monitoring will be conducted at the extraction well, observation wells, and existing monitoring wells in the vicinity, including the BDA-10 cluster (BDA-10DT, BDA-10MT, and BDA-10RX) and monitoring well CHP-43RX. The following readings will be collected.

- Gauging water level and depth to bottom
- Screening well headspace for VOC using a PID (field measured by 11.7 eV lamp PID), oxygen (O<sub>2</sub>), lower explosive limit (LEL), and carbon dioxide (CO<sub>2</sub>)
- Recording wellhead vacuum measurements

This data will provide a set of static/baseline conditions against which to compare data collected during the pilot test.

#### 2.3.2.2 Vacuum Step Testing

Upon completion of baseline monitoring, vacuum extraction will begin with the installation of the drop tube 1 to 2 feet below the static water level in the extraction well. The drop tube will then be lowered in concert with the falling water level until it is at a depth of approximately 28 feet bgs, exposing the targeted 24 to 28 feet bgs depth interval. Should groundwater recovery remain low enough such that the two-phase extraction equipment is able to dewater the extraction well to 28 feet bgs, then the drop tube will be lowered to as deep as the bottom of the extraction well. Once the extraction well is dewatered to the desired depth, vacuum will then be applied to the well in a series of increasing steps to evaluate the response of the formation. During each step the following performance monitoring data will be collected from the extraction well, observation wells, and other surrounding monitoring wells.

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- Water level
- Wellhead vacuum
- Wellhead VOC (field measured by 11.7 eV lamp PID), O<sub>2</sub>, and CO<sub>2</sub>

The following performance monitoring data will be collected from the pilot test system.

- Blower vacuum
- Extraction airflow rate
- Influent air stream temperature
- Vapor-phase influent, mid-effluent (i.e., in between the two VGAC vessels), and effluent VOC (field measured by 11.7 eV lamp PID)
- System influent vapor recovery stream O<sub>2</sub>, LEL, CO<sub>2</sub>, and methane
- Total groundwater recovery volume

The above measurements will be collected approximately every 30 minutes during step testing. Each vacuum step will be maintained for a period of 1 to 3 hours to allow for the field measurements (as identified above) to stabilize. A minimum of three vacuum steps will be conducted and step testing will continue until the maximum wellhead vacuum attainable is reached.

Should the lower explosive limit (LEL) measurement of the vapor-phase influent using a meter calibrated to methylene chloride exceed 25% at any point during the pilot test, field personnel will add dilution air to the vapor recovery stream to reduce the concentrations and will contact the supervising engineer to discuss how to proceed with the test. NYSDEC will be notified should this occur.

### 2.3.2.3 Extended Phase Test

Step testing results will be reviewed to identify the optimal vacuum setting to use for the remainder of the pilot test. Factors considered in this determination will include the vacuum setting that produces the greatest pneumatic influence in the surrounding vadose zone, and/or highest vapor phase VOC mass recovery rate. The system will then be adjusted to operate at this vacuum for the remainder of the pilot test. The system will operate continuously for 24 hours a day during this extended phase of the pilot test. Arcadis will continue to collect the field measurements from the pilot system as discussed under step testing every 1 to 2 hours during daylight hours to monitor formation response. The pilot system will operate unmanned during the night; but will be equipped with process safety devices that will initiate a shutdown in the event of an alarm condition, such as a high water level in the vapor-liquid separator, and telemetry that will notify the operator to respond in the event of an alarm condition.

A PID meter will be used to monitor the vapor recovery stream for VOC during the extended pilot test to determine the effectiveness of VGAC treatment. These readings will be measured at the influent, mid-effluent, and effluent locations along the VGAC treatment train. Draeger Tube® readings will also be measured at these locations at least twice per day, including prior to personnel departing the site for the night. Should the readings indicate that the contaminant removal efficiency across the lead carbon vessel has dropped below 50%, then the carbon vessels will be changed out as follows. The lead VGAC vessel will be replaced with the lag VGAC vessel, and a new VGAC vessel will be placed into the lag position.

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Performance monitoring data will be reviewed periodically to evaluate how the pilot test is progressing and identify whether any operational adjustments are necessary to optimize performance (e.g., adjusting drop tube depth or vacuum strength). After the vapor phase mass recovery rate, pneumatic influence, and groundwater recovery rate have stabilized or are close to stabilizing, the data will be evaluated to determine if and for how long the test should continue, if not for the full 5 days. This decision will be based in part on whether the pilot test objectives have been satisfied, and whether continuing the test would produce any additional useful information. Note, the development of hydraulic influence at the observation wells will also be evaluated but will likely not be a factor in the recommendation of when to terminate the pilot test, as it would likely take several weeks or months for the hydraulic influence to reach steady state around the extraction well in the till formation. Arcadis will obtain NYSDEC approval to shut down the pilot test if prior to the full 5-day duration.

### 2.3.2.4 Air Sampling

Two air samples will be collected for analysis from the influent vapor stream and one from the treated effluent stream during the pilot test. The first influent air sample will be collected approximately 1 to 2 hours after the start of the extended phase of the test. The second influent air sample and the effluent air sample will both be collected at the end of the pilot test before the system is shut down. A field duplicate sample will be collected for analysis with one of the samples above. Air samples will be collected in a Summa® Canister and sent to Eurofins Air Toxics, Inc. laboratories in Folsom, CA to be analyzed for the project-specific list of VOCs in accordance with USEPA Method TO-15. The laboratory will analyze the samples on a standard 10-business-day turn-around and provide a NYSDEC Analytical Services Protocol Category B deliverables package and electronic data deliverable in the site-specific EQUIS format. Data validation will be completed in accordance with NYSDEC and USEPA guidance. A Data Usability Summary Report (DUSR) will be prepared based on the data review.

## 2.4 Waste Management

Waste generated during the pilot test activities will be managed in accordance with Section 12.3 (Management of Investigation-Derived Waste) of the FSAP (OBG 2013a). The following waste streams are expected.

- Soil cuttings from pilot test well installation
- Purge water and decontamination water from pilot test well installation
- Well development water
- Groundwater extracted during pilot test
- Used VGAC from pilot test

All waste generated will be appropriately containerized, labeled, and transported to a central staging area located on-site within secondary containment pending waste profiling results. Soil cuttings and used VGAC will be stored in DOT approved 55-gallon drums. Waste water will be stored in DOT approved 55-gallon drums or 275-gallon DOT-approved plastic totes. The drums/totes will be labeled with contents and generation date. Waste profile samples will be collected and sent to Eurofins Lancaster Laboratories in Lancaster, Pennsylvania, for analysis in accordance with the FSAP (OBG 2013a). Upon receipt of the

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sampling results, waste will be profiled and shipped under manifest or bill of lading for off-site disposal at an appropriate hazardous or non-hazardous disposal facility as dictated by the sample results and profile. Waste water may be discharged to the BMS wastewater pretreatment plant, if determined to be non-hazardous. Tubing, PPE, and other solid waste generated during sampling will be containerized for appropriate disposal.

### 3 PILOT TEST SUMMARY REPORT

Upon completion of the pilot test, the results will be evaluated and compiled into a pilot test summary report, which will be submitted to the NYSDEC for review. The pilot test summary report will include the following information.

- Summary of pilot test well installation including boring/well construction logs
- Description of pilot test activities, field methods, and procedures followed
- Summary and interpretation of pilot test results
- Conclusions regarding the viability of high vacuum extraction as a potential full-scale remedy for addressing MeCl impacts in the till unit

The determination as to whether high vacuum extraction is a viable remedy for the site will be based on several factors including vapor/dissolved phase mass recovery rates, pneumatic radius of influence, estimated size of the treatment area, and other site-specific considerations.

Laboratory analytical results from samples collected during the pilot test will be validated. Data validation results will be documented in a DUSR, which will be included with the laboratory data reports as an appendix to the pilot test summary report.

## 4 SCHEDULE

The following tentative schedule is proposed for the remaining tasks of the high vacuum pilot test.

- High vacuum pilot test – one week after regulatory approval, duration 5 consecutive working days
- Pilot Test Summary Report Submittal to NYSDEC – 7 weeks after completion of pilot test

## 5 REFERENCES

O'Brien and Gere Engineers. 2013a. *Field Sampling and Analysis Plan: BMS Syracuse North Campus Restoration Area Site No. C734138*. March.

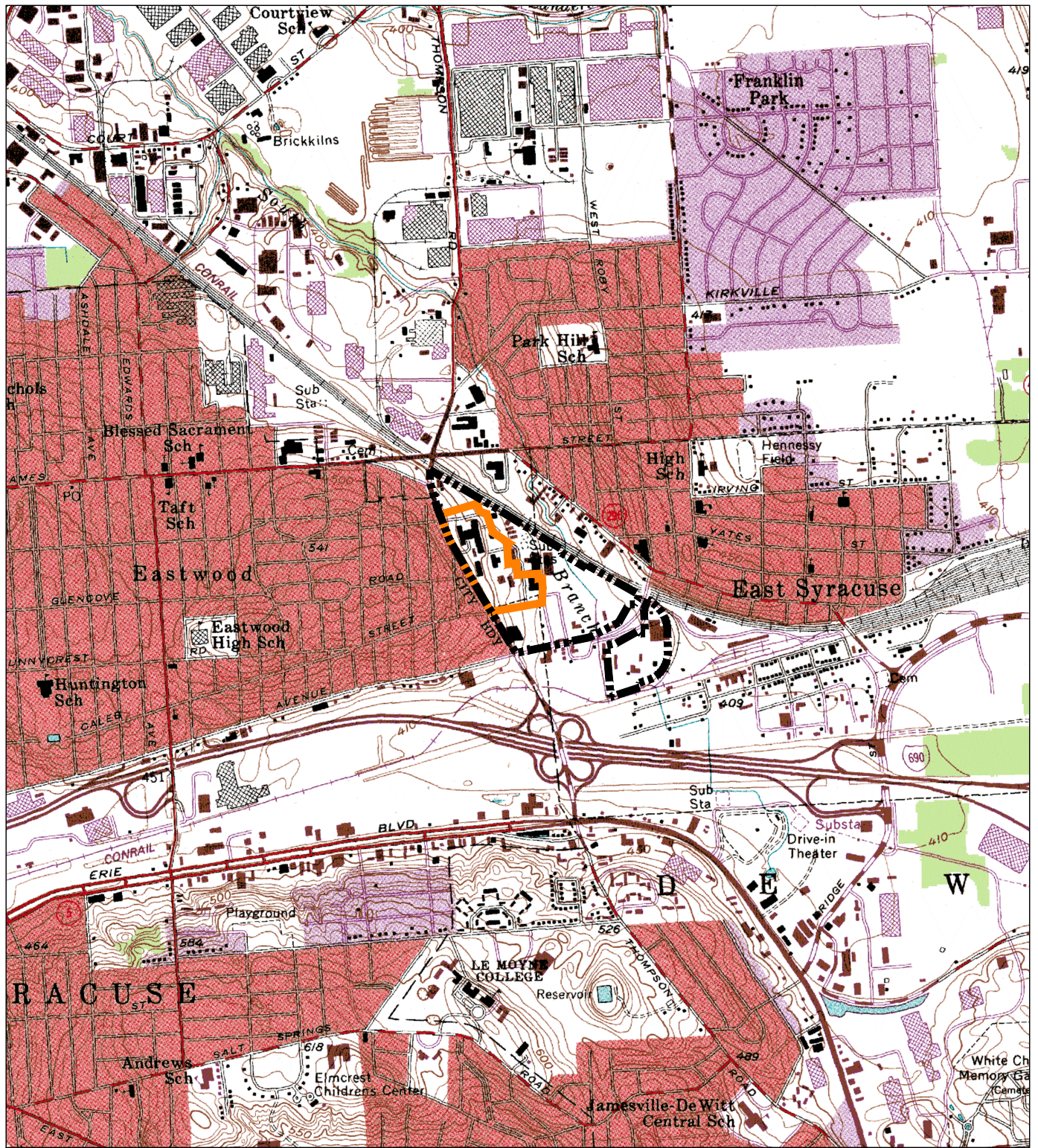
O'Brien and Gere Engineers. 2013b. *Quality Assurance Project Plan: BMS Syracuse North Campus Restoration Area Site No. C734138*. March.

O'Brien and Gere Engineers. 2013c. *Community Air Monitoring Plan: BMS Syracuse North Campus Restoration Area, Site No. C734138*. March.

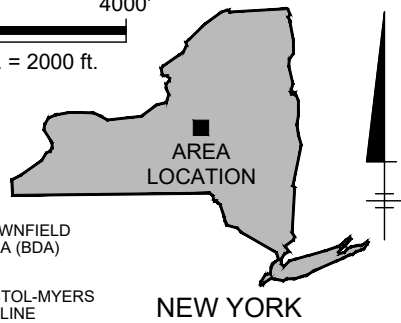
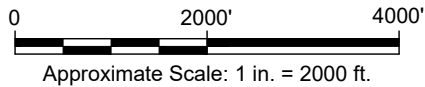
# FIGURES







REFERENCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD., SYRACUSE EAST, NEW YORK, 1957, PHOTOREVISED 1978.



**LEGEND:**

- APPROXIMATE BROWNFIELD DEVELOPMENT AREA (BDA) BOUNDARY
- APPROXIMATE BRISTOL-MYERS SQUIBB PROPERTY LINE

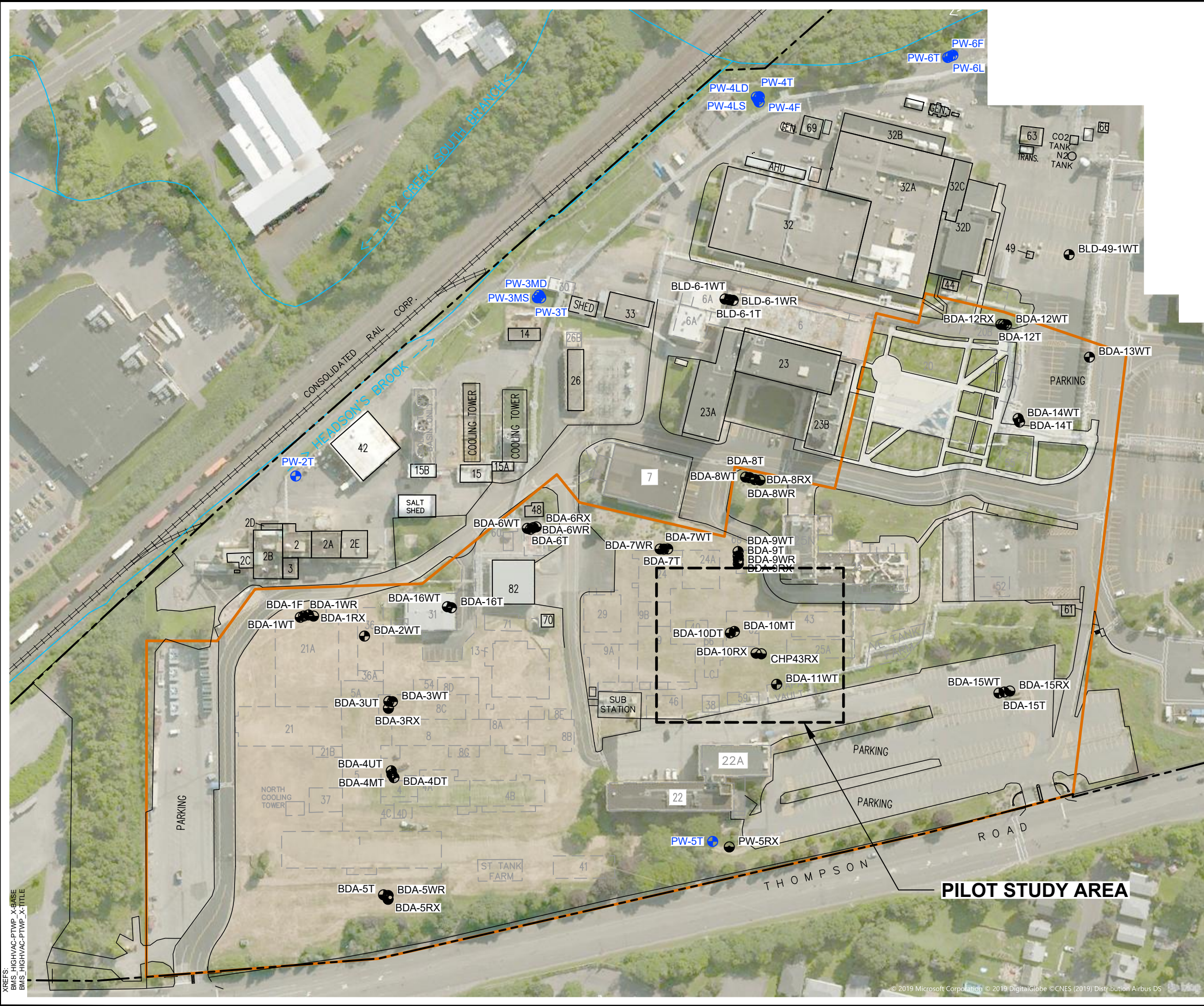
SITE #C734138: BMS SYRACUSE  
 NORTH CAMPUS RESTORATION AREA  
 EAST SYRACUSE, NY  
**HIGH VACUUM PILOT TEST WORK PLAN**

**SITE LOCATION MAP**

	Design & Consultancy for natural and built assets
FIGURE	<b>1</b>



CITY: SYRACUSE, NY DIV: GROUP: EBC-IMDV DBLD: L. POSENAUER - PM/TM: B.MCCLINE LVR: ON\*OFF-REF (FRZ)  
 C:\Users\lposena\OneDrive\BIM\360\arcadis\ANA - BRISTOL-MYERS SQUIBB\Project Files\TECHNICAL SUPPORT\2019\B0067663\063801-DWG\BMS\_HIGHVAC-PTWP\_LAYOUT.dwg LAYOUT: 2 SAVER: 10/10/2019 11:56 AM ACADVER: 23.05 (LMS TECH) PAGES: 1 OF 1 PLOTSTYLETABLE: MONOCHROME.ctb PLOTTED: 10/10/2019 12:17 PM BY: POSENAUER, LISA



- LEGEND:**
- APPROXIMATE BROWNFIELD DEVELOPMENT AREA (BDA) BOUNDARY
  - APPROXIMATE BRISTOL-MYERS SQUIBB PROPERTY LINE
  - DEMOLISHED BUILDINGS
  - EXISTING RAILROAD
  - SITE PERIMETER WELL
  - OVERBURDEN MONITORING WELL
  - BEDROCK MONITORING WELL

- NOTES:**
1. BASEMAP SOURCE: MAP TITLED "BRISTOL-MYERS SQUIBB PART OF LOT 41 - TOWN OF DEWITT AND PART OF THE VILLAGE OF EAST SYRACUSE ONONDAGA COUNTY NEW YORK", DATED MARCH 25, 2010 PREPARED BY COTTRELL LAND SURVEYORS, P.C.. UPDATED BASED ON SUBSEQUENT AERIAL IMAGERY AND SITE VISITS AND SURVEY WITHIN THE BDA BY CT MALE ASSOCIATES, SYRACUSE, NY.
  2. ABBREVIATIONS:  
 BMS = BRISTOL-MYERS SQUIBB COMPANY  
 PDI = PRE-DESIGN INVESTIGATION



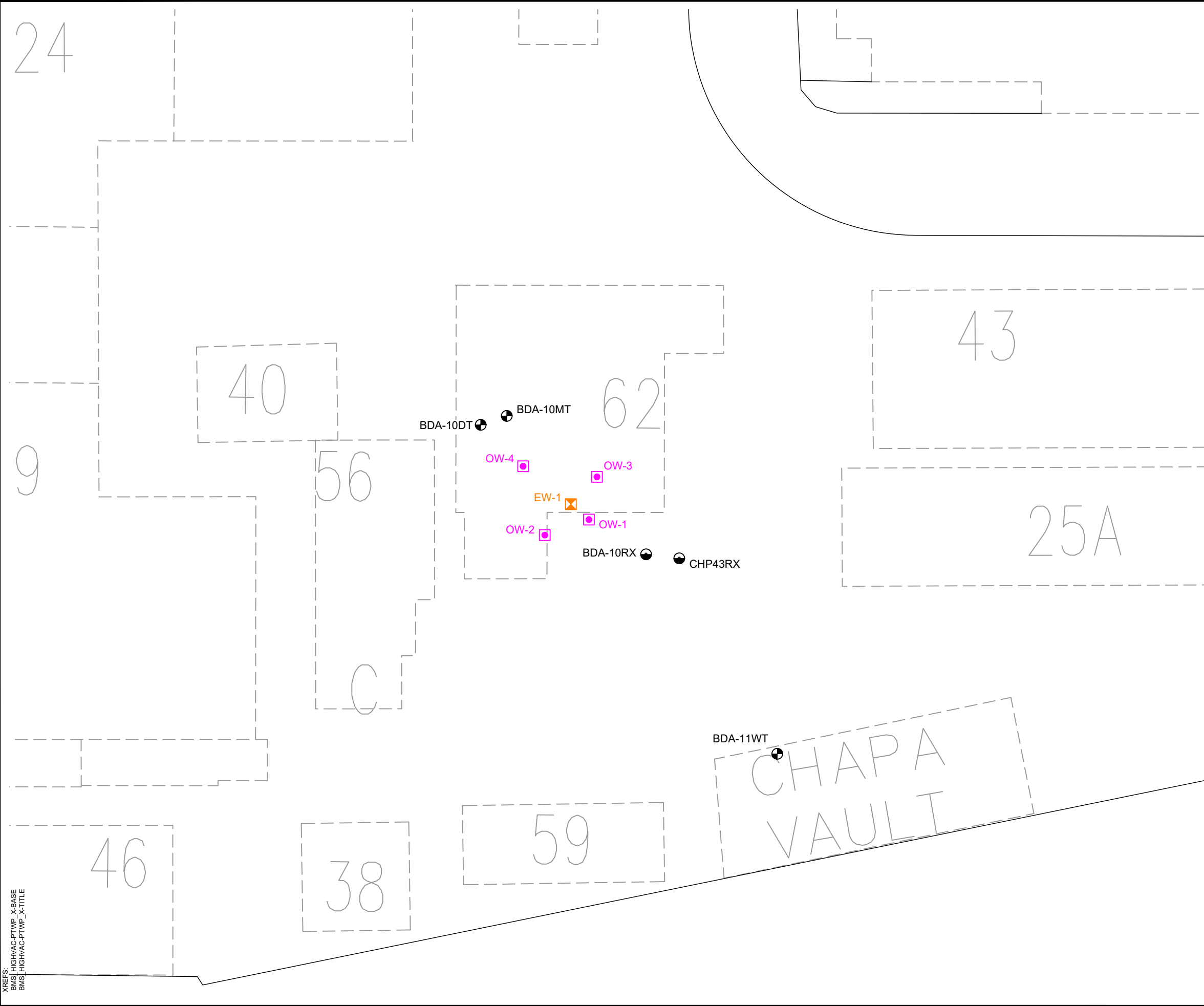
SITE #C734138: BMS SYRACUSE  
 NORTH CAMPUS RESTORATION AREA  
 EAST SYRACUSE, NY  
**HIGH VACUUM PILOT TEST WORK PLAN**

**SITE LAYOUT**

**ARCADIS** Design & Consultancy  
for natural and built assets

FIGURE  
**2**





**LEGEND:**

- DEMOLISHED BUILDINGS
- OVERBURDEN MONITORING WELL
- BEDROCK MONITORING WELL
- PROPOSED PILOT TEST OBSERVATION WELL
- PROPOSED PILOT TEST EXTRACTION WELL

- NOTES:**
- BASEMAP SOURCE: MAP TITLED "BRISTOL-MYERS SQUIBB PART OF LOT 41 - TOWN OF DEWITT AND PART OF THE VILLAGE OF EAST SYRACUSE ONONDAGA COUNTY NEW YORK", DATED MARCH 25, 2010 PREPARED BY COTTRELL LAND SURVEYORS, P.C.. UPDATED BASED ON SUBSEQUENT AERIAL IMAGERY AND SITE VISITS AND SURVEY WITHIN THE BDA BY CT MALE ASSOCIATES, SYRACUSE, NY.
  - ABBREVIATIONS:  
BMS = BRISTOL-MYERS SQUIBB COMPANY



SITE #C734138: BMS SYRACUSE  
 NORTH CAMPUS RESTORATION AREA  
 EAST SYRACUSE, NY  
**HIGH VACUUM PILOT TEST WORK PLAN**

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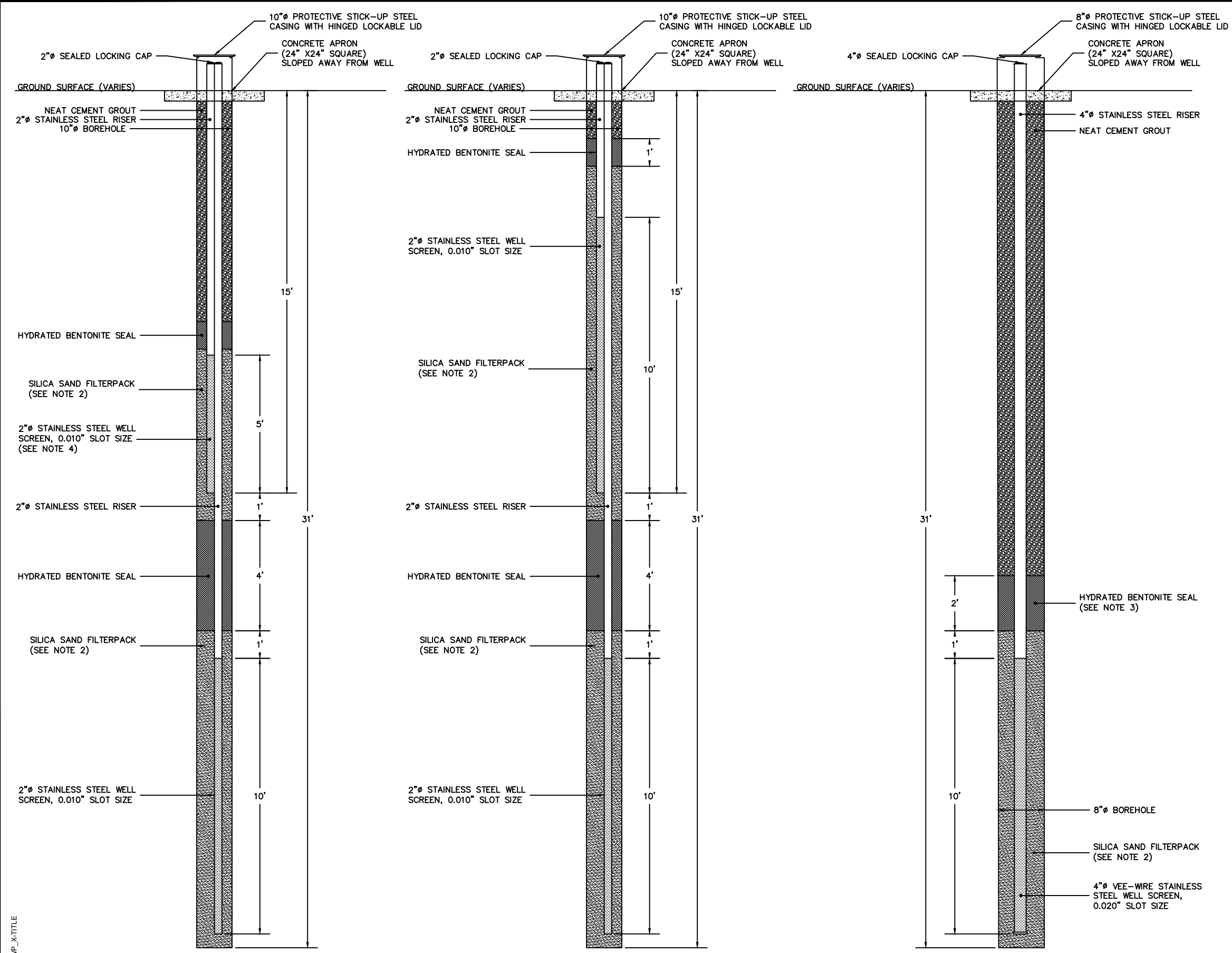
**PILOT TEST AREA AND PROPOSED LOCATIONS**

---

**ARCADIS** Design & Consultancy for natural and built assets

FIGURE  
**3**

CITY: SYRACUSE, NY DIV/GROUP: EBC-IMDV DBUILD: L POSENAUER PIM/TM: B MCCLINE LVR: ON+ OFF=REF (FRZ)  
 C:\Users\lpoenaue\OneDrive\Documents\BMS\_380\Acad\Drawings\BMS\_HIGHVAC-PTWP\_FIG04-PTW CONSTRUCTION DETAILS.dwg LAYOUT: 4  
 C:\Users\lpoenaue\OneDrive\Documents\BMS\_380\Acad\Drawings\BMS\_HIGHVAC-PTWP\_FIG04-PTW CONSTRUCTION DETAILS.dwg LAYOUT: 4  
 XREFS: BMS\_HIGHVAC-PTWP\_X-TITLE




