PELHAM BAY LANDFILL
BRONX, NEW YORK

Operation and Maintenance Manual
Volume IIb

Prepared for:

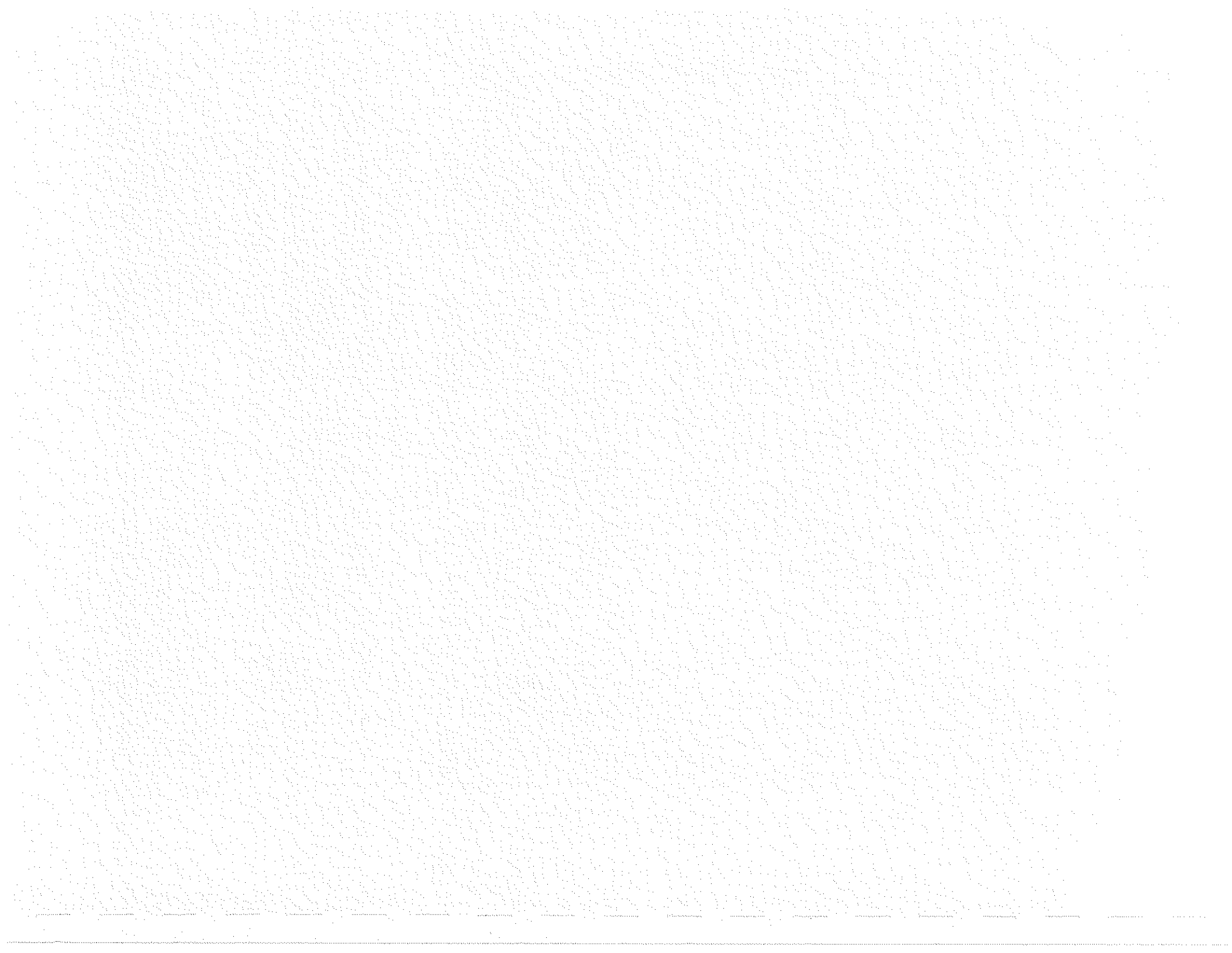
City of New York
Department of Environmental Protection

WCC Project No. 92C4087

November 1996

Prepared by:

Woodward-Clyde Consultants, Inc.
363 Seventh Avenue, 11th Floor
New York, New York 10001



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COMPLETE SYSTEMS DESIGNED AND SUPPLIED
BLOWERS, PUMPS, FANS, SCRUBBERS, OXIDIZERS, & VALVES
AIR, DUST, GAS, LIQUID, & SLURRIES