**OBSERVATION WELL (TYP. OF OW-1, OW-3, AND OW-4)**  
NOT TO SCALE

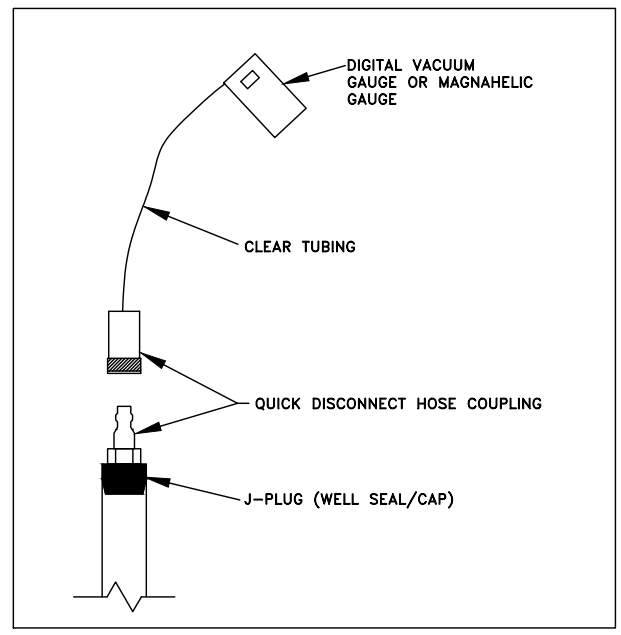
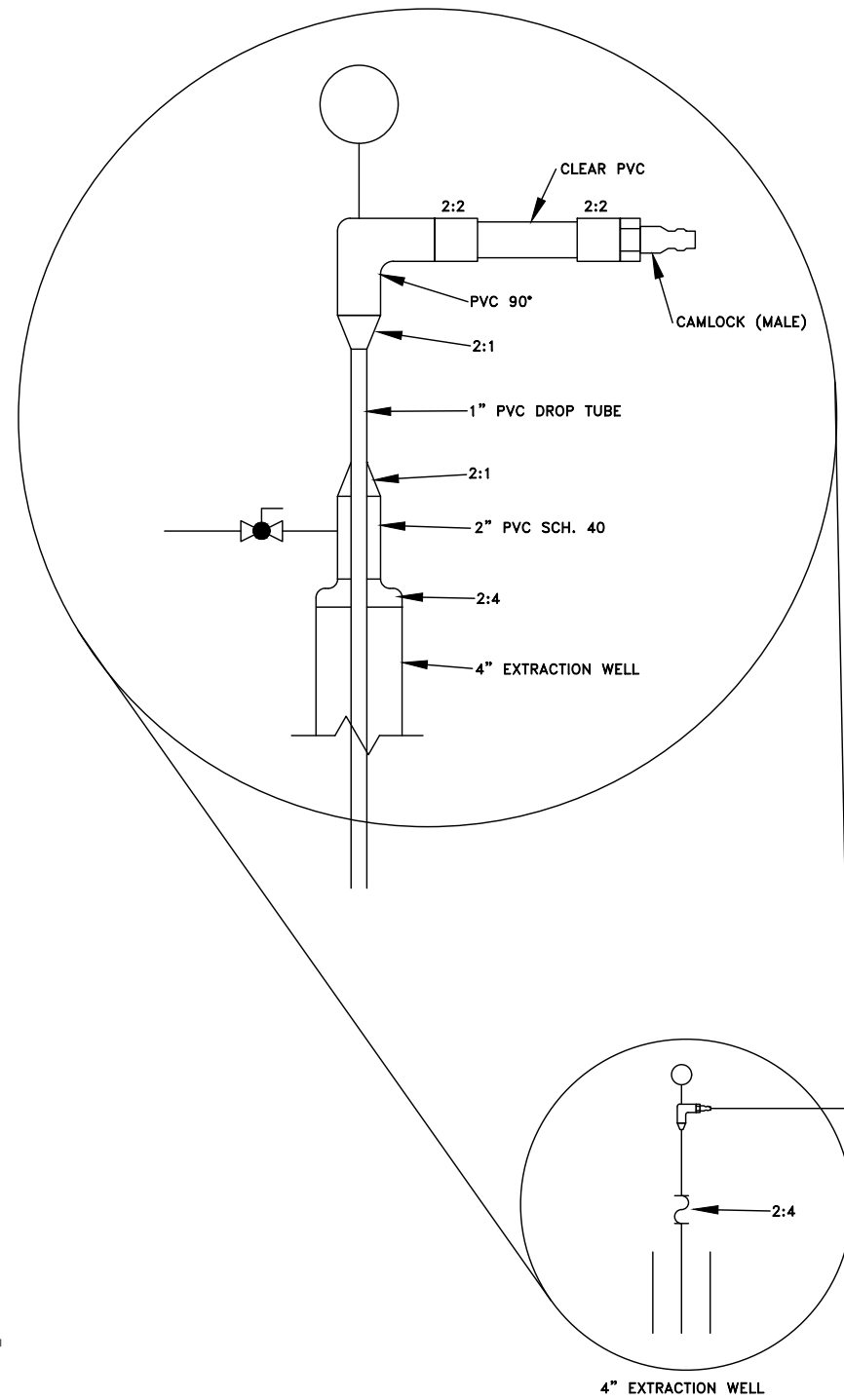
**OBSERVATION WELL (TYP. OF OW-2)**  
NOT TO SCALE

**EXTRACTION WELL TYP.**  
NOT TO SCALE

**NOTES:**

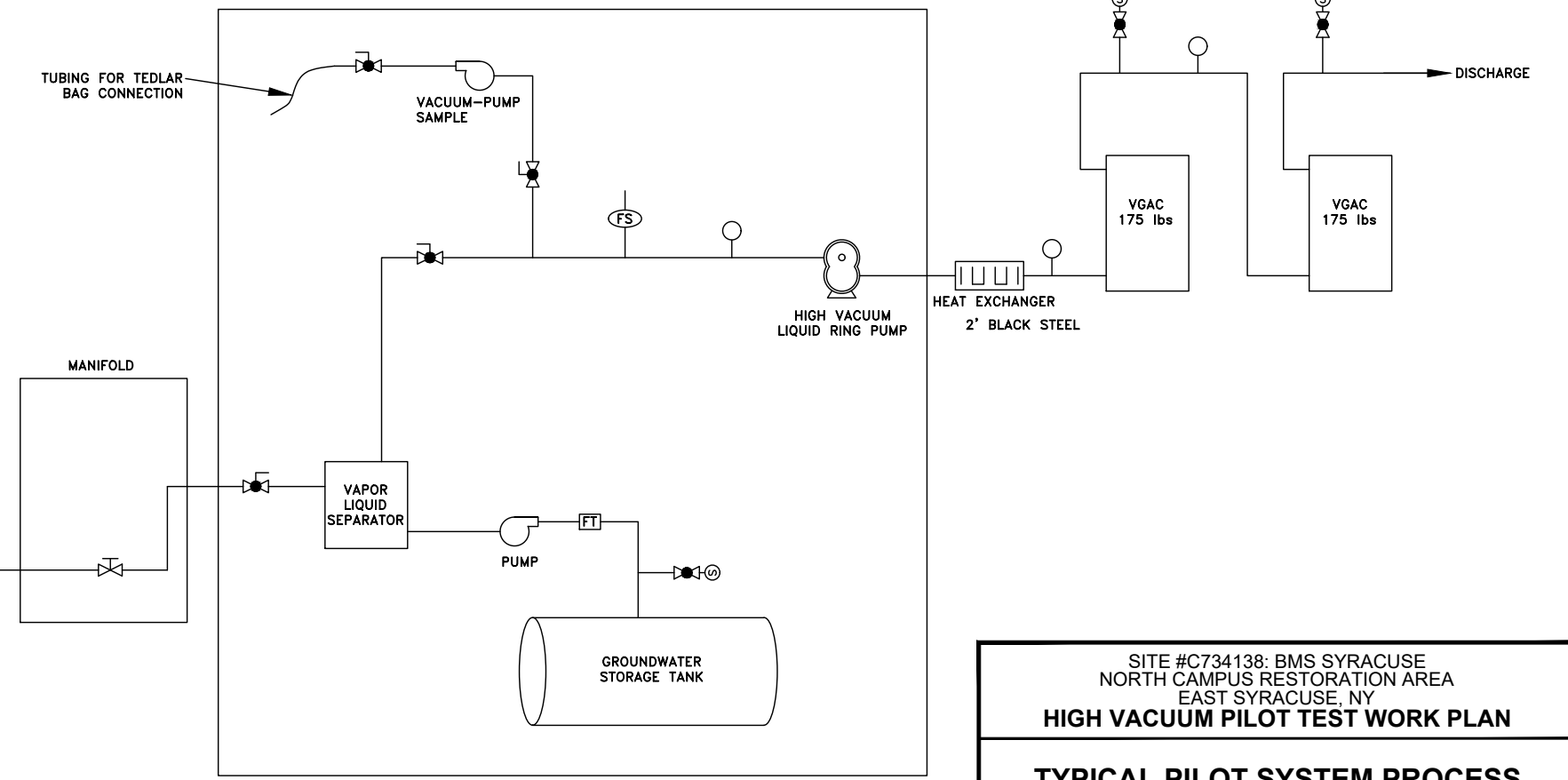
1. FINAL WELL INSTALLATION/COMPLETION DEPTHS TO BE DETERMINED BASED ON SOILS ENCOUNTERED DURING WELL INSTALLATION ACTIVITIES.
2. SILICA SAND FILTER PACK OF SIZE APPROPRIATE FOR THE FORMATION AND WELL SCREEN SLOT SIZE TO BE SELECTED IN CONSULTATION WITH ENGINEER.
3. BENTONITE SHALL BE PELL PLUG UNCOATED HIGH-YIELD PELLETS.
4. ACTUAL TOP OF SCREEN AND SCREEN LENGTH TO BE DETERMINED IN FIELD SUCH THAT SCREEN IS ENTIRELY WITHIN TILL LAYER AND WILL ACCOMMODATE HYDRATED BENTONITE SEAL INSTALLED BETWEEN THE SHALLOW AND DEEP OBSERVATION WELL SCREEN INTERVALS.

SITE #C734138: BMS SYRACUSE NORTH CAMPUS RESTORATION AREA EAST SYRACUSE, NY <b>HIGH VACUUM PILOT TEST WORK PLAN</b>	
<b>PILOT TEST WELL CONSTRUCTION DETAILS</b>	
	FIGURE <b>4</b>



VACUUM MEASUREMENT ASSEMBLY  
(OBSERVATION MONITORING WELL)

- LEGEND**
- BALL VALVE
  - GATE VALVE
  - SAMPLE PORT
  - FERNCO FITTING
  - FLOW TOTALIZER
  - FLOW SENSOR
  - VACUUM/PRESSURE GAUGE



MOBILE PILOT SYSTEM PLATFORM

SITE #C734138: BMS SYRACUSE  
 NORTH CAMPUS RESTORATION AREA  
 EAST SYRACUSE, NY  
**HIGH VACUUM PILOT TEST WORK PLAN**

**TYPICAL PILOT SYSTEM PROCESS  
 FLOW DIAGRAM**

# ATTACHMENT 1

QAPP Supplement



Sediment Sampling Module Addendum  
 Site #C734138: BMS Syracuse North Campus Restoration Area  
 East Syracuse, New York

Matrix	Parameter and Method	Sample Containers and Volumes	Preservation <sup>1</sup>	Holding Times	Number of Samples <sup>2</sup>	QA/QC Sample Frequency <sup>3</sup>				Total Number of Samples <sup>4</sup>
						Field Duplicate	Trip Blank	MS/MSD and/or MS/Lab Duplicate	Field Blank	
Soil	Volatile Organic Compounds (VOC) by USEPA Methods 8260C including top 10 tentatively identified compounds (TIC)	1 - 2-oz glass jar 2 - 40-mL glass vials with Teflon <sup>®</sup> lined septum caps 1 - 40-mL glass vials with Teflon <sup>®</sup> lined septum caps	6°C Deionized Water Methanol	Analysis within 48 hours from collection or frozen and analysis within 14 days; analysis within 14 days from extraction	2	One per 20 samples or one per matrix (for less than 20 samples)	1 each in cooler with VOC samples	One per 20 samples or one per matrix (for less than 20 samples)	One per 20 samples or one per sampling event as required for each matrix	6
Soil	Semivolatile Organic Compounds by USEPA Methods 8270D <sup>4</sup> including top 20 TIC	1 - 4 oz glass jar	6°C	Extraction within 7 days from collection; analysis within 40 days from extraction	2	One per 20 samples or one per matrix (for less than 20 samples)	NA	One per 20 samples or one per matrix (for less than 20 samples)	One per 20 samples or one per sampling event as required for each matrix	5
Soil	Glycols and alcohols by USEPA 8015D	2 - 4 oz mL glass jar	6°C	Analysis within 14 days of collection	2	One per 20 samples or one per matrix (for less than 20 samples)	NA	One per 20 samples or one per matrix (for less than 20 samples)	One per 20 samples or one per sampling event as required for each matrix	5
Soil	Formaldehyde, glutaraldehyde, and acetaldehyde by USEPA 8315A	1 - 4 oz glass jar	6°C	Analysis within 14 days of collection	2	One per 20 samples or one per matrix (for less than 20 samples)	NA	One per 20 samples or one per matrix (for less than 20 samples)	One per 20 samples or one per sampling event as required for each matrix	5
Air	VOC project specific list by USEPA Method TO-15 <sup>5</sup>	1 - 1 or 5 Liter Summa <sup>®</sup> Canister	None	Analysis within 30 days of collection	1	One per 20 samples or one per matrix (for less than 20 samples)	NA	NA	NA	1
Groundwater	Volatile Organic Compounds (VOC) by USEPA Methods 8260C	3 - 40-mL glass vials with Teflon <sup>®</sup> lined septum caps	6°C; HCl to pH ≤ 2; sealed and headspace free	Analysis within 14 days from collection for preserved samples; analysis within 7 days from collection for samples not acid preserved	1	One per 20 samples or one per matrix (for less than 20 samples)	1 each in cooler with VOC samples	One per 20 samples or one per matrix (for less than 20 samples)	One per 20 samples or one per sampling event as required for each matrix	5

Footnotes:

1. HCL indicates hydrochloric acid.
2. Number of samples is listed per sample event.
3. Quality assurance and quality control (QA/QC) samples, including matrix spikes and matrix spike duplicates (MS/MSD), will be collected using the frequencies detailed in the High Vacuum Extraction Pilot Test Work Plan. All QA/QC and parent samples will be processed, preserved, logged onto chain-of-custody forms, and be submitted to and analyzed by Eurofins Lancaster Laboratories located in Lancaster, Pennsylvania.
4. The following site-specific constituents were added to the standard list of semivolatile compounds analyzed by Method SW-846 8270D: Dicyclohexylamine, N,N-Dimethylaniline, and Triethylamine.
5. The site-specific TO-15 constituents will include the same parameters analyzed for during the Build 3 VI Assessment.

# ATTACHMENT 2

DAR-1 Air Dispersion Modeling Analysis





## **DAR-1 AIR DISPERSION MODELING ANALYSIS BRISTOL-MYERS SQUIBB COMPANY – SYRACUSE NORTH CAMPUS**

### **DAR-1 Dispersion Modeling Analysis Summary**

#### **Project Description and Regulatory Basis**

A dispersion modeling analysis following DAR-1 policy was performed to evaluate potential emissions during a high vacuum extraction pilot test that will be performed at the Bristol-Myers Squibb (BMS) North Campus Restoration Area, in Syracuse, New York (Site). The pilot test will be performed in relatively flat and open area situated near the center of the Site with few nearby buildings or other structures. The objective of the test is to determine whether high vacuum extraction is a viable technology for in-situ remediation of methylene chloride (dichloromethane) impacts present in soil and groundwater at the site. During the pilot test, soil vapor containing methylene chloride will be extracted from the subsurface by applying vacuum to a pilot test extraction well. The vacuum will be applied by a liquid ring pump or other high-vacuum extraction blower housed within a pilot test system platform. Carbon canisters (in series) are proposed for controlling emissions from the vapor extraction process. A 95% emissions reduction is expected from the carbon controls. Effluent from the carbon treatment train will be discharged to the atmosphere via a ten-foot tall discharge stack. The test is expected to last a maximum of five days.

This modeling analysis to demonstrate that the emissions from the pilot extraction test will comply with the NYS air toxics offsite impact thresholds will follow New York State (NYS) DAR-1 guidance.

#### **Model Selection**

DAR-1 guidance requires the use of United States Environmental Protection Agency (USEPA) approved air dispersion models, such as AERSCREEN or AERMOD, and following the modeling procedures in DAR-10, to determine the predicted maximum annual and short-term offsite air concentration for each air contaminant. AERSCREEN (version 16216) was used. AERSCREEN is a screening-level air quality dispersion model based upon EPA's AERMOD dispersion model which is recommended for evaluating potential air quality impacts under regulatory programs. AERMOD is steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. Several model options and input parameters are specified in order to customize the dispersion calculations to best approximate actual site aerodynamic conditions. The modeling inputs and parameters are discussed below.

#### **Estimated Emissions**

The expected emissions from the vapor extraction process pilot test extraction well were calculated using data from a recent air sample collected from pilot test extraction well. This sample was collected from the headspace within the well casing immediately above the standing groundwater level in the well, and the results are therefore representative of the highest methylene chloride concentrations that could potentially be present in the vapor recovery stream at the beginning of the test. Actual methylene chloride concentrations in the vapor recovery stream should be much lower during the test. As mentioned previously, dichloromethane (MeCl) is the main constituent found in the sampling analysis. Based on the

## DAR-1 AIR DISPERSION MODELING ANALYSIS

information provided in DAR-1, MeCl has been given a medium toxicity rating and therefore not classified as a High Toxicity Air Contaminant (HTAC).

The pilot test will be of short duration (~5 days), thus the uncontrolled and controlled short-term emissions are provided in the Table 1. If the pilot extraction process were of longer duration, the annual expected emissions would be estimated for MeCl and compared to the 100 lbs/yr criteria. The total potential controlled emissions of MeCl are expected to be far below this 100 lbs/yr or more criteria, to be subject to a Part 212 evaluation.

Even though the emissions are expected to be below the Part 212 evaluation criteria, offsite MeCl impacts are evaluated with respect to its Short-Term Guideline Concentration (SGC). A comparison to its Annual Guideline Concentration (AGC) would only be necessary if the test was long-term in nature.

The emissions calculations of MeCl derived from a recent air sample collected from pilot test extraction well are included in Appendix B.

**Table 1. MeCl Emissions**

Description	MeCl (lb/hr)	MeCl (g/s)	Total Pilot Test Amount (lbs/yr)	>100 lbs/yr? (Yes/No)
Uncontrolled	0.1124	0.0142	13.5	No
Controlled	5.6E-03	7.1E-04	0.67	No

[1] The emissions were based on concentrations determined from lab analysis, and 95% reduction based on the use of carbon (controlled).

### Source Input Parameters

The AERSCREEN model requires the input of data representing site-specific physical parameters in order to produce results that are representative of the actual site conditions. These data depend on the source type. The vapor extraction exhaust point was modeled as a point source. Stack data required for a point source include emission rate, stack height, diameter, exhaust gas temperature and velocity, as well as location based on coordinate system (typically either Universal Transverse Mercator (UTM) or site-specific coordinates). The input source parameters for the exhaust point are provided in Table 2.

**Table 2. Emission Source Parameters**

Description	Source Type	UTM Easting (m)	UTM Northing (m)	Stack Height (ft)	Stack Diameter (in)	Exhaust Flow Rate <sup>1</sup> (acfm)	Exhaust Temperature (F)
Vapor Extraction Exhaust	POINT	411,485	4,768,643	10	3	140	110

[1] Exit flow rates are conservatively based on the minimum flow rate necessary for the equipment and activity.

### Building Downwash

Nearby buildings and outlying topography can significantly affect the air dispersion patterns from the modeled source, resulting in conditions of aerodynamic downwash, including building cavity and wake

effects. The building cavity is a region of turbulent, re-circulating airflow which extends downwind a distance of approximately three building heights from the structure. The building wake is a turbulent zone that extends from the cavity zone to a downwind distance based on the dimensions of the nearby structures. If a pollutant plume is entrained within these regions, nearby impact concentrations can be higher than in the absence of such effects. The effects of building downwash can be determined by the EPA-approved Building Profile Input Program -Prime (BPIPPRM Version 04274) to calculate the direction-specific building dimensions for each wind direction (10-degree increments) used by AERSCREEN when accounting for the effects of building downwash.

The buildings in the North Campus restoration site and pilot test extraction area have been demolished. Thus, there are no structures nearby (within five times the lesser of the height or the width of a structure, 5L) and the exhaust point will lie outside of any building downwash influence. Therefore, building downwash is not included in the AERSCREEN model setup.

### **Meteorological Data**

A conservative “default” set of meteorological data was utilized for the modeling analysis. As part of the meteorological inputs, it is necessary to derive the land use coefficients for the area surrounding the plant so that the model can account for surface features, such as the presence of vegetation, water bodies, open spaces, or wooded areas. To do this, a matrix of site-specific screening meteorological conditions was developed based on site-specific surface characteristics generated from the EPA’s AERSURFACE utility. AERSURFACE was executed using the recommended default radius of 1 kilometer for surface roughness lengths. The 1-kilometer distance was based on the extraction location coordinates in Table 2. The study area topography and land cover were divided into 12 sectors to account for variation in surface coefficients expected with changes in direction. Coefficients were generated on a seasonal temporal resolution for “average” surface moisture conditions.

The MAKEMET program within the AERSCREEN interface was utilized to generate surface and profile meteorological files.

### **Receptors and Terrain**

An automated receptor grid was generated by AERSCREEN. Receptors for analysis were placed at 25-meter intervals out to 1000 meters. The minimum distance to near fence line/property line (ambient air) from the extraction location is 350 feet (106 meters). All receptors were modeled at ground-level. The analysis assumed flat terrain.

### **Results**

The modeling analysis was completed for MeCl. The predicted short-term (or 1-hour) are summarized in Table 3. As shown in the table, the short-term impacts are in compliance with the respective guideline concentrations. Therefore, the evaluation demonstrates the BMS pilot extraction test complies with Part 212 and DAR-1 requirements.

## DAR-1 AIR DISPERSION MODELING ANALYSIS

**Table 3. Summary of AERSCREEN Results for MeCl**

Contaminant	CAS No.	Emissions Option (lb/hr)	SGC ( $\mu\text{g}/\text{m}^3$ )	AGC ( $\mu\text{g}/\text{m}^3$ )	Predicted 1-hr Impact <sup>1</sup> ( $\mu\text{g}/\text{m}^3$ )
MeCl	75-09-02	Uncontrolled	14,000	60	41.1
		Controlled			2.06

1. Predicted short-term impacts occurred at the fence line.

The AERSCREEN and AERSURFACE modeling files are provided in Appendix A of this report.

### References

1. NYSDEC. 2016. DAR-1: Guidelines for the Evaluation and Control of Ambient Air Contaminants Under Part 212. New York State Department of Environmental Conservation. August 10, 2016.
2. USEPA. 2013. AERSURFACE User's Guide. EPA-454/B-08-001. January 2008 (Revised January 16, 2013).
3. USEPA. 2016. AERSCREEN User's Guide. EPA-454/B-16-00. December 2016.

**APPENDIX A**  
**AERSCREEN MODELING FILES**

AERSCREEN 16216 / AERMOD 18081

10/07/19  
10:13:34

TITLE: BMS PILOT STUDY - METHYLENE CHLORIDE - CONTROLLED (FENCE LINE)

\*\*\*\*\* STACK PARAMETERS \*\*\*\*\*

SOURCE EMISSION RATE: 0.710E-03 g/s 0.563E-02 lb/hr  
 STACK HEIGHT: 3.05 meters 10.00 feet  
 STACK INNER DIAMETER: 0.076 meters 3.00 inches  
 PLUME EXIT TEMPERATURE: 316.5 K 110.0 Deg F  
 PLUME EXIT VELOCITY: 14.491 m/s 47.54 ft/s  
 STACK AIR FLOW RATE: 140 ACFM  
 RURAL OR URBAN: RURAL  
 INITIAL PROBE DISTANCE = 1500. meters 4921. feet

\*\*\*\*\* BUILDING DOWNWASH PARAMETERS \*\*\*\*\*

NO BUILDING DOWNWASH HAS BEEN REQUESTED FOR THIS ANALYSIS

\*\*\*\*\* PROBE ANALYSIS \*\*\*\*\*

25 meter receptor spacing: 106. meters - 1500. meters

Zo SECTOR	ROUGHNESS LENGTH	1-HR CONC (ug/m3)	DIST (m)	TEMPORAL PERIOD
1	0.483	1.456	106.0	WIN
2	0.550	1.348	106.0	WIN
3	0.584	1.277	106.0	WIN
4	0.623	1.174	106.0	WIN
5	0.501	1.428	106.0	WIN
6	0.323	1.736	106.0	WIN
7*	0.202	2.056	106.0	WIN
8	0.390	1.620	106.0	WIN
9	0.513	1.407	106.0	WIN
10	0.636	1.134	106.0	WIN
11	0.622	1.175	106.0	WIN
12	0.557	1.337	106.0	WIN

\* = worst case flow sector

\*\*\*\*\* MAKEMET METEOROLOGY PARAMETERS \*\*\*\*\*

MIN/MAX TEMPERATURE: 250.0 / 310.0 (K)  
 MINIMUM WIND SPEED: 0.5 m/s  
 ANEMOMETER HEIGHT: 10.000 meters  
 SURFACE CHARACTERISTICS INPUT: C:\Projects\BMS (NY)\AERSURFACE\BMS\_AERSURFACE.out  
 DOMINANT SECTOR: 7 (180 210)  
 DOMINANT SEASON: Winter  
 ALBEDO: 0.44  
 BOWEN RATIO: 0.50  
 ROUGHNESS LENGTH: 0.202 (meters)  
 SURFACE FRICTION VELOCITY (U\*) NOT ADJUSTED

METEOROLOGY CONDITIONS USED TO PREDICT OVERALL MAXIMUM IMPACT

YR MO DY JDY HR  
 10 04 06 6 01

H0	U*	W*	DT/DZ	ZICNV	ZIMCH	M-O LEN	Z0	BOWEN	ALBEDO	REF WS
-9.41	0.103	-9.000	0.020	-999.	75.	10.9	0.202	0.50	0.44	2.00

HT	REF TA	HT
10.0	310.0	2.0

WIND SPEED AT STACK HEIGHT (non-downwash): 1.0 m/s  
 STACK-TIP DOWNWASH ADJUSTED STACK HEIGHT: 3.0 meters  
 ESTIMATED FINAL PLUME RISE (non-downwash): 1.1 meters  
 ESTIMATED FINAL PLUME HEIGHT (non-downwash): 4.2 meters

METEOROLOGY CONDITIONS USED TO PREDICT AMBIENT BOUNDARY IMPACT

YR MO DY JDY HR

10 04 06 6 01

H0 U\* W\* DT/DZ ZICNV ZIMCH M-O LEN Z0 BOWEN ALBEDO REF WS  
 -9.41 0.103 -9.000 0.020 -999. 75. 10.9 0.202 0.50 0.44 2.00

HT REF TA HT  
 10.0 310.0 2.0

WIND SPEED AT STACK HEIGHT (non-downwash): 1.0 m/s  
 STACK-TIP DOWNWASH ADJUSTED STACK HEIGHT: 3.0 meters  
 ESTIMATED FINAL PLUME RISE (non-downwash): 1.1 meters  
 ESTIMATED FINAL PLUME HEIGHT (non-downwash): 4.2 meters

\*\*\*\*\* AERSCREEN AUTOMATED DISTANCES \*\*\*\*\*  
 OVERALL MAXIMUM CONCENTRATIONS BY DISTANCE

DIST (m)	MAXIMUM 1-HR CONC (ug/m3)	DIST (m)	MAXIMUM 1-HR CONC (ug/m3)
106.00	2.056	825.00	0.4705
125.00	1.738	850.00	0.4634
150.00	1.421	875.00	0.4562
175.00	1.197	900.00	0.4490
200.00	1.042	925.00	0.4419
225.00	0.9152	950.00	0.4348
250.00	0.8118	975.00	0.4277
275.00	0.7391	1000.00	0.4207
300.00	0.6773	1025.00	0.4138
325.00	0.6231	1050.00	0.4070
350.00	0.5754	1075.00	0.4003
375.00	0.5334	1100.00	0.3937
400.00	0.5038	1125.00	0.3872
425.00	0.5157	1150.00	0.3808
450.00	0.5217	1175.00	0.3746
475.00	0.5245	1200.00	0.3684
500.00	0.5251	1225.00	0.3624
525.00	0.5262	1250.00	0.3566
550.00	0.5264	1275.00	0.3508
575.00	0.5251	1300.00	0.3452
600.00	0.5225	1325.00	0.3396
625.00	0.5189	1350.00	0.3343
650.00	0.5145	1375.00	0.3290
675.00	0.5094	1400.00	0.3238
700.00	0.5037	1425.00	0.3188
725.00	0.4976	1450.00	0.3138
750.00	0.4911	1475.00	0.3090
775.00	0.4844	1500.00	0.3043
800.00	0.4775		

\*\*\*\*\* AERSCREEN MAXIMUM IMPACT SUMMARY \*\*\*\*\*

CALCULATION PROCEDURE	MAXIMUM 1-HOUR CONC (ug/m3)	SCALED 3-HOUR CONC (ug/m3)	SCALED 8-HOUR CONC (ug/m3)	SCALED 24-HOUR CONC (ug/m3)	SCALED ANNUAL CONC (ug/m3)
FLAT TERRAIN	2.056	2.056	1.850	1.234	0.2056
DISTANCE FROM SOURCE	106.00 meters				
IMPACT AT THE AMBIENT BOUNDARY	2.056	2.056	1.850	1.234	0.2056
DISTANCE FROM SOURCE	106.00 meters				

AERSCREEN 16216 / AERMOD 18081

10/07/19  
10:18:32

TITLE: BMS PILOT STUDY - METHYLENE CHLORIDE (FENCE LINE) UNCONTROLLED

\*\*\*\*\* STACK PARAMETERS \*\*\*\*\*

SOURCE EMISSION RATE: 0.0142 g/s 0.113 lb/hr  
 STACK HEIGHT: 3.05 meters 10.00 feet  
 STACK INNER DIAMETER: 0.076 meters 3.00 inches  
 PLUME EXIT TEMPERATURE: 316.5 K 110.0 Deg F  
 PLUME EXIT VELOCITY: 14.491 m/s 47.54 ft/s  
 STACK AIR FLOW RATE: 140 ACFM  
 RURAL OR URBAN: RURAL  
 INITIAL PROBE DISTANCE = 1500. meters 4921. feet

\*\*\*\*\* BUILDING DOWNWASH PARAMETERS \*\*\*\*\*

NO BUILDING DOWNWASH HAS BEEN REQUESTED FOR THIS ANALYSIS

\*\*\*\*\* PROBE ANALYSIS \*\*\*\*\*

25 meter receptor spacing: 106. meters - 1500. meters

Zo SECTOR	ROUGHNESS LENGTH	1-HR CONC (ug/m3)	DIST (m)	TEMPORAL PERIOD
1	0.483	29.13	106.0	WIN
2	0.550	26.96	106.0	WIN
3	0.584	25.54	106.0	WIN
4	0.623	23.49	106.0	WIN
5	0.501	28.56	106.0	WIN
6	0.323	34.73	106.0	WIN
7*	0.202	41.12	106.0	WIN
8	0.390	32.40	106.0	WIN
9	0.513	28.14	106.0	WIN
10	0.636	22.68	106.0	WIN
11	0.622	23.51	106.0	WIN
12	0.557	26.73	106.0	WIN

\* = worst case flow sector

\*\*\*\*\* MAKEMET METEOROLOGY PARAMETERS \*\*\*\*\*

MIN/MAX TEMPERATURE: 250.0 / 310.0 (K)  
 MINIMUM WIND SPEED: 0.5 m/s  
 ANEMOMETER HEIGHT: 10.000 meters  
 SURFACE CHARACTERISTICS INPUT: C:\Projects\BMS (NY)\AERSURFACE\BMS\_AERSURFACE.out  
 DOMINANT SECTOR: 7 (180 210)  
 DOMINANT SEASON: Winter  
 ALBEDO: 0.44  
 BOWEN RATIO: 0.50  
 ROUGHNESS LENGTH: 0.202 (meters)  
 SURFACE FRICTION VELOCITY (U\*) NOT ADJUSTED

METEOROLOGY CONDITIONS USED TO PREDICT OVERALL MAXIMUM IMPACT

YR MO DY JDY HR  
 10 04 06 6 01

H0	U*	W*	DT/DZ	ZICNV	ZIMCH	M-O LEN	Z0	BOWEN	ALBEDO	REF WS
-9.41	0.103	-9.000	0.020	-999.	75.	10.9	0.202	0.50	0.44	2.00

HT	REF TA	HT
10.0	310.0	2.0

WIND SPEED AT STACK HEIGHT (non-downwash): 1.0 m/s  
 STACK-TIP DOWNWASH ADJUSTED STACK HEIGHT: 3.0 meters  
 ESTIMATED FINAL PLUME RISE (non-downwash): 1.1 meters  
 ESTIMATED FINAL PLUME HEIGHT (non-downwash): 4.2 meters



METEOROLOGY CONDITIONS USED TO PREDICT AMBIENT BOUNDARY IMPACT

YR MO DY JDY HR

10 04 06 6 01

H0 U\* W\* DT/DZ ZICNV ZIMCH M-O LEN Z0 BOWEN ALBEDO REF WS  
 -9.41 0.103 -9.000 0.020 -999. 75. 10.9 0.202 0.50 0.44 2.00

HT REF TA HT  
 10.0 310.0 2.0

WIND SPEED AT STACK HEIGHT (non-downwash): 1.0 m/s  
 STACK-TIP DOWNWASH ADJUSTED STACK HEIGHT: 3.0 meters  
 ESTIMATED FINAL PLUME RISE (non-downwash): 1.1 meters  
 ESTIMATED FINAL PLUME HEIGHT (non-downwash): 4.2 meters

\*\*\*\*\* AERSCREEN AUTOMATED DISTANCES \*\*\*\*\*  
 OVERALL MAXIMUM CONCENTRATIONS BY DISTANCE

DIST (m)	MAXIMUM 1-HR CONC (ug/m3)	DIST (m)	MAXIMUM 1-HR CONC (ug/m3)
106.00	41.12	825.00	9.410
125.00	34.76	850.00	9.268
150.00	28.42	875.00	9.124
175.00	23.95	900.00	8.981
200.00	20.83	925.00	8.838
225.00	18.30	950.00	8.695
250.00	16.24	975.00	8.554
275.00	14.78	1000.00	8.414
300.00	13.55	1025.00	8.276
325.00	12.46	1050.00	8.140
350.00	11.51	1075.00	8.005
375.00	10.67	1100.00	7.873
400.00	10.08	1125.00	7.744
425.00	10.31	1150.00	7.616
450.00	10.43	1175.00	7.491
475.00	10.49	1200.00	7.369
500.00	10.50	1225.00	7.249
525.00	10.52	1250.00	7.131
550.00	10.53	1275.00	7.016
575.00	10.50	1300.00	6.903
600.00	10.45	1325.00	6.793
625.00	10.38	1350.00	6.685
650.00	10.29	1375.00	6.580
675.00	10.19	1400.00	6.476
700.00	10.07	1425.00	6.375
725.00	9.951	1450.00	6.277
750.00	9.823	1475.00	6.180
775.00	9.688	1500.00	6.086
800.00	9.551		

\*\*\*\*\* AERSCREEN MAXIMUM IMPACT SUMMARY \*\*\*\*\*

CALCULATION PROCEDURE	MAXIMUM 1-HOUR CONC (ug/m3)	SCALED 3-HOUR CONC (ug/m3)	SCALED 8-HOUR CONC (ug/m3)	SCALED 24-HOUR CONC (ug/m3)	SCALED ANNUAL CONC (ug/m3)
FLAT TERRAIN	41.12	41.12	37.01	24.67	4.112
DISTANCE FROM SOURCE	106.00 meters				
IMPACT AT THE AMBIENT BOUNDARY	41.12	41.12	37.01	24.67	4.112
DISTANCE FROM SOURCE	106.00 meters				

\*\* Generated by AERSURFACE, dated 13016  
 \*\* Generated from "new\_york\_NLCD\_flat\_070600.bin"  
 \*\* Center Latitude (decimal degrees): 43.065333  
 \*\* Center Longitude (decimal degrees): -76.087111  
 \*\* Datum: NAD83  
 \*\* Study radius (km) for surface roughness: 1.0  
 \*\* Airport? N, Continuous snow cover? Y  
 \*\* Surface moisture? Average, Arid region? N  
 \*\* Month/Season assignments? Default  
 \*\* Late autumn after frost and harvest, or winter with no snow: 0  
 \*\* Winter with continuous snow on the ground: 12 1 2  
 \*\* Transitional spring (partial green coverage, short annuals): 3 4 5  
 \*\* Midsummer with lush vegetation: 6 7 8  
 \*\* Autumn with unharvested cropland: 9 10 11

FREQ_SECT	SEASONAL 12		
SECTOR 1	0	30	
SECTOR 2	30	60	
SECTOR 3	60	90	
SECTOR 4	90	120	
SECTOR 5	120	150	
SECTOR 6	150	180	
SECTOR 7	180	210	
SECTOR 8	210	240	
SECTOR 9	240	270	
SECTOR 10	270	300	
SECTOR 11	300	330	
SECTOR 12	330	360	

** SITE_CHAR	Season	Sect	Alb	Bo	Zo
SITE_CHAR 1	1	1	0.44	0.50	0.483
SITE_CHAR 1	1	2	0.44	0.50	0.550
SITE_CHAR 1	1	3	0.44	0.50	0.584
SITE_CHAR 1	1	4	0.44	0.50	0.623
SITE_CHAR 1	1	5	0.44	0.50	0.501
SITE_CHAR 1	1	6	0.44	0.50	0.323
SITE_CHAR 1	1	7	0.44	0.50	0.202
SITE_CHAR 1	1	8	0.44	0.50	0.390
SITE_CHAR 1	1	9	0.44	0.50	0.513
SITE_CHAR 1	1	10	0.44	0.50	0.636
SITE_CHAR 1	1	11	0.44	0.50	0.622
SITE_CHAR 1	1	12	0.44	0.50	0.557
SITE_CHAR 2	2	1	0.16	0.81	0.565
SITE_CHAR 2	2	2	0.16	0.81	0.661
SITE_CHAR 2	2	3	0.16	0.81	0.683
SITE_CHAR 2	2	4	0.16	0.81	0.677
SITE_CHAR 2	2	5	0.16	0.81	0.567
SITE_CHAR 2	2	6	0.16	0.81	0.427
SITE_CHAR 2	2	7	0.16	0.81	0.316
SITE_CHAR 2	2	8	0.16	0.81	0.484
SITE_CHAR 2	2	9	0.16	0.81	0.594
SITE_CHAR 2	2	10	0.16	0.81	0.708
SITE_CHAR 2	2	11	0.16	0.81	0.673
SITE_CHAR 2	2	12	0.16	0.81	0.620
SITE_CHAR 3	3	1	0.17	0.72	0.585
SITE_CHAR 3	3	2	0.17	0.72	0.692
SITE_CHAR 3	3	3	0.17	0.72	0.727
SITE_CHAR 3	3	4	0.17	0.72	0.708
SITE_CHAR 3	3	5	0.17	0.72	0.636
SITE_CHAR 3	3	6	0.17	0.72	0.558
SITE_CHAR 3	3	7	0.17	0.72	0.509
SITE_CHAR 3	3	8	0.17	0.72	0.538
SITE_CHAR 3	3	9	0.17	0.72	0.601
SITE_CHAR 3	3	10	0.17	0.72	0.712
SITE_CHAR 3	3	11	0.17	0.72	0.688
SITE_CHAR 3	3	12	0.17	0.72	0.669
SITE_CHAR 4	4	1	0.17	1.06	0.581
SITE_CHAR 4	4	2	0.17	1.06	0.692
SITE_CHAR 4	4	3	0.17	1.06	0.727
SITE_CHAR 4	4	4	0.17	1.06	0.708
SITE_CHAR 4	4	5	0.17	1.06	0.634
SITE_CHAR 4	4	6	0.17	1.06	0.553
SITE_CHAR 4	4	7	0.17	1.06	0.503
SITE_CHAR 4	4	8	0.17	1.06	0.537
SITE_CHAR 4	4	9	0.17	1.06	0.601
SITE_CHAR 4	4	10	0.17	1.06	0.712
SITE_CHAR 4	4	11	0.17	1.06	0.687
SITE_CHAR 4	4	12	0.17	1.06	0.669

## **APPENDIX B**

### **EMISSION CALCULATIONS**

**Bristol-Myers Squibb Company –Syracuse North Campus Restoration Area**  
**Extraction Pilot Test**  
**Calculation of Potential Short-term Emissions**

Constituent	Sample Location	CAS No.	MW (g/mol)	NY SCG	Max Concentration Detected <sup>(1)</sup>	
				(ug/m3)	(ppm)	(ug/m3)
Methylene Chloride	EW-1 (Lab data)	75-09-02	84.93	14,000	458	1,500,000

Estimated Max Airflow Rate from Extraction Well During Pilot Test: 20 scfm

Estimated max short-term emission rate during pilot test:	Uncontrolled	0.01416 g/s
	Controlled <sup>(2)</sup>	0.00071 g/s
	Uncontrolled	0.1124 lb/hr
	Controlled <sup>(2)</sup>	0.0056 lb/hr

Estimated emissions during pilot test:	Uncontrolled	13.49 lbs/pilot test
	Controlled <sup>(2)</sup>	0.67 lbs/pilot test

**Notes:**

(1) Based on data from a recent air sample collected from pilot test extraction well. Sample collected from the headspace within the well casing immediately above the standing groundwater level in the well.

(2) Assumes carbon treatment with 2 vessels in series and resulting in 95% reduction of ambient concentrations.

$$\text{ug}/\text{m}^3 = (\text{ppm} * P * \text{mw}) / (R * T)$$

P = 1 atm

mw = varies per compound

T = 110 F = 316 K (max estimated SVE exhaust temperature post heat exchanger)

R = 8.205 \* 10<sup>-5</sup> (m<sup>3</sup> \* atm / mole \* k)

Constituent	MW (g/mol)	%	LEL?		OSHA/NIOSH Limits			NY SCG (ug/m3)	Max Concentration Detected <sup>(1)</sup>		location	
			LFL	ppm	(ug/m3)	PEL (ppm)	STEL (ppm)		LILH (ppm)	(ppm)		(ug/m3)
Methylene Chloride	84.93	12.00%		120000	393,076,158	25	124	2,300	14,000	458	1,500,000	EW-1 (Lab data)
Estimated Max Airflow Rate from Extraction Well During Pilot Test					20 scfm					(ppb) 457,927	1,590,663	
Estimated max short-term emission rate during pilot				Uncontrolled	0.01416 g/s		0.1124 lb/hr			0.0150162 g/s		
				Controlled <sup>(2)</sup>	0.00071 g/s		0.0056 lb/hr			0.0007508 g/s		

**Notes**

- (1) Based on max PID reading recorded in till from boring logs for existing wells in pilot test area. Assumes PID detections are 100% MeCl, which is considered appropriate based on contaminate distribution from available soil and GW data for the pilot test area.
- (2) Assumes carbon treatment with 2 vessels in series and resulting 90% reduction in concentrations

$$ug/m^3 = (ppm * P * mw) / (R * T)$$

P = 1 atm  
mw = varies per compound  
T = 110 F = 316 K (max estimated SVE exhaust temperature post heat exchanger)  
R = 8.205 \* 10<sup>-5</sup> (m<sup>3</sup> \* atm / mole \* k)

	Pilot Test Total	8760 hrs Total
	lb/yr	lb/yr
uncontrolled	13.49	984.48
Controlled	0.67	49.22

1 g/m3 = 1 mg/L = 1 ppm  
molar volume at 1 atm and 25°C is 24.45 L.

Constituent	MW (g/mol)	%	LFL		OSHA/NIOSH Limits			NY SCG (ug/m3)	Max Concentration Detected <sup>(1)</sup>		location
			ppm	(ug/m3)	PEL (ppm)	STEL (ppm)	LILH (ppm)		(ppm)	(ug/m3)	
Methylene Chloride	84.93	12.00%	120000	393,076,158	25	124	2,300	14,000	219 (ppb)	717,364	CHP43RX - 26-28 ft bgs
Estimated Max Airflow Rate from Extraction Well During Pilot Test				20 scfm					219,000	760,723	
Estimated max short-term emission rate during pilot				Uncontrolled	0.0067721 g/s		0.0537 lb/hr			0.0071814 g/s	
				Controlled <sup>(2)</sup>	0.0003386 g/s		0.0027 lb/hr			0.0003591 g/s	

**Notes**

- (1) Based on max PID reading recorded in till from boring logs for existing wells in pilot test area. Assumes PID detections are 100% MeCl, which is considered appropriate based on contaminate distribution from available soil and GW data for the pilot test area.
- (2) Assumes carbon treatment with 2 vessels in series and resulting 90% reduction in concentrations

$$ug/m^3 = (ppm * P * mw) / (R * T)$$

P = 1 atm  
mw = varies per compound  
T = 110 F = 316 K (max estimated SVE exhaust temperature post heat exchanger)  
R = 8.205 \* 10<sup>-5</sup> (m<sup>3</sup> \* atm / mole \* k)

1 g/m3 = 1 mg/L = 1 ppm  
molar volume at 1 atm and 25°C is 24.45 L.

# ATTACHMENT 3

Major Equipment Specifications



Operating &  
Maintenance  
Manual

*for* **Liquid Ring  
Vacuum Pumps,  
Compressors  
& Systems**



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Continuing research of TRAVAINI PUMPS USA results in product improvements; therefore any specifications may be subject to change without notice.

PRINTED IN USA  
F:/MVUOTGB4

DATE 4/02

**TRH-TRS-TRM-TRV-SA**  
**Water Sealed & Oil Sealed (DynaSeal™)**  
**Systems**





# **OPERATING MANUAL FOR INSTALLATION, START-UP AND MAINTENANCE FOR LIQUID RING VACUUM PUMPS, COMPRESSORS AND SYSTEMS**

This manual applies to TRAVAINI PUMPS USA liquid ring pumps single stage series TRM, TRS, TRV, double stage series TRH, compressors series SA and systems series water sealed and oil sealed (DynaSeal™) Systems, which utilize above pump series. (Please see section 18 or 19 for details pertaining to systems).

**NOTE:** Unless otherwise specified, the term pump used throughout this manual means also pump/motor assembly or system type water sealed or oil sealed (DynaSeal™).

## **MANUFACTURER:**

### **TRAVAINI PUMPS USA**

200 Newsome Drive  
Yorktown, VA 23692  
Telephone: (757) 988-3930  
Fax: (757) 988-3975  
Website: [www.travaini.com](http://www.travaini.com)

## **WARRANTY:**

All products manufactured by TRAVAINI PUMPS USA are guaranteed to meet the conditions listed on the general terms & conditions of sales and/or conditions listed on the order confirmations. Failure to strictly adhere to the instructions and recommendations listed in this manual, will void the manufacturer's warranty. Detailed warranty policy can be found in Section 21.

## **PROPRIETY DOCUMENT:**

This document and the information enclosed herein are proprietary to Travaini Pumps USA and must, along with any copies, be returned upon demand. Reproduction or use of any information disclosed herein, or the manufacture of any assembly or part depicted herein is permissible only to the extent expressly authorized in writing by Travaini Pumps USA on and for which this document is provided.

In preparing this manual, every possible effort has been made to help the customer and operator with the proper installation and operation of the pump and/or system. Should you find errors, misunderstandings or discrepancies please do not hesitate to bring them to our attention.

## **OUR PRODUCTS**

**LIQUID RING  
VACUUM PUMPS**

**LIQUID RING COMPRESSORS**

**ROTARY VANE VACUUM PUMPS**

**ROTARY VANE VACUUM SYSTEMS**

**MEDICAL SYSTEMS (NFPA99)**

**PACKAGE VACUUM SYSTEMS  
WITH PARTIAL OR TOTAL  
SERVICE RECIRCULATION**

**CUSTOM ENGINEERED  
VACUUM SOLUTIONS**

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# 1 – GENERAL INSTRUCTIONS

This manual is intended to provide reference to:

- application and operating safety
- installation and maintenance for pump or system
- starting, operating and stopping procedures for pump or system

NOTE: All references made to pumps are also applicable to systems that employ these pumps, unless otherwise specified.

Upon receipt of this manual, the operator should complete the Product Data sheet with the requested data. The manual should then be read **CAREFULLY** and kept in a safe file for future reference. It should always be available to the qualified operating and maintenance personnel responsible for the safe operation of the pump or system. (Qualified personnel should be experienced and knowledgeable of Safety Standards, should be recognized by the safety department manager as being capable to effectively act on safety issues, should the need arise and knowledge of first aid should also be required).

	<p>The pump is to be used only for the applications specified on the confirming order for which TRAVAINI PUMPS USA has selected the design, materials of construction and tested the pump to meet the order specifications. Therefore, the pump or system <b>CANNOT</b> be used for applications other than those specified on the order confirmation.</p>
---	--

In the event the pump is to be used for different applications, please consult TRAVAINI PUMPS USA or a representative of the manufacturer. TRAVAINI PUMPS USA declines to assume any responsibility if the pump is used for different applications without prior written consent. The user is responsible for the verification of the ambient conditions where the pump will be stored or installed. Extreme low or high temperatures may severely damage the pump or system unless proper precautions are taken. TRAVAINI PUMPS USA does not guarantee repairs or alterations done by user or other unauthorized personnel. Special designs and constructions may vary from the information given in this manual. Please contact TRAVAINI PUMPS USA should you have any difficulty or doubt.

NOTE: Drawings appearing in this manual are only schematics. These drawings are not for construction.

# 2 - SAFETY INSTRUCTIONS

	<p><b>CAUTION: CAREFULLY READ FOLLOWING INSTRUCTIONS. STRICTLY ADHERE TO THE INSTRUCTIONS LISTED BELOW TO PREVENT PERSONAL INJURIES AND/OR EQUIPMENT DAMAGE.</b></p>
---	--

- **ALWAYS** apply the pump for the conditions outlined on the confirming order.
- Electrical connections on the motor or accessories must **ALWAYS** be carried out by authorized personnel and in accordance to the local codes.
- Any work on the pump should be carried out by at least 2 people.

When approaching the pump **ALWAYS** be properly dressed (avoid use of clothing with wide sleeves, neckties, necklaces, etc.) and/or wear safety equipment (hard hat, safety glasses, safety shoes, etc.) adequate for the work to be done.

- **ALWAYS** stop the pump prior to touching it, regardless of the reason.
- **ALWAYS** disconnect the power to the motor prior to working or removing the pump from the installation.
- **NEVER** work on the pump when it is hot.
- After completion of the work **ALWAYS** re-install the safety guards previously removed.
- **ALWAYS** be careful when handling pumps that convey acids or hazardous fluids.
- **ALWAYS** has a fire extinguisher in the vicinity of the pump installation.
- **DO NOT** operate the pump in the wrong direction of rotation.
- **NEVER** put hands or fingers in the pump or system openings or cavities.
- **NEVER** step on pump and/or piping connected to the pump.
- Pump or piping (connected to the pump) must **NEVER** be under pressure or vacuum when maintenance or repair is carried out.

NOTE: There are materials in the pump that may be hazardous to people suffering from allergies. Maintenance and operating personnel should consult Table 1 for such materials.

TABLE 1

MATERIAL	USE	POSSIBLE DANGER
Oil and Grease	General lubrication, ball or roller bearings	Skin and eye irritation
Plastic and elastomer components	O-Ring, V-Ring, Splash ring, Oil seals	Release of fumes and vapours when overheated
Teflon & Kevlar fibers	Packing rings	Release of dangerous powders, release of fumes when overheated
Varnishes	Exterior pump surface	Release of powder and fumes in case of rework, flammable
Protective liquid	Pump inside surface	Skin and eye rash
Liquid compound	Gasket between flat surfaces	Skin, eye and breathing organs irritation

# 3 - IN CASE OF EMERGENCY

Should the pump break down leak gas and/or service liquid, immediately disconnect the electrical power following the instructions given in section 11. Alert the maintenance personnel, at least two people should intervene using precautions, as it is required for the specific installation: pump may be handling dangerous and/or hazardous fluids.

After correction of all the problems that created the emergency situation, it is necessary to carry out all the recommended starting procedures (see section 10).

## 3.1 - BASIC FIRST AID

In the event dangerous substances have been inhaled and/or have come in contact with the human body, immediately contact the medical staff and follow the instructions given by the company's internal medical safety procedures.

## 4 - PUMP OUTLINES

The instructions given in this manual are for liquid ring vacuum pumps and compressors and for systems type WATER SEALED or OIL SEALED (DynaSeal™) which utilize said pumps.

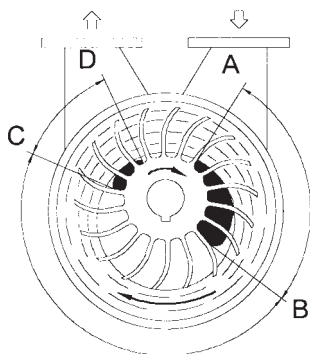
NOTE: Capacities, vacuum and pressures are nominal and are the maximum attainable values under standard operating conditions. Please contact TRAVAINI PUMPS USA for data on liquid ring compressors series TR...

TRM	Single stage liquid ring vacuum pumps Capacity to 210 ACFM, max vacuum 33 mbar (25 Torr)
TRS	Single stage liquid ring vacuum pumps Capacity to 2100 ACFM, max vacuum 150 mbar (100 Torr)
TRV	Single stage vacuum pumps Capacity to 300 ACFM, max vacuum 33 mbar (25 Torr)
TRH	Two stage liquid ring vacuum pumps Capacity to 2100 ACFM, max vacuum 33 mbar (25 Torr)
SA	Double acting liquid ring compressors Capacity to 110 ACFM, pressures to 10 bar-(145 psig)

### 4.1 - PRINCIPLE OF OPERATION

(See figure at side)

The aspirated gas enters the pump chamber A-B via the pump suction flange. The gas is trapped between two (2) impeller vanes. The impeller rotates eccentrically in relation to the centerline of the liquid ring that, by centrifugal force, assumes the shape of the impeller casing. The progressive change of volume between the two (2) vanes, the impeller hub and the liquid ring first creates a vacuum and then a compression of the gas in the B-C area till the gas is discharged, together with a portion of the liquid, through the discharge port C-D. The lost liquid must then be replenished.



### 4.2 - SERVICE LIQUID PROPERTIES

For good operation, the liquid ring pumps must be supplied with a service liquid, which is clean, non-abrasive and free of any solids. The service liquid temperature should not exceed 80 °C and the gas handled should be maximum 100 °C; the liquid density should be between 0.8 and 1.2 g/cm<sup>3</sup> and the viscosity should be less than 40 °C (the pump performance will change if the service liquid has properties different than those of water at 15°C (60°F). All engineering data is based on the use of 15°C (60°F) as service liquid, see section 17 for additional information. Contact TRAVAINI PUMPS USA before using liquids with properties outside the ranges listed above.

### 4.3 - PUMP MODELS AND TABLES FOR MATERIAL OF CONSTRUCTION

On the pump nameplate are printed the pump serial number, the year of manufacture and the pump model. Refer to the following example for understanding the coding of the pump model. Every letter or number in the pump model designation has a specific meaning relating to the pump design.

Example of pump model number:

T R H C 80 - 750 / C - M / GH	
<b>T</b> - Manufacturer POMPETRAVAINI	<b>750</b> - Nominal capacity in m <sup>3</sup> /h
<b>R</b> - Liquid ring pump	<b>C</b> - C = Shaft sealing by mechanical seal B = Shaft sealing by stuffing box
<b>H</b> - M and V = Single stage pump with high vacuum S = Single stage pump with medium vacuum H = Two stage pump with high vacuum	<b>M</b> - Monoblock design with motor flange (upon request)
<b>C</b> - Revision of hydraulic design	<b>GH</b> - Material of construction GH - F - RZ - RA - A3 (see following table)
<b>80</b> - Ø Flange size (mm)	

#### STANDARD materials of construction

VDMA	Description	GH	F	RZ	RA	A3
106	Suction casing	Cast iron 1561				
107	Discharge casing	Cast iron 1561				
137	Intermediate plate	Carbon Steel				
110	Center body	Carbon Steel				
210	Shaft	Stainless steel AISI 420		Stainless steel AISI 316		
147	Manifold	Carbon steel				
357	Bearings & M.S. Hous.	Cast iron 1561				
230	Impeller	Bronze	Ductile iron	Stainless steel AISI 316		

For additional details regarding standard or special materials contact TRAVAINI PUMPS USA.

## 5 - UNCRATING, LIFTING AND MOVING INSTRUCTIONS

Upon receipt, verify that the material received is in exact compliance with that listed on the packing slip.


When uncrating, follow the instructions listed below:

- check for visible damages on the crate that could have occurred during transport
- carefully remove the packaging material
- check the pump/or accessories such as tanks, piping, valves, etc. to ensure that it is free of visible markings such as dents and damage which may have occurred during transportation
- in the event of damage, report this immediately to the transport company and to TRAVAINI PUMPS USA Customer Service department.

Discard through controlled disposals all packaging materials that may constitute personal injury (sharp objects, nails, etc.).

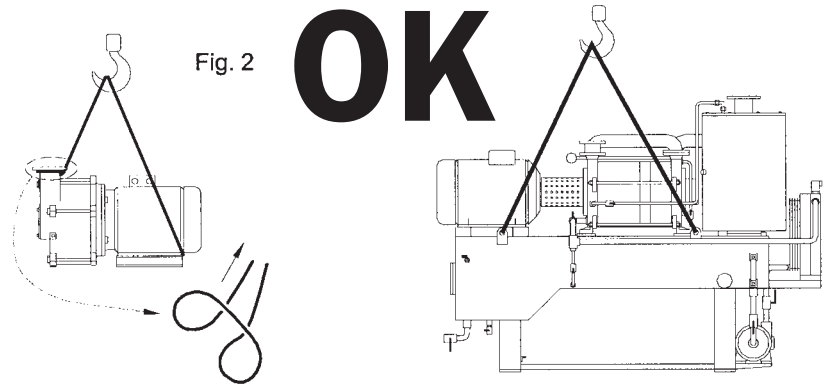
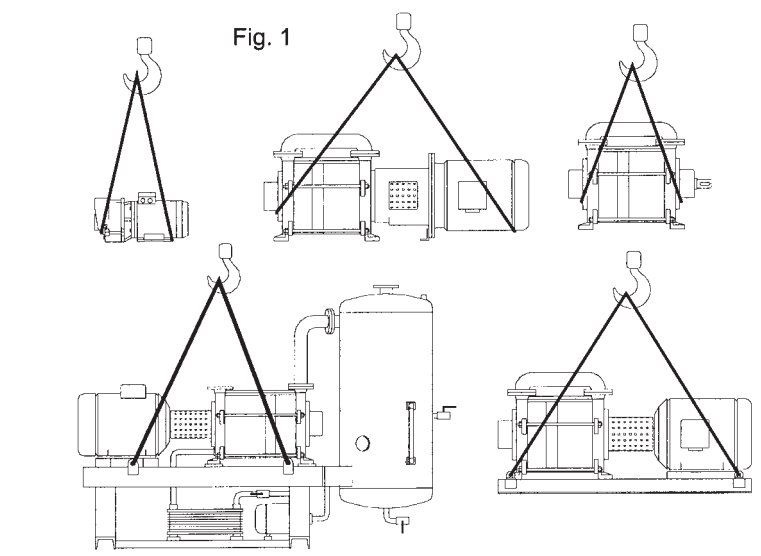
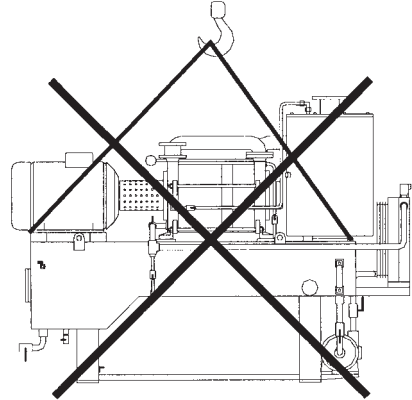
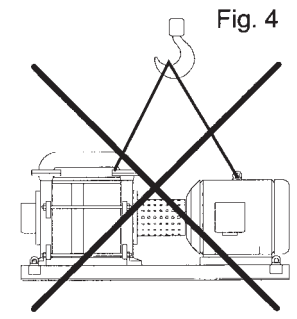
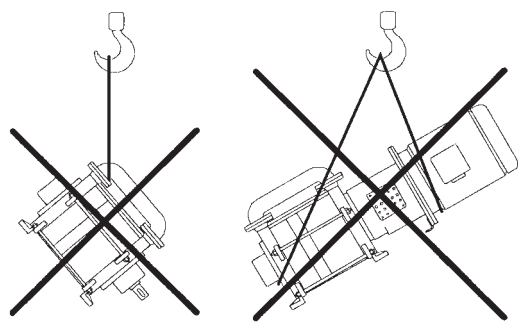
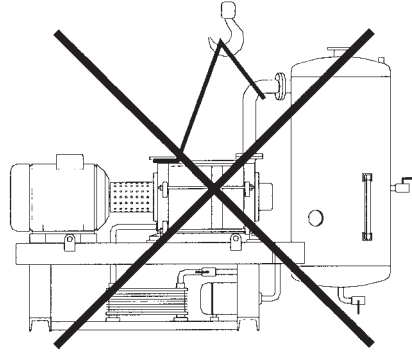
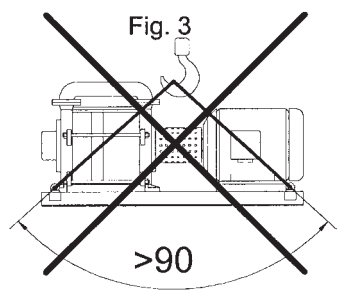
The pump or assembly must **ALWAYS** be moved and transported in the horizontal position. Prior to moving the unit find the following:

- total weight
- center of gravity
- maximum outside dimensions
- lifting points location.