AER-X-DUST

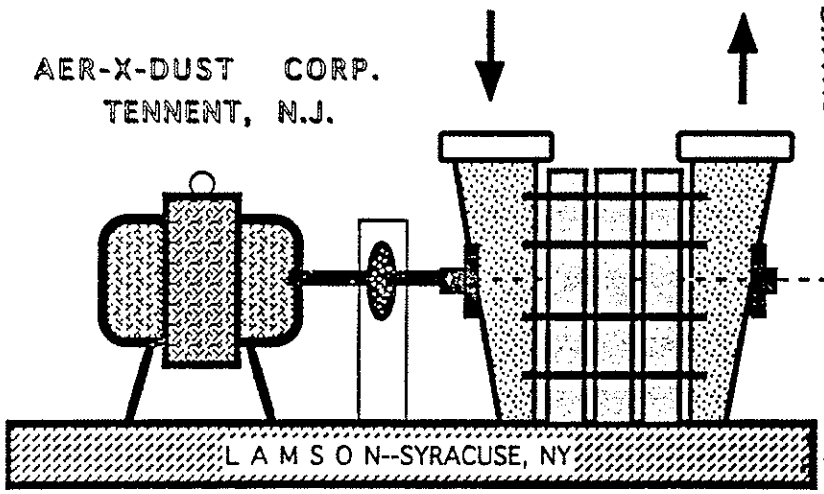
PO BOX 93
TENNENT, NJ 07763

GUY D. CUSUMANO
[908] 431-1505 FAX 308-1367

SUBMITTAL PACKAGE
PELHAM LANDFILL
BRONX, NY

PELHAM BAY LANDFILL, BRONX, NY PROJECT # 876-HP
LAMSON CENTRIFUGAL LFG BLOWERS & CONTROLS
SECTION #15860

BRECO MECHANICAL GROUP
201 SAW MILL RIVER ROAD
YONKERS, NY 10701-6694
ATT: BRIAN R. DYER
PO# 1050, PROJECT # 876-HP
FEB. 1995



BRECO MECHANICAL GROUP, INC.
DATE: 2/13/95
CONTACT: 876-HP
ITEM: Lamson Centrifugal Blowers
SPEC. SECTION: 15860
PARAGRAPH: 2.1 - 2.3
PAGE NO.: 15860-1, 2, 3
DRAWING NO.: GSP 2
LOCATION:
SUBMITTAL NO.: 876-HP-#5
APPROVED BY: BJD

WOODWARD-CLYDE
SUBMITTAL REVIEW

NO EXCEPTIONS TAKEN ☑
MAKE CORRECTIONS NOTED ☐
REVISE & RESUBMIT ☐

This review has been limited to an evaluation of whether the submittal is in general conformance with the Contract Documents. Contractor is responsible for dimensions and quantities in the field. This review shall not relieve Contractor of responsibility for compliance with the Contract Documents relating to this submittal.

Date 2/16/95 By SHM for AKM

SUBMITTAL ID NUMBER 48

WC PROJECT NO 926087

LEADERS IN NON SPARKING LANDFILL GAS BLOWER EQUIPMENT

SO# 65053

GUY D. CUSUMANO, AER-X-DUST CORPORATION
PH-908-431-1505/FAX-908-308-1367

THE KEY TO SUCCESS IS SERVICE AFTER THE SALE!