	<p>For safe lifting to prevent material damages and/or personal injuries is recommended to use ropes, or belts properly positioned on the pump and/or lifting eyebolts and make correct movements. NOTE: Lifting eyebolts fitted on single components of the assembly (pump or motor) should not be used to lift the total assembly.</p>
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Avoid lifts whereby the ropes or straps, form a triangle with the top angle over 90° (see fig. 3). The fig. 4 shows several additional examples of lifting to be avoided. Prior to moving the unit from an installation, always drain any pumped fluid from the pump, piping and accessories, rinse and plug all openings to prevent spillage. For instructions to remove the unit from installation see section 15.

# NO





## 6 - STORAGE INSTRUCTIONS

After receipt and inspection, if not immediately installed, the unit must be repackaged and stored. For a proper storage proceed as follows:

- store the pump in a location that is closed, clean, dry and free of vibrations
- do not store in areas with less than 5 °C (41 °F) temperature (for lower temperature it is necessary to completely drain the pump of any liquids that are subject to freezing)



### **FREEZING DANGER!**

Where the ambient temperature is less than 5 °C (41°F) it is recommended to drain the pump, piping, separator, heat exchanger, etc. or add an anti-freeze solution to prevent damage to the equipment.

- fill the pump halfway with an anti-rust liquid but compatible with gaskets and elastomers materials, rotate the pump shaft by hand so that all internal parts get wet and then drain the pump of the excessive anti-rust liquid
- plug all openings that connect the pump internals to the atmosphere
- protect all machined surfaces with an anti-rust material (grease, oils, etc.)
- cover the unit with plastic sheet or similar protective material
- rotate pump shaft at least every three months to avoid possible rust build-up which may result in seizing of the pump.
- pump accessories should be subjected to similar procedure.

## 7 - MOUNTING AND ALIGNMENT INSTRUCTIONS

### 7.1 - ASSEMBLY OF BASE MOUNTED PUMP UNIT



In some cases such as bare pump orders, pumps are shipped with anti-rust and anti-freeze agents. Ensure pump is thoroughly flushed and these agents are removed prior to installation.

If the pump has been purchased with a free shaft end, a proper baseplate is required to mount the pump/motor assembly. The baseplate must be properly designed for maximum rigidity to prevent vibrations and distortions. It is recommended the use of a fabricated baseplate manufactured with rigid "U" shaped channel (fig. 16 illustrates an example).

When the pump has been purchased without the electric motor, it is then required to select the proper motor before proceeding to the installation of the unit. When selecting a motor the following must be considered:

- maximum power absorbed by the pump over the total operating range
- pump operating speed (RPM)
- available power (Hertz, voltage, etc.)
- motor enclosure type (ODP, TEFC, EX.PR., etc.)
- motor mount (B3, B5, horizontal, vertical, C-flange, D-flange, etc.).

When selecting Flexible couplings the following must be considered:

- nominal motor horsepower
- motor operating speed
- coupling guard must meet safety standards as dictated by OSHA, etc.

Flexible couplings must be properly aligned. Bad alignments will result in coupling failures and damage to pump and motor bearings.

Assembly instructions for MONOBLOCK design are listed on paragraph 7.3 steps 1, 2, 4, 5, 6.

Assembly instructions for PUMP-MOTOR ON BASEPLATE are listed on paragraph 7.3 steps 7, 1, 8, 5, 9, 10, 11.

For pump driven with V-Belt, please consult TRAVAINI PUMPS USA for further information.

### 7.2 - ALIGNMENT PROCEDURES FOR MONOBLOCK AND FOR PUMP/MOTOR ASSEMBLY ON BASEPLATE.

TRAVAINI PUMPS USA prior to shipment properly aligns the pump/motor assembly. It is however required to verify the alignment prior to the start-up. Misalignment can occur during handling, transportation, grouting of assembly, etc.

For alignment procedures of MONOBLOCK design see paragraph 7.3 steps 3, 4, 5, 6.

For alignment procedure of BASEPLATE design see paragraph 7.3 steps 7, 5, 9, 10, 11.

**NOTE:** Coupling sizes and permissible coupling tolerances listed in this manual are applicable to the particular coupling brand installed by TRAVAINI PUMPS USA as a standard. For sizes and tolerances of other type of couplings, follow the instructions given by their respective manufacturer.

### 7.3 - ALIGNMENT INSTRUCTIONS

**NOTE:** Alignment should be done at ambient temperature, with power to the motor disconnected and following the safety procedures to avoid accidental starting (see section 2).

Should the pump operate at high temperatures that could upset the coupling alignment, it is necessary to check the alignment to secure proper working operation at such operating temperatures. It is recommended the use of proper hand protections such as gloves, when carrying out the operations listed below (schematics for various assemblies are shown).

**NOTE:** The following points must be followed with the sequence stated above and depending upon the type of operation: alignment assembly or alignment verification.

**1** - Thoroughly clean motor/pump shaft ends and shaft keys, place the shaft keys in the proper key way slots and fit the coupling halves in line with the shaft ends. The use of rubber hammers and even pre-heating of the metal half couplings may be required (see fig. 5). Lightly tighten the set screws. Verify that both pump and motor shafts rotate freely.

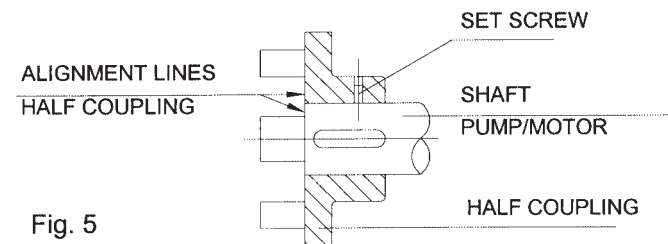


Fig. 5

**2** - Insert the perforated metal sheet coupling guard inside the lantern so that the coupling is accessible from one of the lateral openings. Couple the electric motor to the pump lantern engaging the two coupling halves, hands may reach the coupling halves through the lateral opening (see fig. 7) tighten the assembly with bolts supplied with the unit and install the supporting foot, when applicable (see fig. 6).

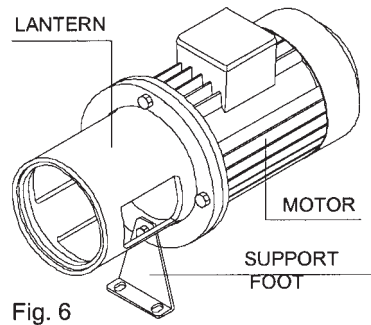


Fig. 6

**3** - Applying slight hand pressure to the coupling guard, rotate it so that one opening of the lantern is accessible (see fig. 8).

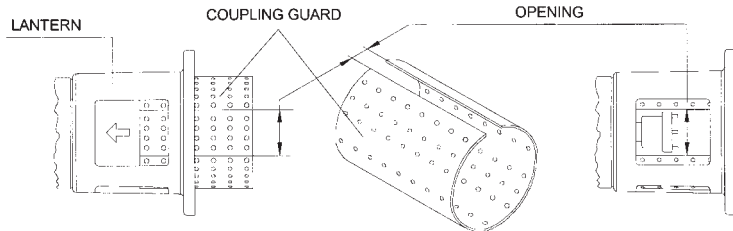


Fig. 7 - PREPARING TO ASSEMBLE THE MONOBLOCK DESIGN

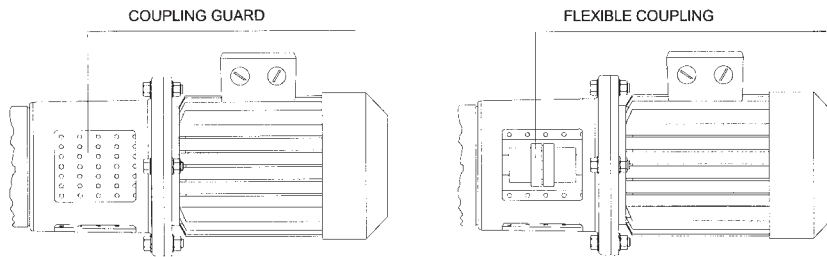


Fig. 8 - CHECKING THE ALIGNMENT ON MONOBLOCK DESIGN

**4** - Rotate by hand the coupling through the lateral opening of the lantern to make sure the pump is free.

**5** - With a feeler gauge, check the distance between the two coupling halves. The gap value "S" should be as listed on table 2 or as given by the coupling manufacturer. In the event, an adjustment is necessary, loosen the set screws on the coupling half and with a screw driver move the coupling half to attain the gap "S" (see fig. 12). Then tighten the set screw and rotate the rotor by hand to make sure, once more, that there is no obstruction.

**6** - Rotate back the coupling guard by hand through the two openings of the lantern so that both openings are completely covered. This will complete the alignment verification of the MONOBLOCK design.

**7** - Remove the coupling guard and its extension (if there is one) attached to the pump, by removing the two locking screws (see fig. 9 and 10).

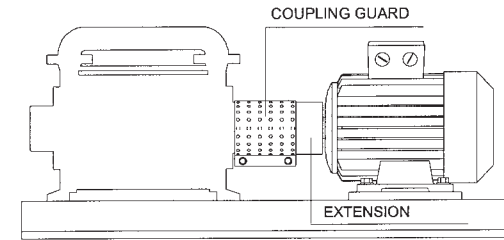


Fig 9 - CHECKING ALIGNMENT ON BASE MOUNTED PUMP DESIGN

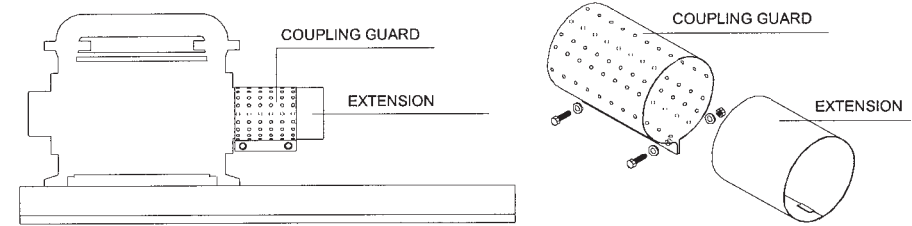


Fig. 10 - ASSEMBLING THE UNIT ON THE BASEPLATE

**8** - Place the electric motor on the baseplate and bring the two coupling halves together with approx. 2mm gap between them keeping the motor axially aligned with the pump shaft. In the event the two shaft heights do not align, proper shimming under the pump or motor feet will be required. Mark the motor and/or pump anchoring bolt holes. Remove motor and/or pump, drill and tap the holes, clean and mount pump and/or motor in place and lightly tighten the bolts (see fig. 11).

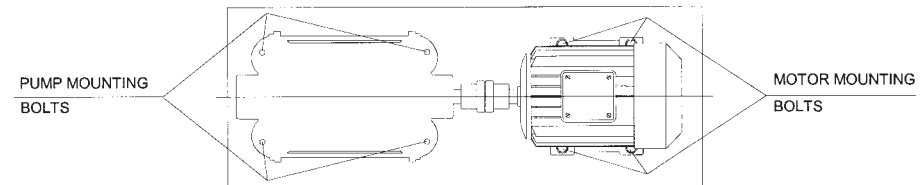


Fig. 11

**9** - With a straight edge ruler check the parallelism of the two coupling halves at several points, 90° from each other (see fig. 13).

**NOTE:** Easier and more accurate readings can be attained with instruments such as Dial Indicators (if readily available).

If the maximum value of "X" is higher than that listed in the table 2 (for the given coupling size) it will be required to correct the alignment by using shims under the pump or motor feet. When the measured values fall within the tolerances (tolerances only given for "S"), the pump and motor mounting bolts can be tightened.

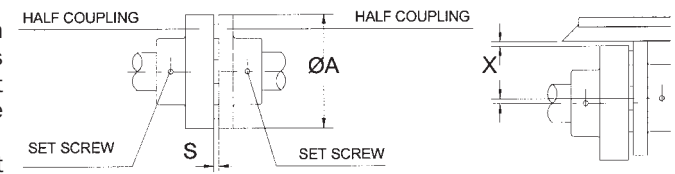


Fig. 12 (Center - Under view)

Fig. 13

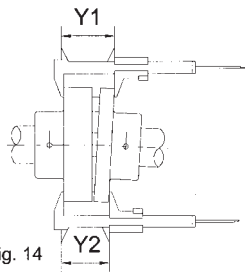


Fig. 14

**10** - Angular misalignment can be measured with a Caliper. Measure the outside coupling dimension at several points (see fig. 14). Find the minimum and maximum width of the coupling, the difference between these two readings "Y" (Y1-Y2) should not exceed the value listed in table 2 for the given coupling size. Should this value be greater it will be necessary to correct the alignment by shimming the pump and/or motor. Following this operation it is recommended to check once more the value "X" to make sure that both values are within the allowed tolerance (see point 9). Make sure that both set screws on the coupling halves are properly secured.

Table 2

COUPLING "Ø A" mm	GAP "S" mm	PARALLEL "X" mm	ANGULAR "Y" mm
60	2 to 2.50	0.10	0.20
80	2 to 2.50	0.10	0.20
100	2 to 2.50	0.15	0.25
130	2 to 2.50	0.15	0.25
150	3 to 3.75	0.15	0.30
180	3 to 3.75	0.15	0.30
200	3 to 3.75	0.15	0.30

**11** - Install the coupling guard and its extension (if applicable) on the pump, secure the two locking bolts. The gap between motor frame and the guard should not be greater than 2 to 3mm (see fig. 15).

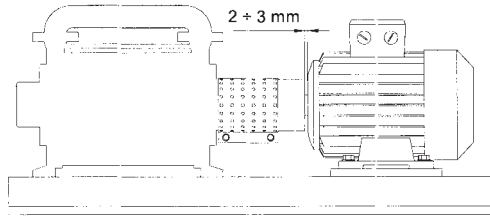


Fig. 15

## 8 - ELECTRICAL CONNECTIONS



Electrical connections must be made exclusively by qualified personnel in accordance with the instructions from the manufacturer of the motor or other electrical components and must adhere to the local National Electrical Code.



**FOLLOW ALL SAFETY PRECAUTIONS AS LISTED IN SECTION 2. BEFORE DOING ANY WORK TO THE INSTALLATION, DISCONNECT ALL POWER SUPPLIES.**

It is recommended that electric motors be protected against overloading by means of circuit breakers and/or fuses. Circuit breakers and fuses must be sized in accordance with the full load amperage appearing on the motor nameplate. It is advisable to have an electrical switch near the pump for emergency situations. Prior to connecting the electrical wiring, turn the pump shaft by hand to make sure that it rotates freely. Connect the electrical wiring in accordance with local electrical codes and be sure to ground the motor. Motor connection should be as indicated on the motor tag (frequency and voltage) and as discussed in the motor instruction manual. It is recommended that motors over 75Hp be wired for soft

start, to avoid electrical overloads to the motor and mechanical overloads to the pump. Be sure to replace all safety guards before switching on the electrical power. If possible check the direction of rotation before the motor is coupled to the pump but protect the motor shaft to prevent any accidents. When this is not possible briefly jog the pump to check its direction of rotation (see arrow on pump for correct rotation). If the direction must be changed two of the three electrical wire leads must be alternated with each other (at the terminal box or at the motor starter). Be aware that rotation in the wrong direction and/or pump running dry may cause severe pump damage. Electrical instrumentation such as solenoid valves, level switches, temperature switches, etc. which are supplied with the pump or systems must be connected and handled in accordance with the instructions supplied by their respective manufacturers. Contact TRAVAINI PUMPS USA for specific details.

## 9 - INSTALLATION INSTRUCTIONS

Information to determine the piping sizes and floor space requirements can be obtained from dimensional drawings and other engineering data. The information required is:

- size and location of suction and discharge flanges
- size and location of service liquid connection and connections for cooling, heating, flushing, draining, etc.
- location and size for mounting bolts for monoblock pump and/or baseplate and/or frame.

In the event additional accessories are required to complete the installation such as separators, piping, valves, etc. refer to sections 9.2 to 9.8. Proper lifting devices should be available for installation and repair operations. Pump assembly should be installed in an accessible location with adequate clear and clean space all around for maintenance, so that an efficient and proper installation can be made. It is important to have proper room around the unit for ventilation of motor and air-cooled radiator, if applicable. Avoid installing the unit in hidden locations, dusty and lacking of ventilation. Select a mounting pad that will minimize vibrations or torsion of the pump baseplate or frame. It is generally preferred to have a concrete base or sturdy steel beams. It is important to provide adequate anchor bolting for the pump frame or baseplate to be firmly attached to the foundations (see fig. 16).

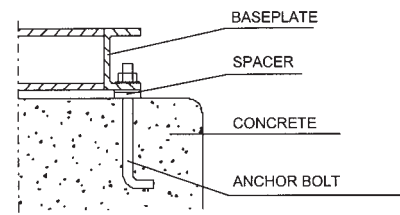
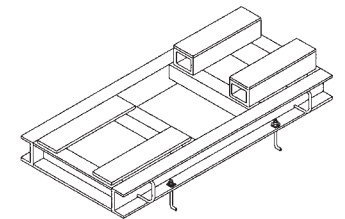


Fig. 16



Concrete pads and other concrete works must be aged, dry and clean before the pump assembly can be positioned in place. Complete all the work relating to the foundations and grouting of the pump assembly, before proceeding with the mechanical and electrical portion of the installation.



## 9.1 - PIPING CONNECTIONS

Identify first locations and dimensions of all connections required to interconnect the pump with the installation, then proceed with the actual piping: connect the pump suction and discharge flanges, the service liquid line and all other service connections (see fig. 17 to 26).



**BE SURE TO PIPE THE CORRECT CONNECTION FROM THE INSTALLATION TO THE RESPECTIVE PUMP CONNECTION!**

To prevent foreign matters from entering the pump during installation, do not remove protection cap from flanges or cover from openings until the piping is ready for hook-up. Verify that all foreign objects such as welding bits, bolts, nuts, rags and dirt are removed from piping, separators, etc. before these are connected to the pump. Flanges should be connected parallel with each other, without stress and with bolt holes lined up. The flange gaskets should not interfere with the inside diameter of piping and/or flange. All piping must be independently supported, easily located and must not transmit forces or torque to the pump due to the weight or to thermal expansions. Piping size must never be less than the respective connection on the pump. Suction and discharge flanges are vertical and identified with arrows. To minimize friction losses and back-pressures, the discharge piping should be one size larger than the pump connection size. To avoid back-pressure and possibility of flooding the pump when it stops, it is recommended to limit the rise of the discharge piping to approximately 2 feet above the pump discharge flange. Upon completion, piping and connections should be tested for leakage under vacuum.

## 9.2 - ACCESSORIES

Listed below are common accessories that may be supplied with the pump or added at a later date. See fig. 17 to 26 for locations and connection sizes on the pumps.

### Non return valve, (check valve)

Prevent back-flow of gas and liquid in the suction piping and/or discharge piping when the pump stops. Is installed on the pump suction flange in the case of vacuum service or on the pump discharge flange in the case of compressor service.

### Vacuum relief valve

It is used to protect the pump from cavitation or to regulate the suction minimum pressure (or max vacuum).

When the pump capacity exceeds the system load at a given vacuum, the relief valve opens letting in atmospheric air or gas (if connected to the discharge separator) keeping constant the pre-set vacuum.

### Automatic draining valve

It is used to drain the pump to the shaft centerline when the pump stops so to prevent that the pump has excessive liquid for the next start-up. Starting the pump full or with too much liquid could severely damage the pump and may cause excessive Amp draw from the motor.

### Vacuum gauge

It usually installed under the pump suction flange and will provide an indication of the pump operating vacuum (pressure).

### Discharge reservoir separator

It separates the service liquid from the gases at the pump discharge. It can be mounted on the pump discharge flange or on the pump baseplate. It is required when the system is with partial or total recovery of the service liquid.

## Heat exchanger

It cools the service liquid for those systems with total liquid recovery: it can be plate and frame, shell and tube or radiator type, depending upon the application.

## Filter

Required to stop solids from entering the pump suction. Sizing of the filter is very important as it could create excessive pressure drops, which would affect the pump performance.

## 9.3 - INSTALLATION SCHEMATICS FOR LIQUID RING VACUUM PUMPS

The working principle of the vacuum pump requires a continuous flow of fresh and clean liquid that enters the pump at the service liquid connection identified by the letter **Z** (see section 9.11). The liquid is discharged together with the handled gas through the pump discharge flange. The quantity of said liquid will vary with pump size and degree of working vacuum (see performance curves and/or table 3). The service liquid absorbs the compression heat generated by the pump compression, which results in a temperature rise of the service liquid (for additional information, see chapter 17). There are three basic installation schematics listed below that may be considered, depending upon the quantity of service liquid that is desired and possible to be recycled.

### 9.3.1 - Service liquid: Once-through system (no recovery)

All the service liquid is supplied from an external source. The liquid is separated from the incoming gas in the discharge separator and is completely drained. This is a popular installation and is used where there is an abundant supply of fresh liquid and/or there is no contamination of the same. The service liquid should be supplied at the pump connection with a pressure of 5.8psig maximum to avoid flooding the pump with too much liquid. If this is not possible it is recommended to install a reservoir fitted with a float valve, this tank is supplied with the liquid that is then pulled by the pump as required by the operating conditions. The liquid level in the reservoir should be approximately at the pump shaft centerline. Schematic fig. 17 illustrates the once-through system.

### 9.3.2 - Service liquid: Partial recovery system

This type of installation is used where it is desired to minimize the use of fresh service liquid (for calculations see section 17). The service liquid enters and leaves the pump same as the once through system, however part of the liquid is recycled from the discharge separator and the balance is continuously supplied from an external source. The excessive liquid is drained through the separator overflow connection. The temperature of the mixed liquid supplied to the pump will be higher than the temperature of the make-up liquid. Its final temperature will depend upon the amount of the recycled liquid. It is important to remember that with higher service liquid temperature the pump performance will decrease (see section 17) with the possibility of operating the pump in the cavitation area. When the separator/reservoir is installed along side of the pump, its liquid level should not be above the pump shaft centerline. When flanged separators are mounted on the pump discharge flange, the liquid level is automatically maintained by the location of the connections. Schematic fig. 18 illustrates the system with partial recovery of the service liquid.

### 9.3.3 - Service liquid: Total recovery system

This system has total recycle of the service liquid without fresh liquid make-up from an outside source. A heat exchanger is required to lower and control the temperature of the recycled service liquid: for sizing and calculations of heat loads

see section 17. A circulating pump will be required for those applications where the vacuum pump operates for extended periods of times in the pressure ranges above 20”Hg vacuum or when there are high pressure drops in the closed loop including the heat exchanger (over approximately 30psi.). The liquid level in the separator/reservoir should not be above the pump shaft centerline. Losses of liquid from the closed loop must be compensated with an equal amount from an outside source. Schematic fig. 19 illustrates the system with total recovery of the service liquid.

#### 9.4 - INSTALLATION SCHEMATICS FOR LIQUID RING COMPRESSORS

The liquid ring vacuum pump can also operate as a compressor up to a maximum differential pressure, depending upon the models, of about 30 psig. The compressor series SA are specifically engineered to perform with differential pressures of up to 150 psig, depending on models. The principle of operation is same as given in previous paragraph (9.3 for vacuum pumps) and there are three possible types of installation: once-through service liquid, partial recovery service liquid and total recovery service liquid. The service liquid entering the compressor connection should have a pressure of minimum 5psig. above the compressor operating inlet pressure. A booster pump will be required if the service liquid is available at lower pressures. Separator/reservoir is considered a pressure vessel and as such it must be engineered and built to the applicable codes (ASME, etc.). Accessories such as a pressure relief valve, check valve (non-return valve), automatic float type drain valve (water trap), etc. are required in a compressor system. Fig. 20, 21 and 22 illustrate the three possible types of installations.

#### 9.5 - INSTALLATION OF “WATER SEALED” SYSTEMS

WATER SEALED systems are factory assembled and piped including discharge separator/reservoir, heat exchanger (air/liquid or air/air), circulating pump, and all required accessories mounted on a common compact baseplate/frame. See section 18 for additional details. Installation of WATER SEALED system is similar to that of a vacuum pump or a compressor with partial recovery or total recovery of service liquid depending upon the application (see section 9.3 or 9.4). It is important to properly engineer the connecting piping to the system suction and discharge, cooling lines, flushing lines, and draining lines. The used heat exchanger is designed with service liquid being cooled approximately 4 to 6°C (39 to 43 °F) over the available cooling media temperature. The cooling liquid flow is approximately the same as the service liquid flow needed by the pump at the operating conditions (see section 9.7 or 9.8). Schematics for once-through, partial and total service liquid recovery are shown in fig. 18 - 19 - 21 - 22.

#### 9.6 - INSTALLATION OF “OIL SEALED (DynaSeal™)” SYSTEMS

OIL SEALED (DynaSeal™) are factory packaged systems including liquid ring vacuum pump using oil for service liquid. For additional details see section 19. Installation is simple and does not require additional details other than those already discussed in the previous chapter. Suction and discharge piping should be connected to the respective pump flanges. When locating the discharge piping it should be noted that although the system is fitted with oil demister, there may still be traces of oil fumes carried by the vented gas. Make sure therefore, that the selected area for vacuum pump discharge is suitable for such purpose. All other connections, (heat exchanger, draining, etc.) must be properly done. See fig. 37 for location of connections.

	<b>ATTENTION: HOT SURFACES, DO NOT TOUCH TO AVOID POSSIBLE BURNS!</b>
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During operation, the temperature of pump, frame, separator and piping can reach values over 60 °C. Therefore, take all precautions necessary to comply with the safety regulations.

#### 9.7 - SERVICE LIQUID (H<sub>2</sub>O at 60 °F) FLOW (in GPM) FOR VACUUM PUMPS

The listed values are referred to the system with “Once-through” service liquid, handling dry air at 20 °C (68 °F) (for more specific data see the pumps performance curve). To reduce the amount of service liquid flow read the information given in section 17. If the pump is handling saturated or condensable gases at relatively high temperatures, there will be condensation inside the pump. In those cases the service liquid flow listed below can be increased up to 25% to reduce the discharge temperature and minimize the danger of pump cavitation at high vacuum.

Table 3

PUMP MODEL	SUCTION PRESSURE (in Torr)		
	25-150	>150-450	>450
TRH 32-4	0.9	0.9	0.7
TRH 32-20	1.5	1.3	1.2
TRH 32-45			
TRH 32-60	4.0	3.0	2.6
TRH 40-110			
TRH 40-140			
TRH 40-190	4.4	3.7	3.0
TRH 50-280	10.5	7.5	4.0
TRH 50-340	13.0	9.8	5.3
TRH 50-420	15.8	12.0	7.0
TRH 80-600	11.0	8.7	5.7
TRH 80-750	13.0	10.6	7.0
TRH 100-870	32.5	25.0	16.7
TRH 100-1260			
TRH 100-1600			
TRH 150-2000	53	42	26
TRH 150-2600	58	49	29
TRH 150-3100	16.20	14.10	8.70

PUMP MODEL	SUCTION PRESSURE (in mbar)	
	150 - 450	> 450
TRS 32-20	1.5	1.0
TRS 32-50		
TRS 40-55	3.4	1.9
TRS 40-80		
TRS 40-100	4.2	2.5
TRS 40-150	5.1	3.2
TRS 50-220	10.6	5.7
TRS 100-550	12.8	7.7
TRS 100-700	14.5	9.2
TRS 100-980	40	24
TRS 125-1250	38	18
TRS 125-1550	44	20
TRS 200-1950	80	50
TRS 200-2500	88	51
TRS 200-3100	114	77

PUMP MODEL	SUCTION PRESSURE (in Torr)		
	25-150	>150-450	>450
TRM 32-25	1.8	0.9	0.6
TRM 32-50	2.0	1.0	0.7
TRM 32-75	3.0	1.8	1.5
TRM/V 40-110	5.3	3.5	2.2
TRM/V 40-150			2.4
TRM/V 40-200	5.7	4.0	2.6
TRM/V 50-300	7.0	5.3	3.5
TRV 65-300			
TRV 65-450	10.5	7.4	4.0

For the above pumps running as compressors without the specific performance curves, please contact TRAVAINI PUMPS USA.

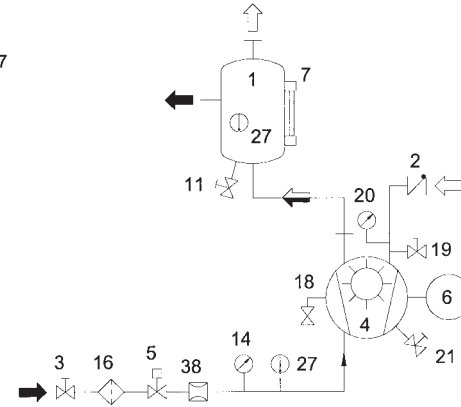
### 9.8 - SERVICE LIQUID FLOW (H<sub>2</sub>O at 60°F) AND PRESSURE FOR COMPRESSORS SERIES "SA"

Values are applicable when the compressor suction is barometric pressure (1013 mbar) and the gas is air at 20°C (68 °F). The indicated flow and pressure requirements are valid for the compressor total performance curve.

- SA0E3U = 4 GPM at minimum pressure of 20 to 40psi.
- SA0G2D = 4 GPM at minimum pressure of 20 to 40psi.
- SA0G2G = 6 GPM at minimum pressure of 20 to 40psi.