PRODUCT DATA

1 Lamson Street • P.O. Box 4857 • Syracuse, NY 13221 • Ph. 315-433-5500 • FAX 315-433-5451

LAMSON corporation
Dynamic Innovation Since 1880

CENTRIFUGAL AIR SYSTEMS

BLOWERS/ EXHAUSTERS

☒ For Approval ☐ Certified For

QUANTITY 2

"600" Series Gas, Inlet Driven Direct Drive - Dimensions

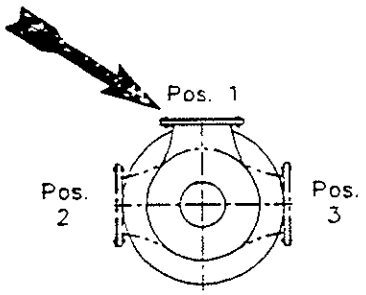
AXD Service Industries

LFG Blowers

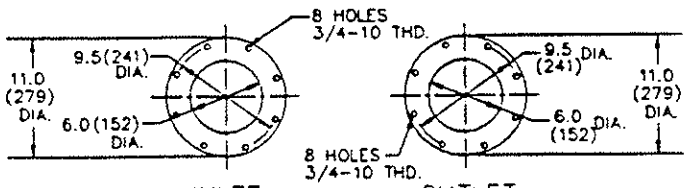
Project Pelham Bay Landfill

Your Order # AXD-050B

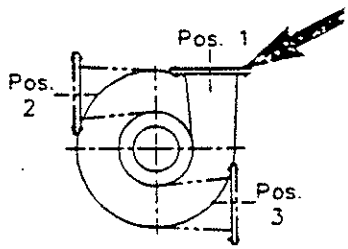
Our Order # 65053 By CS



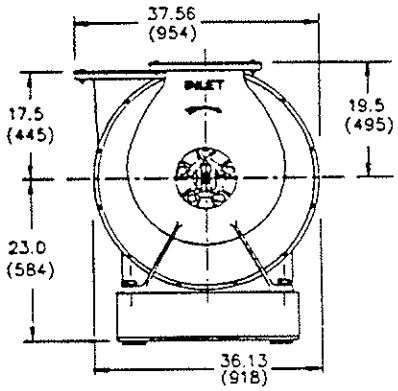
Inlet Positions



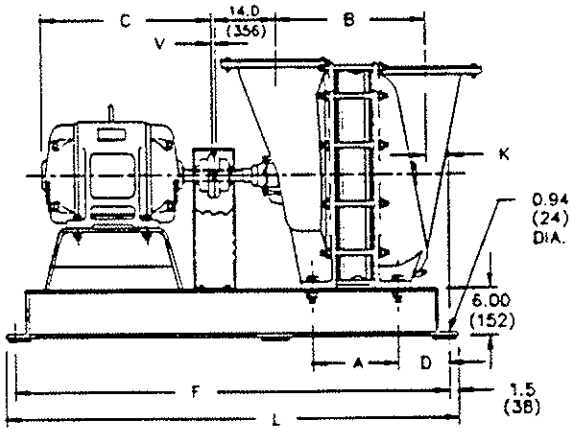
INLET OUTLET

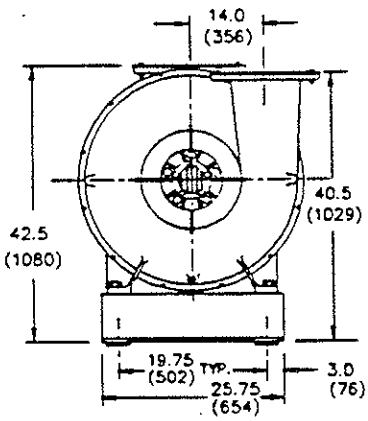


Outlet Positions



(END VIEW OF MACHINE ONLY)





Frame No.	Dimensions						
	A	B	C	D	F	L	K
601	6.00 (152)	8.13 (206)	254T	9.50 (241)	61 (1549)	64 (1626)	9.25 (235)
602	10.50 (267)	12.63 (321)	286TS	9.50 (241)	69 (1753)	69 (1753)	9.25 (235)
603	15.00 (381)	17.13 (435)	286TS	9.50 (241)	72 (1829)	75 (1905)	9.25 (235)
604	19.50 (495)	21.63 (549)	286TS	14.00 (356)	88 (2235)	91 (2311)	13.75 (349)
605	24.00 (610)	26.13 (664)	365TS	9.50 (241)	88 (2235)	91 (2311)	9.25 (235)
606	28.00 (711)	30.63 (778)	405TS	14.00 (356)	100 (2540)	103 (2616)	13.75 (349)
607	33.00 (838)	35.13 (892)	405TS	9.50 (241)	100 (2540)	103 (2616)	9.25 (235)
608	37.50 (953)	39.63 (1006)	444TS	14.00 (356)	112 (2845)	115 (2921)	13.75 (349)
609	42.00 (1067)	44.13 (1121)	445TS	9.50 (241)	112 (2845)	115 (2921)	9.25 (235)

NOTES:
1. Column "C" lists maximum NEMA motor frame typically required for the machine indicated.
2. Dimensions in inches and (mm).
3. Flange dimensions conform to 125 pound ANSI cast iron flanged fittings.
4. Dimension "V" is distance between shaft ends which varies depending on the coupling used. Refer to coupling data sheet for more information.
5. Specifications subject to change without notice.

1 Lamson Street • P.O. Box 4857 • Syracuse, New York 13221• Ph 315-433-5500 • Fax 315-433-5451

TECHNICAL DATA
600 SERIES

DESIGN

gas
Number of stages .....4. (60 HZ)
Inlet driven ..... Inlet standard
Inlet connection..... 6" flange, matches 125# ANSI
Outlet connection..... 6" flange, matches 125# ANSI
Operating speed ..... 3,550 RPM (60 Hz)
2,960 RPM (50 Hz)
Maximum casing pressure.....15 PSIG (1.03 bar)

Seals (gas) ..... Stuffing box type standard; special seals available
Bearings ..... Ball, life per AFBMA spe. #B-10
Lubrication ..... Grease
Impeller diameter 22.1 (561.3)
Impeller tip speed ..... 20,539 FPM (6,260m/m)
Direct drive ..... Standard shaft diameter at coupling.....1.875 (47.63)

Vibration tolerance ..... 1.25 mils measured in vertical plane at top of bearing housing (.032mm)

Unit Weights & Inertia Data				
Stage	Weight Machine & Base		WK^2	
1	1,150	(522)		
2	1,425	(646)	12	(.5)
3	1,700	(771)	18	(.8)
4	1,975	(896)	24	(1.0)
5	2,250	(1,021)	30	(1.3)
6	2,525	(1,145)	36	(1.5)
7	2,800	(1,270)	42	(1.8)
8	3,075	(1,395)	48	(2.0)
9	3,350	(1,520)	54	(2.3)

CAPACITIES

SEE ATTACHED PERFORMANCE CURVE

MATERIALS OF CONSTRUCTION

Casing ..... Cast iron ASTM A48 grade 25/30*
Bearing housings ..... Cast iron with bronze insert
Bearing caps & oil reservoirs ..... Cast iron
Tie rods ..... Steel

Gas seals ..... Braided packing
Labyrinth seals ..... Cast iron, with babbitt insert
Joint sealing compound ..... RTV-Silicone rubber
Shaft ..... Hot rolled carbon steel
Impellers ..... Cast aluminum alloy
Base & pedestal ..... Steel
Bisonite Coated Impellers, Sections and Heads.
Casing Drains
Anchor Bolts