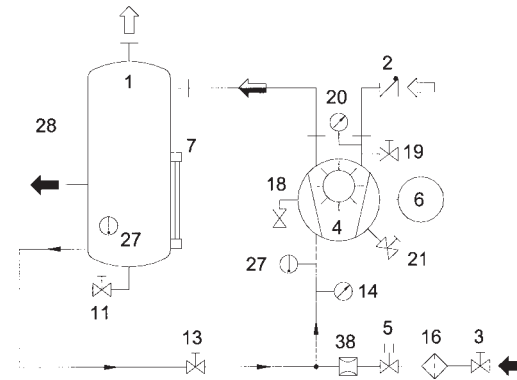
### 9.9 - TYPICAL INSTALLATION SCHEMATICS FOR VACUUM PUMPS

Fig. 17



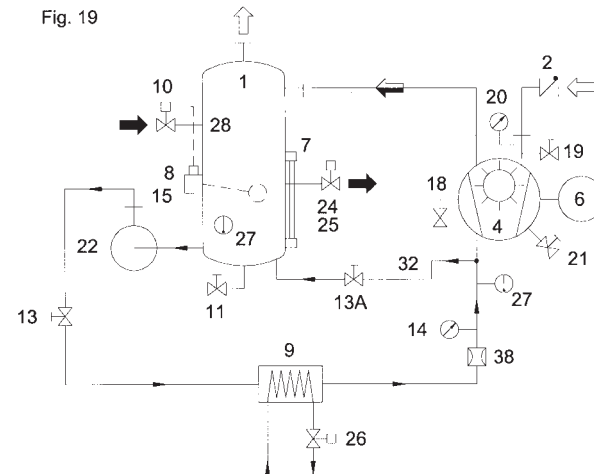
- 1 Separator/reservoir
- 2 Non-return valve
- 3 Shut-off valve (check valve)
- 4 Liquid ring vacuum pump
- 5 Solenoid valve
- 6 Electric motor

Fig. 18



- 7 Level gauge glass
- 8 Float valve
- 9 Heat exchanger
- 10 Make-up solenoid valve
- 11 Drain valve
- 13 Flow control valve
- 13A By-pass valve

Fig. 19



- 14 Pressure gauge
- 15 Level switch
- 16 Filter (y-strainer)
- 18 Automatic drain valve (check valve)

## 9.10 - TYPICAL INSTALLATION SCHEMATICS FOR COMPRESSORS

Fig. 20

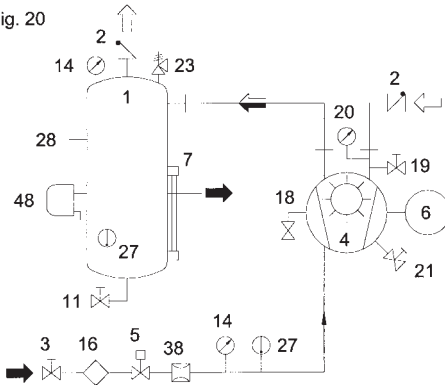


Fig. 21

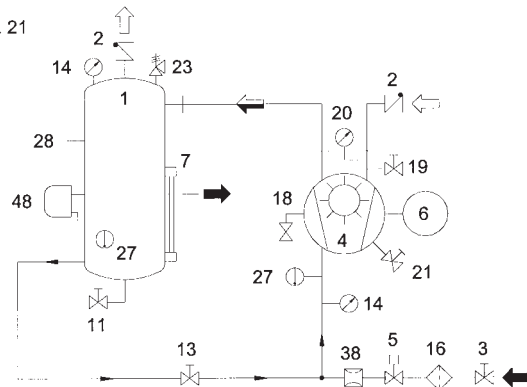
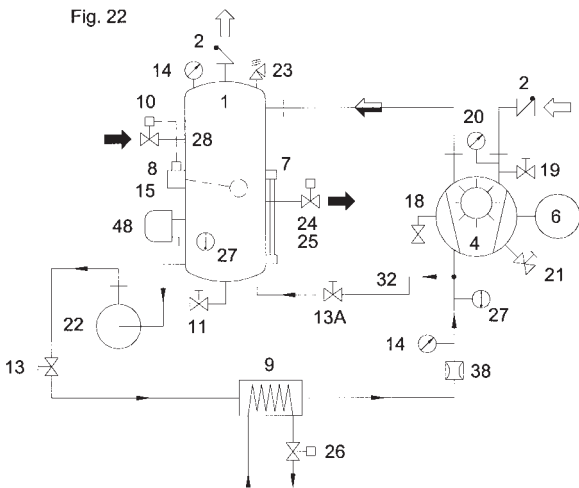


Fig. 22



- 19 Valve for spare vacuum connection
- 20 Vacuum gauge
- 21 Anti-cavitation valve
- 22 Circulating pump
- 23 Pressure relief valve

- 24 Overflow valve
- 25 Draining solenoid valve
- 26 Solenoid valve for heat exchanger cooling liquid
- 27 Temperature gauge

- 28 Fill connection
- 32 By-pass piping
- 38 Orifice flow

- 48 Automatic drain valve or water trap

↑ Air or Gas

↑ Liquid-Gas mixture

↑ Liquid

## 9.11 - CONNECTIONS LOCATION

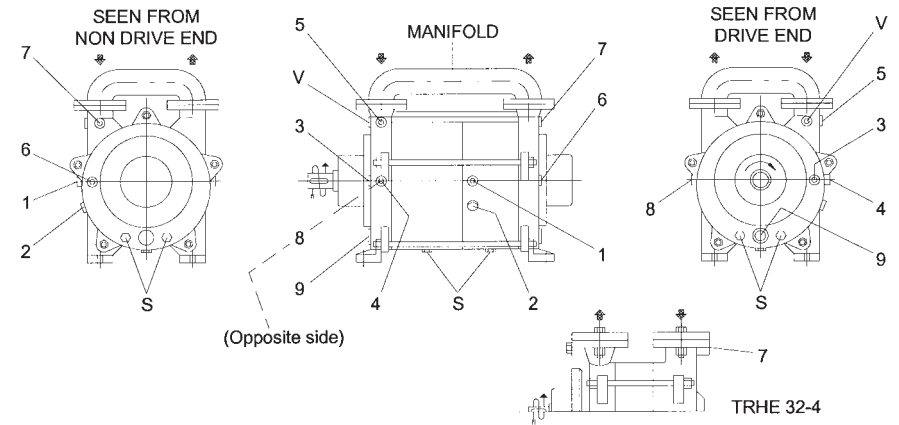


Fig. 23 - Pump series TRH (for details, see table 4)

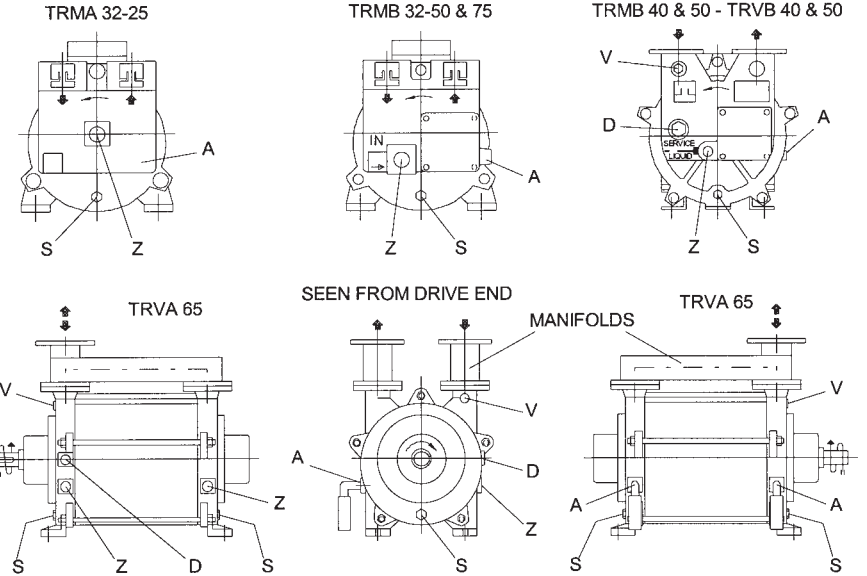


Fig. 24 - Pump series TRM - TRV (for details see table 5)

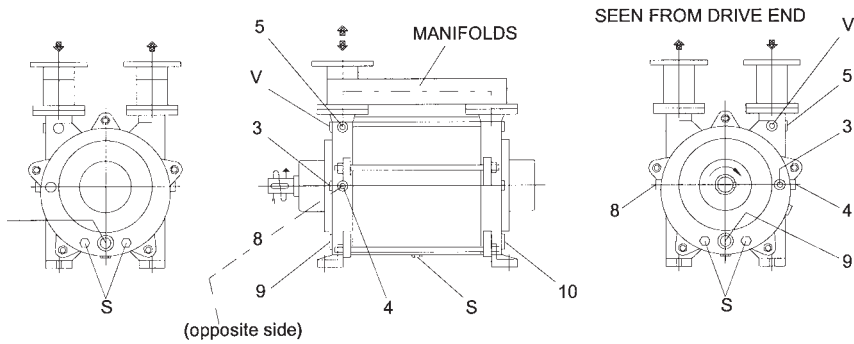


Fig. 25 - Pump series TRS (for details, see table 6)

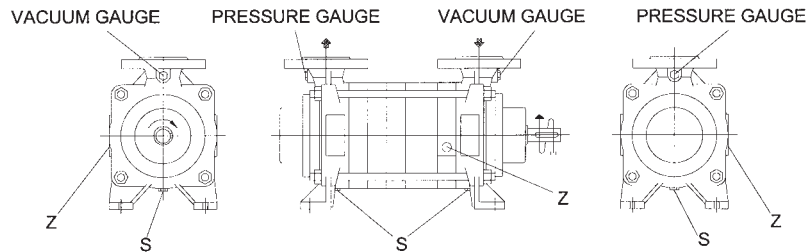


Fig. 26 - Pump series SA (for details, see table 7)

Table 4 - Pump series TRH

PUMP MODEL	A		D		Z		Qty. Manifolds
	Location	Connection Size	Location	Connection Size	Location	Connection Size	
TRHE 32-4	-	-	-	-	7	1/4" GAS	-
TRHE 32-20 & 45	1	1/4" GAS	-	-	8	3/8" GAS	
TRHC 32-20 & 45					2	1/4" GAS	1/2" GAS
TRHE & TRHC 32-60	2	1/4" GAS	1/2" GAS	9			
TRHE 40-110					4	1/2" GAS	
TRHC 40-110	2	1/4" GAS	1/2" GAS	9	3	3/4" GAS	
TRHE 40-140 & 190					4	1/2" GAS	
TRHC 40-140 & 190	7	3/8" GAS	4	1" GAS	9	1/2" GAS	1
TRHB 50						3	
TRHC 80	6	3/8" GAS	4	1" GAS	9	1 1/4" GAS	1
TRHE 100	7	3/4" GAS	4-5	1" GAS	9	1 1/2" GAS	
TRHA 150					9	2 1/2" GAS	

Table 5 - Pump series TRM - TRV

PUMP MODEL	A	Connection Size			Qty. Manifolds
		D	S	Z	
TRMA 32-25 & TRMB 32-50	1/8" GAS	-	1/8" GAS	1/4" GAS	-
TRMB 32-75		-	1/8" GAS	3/8" GAS	
TRMB & TRVB 40		1/2" GAS	1/4" GAS	1/2" GAS	
TRMB & TRVB 50		3/4" GAS	1/4" GAS	3/4" GAS	
TRVA 65		1/2" GAS	1/4" GAS	1/2" GAS	

Table 6 - Pump series TRS

PUMP MODEL	D		Z		Qty. Manifolds
	Location	Connection Size	Location	Connection Size	
TRSE 32	-	-	8	3/8" GAS	-
TRSC 32			4		
TRSE 40-55 to 150	4	1/2" GAS	9	3/4" GAS	1
TRSC 40-55 to 100			9		
TRSE 50-220	3	1/2" GAS	9-10	3/4" GAS	2
TRSC 50-220	4			1/2" GAS	
TRSB & TRSC 100		4	1" GAS	9-10	1 1/4" GAS
TRSE 125	1 1/2" GAS				
TRSA 200	4-5	1" GAS	9-10	2 1/2" GAS	2

Table 7 - Pump series SA

COMPRESSOR MODEL	Connection Size	
	S	Z
SA0E3U	1/4" GAS	3/8" GAS
SA0G2D		1/2" GAS
SA0G2G		

- GAS = Straight pipe thread  
A = Connection anti-cavitation  
D = Auxiliary connection for automatic draining valve, connection valve for spare vacuum pick-up, vacuum relief valve  
S = Connection for drain plugs or valves  
V = Connection for vacuum gauge 1/4" GAS (series 32 excluded)  
Z = Connection for service liquid

All drawings are general and schematics (for additional details see the specific pump catalogue).



9.12 - PUMP ENGINEERING DATA

Table 8

PUMP MODEL	Noise Level dB(A)	Weight Bare Pump lbs.	Weight assembly Monoblock (B5 design) lbs.	Weight assembly with baseplate lbs.	Operating Speed		Installed Motor Size	
					RPM		kW	
					50 Hz	60 Hz	50 Hz	60 Hz
TRHE 32-4	67	30	42	70	1450	1750	0.55	0.75
TRHC 32-20	66	55	68	90	2900	3500	1.1	1.5
TRHE 32-20	66	40	50	75	2900	3500	1.1	1.5
TRHC 32-45	66	62	75	97	2900	3500	1.5	2.0
TRHE 32-45	66	46	56	81	2900	3500	1.5	2.0
TRHC 32-60	66	66	79	103	2900	3500	2.2	3
TRHE 32-60	66	57	68	95	2900	3500	2.2	3
TRHC 40-110	65	147	174	202	1450	1750	4	5
TRHE 40-110	65	108	134	160	1450	1750	4	5
TRHC 40-140	65	174	194	262	1450	1750	4	5
TRHE 40-140	65	147	167	220	1450	1750	4	5
TRHC 40-190	65	191	231	301	1450	1750	5.5	7.5
TRHE 40-190	65	165	205	260	1450	1750	5.5	7.5
TRHB 50-280	70	286	321	429	1450	1750	9	15
TRHB 50-340	70	308	374	466	1450	1750	11	15
TRHB 50-420	71	319	392	484	1450	1750	15	20
TRHC 80-600	76	484	539	792	1450	1750	22	30
TRHC 80-750	76	528	616	829	1450	1750	30	40
TRHE 100-870	79	906	—	1263	960	1150	30	40
TRHE 100-1260	79	1067	—	1434	960	1150	37	50
TRHE 100-1600	79	1140	—	1518	960	1150	45	60
TRHA 150-2000	83	2926	—	3971	730	880	75	100
TRHA 150-2600	84	3256	—	4609	730	880	90	125
TRHA 150-3100	84	3586	—	4939	730	880	110	150
TRSC 32-20	69	42	55	85	2900	3500	1.1	1.5
TRSE 32-20	69	32	45	68	2900	3500	1.1	1.5
TRSC 32-50	69	44	58	89	2900	3500	1.5	2.0
TRSE 32-50	69	38	47	73	2900	3500	1.5	2.0
TRSC 40-55	66	119	147	73	1450	1750	2.2	3
TRSE 40-55	66	75	103	130	1450	1750	2.2	3
TRSC 40-80	66	125	154	180	1450	1750	3	5.0
TRSE 40-80	66	81	110	136	1450	1750	3	5.0
TRSC 40-100	67	132	158	187	1450	1750	3	5.0
TRSE 40-100	67	86	114	141	1450	1750	3	5.0
TRSC 40-150	67	156	194	211	1450	1750	4	5.0
TRSE 40-150	67	97	125	152	1450	1750	4	5.0
TRSC 50-220	67	191	229	268	1450	1750	5.5	7.5
TRSE 50-220	67	162	202	240	1450	1750	5.5	7.5
TRSC 100-550	76	440	495	719	1450	1750	15	20
TRSC 100-700	76	506	561	836	1450	1750	18.5	30
TRSB 100-980	78	550	638	847	1450	1750	30	40
TRSE 125-1250	174	959	—	596	960	1150	37	50
TRSE 125-1550	174	1016	—	634	960	1150	45	60
TRSA 200-1950	183	2475	—	1600	730	880	75	100
TRSA 200-2500	184	2695	—	1700	730	880	75	100
TRSA 200-3100	184	2915	—	1800	730	880	110	160

Table 8 (continued)

PUMP MODEL	Noise Level dB(A)	Weight assembly Monoblock 50 Hz motor lbs.	Weight assembly Monoblock 60 Hz motor lbs.	Operating Speed		Installed Motor Size	
				RPM		kW	
				50 Hz	60 Hz	50 Hz	60 Hz
TRMA 32-25	69	37	40	2900	3500	0.75	1.1
TRMB 32-50	69	53	57	2900	3500	1.5	2.2
TRMB 32-75	70	81	91	2900	3500	3	4
TRMB 40-110	68	145	156	1450	1750	3	4
TRMB 40-150	69	167	233	1450	1750	4	5.5
TRMB 40-200	72	227	244	1450	1750	5.5	7.5
TRMB 50-300	72	277	—	1450	—	7.5	—

PUMP MODEL	Noise Level dB(A)	Weight Bare Pump lbs.	Weight assembly Monoblock (B5 design) lbs.	Weight assembly with baseplate lbs.	Operating Speed		Installed Motor Size	
					RPM		kW	
					50 Hz	60 Hz	50 Hz	60 Hz
TRVB 40-110	68	—	136	—	1450	1750	3	4
TRVB 40-150	69	—	141	—	1450	1750	4	5.5
TRVB 40-200	72	—	172	—	1450	1750	5.5	7.5
TRVB 50-300	72	—	194	—	1450	1750	7.5	10
TRVA 65-300	70	293	341	354	1450	1750	7.5	10
TRVA 65-450	70	321	387	442	1450	1750	11	15

PUMP MODEL	Noise Level dB(A)	Weight assembly Monoblock 50 Hz motor lbs.	Weight assembly Monoblock 60 Hz motor lbs.	Operating Speed		Installed Motor Size	
				RPM		kW	
				50 Hz	60 Hz	50 Hz	60 Hz
SA0E3U	67	123	242	2900	3500	11 15	15 20
SA0G2D	69	183	297	2900	3500	11 15	18.5 25
SA0G2G	69	191	139 157	2900	3500	15 22	20 30

**NOTES:**

- Noise level (measured at 3 feet distance, without motor, with pump installed in the system) for pump series TRH, TRM, TRV when operating at 60 Torr and pump series TRS when operating at 175 Torr. Noise level test to ISO 3746 standards and with pumps at 50 Hz operating speeds.
- Weights are for pumps fitted with Mechanical Seals and in Cast Iron materials (tolerance ± 10%).
- The assemblies, Monoblock and with Baseplate, are suitable for 50 Hz motors, except where otherwise noted. Indicated total weights for the assemblies are without motors.
- The installed motor size will cover the whole performance curve when operating as vacuum pump.

## 10 - CHECK LIST PRIOR TO START-UP



All questions listed below must have **POSITIVE** answers prior to proceeding to the pump start-up. Please note that the following is a partial list. Special installations may require further precautions therefore; additional safety steps must be taken as the case dictates.

- **This manual has been completely read, including the following chapters, and is understood in its entirety?**
- **The piping system has been flushed of any foreign particles, welding impurities, etc.?**
- **Have all piping and pump obstruction been removed?**
- **All connections and piping are leak proof and there are no external forces or moments applied to the piping or pump flanges?**
- **Pump and motor are properly lubricated, per instructions?**
- **Pump/motor alignment has been checked?**
- **Mechanical seal flushing line has been connected, where required?**
- **All valves in the installation are in the correct position?**
- **All safety guards are in place?**
- **Pump direction of rotation has been checked by jogging the motor?**
- **The pump Stop switch is clear and visible?**
- **Pump as well as installation are ready for start-up?**

## 11 - STARTING, OPERATING AND STOPPING PROCEDURES

Upon receipt and/or completion of installation, before turning on the power to the electric motor, rotate the pump shaft by hand to make sure that the pump rotor is free. In the event the shaft does not turn, try to free the rotor by applying a torque to the pump coupling with a pipe wrench. To free the rotor of a monoblock style pump (without coupling) introduce a bolt (or similar tool) at the motor shaft end that has a threaded connection and apply the torque by hand. In the event the pump does not become free with the above procedures, fill up the pump with a suitable solvent or lubricating liquid, let it rest for several hours to allow softening of the rust build-up inside the pump, drain the pump and apply torque to the pump shaft as described above to finally free the rotor.

**NOTE:** The selected solvent or lubricating fluid must be compatible with the pump, seals and gasketing materials.



### **CHECK PUMP-MOTOR COUPLING ALIGNMENT!**

This must be done prior to the first start-up and before every start-up if pump or motor has been removed from the installation for maintenance or other reasons. See section 7.2.

Prior to starting the pump verify that all auxiliary components are available, ready for use and, where required, they are in the open position (i.e.: double mechanical seals are pressurized with buffer liquid, cooling liquid to heat exchanger is open, etc.) and the pump bearings are lubricated. If the gas and/or service liquid temperatures are in the dangerous levels, it is recommended to insulate the pump, piping and separator to avoid direct contact with their surface, avoid freezing, thermal shock or losing heat energy.

**NOTE:** See section 11.4 to 11.6 for OIL SEALED (DynaSeal™) systems start-up, operation and shut-down.

### **11.1 - START-UP of WATER SEALED Systems**

(In the following, reference is made to certain ITEM numbers, which appear on fig. 17 to 22 of section 9 and 18).

Open valve at gas discharge if installed and partially open the valve at the suction side. When operating the pump as a compressor, there must be a check valve ITEM 2, fitted at the discharge side. When pump ITEM 4, is fitted in a partial recovery or total recovery or WATER SEALED systems, as built by TRAVAINI PUMPS USA, it is required to have drain valve ITEM 11, at separator ITEM 1, in the closed position, flow regulating valve ITEM 13, in the open positions. Before start-up fill the pump to the shaft centerline, separator and piping of system with service liquid through pump inlet flange or fill connection ITEM 28. Check all components for leakage. Start all accessories (temperature switches, level switches, pressure switches, etc.) open cooling and flushing lines. Start the pump and open the service liquid valve, ITEM 3 if applicable, soon after, start the circulating pump, ITEM 22 (if applicable) and adjust the service liquid flow (see table 3). Gradually open the valve at gas suction side till the required vacuum level is reached. Check the system for abnormal conditions (see section 12 and 14). If the system is fitted with a circulating pump and/or the service liquid has an excessive pressure the by-pass valve ITEM 13A, (if available) or valve, ITEM 13 can be adjusted to reduce the service liquid flow to the vacuum pump and/or optimize the thermodynamic efficiency of the heat exchanger ITEM 9.

**NOTE:** WATER SEALED systems engineered with multiple pumps are fitted with isolating valves at suction, discharge, and service liquid lines of each pump. When one or more pumps are not operating it is required to isolate the idle pump(s) by closing these valves. When the pumps are put back into service the said valves (at suction and discharge) must be opened.

### **11.2 - OPERATION**

After starting the vacuum pump check the following:

- the vacuum level is as desired or adjust the flow-regulating valve to the required vacuum
- flow and temperature of service liquid and/or cooling liquid are as expected (within 25% tolerance)
- motor does not draw more amperage than shown on its nameplate
- the pump-motor assembly does not have abnormal vibrations and noises such as cavitation
- the operating temperature at full load does not exceed approximately 85°C
- there are no leaks from mechanical seals, joints and flushing or cooling liquid lines
- liquid level in separator is between the minimum and the maximum.



### **NEVER OPERATE THE PUMP DRY!**

If the gas discharge is not open to the immediate atmosphere but it is piped to other locations, the pump discharge should be checked for back-pressures that could cause higher power consumption and loss of pump capacity.

### 11.3 - SHUT DOWN of “WATER SEALED” SYSTEMS

First close the service liquid flow and cooling liquid flow (if applicable) then shut down the circulating pump, ITEM 22, (if applicable). Where possible, gradually decrease the vacuum level to 300-675 Torr in about 10 seconds max or, if compressor, decrease the discharge pressure. The discharged service liquid from pump, ITEM 4, helps produce a slow deceleration rather than sudden stop. Turn off the power to motor ITEM 6 and close any accessories and flushing lines. Make sure the non-return valves, ITEM 2 or similar, at suction and discharge lines are leak tight. Should the system be idle for an extended period of time it is recommended to disconnect the electricity to the motor or control panel and drain all liquids from pump, separator and piping. Refer to chapter 6 for storage procedures.

### 11.4 – START-UP OF “OIL SEALED (DynaSeal™)” SYSTEMS

(In the following, reference is made to certain ITEM numbers which are listed in the figures and legend of section 12.1 and 19). Open the valve at the gas discharge, if applicable, and partially close the valve at the suction side. Close draining valve ITEM 11, and valves for condensate recovery ITEMS 13F and 13L, which are on the frame separator, ITEM 1B; open the valve ITEM 13D which is between the circulating pump, ITEM 22, and the frame separator, ITEM 1B, then partially open flow regulating valve, ITEM 13 between the discharge of circulating pump, ITEM 22 and the heat exchanger, ITEM 9, and the by-pass valve, ITEM 13A. If the system is fitted with a separator cyclone, ITEM 1D, and the adjacent collecting tank, ITEM 1E, it is required to close valves, ITEM 11A and 12 and open valve ITEM 13E. Fill frame separator with service oil through the filling plugs ITEM 28. Proper oil level can be seen on sight glass ITEM 7. Refer to table 12 and 13 for the required oil quantity. Start and/or open applicable accessories (temperature switches, level switches, etc.) and circuitry for cooling and flushing. Start vacuum pump, ITEM 4, and soon after, start the circulating pump, ITEM 22. Adjust the circulating pump capacity with valve ITEM 13. Gradually open the system suction valve till the desired vacuum is achieved. Check the systems for abnormal noises or vibrations (see section 12 and 14). Adjust by-pass valve ITEM 13A, to regulate the oil flow to the vacuum pump or to improve the thermodynamic efficiency of the heat exchanger.

**NOTE:** OIL SEALED (DynaSeal™) systems engineered with multiple pumps are fitted with isolating valves at suction, discharge, and service liquid lines of each pump. When one or more pumps are not operating, it is required to isolate the idle pump(s) by closing these valves. When the pumps are put back into service the said valves (at suction and discharge) must be opened.

### 11.5 - OPERATION OF “OIL SEALED (DynaSeal™)” SYSTEMS

After starting the vacuum pump check the following:

- the vacuum level is as desired or adjust the flow-regulating valve to the required vacuum
- the oil temperature is between 140 and 175°F. If required, adjust the thermostat on the radiator or in case of water/oil heat exchanger adjust the cooling water flow
- motor does not draw more amperage than shown on its nameplate
- the pump-motor assembly does not have abnormal vibrations or noises such as cavitation
- the surface temperature at full load, does not exceed approximately 85°F
- that there are no leaks from mechanical seals, joints, flushing or cooling liquid lines
- liquid level in separator and pump is between the minimum and the maximum

- the pressure gauge of the oil demister separator does not read more than 4 psi. When this value is exceeded, it will be required to change the filter element.

If the gas discharge is not open to the immediate atmosphere but it is piped to other locations, the pump discharge should be checked for back-pressures that could cause higher power consumption and loss of pump capacity.

### 11.6 - SHUT DOWN OF “OIL SEALED (DynaSeal™)” SYSTEMS

Close, if applicable, the cooling water to the water/oil heat exchanger ITEM 9, then turn off the power to the circulating pump ITEM 22. Where possible, gradually decrease the vacuum level to 300-625 Torr in about 10 seconds max. The discharged service liquid from pump ITEM 4 helps producing a slow deceleration rather than sudden stop.

Turn off motor ITEM 6, radiator ITEM 9 and any accessories and flushing circuitry. Make sure the non-return valves ITEM 2, or similar, at suction and discharge lines are leak tight. Should the system be idle for an extended period of time it is recommended to disconnect the electricity to the motor panel, drain all liquids from pump, separator and piping. Refer to chapter 6 for storage procedures.

## 12 - OPERATING MAINTENANCE

Periodically check the working conditions of the system by means of the instrumentation on the installation (pressure gauges, vacuum gauges, temperature gauges, ampmeters, etc.) and that the pump is consistently handling the application for which it was selected. The operation of the pump should be without abnormal vibrations or noises, if any of these problems is noticed, the pump should be stopped immediately, search for the cause and make the necessary corrections. It is good practice to check the pump/motor alignment, the running conditions of the bearings and of the mechanical seals (see section 13) at least once a year, even if no abnormalities have been noticed. If there is a deterioration of the pump performance, which is not attributable to changes in system demands, the pump must be stopped and proceed with necessary repairs or replacement. If the mechanical seals are fitted with external flushing and/or quenching lines their pressures, temperatures and flows must be checked constantly.



**NEVER ALLOW THE PUMP TO OPERATE IN THE CAVITATION AREA!**

Cavitation has the characteristic metallic sound, like if gravel was rotating inside the pump, and it causes also high pump vibrations. This happens when the pump is running at absolute pressures close to the vapor pressure of the service liquid at the running conditions. This is a damaging condition for the impellers, port plates and casings. The cavitation causes erosion taking away metal particles and attacking the surface of the pump components. This is particularly damaging if the pump is handling corrosive gases, see chapter 14 for suggestions to correct the problem.

Pump series TRH, TRM and TRV are fitted with an anti-cavitation valve that should be left open (if required) see fig. 23 and 24 for the location. This valve should be connected toward the upper part of the discharge separator so that, depending upon the operating vacuum, the pump can either take air or discharge excessive liquid. For OIL SEALED (DynaSeal™) systems the anti-cavitation valve ITEM 13H is piped from pump ITEM 4 to the frame separator ITEM 1B.



During operation it must be avoided to have sudden and frequent variations from high to low vacuum. (e.g. suddenly opening the suction valve when the pump is operating at pressures lower than 150 Torr). This would flood the pump creating high power absorption that would put heavy stress on the motor and coupling.