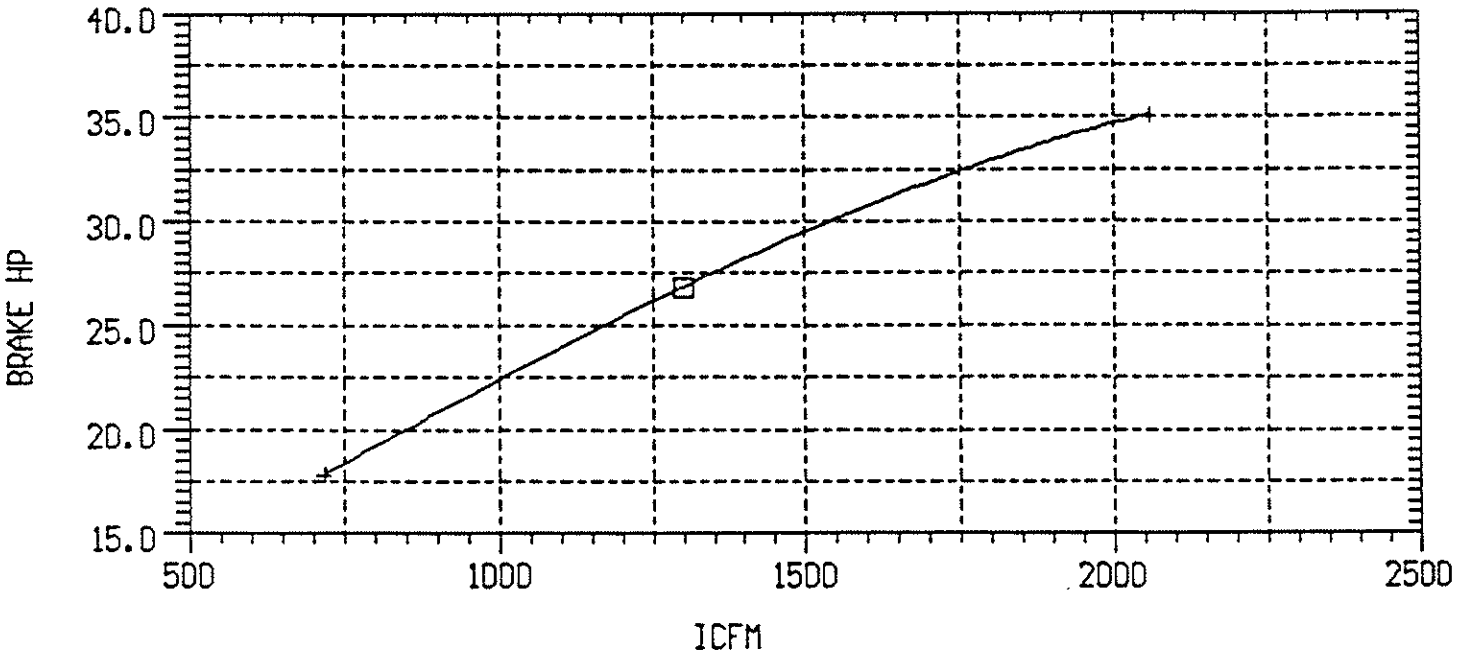
MISCELLANEOUS

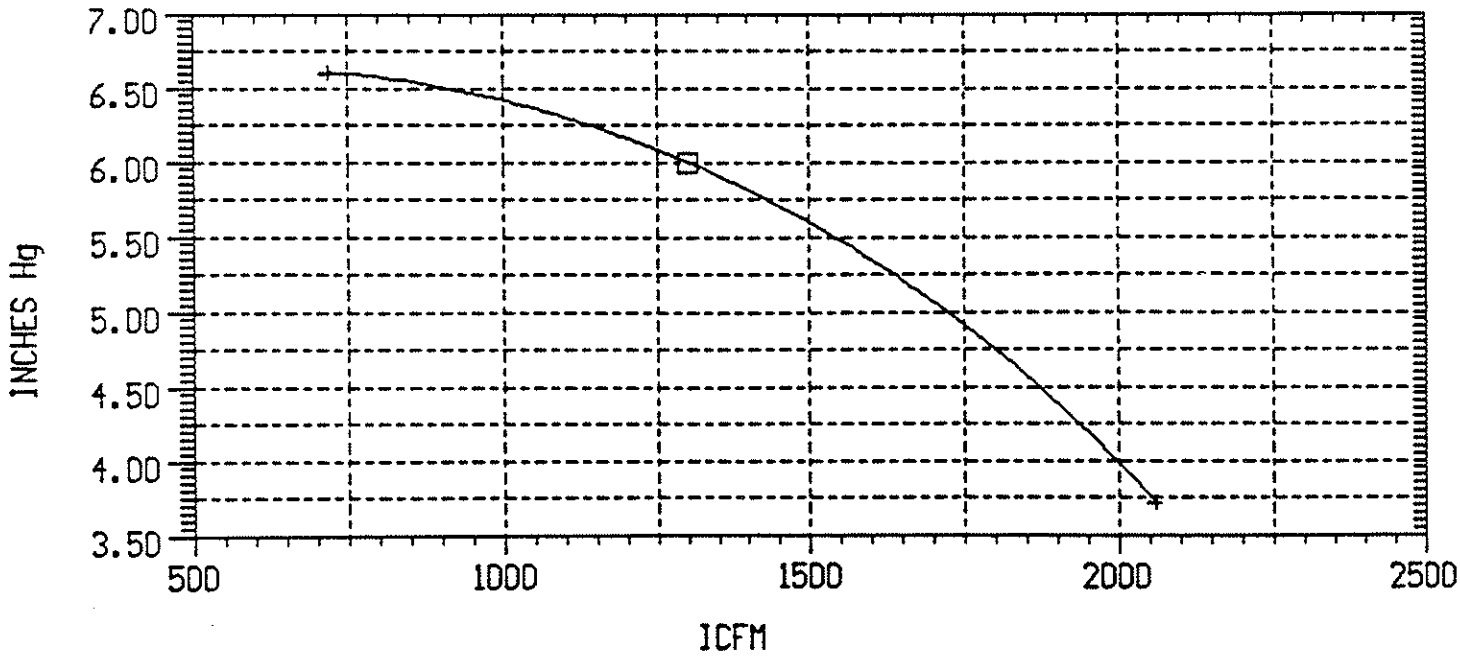
Finish ..... See page 25.10.16
Base pads ..... Molded synthetic rubber 0.5 (13) thick; see page 25.23.09

Notes:
1. Dimensions given in inches and (mm). Weights given in lbs and (kg). WK^2 given in lb-ft² and (kg-m²).
2. Specifications subject to change without notice.
3. *Under Meehanite License.

Lamson Predicted Exhauster Performance (+- 3% on vol.) Ver: 2.52S

LEGEND : Curve -+ = Job
Dsn Point -□ = Job





Model: 600, 4 Stage, 3550 RPM
Impellers: 1 Stage(s) of 1D01
3 Stage(s) of 1D03
Diameter: 22.1D
Gas: Air