Particular attention should be put on the quantity of the service liquid flow. The flow will depend upon the type of installation (see section 9), the pump size, and/or the desired temperature rise. The flow of service water at 15 °C, for standard pumps and normal operating conditions at various vacuum levels, is listed on the specific pump curves and/or on table 3 of section 9.7. Usually the temperature rise of service water, when handling dry air at 68 °F, is approximately 10 °F. When condensable (e.g.: vapours) are present in the gas stream the heat load to be removed by the service water will be higher, therefore the service water temperature rise will be higher. The service liquid flow and its temperature will affect the pump performance. Generally the low service liquid flow will decrease the pump capacity, while a high service liquid flow will increase the absorbed power by flooding the pump (see section 17 for information and calculations). Hard service water will generate lime build-up inside the pump. The severity of the deposit will vary with the water temperature. Lime or mineral deposits on the surface of the internal pump components will cause an increase of absorbed power, wear of the components and eventually will seize the pump. It is recommended to monitor the water hardness and, if too high, treat the water. If there are no alternatives, there should be periodical flushing of the pump with a solution that will remove the specific deposits, or the pump must be periodically disassembled, cleaned of all incrustations and re-assembled. Systems with total service liquid recovery require periodical change of the service liquid contained in the closed loop. The heat exchanger must be kept well cleaned of all mineral deposits for an effective thermodynamic heat exchange. During operation, a closed loop system will lose some of the service liquid, due to evaporation and/or saturation of the discharged gases. It will be required to periodically make-up fresh liquid into the system. This operation is not required for those systems that are fitted with a float type automatic make-up valve ITEM 8. This valve requires water at a pressure of approximately 2 bar. Systems that handle condensable will experience a rise in the level of the service liquid in the separator. The excessive liquid will be overflowed through the overflow valve or connection. If the specific gravity of the condensable is higher than that of the service liquid, the condensable must be discharged through the separator drain valve ITEM 11, preferably with system not running.

### 12.1 - "OIL SEALED (DynaSeal™)" SYSTEMS

(For ITEM numbers refer to fig. 27 and it's legend).

It is very important to keep the service oil temperature under control when the oil temperature exceeds 90 °C there is the danger of seizing the pump and the gasketing may start leaking.

Every 100 - 200 working hours it is suggested to check the oil level in the oil reservoir, make-up oil if necessary and change the oil every 10,000 working hours (depending upon the use and the application).

Those installations where the handled gases are contaminated with dust or suspended solids that can alter the oil characteristics will require more frequent oil check and changes.

Condensable vapors, if present during evacuation, can be flushed right through the discharge of the separator (if they have low boiling point) or, when the system is idle, can be drained by opening valves, ITEM 16. During operation, the oil demister filter will be impregnated with oil particles; the pressure gauge, ITEM 2,

installed at the housing, ITEM 2, will provide an indication of the filter being plugged; pressure reading over 4 psi. maybe an indication that the filter needs replacement. At higher discharge pressures the discharged air quality will decrease and the vacuum pump absorbed power will increase.

To replace the oil demister filter, simply disconnect the oil scavenger line, remove the cover, ITEM 25, remove the used filter element, apply a gasketing material over the gasket faces of the new filter and place the latter in the housing, put in place the cover and the scavenger line.

TYPICAL BILL OF MATERIALS	
ITEM	DESCRIPTION
1	VACUUM GAUGE (STD)
2	PRESSURE GAUGE (STD)
3	TEMPERATURE GAUGE (STD)
4	COMPOUND GAUGE (STD)
5	LEVEL GAUGE (STD)
6	BULLSEYE GAUGE (STD)
7	BACK PRESSURE SWITCH (OPT)
8	LEVEL SWITCH, HIGH AND LOW (OPT)
9	TEMPERATURE SWITCH (STD)
10	HEAT EXCHANGER AIR OR WATER COOLED (STD)
11	FILTER SILENCER (STD)
12	INLET FILTER (OPT)
13	SPIN-ON OIL FILTER (OPT)
14	Y-STRAINER (STD)
15	SEPARATOR ELEMENT (STD)
16	BALL VALVE (STD)
17	BALL VALVE STRAINER ISOLATOR (STD)
18	MANUAL UNLOADING VALVE (STD)
19	AUTOMATIC UNLOADING VALVE (OPT)
20	GLOBE VALVE (STD)
21	CHECK VALVE (STD)
22	VACUUM RELIEF VALVE (OPT)
23	SOLENOID VALVE (NOT USED WITH ITEM 22)(OPT)
24	TEMPERATURE CONTROL VALVE (OPT)
25	SEPARATOR TANK (STD)
26	CIRCULATION PUMP (OPT)
27	TRAVANI LIQUID RING VACUUM PUMP (STD)
28	CONTROL PANEL NEMA 12 (STD)

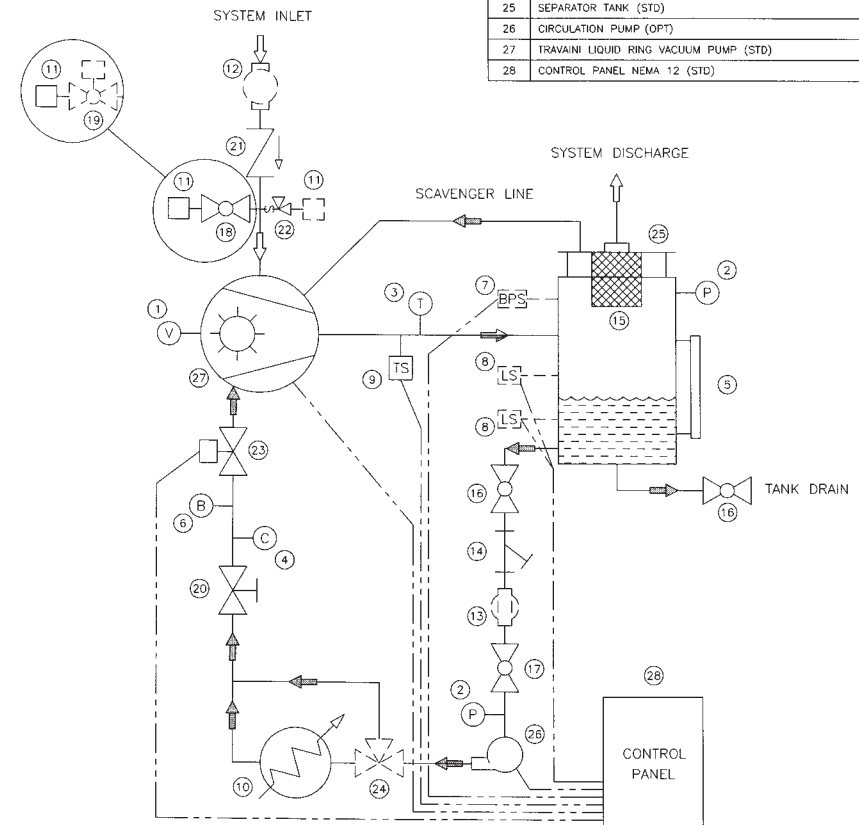


Fig 27 (General Schematic Drawing)

# 13 - BEARINGS AND MECHANICAL SEALS MAINTENANCE

**WARNING:** The maintenance must be carried out with the pump turned off and the electrical power, or other driving mechanism, must be disconnected. The power should only be turned back on by the same person doing the maintenance. It is, however, recommended to have at least a team of two workers doing the maintenance and the supervisors should be fully aware of the work in progress.

**CAREFULLY FOLLOW THE SAFETY PROCEDURES LISTED IN CHAPTER 2.**

### 13.1 - BEARINGS

At assembly time the pump bearings are lubricated with quality grease (sealed bearings are greased for life). Some of the recommended greases are:

- BP - ENERGREASE LS - EP 2      MOBIL - MOBILUX EP 2
- EXXON - BEACON EP 2            SHELL - SHELL ALVANIA EP GREASER

Bearings for pumps working in standard conditions should be lubricated every 2000/2500 working hours with a quality grease (see "Disassembly & Assembly" for the replacement of bearings). Bearing temperature should not exceed the 85 °C during normal working conditions and normal environments. Bearings can overheat for reasons such as too much grease, misalignment of flexible coupling, wrong bearings, excessive vibrations, bearing wear. See tab. 9 for bearing numbers and type used for each pump.

### 13.2 - MECHANICAL SEALS

Mechanical seals can be with many types of materials, design and installations (see fig. 28). TRAVAINI PUMPS USA has evaluated their selection at the time of pump design; it is a function of the fluid and working conditions. The seals are supplied with the proper flow of liquid for their lubrication, through internal pump passages. Upon request, the pump can be provided with seal lubrication coming from an outside source; the set-up must be such that the seals are guaranteed the liquid quantity and pressure as recommended by TRAVAINI PUMPS USA or by the seal manufacturer.

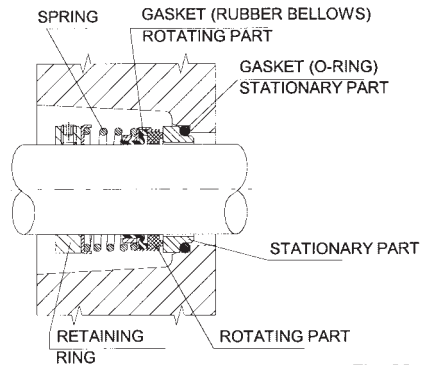


Fig. 28

For mechanical seal shaft size see table 9.

Mechanical seals normally fitted in the vacuum pumps are to DIN 24960 standards. See "Disassembly & Assembly Instructions" for major seal dimensions. Normally mechanical seals do not require maintenance until there is a visible liquid loss (leakage). See "Disassembly & Assembly Instructions" for seal replacement.

Mechanical seals **MUST NOT** run dry! When seals are operated with out lubricant and/or flushing liquid their faces and the elastomers may suffer damages beyond repair. It is suggested to check the conditions of the seal faces every approximately 4000 working hours.

Table 9

PUMP MODEL	BEARING			MECHANICAL SEAL	
	Quantity	Type	Grease Quantity each bearing - gr.	Quantity	Diameter mm
TRHE 32-4	1	6302.2RSR		1	16
TRHC and TRSC 32	2	6304.2RSR		2	22
TRHE 32-20/45/60-TRSE 32					28
TRHE 40-110 - TRSE 40					24
TRMA 32-25	1	6304.2RSR		1	28
	1	6204.2RSR			
TRMB 32-50	1	6305.2RSR		1	24
	1	6205.2RSR			
TRMB 32-75	1	6306.2RSR		1	28
	1	6206.2RSR			
TRMB 40-110	1	3208.2RSR	—	1	35
	1	6206.2RSR			
TRMB 40-150	1	3208.2RSR		1	45
	1	6306.2RSR			
TRVB 40-110/150	2	6208.2RSR		2	35
TRMB 40-200 and 50-300	1	3210.2RSR			
	1	6308.2RSR		2	55
TRVB 40-200 and 50-300	1	6210.2RSR			
	1	6208.2RSR		2	75
TRHC and TRSC 40	2	6306.2RSR			
TRHE 40-140/190	2	6308	20	2	43
TRSC and TRSE 50					35
TRHB 50 - TRVA 50 and 65					50
TRHB/C 80 - TRSB/C 100	1	6314		2	110
TRHE 100 - TRSE 125	1	NU 314			
TRHA 150 - TRSA 200	2	7320B.MB.UA	180	2	110
	1	22320ES.TVPB.C3			

**NOTE:** The supplied data are for pumps in STANDARD construction. For special construction please contact TRAVAINI PUMPS USA.

## 14 - TROUBLE SHOOTING: PROBLEMS, CAUSES AND SOLUTIONS

Consult the following table when problems are experienced, if solutions are not found in this chart or should there be any doubts; do not hesitate to contact TRAVAINI PUMPS USA or your local distributor.

**Table 10 - LIST OF PROBLEMS**


PROBLEM	LIST OF POSSIBLE CAUSES
Pump does not create or the vacuum is too low	1 - 2 - 3 - 4 - 9 - 11 - 18 - 19 - 22 - 23 - 24 - 25
Excessive noise	1 - 4 - 5 - 6 - 7 - 10 - 24
High power consumption	1 - 5 - 6 - 8 - 9 - 15 - 24 - 25
Vibration	5 - 6 - 7 - 8 - 10 - 12 - 13 - 24
Mechanical seal leaking	11 - 14
Pump loses liquid	11 - 19 - 23
Bearing failure	5 - 6 - 7
Pump does not start	1 - 6 - 20 - 21
Shaft partially or totally locked	6 - 10 - 15 - 16 - 21
Cavitation	3 - 4 - 8 - 9 - 17 - 24

CAUSES	SOLUTIONS
1 Defective motor or wired wrong	Check the voltage, the frequency, motor type, power consumption, rotation, wiring connections, phase consistency
2 Leakage in suction piping	Repair piping; check valves for leakage
3 Service liquid high temperature	Lower the service liquid temperature; check the level of the service liquid; adjust the cooling liquid flow; adjust the radiator thermostat to lower temperature setting
4 Low service liquid flow	Increase the service liquid flow
5 Coupling misalignment	Re-align the coupling and the pump/motor assembly (see cap. 7)
6 Faulty bearing	Replace the bearing(see "Disassembly & Assembly Instructions")
7 Cavitation	Open the anti-cavitation valve or set the relief valve to a lower vacuum (see table 4 to 6)
8 High service liquid flow	Reduce the service liquid flow; adjust the by-pass valve
9 High back pressure	Check the discharge line for obstructions or high friction losses; reduce the back-pressure to maximum 0.1 bar
10 Wrong pump/motor assembly	Verify that the base surface is level and that all pump feet are resting on the surface, add spacers if required (see section 11)
11 Mechanical seal failure	Change the mechanical seal (see "Disassembly & Assembly Instructions")
12 Wrong pump mounting	Remount the pump (see section 7)
13 Piping weight resting on pump	Support the piping with hangers or other means (see section 11)

	CAUSES	SOLUTIONS
14	Inadequate seal lubrication	Check flushing liquid temperature, flow and pressure
15	Mineral deposits from hard water	Clean the pump
16	Foreign particles in pump	Disassemble the pump to remove the foreign objects (see "Disassembly & Assembly Instructions")
17	Low suction pressure	Open the vacuum regulating valve and/or the anti-cavitation valve (vacuum relief valve)
18	Wrong pump rotation	Reverse the rotation (see section 8)
19	Bad gaskets	Replace the defective gaskets (see the "Disassembly & Assembly Instructions")
20	Wrong motor connections	Check the electrical connections (connectors, fuses, breakers) and the power supply line (see section 8)
21	Pump seized	Disassemble and repair the pump (see "Disassembly & Assembly Instructions")
22	Pump undersized	Select a pump with higher capacity
23	Pump worn-out	Disassemble and repair the pump (see "Disassembly & Assembly Instructions")
24	Excessive liquid flow through suction line	Reduce the liquid flow through the pump suction; install a centrifugal separator (cyclone) before the pump
25	Instrumentation out of calibration	Check the working characteristics, replace if required

## 15 - REPAIRING AND REMOVING PUMP FROM THE INSTALLATION

Should there be the need for pump repair a knowledge of the specific "Disassembly and Assembly Instructions" is required.



**FOLLOW THE SAFETY PRECAUTION MEASURES OUTLINED IN CHAPTER 2.**

### Before working on the pump it is important to:

- procure and wear the proper safety equipment (hard hat, safety glasses, gloves, safety shoes, etc.)
- disconnect the electrical power supply and, if required, disconnect the electrical cable from the motor
- close the isolating valves at pump inlet, outlet and service liquid
- let the pump cool down to ambient temperature if it has been handling hot fluids
- adopt safety measures if the pump has been handling hazardous liquids
- drain the pump internals of the pumped liquid through the draining connections, if necessary rinse with neutral liquid.

### To remove the pump and the motor from the installation proceed as follows:

- remove bolts from pump suction and discharge flanges
- remove the coupling guard
- remove the spacer of the coupling, if there is one

- if required, remove the motor anchor bolts on the baseplate, for base mounted assembly, or the bolts on the adapter flange in the case of monoblock design
- remove the pump anchor bolts on the baseplate
- remove the pump from the installation. Avoid damaging other system components.

After pump repairs, re-install following the steps from “Assembly and Alignment” procedures and after (see the applicable chapters).

## 16 - SPARE PARTS

When ordering the pump it is good practice to also order the necessary spare parts, especially when there are no stand-by pumps in the installation. This will minimize unnecessary down times in the event of pump failure or routine maintenance.

It is therefore, recommended to stock the following spare parts for each pump size:

- (1) Impeller set
- (1) Complete shaft assembly
- (1) Bearing set
- (1) Mechanical seal set (or packing set)
- (1) Gasket sets
- (1) Radial seal ring set
- (1) Bearing spacer set
- (1) Coupling rubber insert set

For better parts management, the VDMA 24296 standards suggest to stock the number of parts as a function of the number of pumps being used in the plant. On the pump nameplate are printed pump model, year of manufacture and pump serial number. When ordering spare parts always provide this information. Pump type, parts item number (VDMA) and description as per the pump sectional drawing and parts list is useful information that helps to supply correct spare parts for your pump. We recommend the use of original spares: in case this is not respected, TRAVAINI PUMPS USA declines any responsibility for eventual damages and not correct running caused by not original spare parts.

## 17 - ENGINEERING DATA

### 17.1 - INFLUENCE OF SERVICE LIQUID TEMPERATURE, SPECIFIC GRAVITY AND VISCOSITY ON PUMP PERFORMANCE

The performance of liquid ring vacuum pumps is based on the use of water at 15 °C as service liquid. With water at different temperatures the pump capacity and the maximum attainable vacuum level will vary as a function of the type of pump, as illustrated by the curve sets of fig. 29 and 30.

**EXAMPLE:** Pressure = 45 Torr - Water temperature = 24°C - Pump series TRH - Capacity (15°C water) = 310 ACFM From curves of fig. 30 we find the correcting factor of 0.80, therefore the actual capacity for the pump at the given conditions will be:  $310 \times 0.80 = 248$  ACFM. The maximum suction pressure before incurring cavitation will be approximately 35 Torr.

Regarding the performance variation due to changes of specific gravity and viscosity, it can be assumed a proportional variation in power consumption however; the changes in capacity at different pressures must be analyzed case by case. Please refer the conditions to TRAVAINI PUMPS USA when these corrections are needed.

Fig. 29  
Single stage pump  
(series TRM, TRS, TRV)

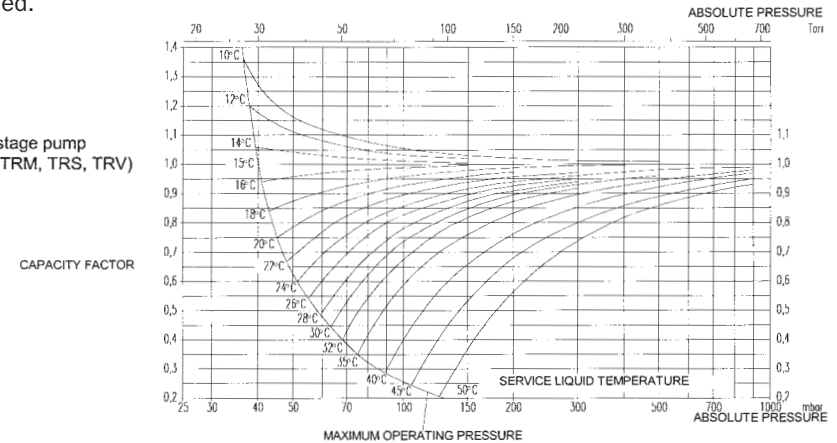
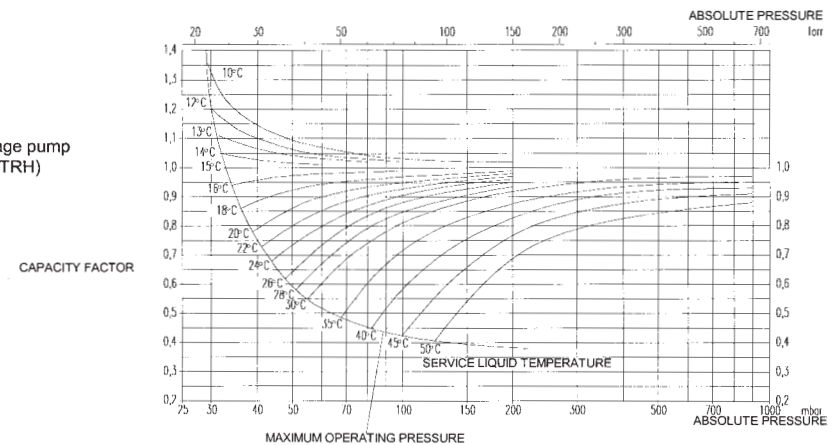


Fig. 30  
Two stage pump  
(series TRH)



### 17.2 - SERVICE LIQUID TEMPERATURE CHANGE ACROSS THE PUMP

The service liquid of a liquid ring pump absorbs total heat  $Q_T$  as follows:

$$Q_T \text{ (BTU)} = Q_c + Q_K + Q_R$$

Where:

$$\begin{aligned} Q_c &= 0.9 \times \text{BHP} \times 2545 &= \text{Isothermal compression heat} \\ Q_K &= m_v \times r &= \text{Condensation heat} \\ Q_R &= m_g \times c_p \times \Delta T_a &= \text{Cooling heat (Generally negligible,} \\ & & \text{ignored in calculation of } Q_T) \end{aligned}$$

$$\begin{aligned} m_v &= \text{mass condensed incoming vapor in PPH} \\ m_g &= \text{mass incoming gas in PPH} \\ P &= \text{absorbed power at operating point in kW} \\ c_p &= \text{gas specific heat in BTU/1B/}^\circ\text{F} \\ r &= \text{heat of vaporization in BTU's} \\ \Delta T_a &= \text{differential temperature in R, between incoming gas TG and service} \\ & \text{liquid discharge temperature } (T^2 + \Delta T) \\ K &= \text{Kelvin temperature} \end{aligned}$$

Once the  $Q_T$  is known it is possible to calculate the differential temperature  $\Delta T$  of the pump service liquid:

$$\Delta T = \frac{Q_T}{Q_A \cdot \rho \cdot c_p}$$

Where:

$$\begin{aligned} Q_T &= \text{total heat load before calculated in BTU/hour} \\ Q_A &= \text{pump service liquid flow in GPM} \\ \rho &= \text{service liquid density in kg/m}^3 \text{ (water = 1.0)} \\ c_p &= \text{service liquid specific heat} \end{aligned}$$

**NOTE:** It can be assumed that the discharge gas and service liquid have same temperature.

### 17.3 - OPERATION WITH PARTIAL RECOVERY OF SERVICE LIQUID

Where the working conditions will allow it, the service liquid temperature can be increased utilizing a smaller quantity of fresh liquid from an outside source. A similar flow as the make-up is discharged to the drain while the balance of liquid required by the pump is recirculated. In these cases the service liquid working temperature rises and the pump capacity will require correction per curves of fig. 29 and 30. The system installation will be similar to the schematic of fig. 31. Depending upon the affordable loss of capacity the service liquid temperature  $T_2$  may be set and the make-up flow of fresh liquid  $Q_F$  can then be calculated:

$$Q_F \text{ (m}^3\text{/h)} = \frac{Q_A \cdot \Delta T}{T_2 - T_1 + \Delta T}$$

Where:

$$\begin{aligned} Q_F &= \text{Fresh make-up flow from outside source in m}^3\text{/h} \\ Q_A &= \text{Total service liquid flow required for the operating} \\ & \text{conditions in m}^3\text{/h} \\ \Delta T &= \text{Service liquid temperature rise (see section 17.2)} \\ T_2 &= \text{Service liquid temperature to pump} \\ T_1 &= \text{Temperature of make-up liquid} \end{aligned}$$

The fig. 31 indicates a generic schematic of a liquid ring vacuum pump in a partial recovery system. By closing the recirculation line the system would become a "once through" installation where all the service liquid is drained, therefore:

$$Q_A = Q_F \quad \text{and} \quad T_2 = T_1$$

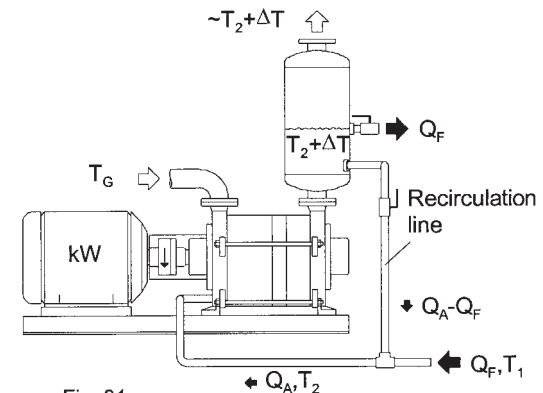
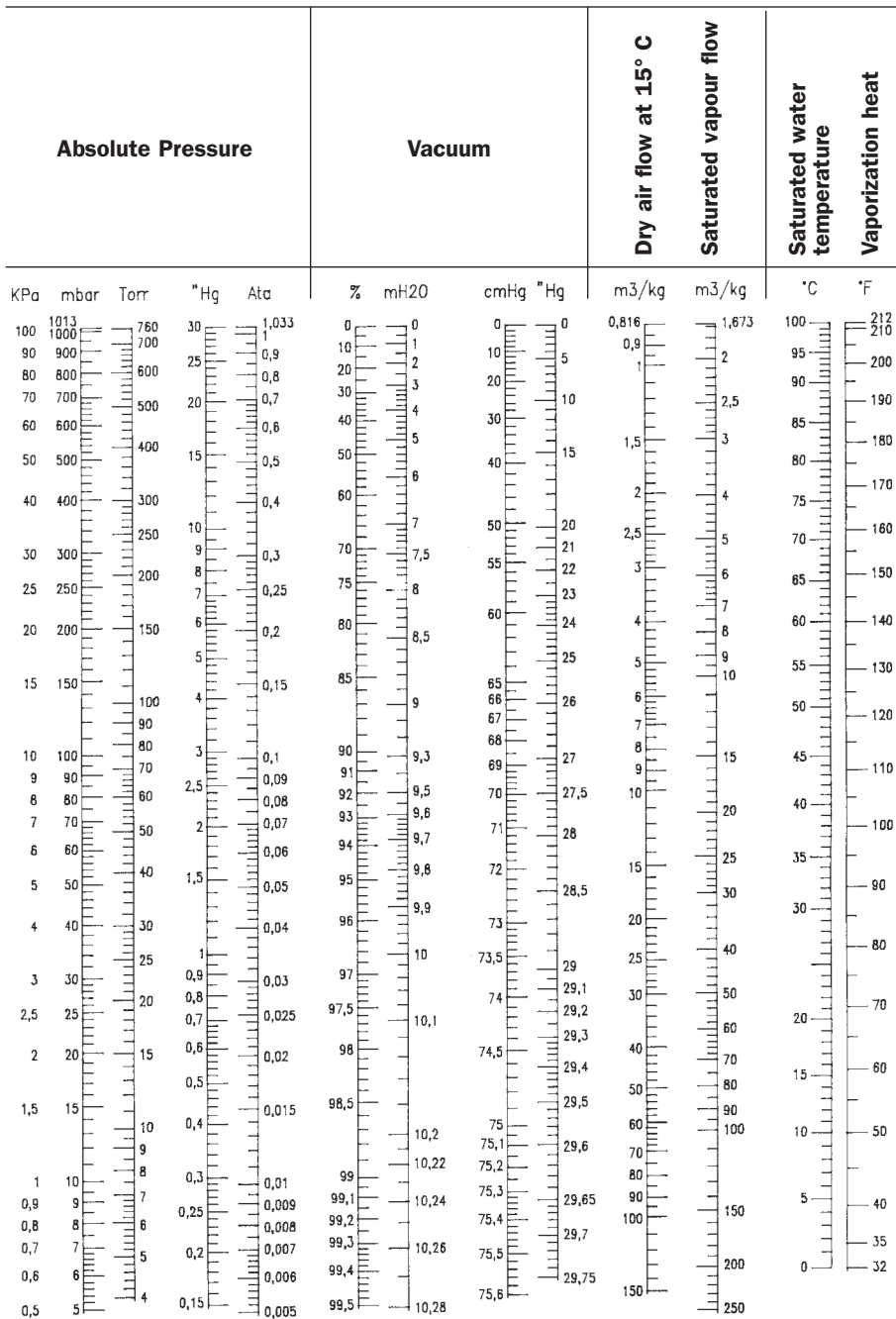


Fig. 31



17.4 - UNIT CONVERSION TABLE



18 - ENGINEERING DATA FOR "WATER SEALED" SYSTEMS

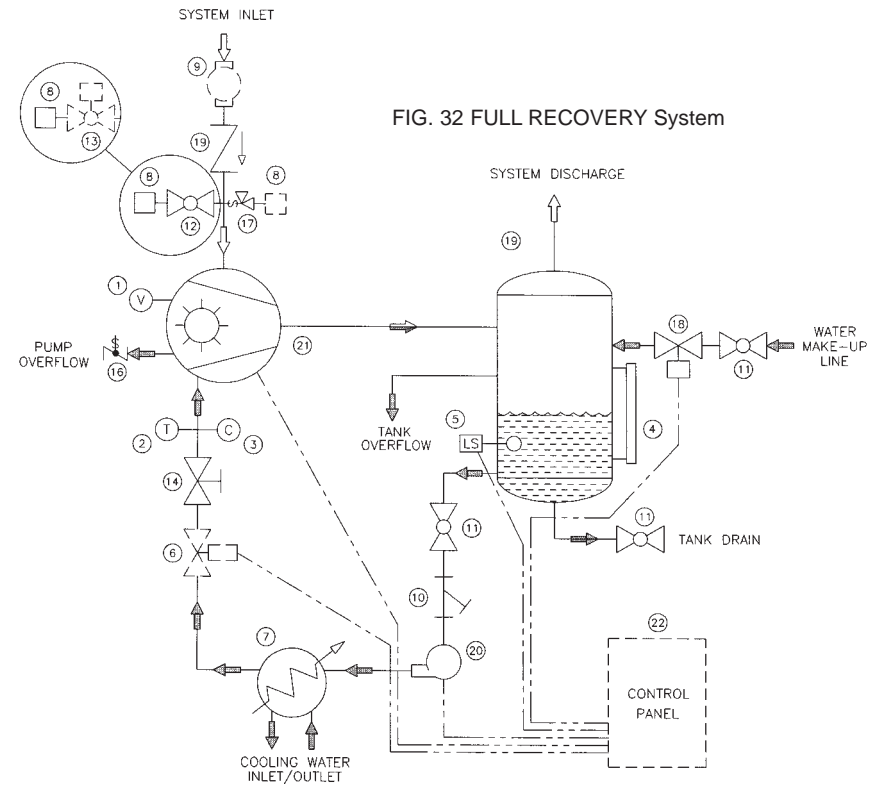


FIG. 32 FULL RECOVERY System

TYPICAL BILL OF MATERIALS	
ITEM	DESCRIPTION
1	VACUUM GAUGE (STD)
2	TEMPERATURE GAUGE (STD)
3	COMPOUND GAUGE (STD)
4	LEVEL GAUGE (STD)
5	LEVEL SWITCH (STD)
6	FLOW SWITCH (OPT)
7	HEAT EXCHANGER WATER COOLED (STD)
8	FILTER SILENCER (STD)
9	INLET FILTER (OPT)
10	Y-STRAINER (STD)
11	BALL VALVE (STD)
12	MANUAL UNLOADING VALVE (STD)
13	AUTOMATIC UNLOADING VALVE (OPT)
14	GLOBE VALVE (STD)
15	CHECK HINGE VALVE (STD)
16	CHECK SWING VALVE (STD)
17	VACUUM RELIEF VALVE (OPT)
18	SOLENOID VALVE (STD)
19	SEPARATOR TANK (STD)
20	CIRCULATION PUMP (STD 50HP AND UP)
21	TRAVAINI LIQUID RING VACUUM PUMP (STD)
22	CONTROL PANEL NEMA 12 (OPT)

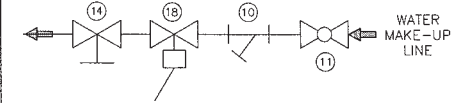


FIG. 32a PARTIAL RECOVERY System

WORKING PRINCIPLE

The WATER SEALED packages main components are: a liquid ring vacuum pump ITEM 21 from series TRH, TRS, TRM, TRV, an air/liquid separator reservoir ITEM 19, a heat exchanger ITEM 7, all mounted on a common base. When operating the vacuum pump discharges from the discharge port the gas handled with a portion of the liquid from the pump internal liquid ring. This liquid must be continuously returned to the pump.