1300 ICFM @ 6" HG
14.7 PSIA, 68 DEG. F.
LANDFILL GAS

Project:
Engineer:
S.O. Number:
Date: 05/18/9-

DUTY MASTER ALTERNATING CURRENT MOTORS

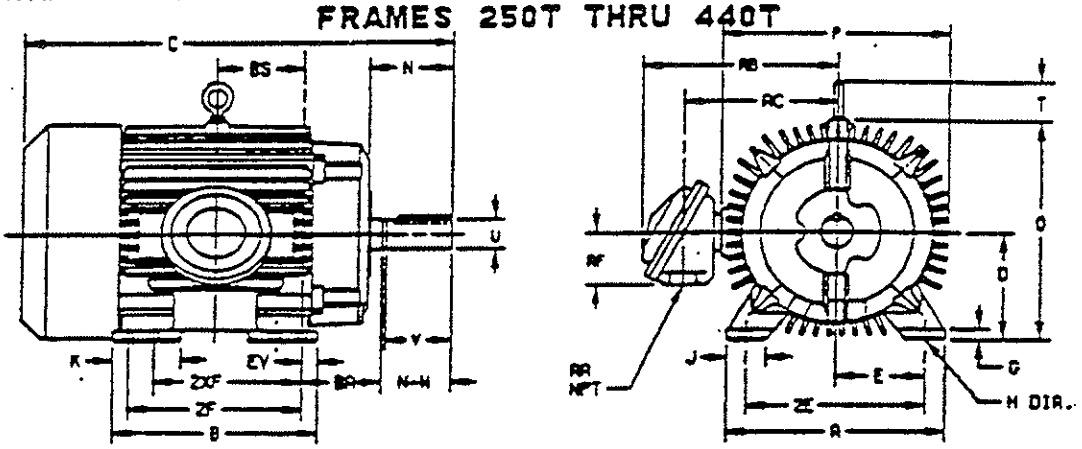
SQUIRREL-CAGE INDUCTION

ENCLOSURE: TOTALLY ENCLOSED — COOLING: FAN COOLED

UNDERWRITERS LISTED MOTOR

MOUNTING: FOOT

FRAMES 250T THRU 440T



DIMENSIONS ARE IN INCHES; SEE SHEET 2 FOR DIMENSIONS IN MILLIMETERS

FRAME	A	D(2)	E	G	H	J	K	O	P	T	AP TERMINAL BOX RR	RB	RC	RF	BA	EY
~~Z5OT-Z5OTS~~	~~12.50~~	~~6.00~~	~~5.00~~	~~.75~~	~~.56~~	~~2.50~~	~~—~~	~~12.50~~	~~12.88~~	~~2.12~~	~~1-1/2~~	~~11.25~~	~~9.06~~	~~3.38~~	~~4.75~~	~~1.00~~
286T-286TS	13.75	7.00	5.50	.75	.56	2.50	—	14.75	14.88	2.12	1-1/2	13.25	10.56	3.38	4.75	1.00
~~324T-326TS~~	~~15.50~~	~~8.00~~	~~8.25~~	~~.88~~	~~.69~~	~~3.00~~	~~5.25~~	~~16.50~~	~~17.38~~	~~2.62~~	~~2~~	~~14.25~~	~~12.38~~	~~4.25~~	~~5.88~~	~~1.50~~
364T-365TS	17.00	9.00	7.00	.88	.69	2.75	4.00	18.50	19.50	2.50	3	18.81	14.25	4.25	5.88	1.38
404T-405TS	19.00	10.00	8.00	1.12	.81	3.25	5.25	21.31	22.50	2.50	3	20.50	15.88	4.25	6.62	1.13
~~444T-444TS~~	21.00	11.00	9.00	1.12	.81	3.25	5.25	23.38	25.25	3.25	~~3~~	~~25.25~~	20.38	6.00	7.50	1.25
(1)																

FRAME SIZE	C	BS	B	ZF	(4) Z2F	N	SHAFT AND KEY N-W(6)	U(3)	V	SQ.	LGTH.	WEIGHT LBS. (5)
~~25T~~	~~24.56~~	5.00	12.00	—	8.25	4.06	4.00	1.625	3.75	.375	2.88	335
256T	24.56	5.00	12.00	—	—	4.06	4.00	1.625	3.75	.375	2.88	345
284T	27.44	5.50	13.00	—	9.50	4.25	4.25	1.875	4.38	.500	3.25	495
284TS	26.06	5.50	13.00	—	9.50	3.31	3.25	1.625	3.00	.375	2.88	495
~~286T~~	~~27.44~~	~~5.50~~	~~13.00~~	~~11.00~~	—	~~4.25~~	~~4.25~~	~~1.875~~	~~4.38~~	~~.500~~	~~3.25~~	~~510~~
286TS	25.06	5.50	13.00	11.00	—	3.31	3.25	1.625	3.00	.375	1.88	510
~~324T~~	~~30.44~~	~~6.00~~	~~14.75~~	~~—~~	~~10.50~~	~~4.25~~	~~4.25~~	~~1.875~~	~~4.38~~	~~.500~~	~~3.25~~	~~610~~
324TS	28.94	6.00	14.75	—	10.50	4.12	3.75	1.875	3.50	.500	2.00	610
326T	30.44	6.00	14.75	12.00	—	5.62	5.25	2.125	5.00	.500	3.88	650
326TS	28.94	6.00	14.75	12.00	—	4.12	3.75	1.875	3.50	.500	2.00	650
364T	33.44	6.12	15.00	—	11.25	6.00	5.88	2.375	5.62	.625	4.25	910
364TS	31.31	6.12	15.00	—	11.25	3.88	3.75	1.875	3.50	.500	2.00	904
365T	33.44	6.12	15.00	12.25	—	6.00	5.88	2.375	5.62	.625	4.25	950
365TS	31.31	6.12	15.00	12.25	—	3.88	3.75	1.875	3.50	.500	2.00	934
404T	38.31	6.88	16.00	—	12.25	7.50	7.25	2.875	7.00	.750	5.62	1300
404TS	35.31	6.88	16.00	—	12.25	4.50	4.25	2.125	4.00	.500	2.75	1291
405T	38.31	6.88	16.00	13.75	—	7.50	7.25	2.875	7.00	.750	5.62	1335
405TS	35.31	6.88	16.00	13.75	—	4.50	4.25	2.125	4.00	.500	2.75	1326
444T	44.62	8.25	19.00	—	14.50	8.94	8.50	3.375	8.25	.875	6.88	1770
444TS	40.88	8.25	19.00	—	14.50	5.19	4.75	2.375	4.50	.625	3.00	1754
445T	44.62	8.25	19.00	16.50	—	8.94	8.50	3.375	8.25	.875	6.88	1960
445TS	40.88	8.25	19.00	16.50	—	5.19	4.75	2.375	4.50	.625	3.00	1944
(1)												

(1) SPECIAL DIMENSIONS APPLYING TO THIS ORDER ON THIS LINE.

(2) "D" VARIES — Z5OT - 32OT +.00. -.03. ; 36OT - 44OT +.00. -.06.

(3) "U" VARIES — UP TO 1.625 DIA. +.0000. -.0005 ; 1.625 AND LARGER +.000. -.001.

(4) ALL FRAMES HAVE EIGHT MOUNTING HOLES FOR DUAL MOUNTING.

(5) MOTOR WEIGHTS MAY VARY BY 15% DEPENDING UPON RATING.

(6) "N-W" VARIES +.00. -.25.

CONDUIT BOX LOCATED ON OPPOSITE SIDE WHEN F-2,W-1, W-4,W-5,W-7, OR C-1 MOUNTING IS SPECIFIED.

IF MOUNTING CLEARANCE DETAILS ARE REQUIRED, CONSULT FACTORY.

MAXIMUM PERMISSIBLE SHAFT RUNOUT WHEN MEASURED AT END OF STD. SHAFT EXTENSION IS .002 T.I.R. UP TO AND INCLUDING 1.625 DIA. AND .003 T.I.R. 1.625 DIA. TO 5 INCH DIA.

FRAME- 286TS TYPE- FCXP CERTIFIED FOR- AXD SERVICE INDUSTRIES

ORDER- 65053 ITEM- 2 HP- 30 RPM- 3600 PH- 3 HZ 60 VOLTS 230-460

RELIANCE SALES ORDER- APPROVED BY- CS DATE 1/20/95

RELIANCE ELECTRIC
CLEVELAND, OHIO 44117 U.S.A.

DR. BY S.BRYANT
CK. BY L.T.FOURNIER
APP. BY J.M.PONTIER
DATE 12-08-89

DIMENSION SHEET 611742-1

ISSUE DATE: JULY 31, 1990

SHEET 1 OF 2

C/R 305861

REL. S.O.	FRAME	HP	TYPE	PHASE/ HERTZ	RPM	VOLTS
-	286TS	30	P	3/60	3535	460

AMPS	DUTY	AMB°C/ INSUL.	S.F.	NEMA DESIGN	CODE LETTER	ENCL.
33.7	CONT	40/F	1.15	B	G	FCXP-XEX

E/S	ROTOR	TEST S.O.	TEST DATE	STATOR RES.@25°C OHMS (BETWEEN LINES)
488306	418139-4JE	---	---	.293

PERFORMANCE

LOAD	HP	AMPERES	RPM	% POWER FACTOR	% EFFICIENCY
NO LOAD	0	8.2	3600	6.79	0
1/4	7.52	11.4	3585	67.4	91.6
2/4	15.0	17.6	3570	84.9	93.9
3/4	22.5	25.2	3554	88.8	93.9
4/4	30.0	33.7	3537	89.5	93.2
5/4	37.5	42.5	3518	89.5	92.2