The gas/liquid mixture is separated in a cylindrical tank (separator), the gas is vented through the top mounted discharge flange of the separator and the liquid is collected at the bottom of the separator ready to be returned to the vacuum pump.

During the suction and compression cycle of the vacuum pump, all the energy is transformed into heat energy and almost all of it is absorbed by the service liquid. Therefore the liquid must be cooled prior to be returned to the pump, either with a heat exchanger (total recovery system) or with the addition of cool make-up liquid (partial recovery system).

The **FULL RECOVERY** system (see fig. 32 and legend) does not require an appreciable flow of make-up from an external source but only the necessary amount to compensate for the liquid lost due to evaporation, with the discharged gases.

The heat exchanger sizing should be based on using a minimum amount of cooling liquid (usually water) to keep the service liquid at the ideal temperature for the best efficiency of the vacuum pump. Remember the higher the temperature of the service liquid the higher the losses in pump capacity and maximum vacuum see section 17.

This system is particular suitable where the service liquid and the condensed gases cannot be discharged to the environment, either for pollution reasons or because the fluids are too valuable.

The **PARTIAL RECOVERY** system (see fig. 32a and legend) requires a constant flow of cold make-up liquid from an external source. This liquid must be of the same nature as the service liquid being used by the pump. The mixture of the make-up and the service liquid being discharged by the pump, will have a constant temperature when enters the vacuum pump service liquid connection.

The same amount of service liquid taken from the outside source must be overflowed through the separator overflow connection situated at the pump shaft centerline. This system is utilized in many applications for conditions where there is intermittent use, or low vacuum levels, or there is no danger of pollution and the liquid can easily be drained.

Furthermore, this may prove to be the only alternative to the total recovery system for those installations where the cooling liquid is not available or it is too warm. Numerous accessories are available to meet the customers' requests and suitable for the installation, process and maintenance. For materials of construction and some engineering data see table 11 and 12.

**Table 11 - STANDARD MATERIALS FOR "WATER SEALED" SYSTEMS**

COMPONENT		MATERIAL DESIGN	
Vacuum pump		GH - F - RA - RZ      A3	
Separator reservoir		Carbon steel      AISI 316 SS	
Baseplate			
Heat Exchanger	Plates	Carbon Steel	
	Gaskets	Nitrile rubber / Viton	
Piping		Carbon steel	AISI 316 SS
Valves - Thermometer		Brass	
Level gauge		Polycarbonate	"Pirex" Glass

For vacuum pump materials (GH - F - RA - RZ - A3) see section 4.

**Table 12 - GENERAL AND NOT BINDING ENGINEERING DETAILS FOR "WATER SEALED" and "OIL SEALED (DynaSeal™)" SYSTEMS**

PACKAGE SERIES	Motor Size	Dry weight lbs.		
		WATER SEALED	OIL SEALED (DynaSeal™)	
WATER SEALED	2	5HP	300	450
OIL SEALED		2 poles / 60 Hz		
WATER SEALED	3	5HP	400	800
OIL SEALED		4 poles / 60 Hz		
WATER SEALED	4	10HP	1000	1000
OIL SEALED		4 poles / 60 Hz		
WATER SEALED	5	20HP	1200	1500
OIL SEALED		4 poles / 60 Hz		
WATER SEALED	6	40HP	1800	2000
OIL SEALED		4 poles / 60 Hz		
WATER SEALED	7	60HP	2500	3500
OIL SEALED		6 poles / 60 Hz		

EXAMPLE OF "WATER SEALED" SYSTEM General Schematic and Accessories or Options

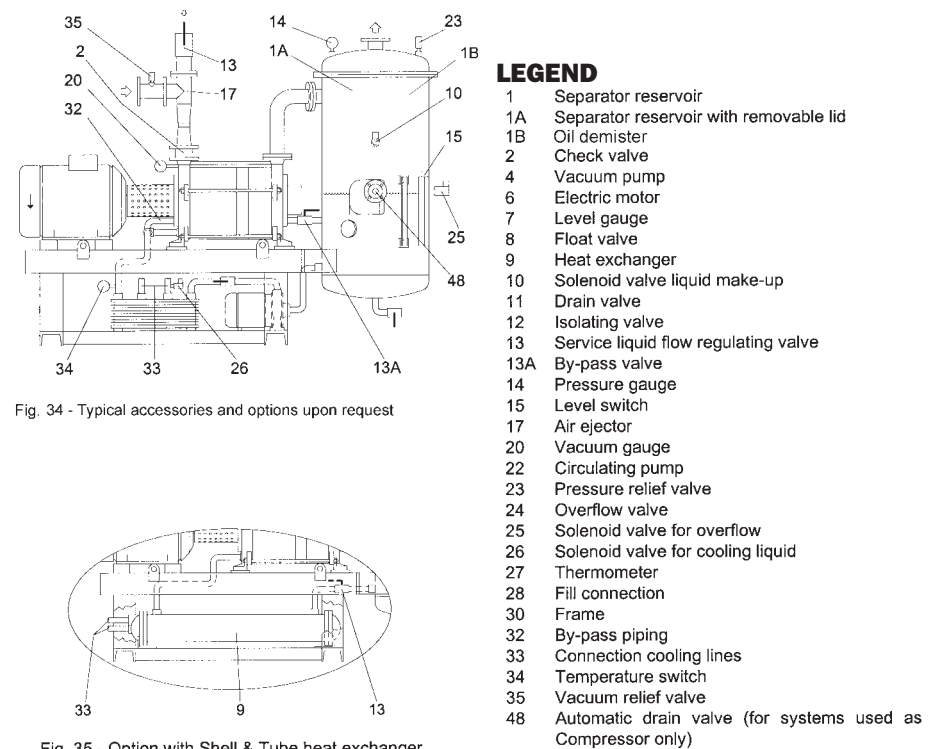


Fig. 34 - Typical accessories and options upon request

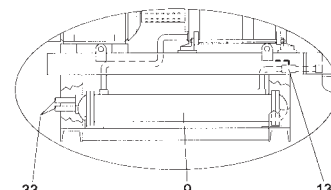


Fig. 35 - Option with Shell & Tube heat exchanger



# 19 - ENGINEERING DATA FOR "OIL SEALED (DynaSeal™)" SYSTEMS

## WORKING PRINCIPLE

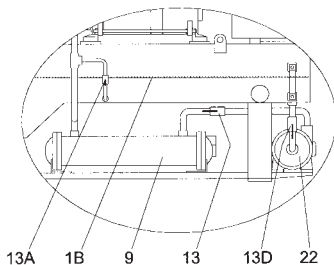
OIL SEALED (DynaSeal™) packages main components are: a liquid ring vacuum pump, ITEM 4, from series **TRH, TRS, TRM, TRV**, an air/liquid separator reservoir, ITEM 1A, a heat exchanger ITEM 9 and an oil demister filter, ITEM 1B.

Turbine type mineral oil, or equal, is used for service liquid. The characteristics of the chosen oil are such that at pressures below 75 Torr, the pump capacity is greater than what would be when using water, and higher vacuum levels are attainable. When operating, the vacuum pump discharges the gas handled with a portion of the liquid in tank, ITEM 15, that acts as separator of gas from the oil and let settle any condensable or particles coming through the pump suction flange. The circulator pump, ITEM 26, pumps the oil back to the vacuum pump after it has been through the heat exchanger, ITEM 10, and cooled at about 140-180 °F. The gas is vented after being cleaned of all oil with the special oil demister element; a pressure gauge, ITEM 2, on the filter housing, ITEM 5, gives indication of the degree of dirt contained by the filter element. Contrary to rotary vane vacuum pumps, there are no moving parts that come in contact with each other, therefore there is no need for lubrication of the pump internals; these are very robust and reliable pump packages which offer extended operating life even when handling condensable gases. See table 14 for materials of construction and table 12 in chapter 18 for some engineering data.

**Table 14 - STANDARD MATERIALS FOR "OIL SEALED (DynaSeal™)" SYSTEMS**

COMPONENT		MATERIAL DESIGN
Vacuum pump		<b>GH - F - RA - RZ</b>
Baseplate		Carbon steel
Heat exchanger air-oil	Cooler core	Aluminium
	Shroud	Carbon steel
	Fan - Guard	Carbon steel-Plastic coated
Piping		Carbon steel -Carburite rubber
Valves - Thermometer		Brass
Level gauge		Polycarbonate

See section 4 for vacuum pump materials of construction (GH-F-RA-RZ).



### LEGEND

- 13H - Anti-cavitation valve
- 13L - Condensate drain valve
- 13M - Flow regulating valve
- 14 - Pressure gauge
- 20 - Vacuum gauge
- 22 - Circulating pump
- 27 - Thermometer
- 28 - Fill connection
- 43 - Inspection openings

Fig. 38 – Option with Shell & Tube heat exchanger

# 20 - PRODUCT DATA INFORMATION FORM

PUMP model	Serial Number	System Number	Year of mfg.
.....	.....	.....	.....

GAS handled	Capacity	Suction Pressure	Discharge Press.	Temp.
.....	.....cfm	.....Torr	.....psi	.....°C/°F
<input type="checkbox"/> Lethal	<input type="checkbox"/> Toxic	<input type="checkbox"/> Noxious	<input type="checkbox"/> Corrosive	<input type="checkbox"/> Malodorous

Service LIQUID	Capacity	Temperature
.....	.....GPM	.....°C

TOTAL WEIGHT
.....lbs

MAXIMUM DIMENSIONS		
X = .....	in	
Y = .....	in	
Z = .....	in	

NOISE (measured at 1 m)	
Pressure	= .....dB(A)
Power	= .....dB(A)

INSTALLATION	
<input type="checkbox"/> Inside	<input type="checkbox"/> Outside
<input type="checkbox"/> Explosive area	<input type="checkbox"/> .....

SERVICE	
<input type="checkbox"/> Continuous	<input type="checkbox"/> Intermittent
<input type="checkbox"/> .....	<input type="checkbox"/> .....

MOTOR type / Frame	No Poles	No Revolutions	Absorbed power	Installed power
.....	.....	.....RPM	.....Amp	.....kW / .....HP
Frequency	Supply	Enclosure	Insulation class	Absorbed power
.....Hz	.....Volt	IP.....	.....	.....kW / .....HP

COMMENTS \_\_\_\_\_

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<h1>WARRANTY</h1>	<h1>TRAVAINI PUMPS USA</h1>
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Subject to the terms and conditions hereof, Travaini Pumps U.S.A., Inc. (hereafter referred to as the "Company") warrants that the products and parts of its manufacture specified below, when shipped, and its services when performed, will be free from defects in material and workmanship for following warranty time periods:

PRODUCT DESCRIPTION	WARRANTY PERIOD FROM DATE OF SHIPMENT
Liquid Ring Vacuum Pump system or pump products	Two (2) years
Rotary vane system or pump products	24 / 18 months if TPUSA oil used / not used
Centrifugal pump products	18 months, or 12 months from date of installation, whichever occurs first
Mechanical seals	3 months
Repaired pumps / systems	6 months for the repair / work performed

This Warranty shall apply to liquid ring vacuum products only if they are operated with Company approved seal fluids and to rotary vane products only if they are operated with Company approved lubricants. In-warranty repaired or replaced products are warranted only for the remaining unexpired portion of the warranty period applicable to the repaired or replaced product(s).

This Warranty does not extend to equipment such as electric motors, starters, heat exchangers and other accessories furnished to the Company by third party manufacturers and/or suppliers. Said accessories are warranted only to the extent of any warranty extended to the Company by such third party manufacturers and/or suppliers. Replacement of maintenance items, including, in particular, seals, bearings, filters, etc. supplied in connection with standard maintenance service provided by the Company are not covered by this Warranty. Any technical assistance, advice, or comments provided by the Company regarding system components, other than those manufactured by the Company, are not covered under this Warranty; the Company disclaims any liability in connection with same. The Company disclaims any liability in connection with the malfunctioning of any system(s) or component(s) of system(s) which conform to designs, specifications and/or instructions mandated by purchasers.

This Warranty is limited exclusively to products and/or parts of the Company properly installed, serviced and maintained in full compliance with the Operating and Maintenance manual of the Company. This Warranty shall not extend to products and/or parts which

have been misused or neglected or not used for the purpose(s) for which they were intended, including, in particular, products operated at/in excessive temperature or dirty environments, products used in conjunction with corrosive, erosive or explosive liquids or gasses, and/or products malfunctioning as a result of build-up of material in the internal parts thereof. Products which are disassembled without the prior written consent of the Company and/or which are repaired, modified, altered or otherwise tampered with in any manner inconsistent with the Operating and Maintenance manual of the Company are not covered under this Warranty. Products and/or parts which are kept in "long term" storage, as such terms are defined in the Operations & Maintenance manual of the Company, and not maintained in accordance with Company long term care procedures specified by the Company are not covered under this Warranty.

Warranty claims must be made within the warranty period specified above for each of the Company's products and services and include the serial number thereof. The Company's obligations under this Warranty are limited, in the Company's sole discretion, to repair, replacement or refund of the purchase price received by the Company for the product, part or service. Notwithstanding the foregoing, the Company shall have the option to provide alternative solutions of a different design. In no event shall the purchaser and/or any subsequent owner or beneficiary of the products, parts and/or services be entitled to recover incidental, special or consequential damages arising out of the breach of this Warranty or any defect, failure or malfunction of the products and/or services supplied by the Company.

A written return authorization must be obtained from the Company prior to the return of any product and/or part under this Warranty. Products and parts are to be returned only to the Company's facilities or such facilities as the Company may designate in writing. Costs of uninstalling/ reinstalling the product and/or any part under Warranty, as well as all costs associated with the shipment thereof to and from the facilities of the Company shall be at the owner's sole expense.

**THIS WARRANTY AND THE COMPANY'S OBLIGATIONS HEREUNDER ARE EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. ALL WARRANTIES WHICH EXCEED THE AFOREMENTIONED OBLIGATIONS ARE HEREBY DISCLAIMED BY THE COMPANY AND EXCLUDED FROM THIS WARRANTY, WHETHER BASED ON CONTRACT, WARRANTY, NEGLIGENCE, INDEMNITY, STRICT LIABILITY OR OTHERWISE. NO EMPLOYEE OF THE COMPANY OR OTHER PERSON IS AUTHORIZED TO GIVE ANY OTHER WARRANTY OR TO ASSUME ANY OTHER LIABILITY ON THE COMPANY'S BEHALF.**

Effective as of January 2007

## **Maintenance Schedule**

To help ensure trouble free system operation, setup a maintenance schedule consisting of the following system checks: (application dependent)

### **First 8 Hours Of Operation:**

Check oil level and inlet filter element. Clean strainers and remove temporary inlet screen. Check for water in the sight gauge and drain if necessary. Check piping for signs of leakage and tighten if necessary. Repeat this procedure every 1000 hours of operation under normal conditions. (application dependent)

### **Every 1000 Hours of Operation:**

Check back pressure on separator tanks. It should not exceed 4psig. Change separator element if gauge reads 4psig or greater. Clean or replace inlet filter element every 1000 to 3000 hours of operation depending on application or if excessive pressure drop is noticed. (application dependent)

\*Running a system at 15”HgV and shallower will result in “carry over”. This is when the discharge of the system becomes greater than the vacuum. The separator element becomes saturated with the sealing fluid oil and the pressure starts forcing an oil mist out of the discharge port. This will result in ruining the separator element, cause the discharge pressure to exceed 4psig and you will have a significant drop in performance of the system. Liquid ring systems are designed to run 17” HgV and deeper.

### **1000 – 3000 Hours of Operation:**

There are grease fittings located on the bearing housings of pump systems of 10HP and larger. Grease bearings with a #2 quality lithium grease. DO NOT OVER GREASE! 2 to 3 pumps with a normal grease gun is sufficient under normal conditions. (application dependent)

### **10,000 Hours of Operation/Once Per Year:**

Change seal fluid. The system must use Travaini DynaLube™ sealing fluid. Change separator element if back pressure exceeds 4 psig. If applicable, check the coupling element for wear and replace if necessary. (application dependent)

### **Grease Requirements:**

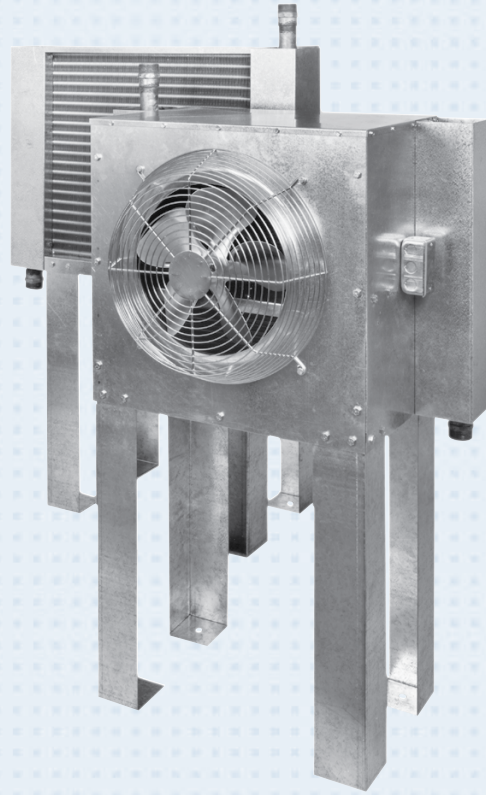
Both ends of the electric motor should be greased once yearly using one pump stroke with 375° to 500° Drop Point lubricant. The vacuum pump should be greased every 4 to 5 months (application dependent) with 2 to 3 strokes per grease fitting.

# COMPRESSED AIR COOLING | Air AA Series

## COPPER TUBE CONSTRUCTION

### Features

- Full Line of Sizes and Features
- Energy Efficient
- High Performance
- Medium Flows 80-300 CFM
- Horizontal Air Flow
- Optional Weatherproof Junction Box
- Floor or Suspended Mounting
- Optional TEFC motor(s)
- Ratings Based on Comprehensive Testing
- Wired for Single Point External Connection



### Ratings

- Maximum Operating Pressure** 250 psig  
**Maximum Operating Temperature** 350° F

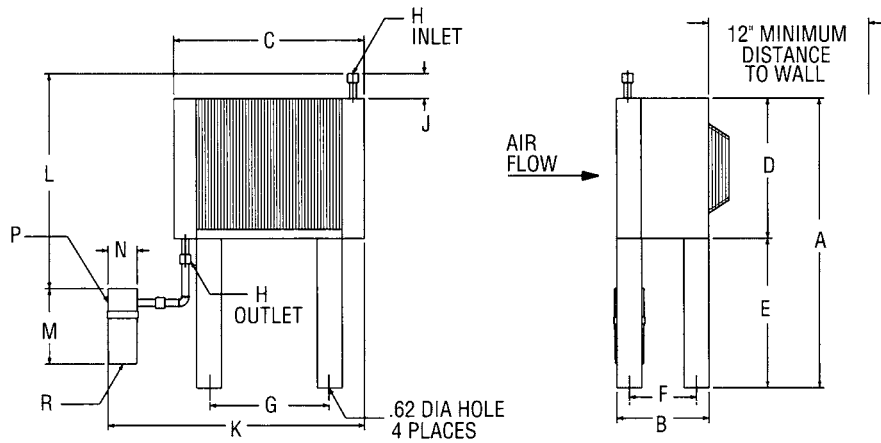
### Materials

- Cabinet** Galvanized Steel  
**Core** Aluminum Fins on Copper Tubes  
**Fan** Heavy Gauge Aluminum with Steel Hub  
**Motor** Open Vented  
**Fan Guard** Steel with Baked Enamel Finish

## How to Order

<b>AA</b>	-	<input type="text"/>	-	<input type="text"/>
<b>Model Series</b> AA		<b>Model Size Selected</b>		<b>Specify Motor Required</b> 0 - No Motor 1 - Single Phase 60 Hz ODP 115 Volt 2 - Single Phase 60 Hz TEFC 115/208-230 Volt 3 - Three Phase 60 Hz TEFC 208-230/460 Volt 5 - Air Motor

# Dimensions



Model	A	B	C	D Approx	E	F	G	H NPT	J	K* Approx	L* Approx	Optional Separator				Recommended Optional Separator Model Number
												M	N	NPT	R	
AA-50	46.50	14.75	30.50	22.50	24.00	10.75	19.09	1.00	4.00	41.12	34.50	10.00	4.62	1	1/4	S-100M or AD
AA-80			43.50					1.50		35.00						
AA-120			47.63	2.00			37.10	12.10		4.70	1					
AA-150			51.68	36.60												
AA-240	49.50	47.63	25.50	58.33	40.60	1-1/2	S-300M									
AA-300	55.50	51.68	31.50	62.38	49.60											

Note: We reserve the right to make reasonable design changes without notice. All Dimensions are in inches.

## Capacity Selection Chart Max. SCFM @ 5, 10, 15 and 20°F Approach

Inlet Temp. °F	150				200				250				300				350				Recommended Optional Separator Model Number	
	5	10	15	20	5	10	15	20	5	10	15	20	5	10	15	20	5	10	15	20		
Model Number	AA-50	34	58	79	99	25	43	59	74	21	36	50	62	18	31	42	52	16	27	38	47	S-100M or AD
	AA-80	50	87	119	150	40	69	94	117	34	59	80	100	30	52	71	89	28	47	65	82	
	AA-120	81	138	190	235	61	105	142	177	51	87	120	150	43	75	102	127	40	69	94	116	S-200M
	AA-150	92	160	220	270	73	125	172	215	63	110	150	187	55	95	130	160	50	86	120	148	
	AA-240	160	275	380	425*	120	207	285	355	100	175	240	300	84	145	204	250	78	135	185	231	
	AA-300	184	318	440	480*	145	250	345	430	125	217	300	375	110	190	257	320	100	175	240	300	

Above specifications are based on 80 to 125 PSIG operating pressures.  
 Maximum pressure drop, less than 3 psi. A flexible metal hose must be properly installed between the compressor and aftercooler to validate warranty.  
 \*Maximum ratings restricted by pressure drop, actual thermal capacities are higher.

## Electric Motor & Fan Data

Model	CFM	Motor H.P.	Standard Motor (ODP)		Optional Motor (TEFC)		Optional Motor (TEFC)*		Optional Air Motor		Approx. Shipping Overload (Lbs.)
			Voltage	Full Load Amps/Motor	Voltage	Full Load Amps/Motor	Voltage	Full Load Amps/Motor	PSI <sup>(1)</sup>	CFM <sup>(2)</sup>	
AA-50	1375	1/4	115/1/60	7.2	115/208 230/1/60	5/2.6-2.5	208-230/ 460/3/60	1.4-1.3/65	50	13	110
AA-80											120
AA-120	2450										140
AA-150	2350										145
AA-240	4600	1/4 <sup>(2)</sup>									200
AA-300	4700										300

Standard Motor(s) = 1600 RPM, Custom Frame, Equipped with Thermal Overload. Optional Motor(s) = 1725 RPM, Nema 48 Frame, No Thermal Overload.  
 Published electrical ratings are approximate, and may vary because of motor brand. Actual ratings are on motor nameplate.

**\*3 phase motors available in 50Hz. Reduce performance by 10%**

(1) Air inlet to motor must be regulated to this pressure.

(2) CFM (Free Air) consumption of the air motor. Lubrication = one drop of oil for every 50-75 CFM of air going through the motor. Use detergent SAE #10 oil. Filter, regulator and lubricators for the air motors are required, but not included.



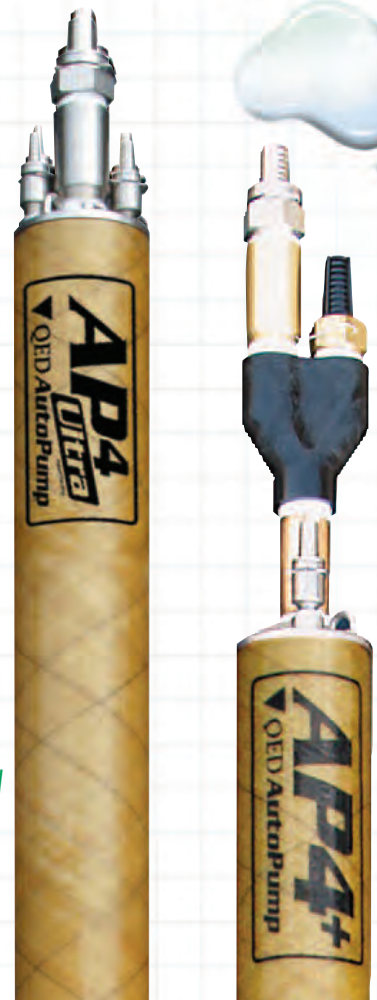
# AutoPump® Catalog

- *The Original Automatic Air-Powered Pumps now including the new low-maintenance AP4 Ultra*
- *Top Choice at Remediation and Landfill Sites Around the World*
- *Complete Systems*



**QED®**  
Innovative Environmental Products

*Featuring the AP4+ Series and  
the new low - maintenance  
AP4 Ultra*





## AutoPump Automatic Air-Powered Pumps



Automatic air-powered pumps offer exceptional capabilities in the severe pumping conditions found at many landfill and remediation sites. QED's AutoPump® (U.S. Patent Number 5,004,405) pumps originated the automatic air-powered pump concept in 1986 and have lead the industry ever since. AutoPumps were designed specifically to handle difficult conditions reliably and safely, including, hydrocarbons, landfill leachates and condensates, solvents, suspended solids, silts, corrosives, and high viscosities, along with high temperatures and frequent starts and stops. Air-powered AutoPumps are proven worldwide at thousands of sites, which is why AutoPumps are the No. 1 choice of professionals based on reliability, durability, performance range, and technical support.

The superiority of the AutoPump design is based on four key strengths:

- high clearance fluid pathways
- using air as the motive force
- materials of construction matched to site conditions
- a simple yet rugged operating mechanism

Unlike electric pumps, air-powered AutoPumps use no high-speed motors, bearings or impellers, so AutoPumps don't heat up, seize up, or get ground up. Liquid shearing is typical of electric pumps, creating oil-water emulsions that reduce the performance of downstream treatment equipment. AutoPumps cause far less liquid shearing than electric submersible pumps so downstream treatment systems can perform better. Air-powered also means eliminating the dangers and costs of electricity at and in the well. Finally, AutoPumps actually have a built-in control system – they pump when there is liquid present and shut down when the level is drawn down, without the need for any sensors in the well or controls at the surface.

### Application Excellence

Remediation applications and landfill fluids pumping are very challenging. QED is dedicated to providing a comprehensive approach to meeting the specific needs of each site and well, taking into account many factors beyond just flow rate and depth, such as:

- Preferred inlet position number – top or bottom
- Pump length to match water column and meet drawdown requirements
- A broad range of materials of construction to match fluid properties and temperature
- Jacketed tubing sets, bundled hose and quick-connect options to ease installation and service
- A wide variety of standard and custom wellhead completions to fit site needs

### Experience and Expertise

The AutoPump specialists at QED have unsurpassed experience in both typical and special applications, providing the quality and care that makes a difference. Call us at 1-800-624-2026 for prompt, professional assistance, or visit our web site at [www.qedenv.com](http://www.qedenv.com) to access product and application information.

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Short AP4 Ultra Bottom Inlet Pump	10 – 13
Long AP4 Ultra Top Inlet Pump	14 – 17
Short AP4 Ultra Top Inlet Pump	18 – 21
Long AP4+ Bottom Inlet Pump	22 – 25
Short AP4+ Bottom Inlet Pump	26 – 29
Low-Drawdown AP4+ Bottom Inlet Pump	30 – 33
Long AP4+ Top Inlet Pump	34 – 37
Short AP4+ Top Inlet Pump	38 – 41
Low-Drawdown AP4+ Top Inlet Pump	42 – 45
Long AP3 Bottom Inlet Pump	46 – 49
Short AP3 Bottom Inlet Pump	50 – 53
Long AP3 Top Inlet Pump	54 – 57
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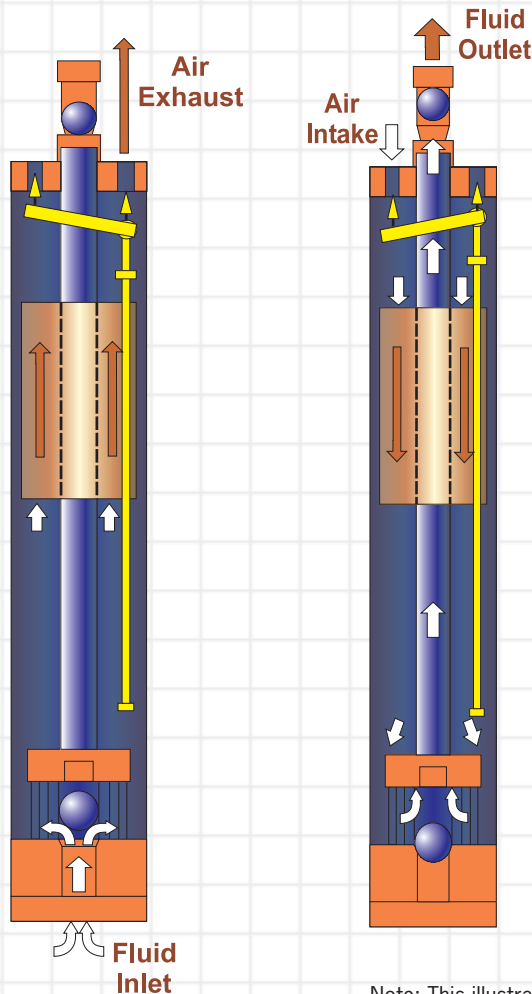
## How AutoPumps Work

### Fill Cycle

The fluid pushes the inlet check valve open and fluid enters the pump.

As the fluid level rises, air is expelled through the exhaust air valve and the internal float rises to the top of its stroke.

In this upper position, the float triggers a lever assembly, which closes the air exhaust valve and opens the air inlet allowing air to enter and pressurize the pump.



### Discharge Cycle

With the air inlet open, air pressure builds up within the pump body. This causes the fluid inlet check valve to close and forces the fluid to be displaced up and out of the fluid outlet.

As the fluid level falls, the float moves downward to the bottom of its stroke.

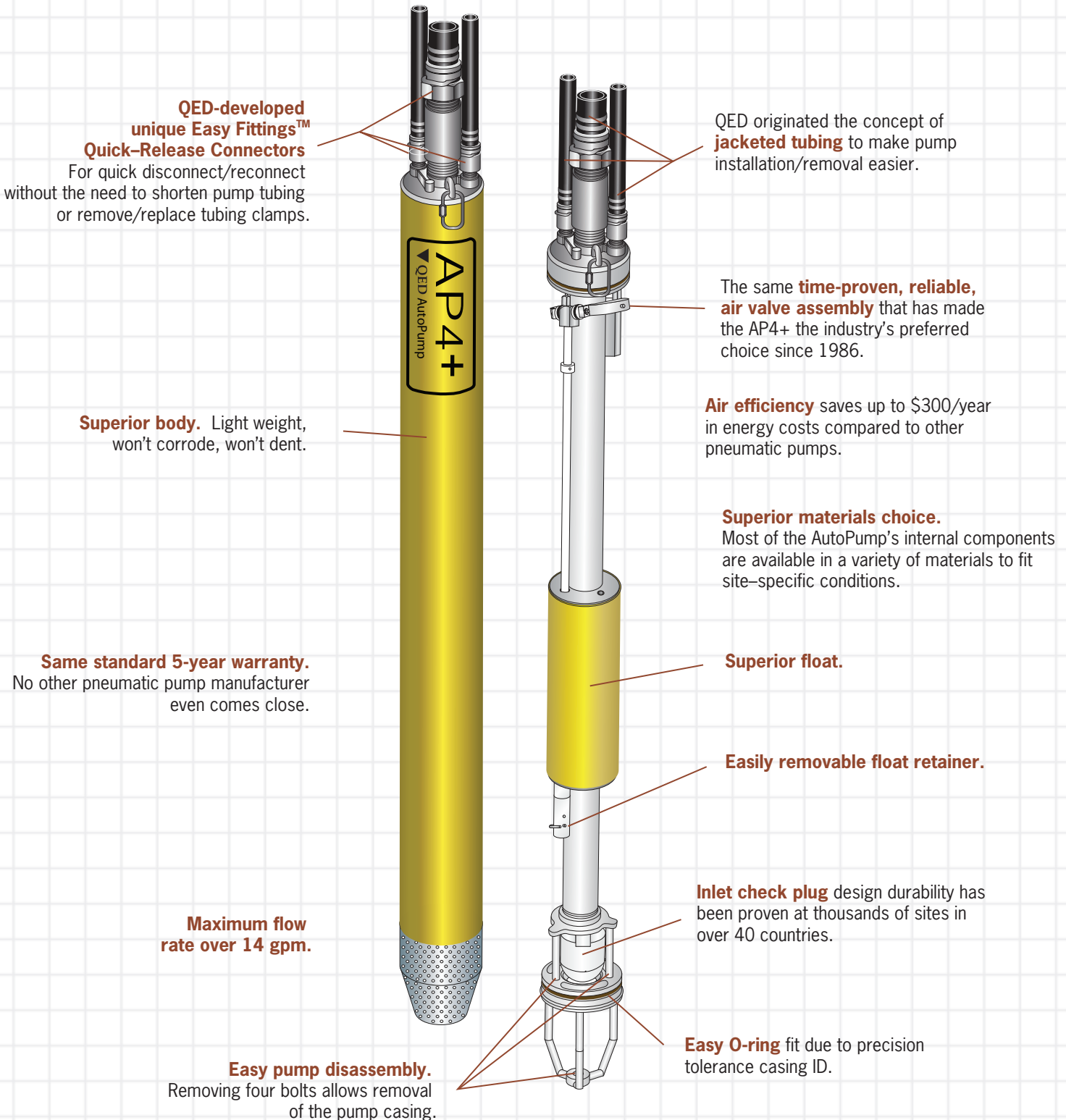
In this lower position, the float triggers the lever assembly to close the air supply and open the air exhaust valve, and a new cycle begins.

Note: This illustration is for a bottom filling format. A top loader is also available with both the inlet and discharge at the top of the pump.

### AutoPump Reliability

The AutoPump® air-powered pump operating cycle diagrams and explanation above tell just part of the story of AutoPump technology. Engineering an automatic pump to function in clear water is just the start. The real secrets of AutoPump durability and reliability are based on over 18 years of site experience in difficult pumping applications. AutoPumps are designed to resist chemical attack, abrasive wear, mechanical wear, solids deposits, viscous fluids and elevated temperatures. The entire air valve control mechanism has been refined in many subtle ways to survive these severe pumping conditions, using special materials, tolerances, and safety factors to provide years of trouble-free cycling. And, now there is the new AutoPump AP4 Ultra, which uses proprietary non-stick finishes on the float and discharge tube to help reduce solid buildups, extending the time between cleaning and making it much faster and easier to clean the pump. AutoPumps are the first of their kind, first in design experience, and first in reliability and durability.

## Why AutoPumps Are Better



## Guide to AutoPump Selection

### Quick Guide to AutoPump Selection

An important advantage of an AutoPump® (U.S. Patent Number 5,004,405) air-powered Pump system is the wide range of choices to truly match site needs. Below is a quick guide to the major configurations and options offered in the AutoPump line, to help you determine which models are best for your project. Of course, you can just call us at 1-800-624-2026, or email us at info@qedenv.com, for fast, personal service by our application specialists.

As a general guideline, pump model selection is usually based on the following primary application criteria. They are presented in the common sequence of consideration, but special site needs may alter the priority.

- **Maximum Flow and Depth** – pump model, depth, submergence, and drive pressure determine the maximum flow rate that can be achieved; see specific pump curves for detailed flow information
- **Pump Diameter** – to fit the well ID; also, larger diameter pumps deliver higher flow rates, all other factors being equal
- **Inlet Position** – top or bottom inlet; a top inlet enhances removal of LNAPLs, while bottom inlets provide the highest flow rates and greatest solids-handling capacity for DNAPL, and landfill fluids
- **Actuation Level** – minimum height of liquid needed to actuate the pump, also equal to the minimum drawdown level; low-drawdown models are optimized for maximum drawdown
- **Materials of Construction** – many models are available in upgraded materials for special applications, such as extremes of pH, suspended solids, high temperatures, and aggressive solvents. The new low-maintenance AutoPump AP4 Ultra uses special non-stick finishes on the float and discharge tube. All metallic parts are 316-grade stainless steel, allowing for greater corrosion resistance.

AutoPumps	Model	Pg#	Inlet Position	Out. Diameter in./cm	Overall Length in./cm	Max. Flow gpm/Lpm	Max. Depth ft./cm	Act. Level in./cm
<b>4" Bottom Inlet AP Pumps</b>								
Long AP4 Ultra Bottom Inlet	Long AP4.0B	07	Bottom	3.6 / 9.1	51.4 / 131	14 / 53	250 / 76	38.4 / 98
Short AP4 Ultra Bottom Inlet	Short AP4.0B	10	Bottom	3.6 / 9.1	39.3 / 100	13 / 49	425 / 130	26.7 / 68
Long AP4+ Bottom Inlet	Long AP4+B	22	Bottom	3.6 / 9.1	51.4 / 131	14 / 53	250 / 76 <sup>2</sup>	38.4 / 98
Short AP4+ Bottom Inlet	Short AP4+B	26	Bottom	3.6 / 9.1	39.3 / 100	13 / 49	250 / 76 <sup>2</sup>	26.7 / 68
Low-Drawdown AP4+ Bottom Inlet	LD AP4+B	30	Bottom	3.6 / 9.1	27.5 / 70	7 / 26.5	250 / 76	15.3 / 39
<b>4" Top Inlet AP Pumps</b>								
Long AP4 Ultra Top Inlet	Long AP4.0T	16	Top	3.6 / 9.1	56.7 / 144	10 / 38	250 / 76	53.3 / 135
Short AP4 Ultra Top Inlet	Short AP4.0T	18	Top	3.6 / 9.1	45 / 110	9 / 34	250 / 76	41.6 / 106
Long AP4+ Top Inlet	Long AP4+T	34	Top	3.6 / 9.1	56.7 / 144	10 / 38	250 / 76 <sup>2</sup>	53.3 / 135
Short AP4+ Top Inlet	Short AP4+T	38	Top	3.6 / 9.1	45 / 110	9 / 34	250 / 76 <sup>2</sup>	41.6 / 106
Low-Drawdown AP4+ Top Inlet	LD AP4+T	42	Top	3.6 / 9.1	30.75 / 78	6.4 / 24	250 / 76	27.4 / 70
<b>3" Bottom Inlet AP Pumps</b>								
Long AP3 Bottom Inlet	Long AP3B	46	Bottom	2.63 / 6.68	52 / 132	7.3 / 27.6	220 / 67	31 / 79
Short AP3-Bottom Inlet	Short AP3B	50	Bottom	2.63 / 6.68	42 / 107	6 / 22.7	175 / 53.3	22 / 56
<b>3" Top Inlet AP Pumps</b>								
Long AP3-Top Inlet	Long AP3T	54	Top	3.4 / 8.64 <sup>3</sup>	57 / 145	5.4 / 20	220 / 67	53 / 135
Short AP3 Top Inlet	Short AP3T	58	Top	3.4 / 8.64 <sup>3</sup>	47 / 119	4.8 / 18.1	175 / 53.3	42 / 107
<b>2" Bottom Inlet AP Pumps</b>								
Long AP2 Bottom Inlet	Long AP2B	62	Bottom	1.75 / 4.45	55 / 139	2.3 / 8.82	300 / 91.4	35 / 89
Short AP2 Bottom Inlet	Short AP2B	66	Bottom	1.75 / 4.45	33 / 85	2 / 7.57	300 / 91.4	20 / 51
<b>2" Top Inlet AP Pumps</b>								
Long AP2-Top Inlet	Long AP2T	70	Top	1.75 / 4.45	57 / 144	1.9 / 7.2	300 / 91.4	52 / 132
Short AP2-Top Inlet	Short AP2T	74	Top	1.75 / 4.45	35 / 89	1.6 / 6.0	300 / 91.4	31 / 78

<sup>1</sup> Consult QED for higher flow requirements

<sup>2</sup> High Pressure Option for 4" AP pumps

<sup>3</sup> Optional 2.63" (6.68cm) OD available



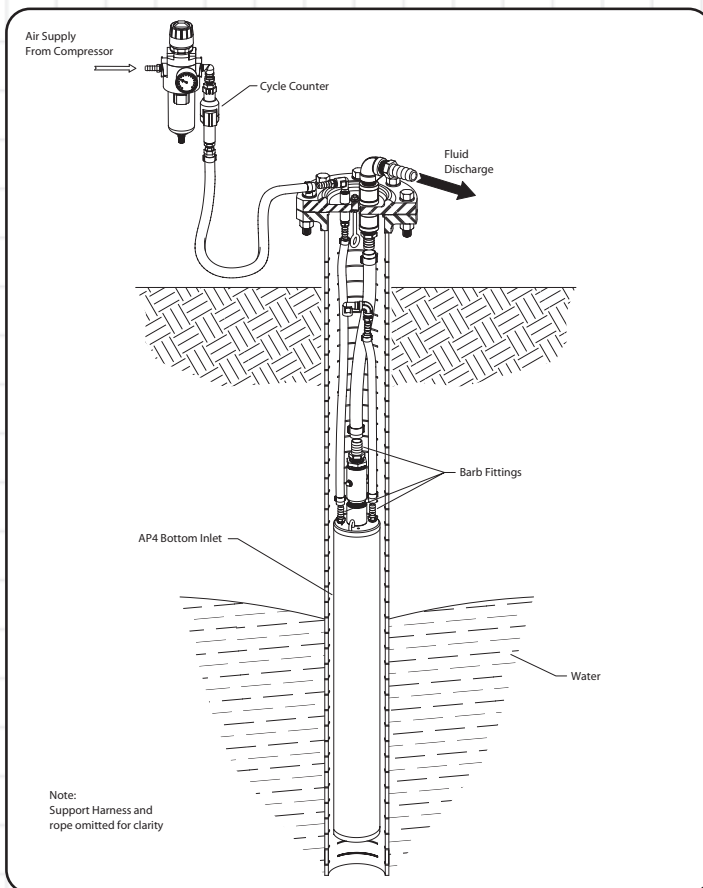
Complete AutoPump® systems offer the greatest assurance of a smooth installation, dependable performance and easy maintenance. Common system components include:

- In-well hose and tubing – see page 78
- Wellhead completion caps and flanges – see page 79
- Cycle counters – see page 80
- Air system filter/regulators – see page 81

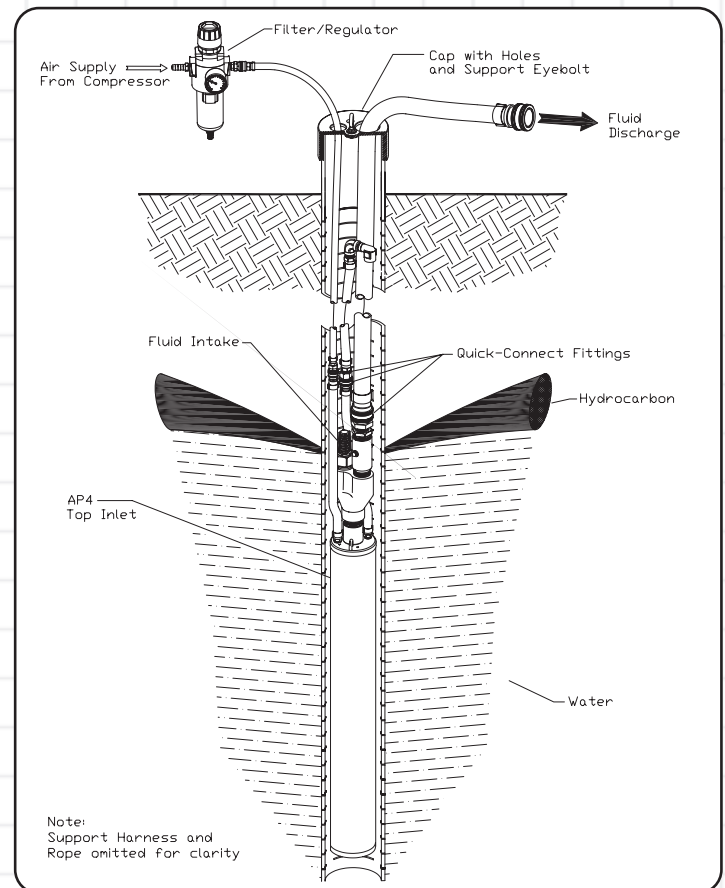
Call 1-800-624-2026 or visit [www.qedenv.com](http://www.qedenv.com) for prompt assistance with all of the above.

## Basic Pump Systems

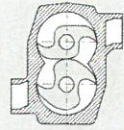
### Basic System Bottom Inlet Pump



### Basic System Top Inlet Pump







Vacuum pumps

Bombas de vacío

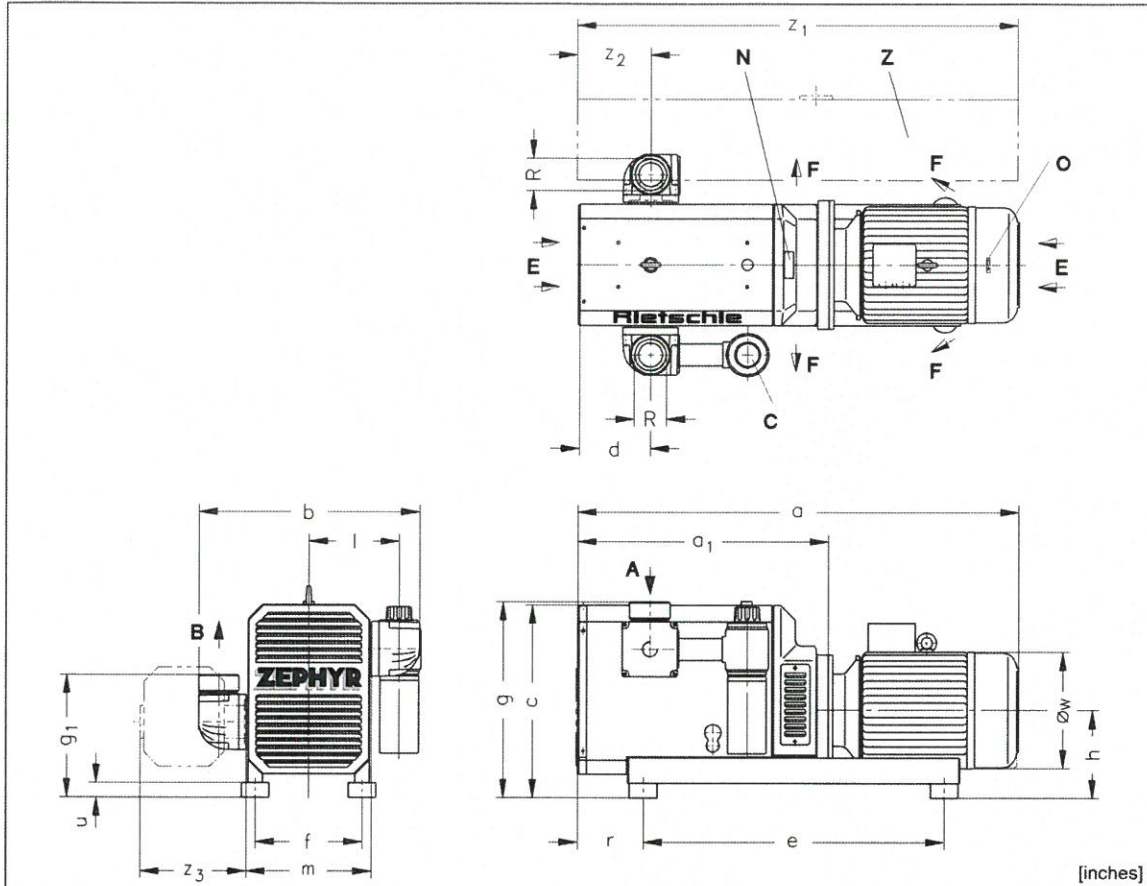
Pompes à vide

Bombas de vácuo

## VLR

# ZEPHYR

- VLR 100
- VLR 250
- VLR 300
- VLR 400
- VLR 500



[inches]

A	Vacuum connection	Conexión vacío	Raccord du vide	Conexão do vácuo
B	Exhaust	Escape	Refolement	Exaustão
C	Vacuum regulating valve	Válvula reguladora de vacío	Valve réglage vide	Válvula de regulagem do vácuo
E	Cooling air entry	Entrada aire refrigerante	Entrée air refroidissement	Entrada do ar refrigerante
F	Cooling air exit	Salida aire refrigerante	Sortie air refroidissement	Saída do ar refrigerante
N	Data plate	Placa fecha	Etiquette caractéristique	Placa da data
O	Rotation arrow	Dirección de rotación	Flèche sens rotation	Direção da rotação
Z	Exhaust silencer	Silenciador escape	Silencieux refolement	Silenciador de exaustão

VLR		100	250	300	400	500	
[inches]	a	50 Hz	26.02	31.73	35.08	41.69	47.28
		60 Hz	29.28	35.43	35.43	42.05	43.89
	a <sub>1</sub>	50 Hz	15.43	19.13	19.13	23.62	26.93
		60 Hz	17.60	19.92	19.92	26.54	27.32
	b		17.48	22.20	22.20	23.62	23.62
	c		14.17	20.67	20.67	20.67	20.67
	d		3.62	3.94	3.39	7.76	7.76
	e		17.32	28.35	28.35	32.28	32.28
	f		8.66	11.42	11.42	11.42	11.42
	g		14.53	19.41	19.41	20.94	20.94
	g <sub>1</sub>		8.23	11.54	11.54	13.07	13.07
	h		5.91	9.45	9.45	9.45	9.45
	l		7.17	9.25	9.25	9.65	9.65
	m		10.24	13.39	13.39	13.39	13.39
	r		3.03	4.37	4.37	7.05	7.05
	u		5.91	1.57	1.57	1.57	1.57
	Øw	50 Hz	6.93	8.66	9.68	9.68	12.28
		60 Hz	6.62	9.57	9.57	9.57	11.47
	z <sub>1</sub> / z <sub>2</sub> / z <sub>3</sub>	25.59 / 3.94 / 7.68	39.37 / 3.15 / 10.63	39.37 / 3.15 / 10.63	47.24 / 7.87 / 11.42	47.24 / 7.87 / 11.42	
	R	1 1/2" NPT	2" NPT	2" NPT	3" NPT	3" NPT	

DA 880

2.2.2000

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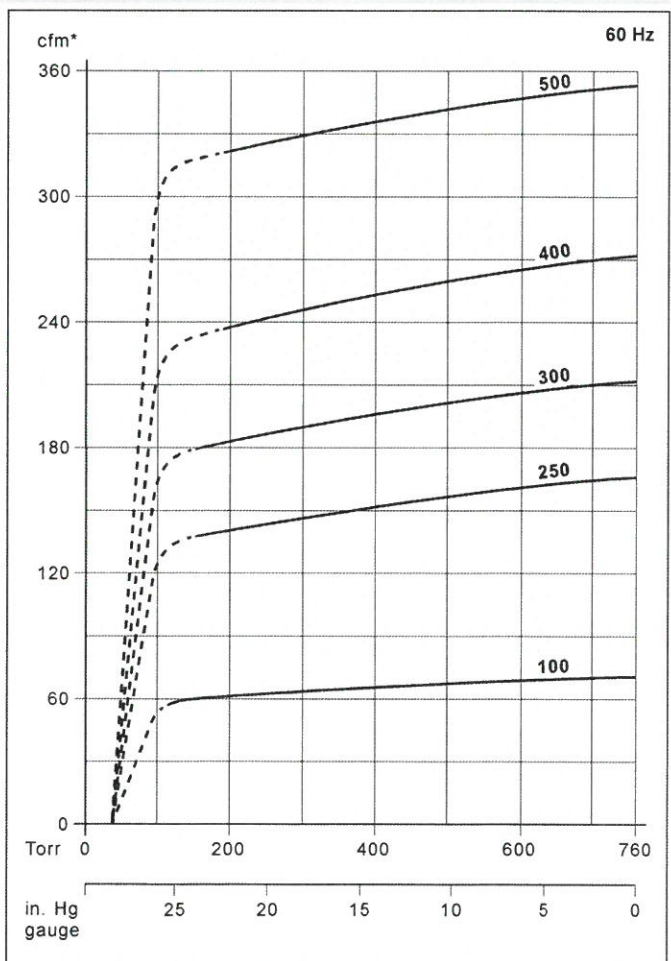
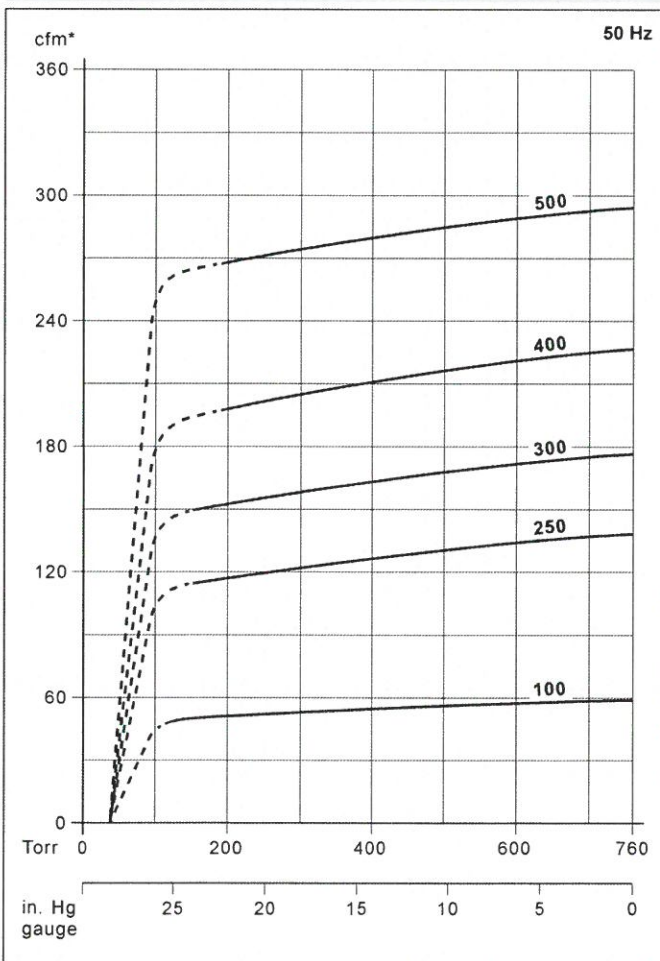
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VLR		100	250	300	400	500
cfm	50 Hz	58.9	138	177	227	294
	60 Hz	70.6	166	212	272	353
p <sub>1</sub>	38 Torr - 28.44 in. Hg (gauge)					
p <sub>2</sub>	113 Torr-24.49 in.Hg(gauge)		150 Torr - 24.02 in. Hg (gauge)		188 Torr - 22.54 in. Hg (gauge)	
3~	50 Hz	230/400V ± 10%			400/690V ± 10%	
	60 Hz	208-230/460V ± 10%				
kw	50 Hz	2.2	4.0	5.5	7.5	9.0
hp	60 Hz	3.0	7.5	7.5	10	15
A	50 Hz	8.7/5.0	14.4/8.3	11.0/6.4	15.0/8.7	19.0/11.0
	60 Hz	8.1-7.6/3.8	21-18.8/9.4	21-18.8/9.4	25-24/12	39-37/18.5
rpm	50 Hz	2850				
	60 Hz	3450				
dB(A)	50 Hz	78	78	79	82	82
	60 Hz	82	82	83	84	84
lbs	50 Hz	220	386	496	551	606
	60 Hz	237	430	496	565	639
l		0.5	0.9	0.9	0.9	0.9
ZRK / ZVF		40 (03) / 32 (54)	50 (03) / 50 (53)	50 (03) / 50 (53)	80 (03) / 100 (51)	80 (03) / 100 (51)
ZMS / ZSZ / ZAD		#	#	#	#	#

cfm	Capacity	Capacidad	Débit	Capacidade
p <sub>1</sub>	Ultimate vacuum max.	Vacío final máx.	Vide limite maxi.	Vácuo final max.
p <sub>2</sub>	Ult. vacuum continuous operation	Vacío final permanente	Vide limite fonctionnement continu	Vácuo final permanente
3~	Motor version	Versión motor	Exécution moteur	Versão do motor
kw / hp	Motor rating	Datos motor	Puissance moteur	Potência do motor
A	Full load amperage	Amperaje de plena carga	Intensité absorbée	Amperagem da carga total
rpm	Speed	Velocidad	Vitesse rotation	Velocidade
dB(A)	Average noise level + ZSZ	Nivel de ruido medio + ZSZ	Niveau sonore moyen + ZSZ	Nível médio de ruido + ZSZ
lbs	Weight	Peso	Poids	Peso
l	Oil capacity (Gear)	Instrumentos capacidad aceite	Charge d'huile (Engrenage)	Engrenagem da capacidade do óleo
ZRK	Accessories	Accesorios	Accessoires	Acessórios
ZVF	Non return valve	Válvula retención	Clapet anti-retour	Válvula sem retorno
ZMS	Vacuum tight suction filter	Filtro succión hermético	Filtere d'aspiration étanche	Filtro de sucção à prova de vácuo
ZSZ	Motor starter	Arranque motor	Disjoncteur moteur	Arranque do motor
ZAD	Exhaust silencer	Silenciador extractor	Silencieux refoulement	Silenciador de descarga
	Soft starter	Soft starter	Démarrage progressif	Soft starter



\* Relates to pump inlet conditions. / se refiere a las condiciones de entrada de la bomba. / relatif à l'état régnant à l'aspiration. / refere-se a condições de entrada da bomba.  
 Curves and tables refer to vacuum pump at normal operating temperature. / Las curvas y las tablas se refieren a la bomba de vacío a la temperatura normal de operación. / Les courbes et tableaux sont établies, pompe à température de fonctionnement. / As curvas e tabelas referem-se à bomba a vácuo a temperatura normal de operação.  
 Technical information is subject to change without notice! / La información técnica está sujeta a cambios sin previo aviso! / Sous réserve de modification technique. / A informação técnica está sujeita a mudança sem aviso prévio!  
 The listed values for a, ø w and full load amperage may vary because of different motor manufacturers. / Los valores listados para a, ø w y para el amperaje de carga completa pueden variar para distintos fabricantes de motores. / Les dimensions a et ø w ainsi que l'ampérage peuvent différer des données indiquées ci-dessus, selon le fabricant du moteur. / Como variam os fabricantes de motores, poderá haver variação dos valores indicados para a, ø w e para uma amperagem da carga total.  
 # on request # on pedido # sur demande # a pedido