SPEED TORQUE

	RPM	TORQUE % FULL LOAD	TORQUE LB.-FT.	AMPERES
LOCKED ROTOR	0	175	78.0	217
PULL UP	720	157	70.0	213
BREAKDOWN	3264	270	120	129
FULL LOAD	3537	100	44.5	33.7

AMPERES SHOWN FOR 460. VOLT CONNECTION. IF OTHER VOLTAGE CONNECTIONS ARE AVAILABLE, THE AMPERES WILL VARY INVERSELY WITH THE RATED VOLTAGE

REMARKS: TYPICAL DATA
XE MOTOR-NEMA NOM. EFF. 93.0 %
GUARANTEED MIN. EFF. 92.4%
OVERTEMP SWITCHES, SPACE HEATERS, FUNGUS PROOF & BREATHER.

RELIANCE ELECTRIC
CLEVELAND, OHIO 44117 U.S.A.

DR. BY J.E.SUMRELL
CK. BY D.M.BYRD
APP. BY D.M.BYRD
DATE 10/28/91

A-C MOTOR PERFORMANCE DATA

E09906-A-A002
ISSUE DATE 10/28/91

File Z79232 S

PRODUCT DATA

LAMSON corporation
SINCE 1880
P.O. BOX 4857 SYRACUSE, NEW YORK 13221
(315)432-5500 • TELEX937215 • FAX(315)432-5451

CENTRIFUGAL AIR SYSTEMS

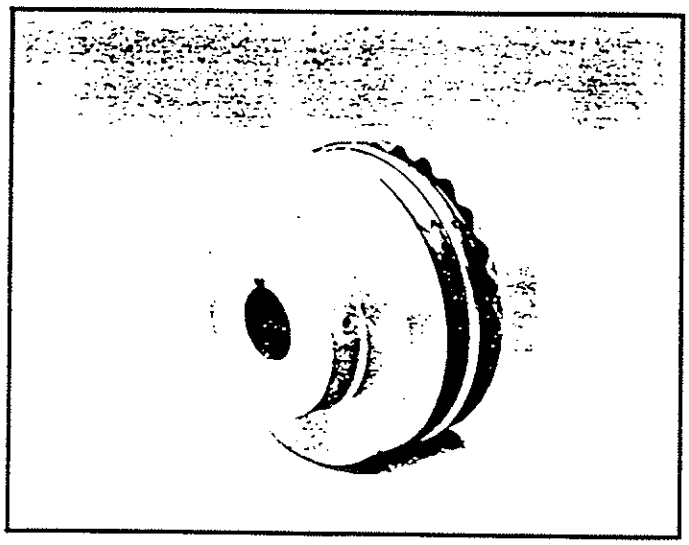
BLOWERS/ EXHAUSTERS

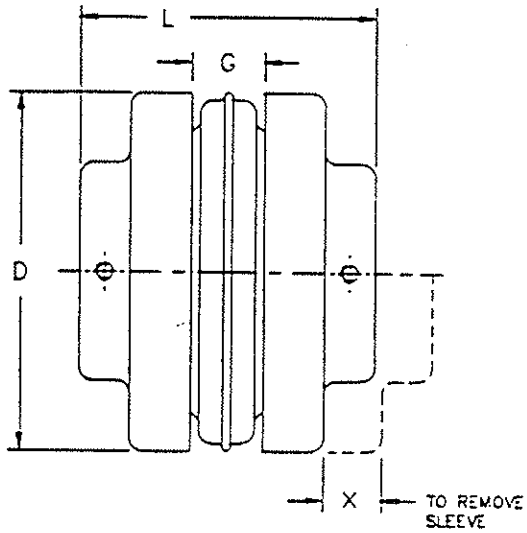
QUANTITY 2

LOVEJOY FLEXIBLE SLEEVE COUPLINGS

☒ For Approval ☐ Certified For

AXD Service Industries
LFG Blowers
Project Pelham Bay Landfill
Your Order # AXD-050B
Our Order # 65053 By CS





ADVANTAGES

The flexible sleeve couplings used on LAMSON blowers/ exhausters have exceptional torsional flexibility. The unique design of the coupling's teeth allows for the absorption of angular misalignment without wear. The lateral flexibility of the coupling sleeve minimizes radial bearing loads normally associated with parallel misalignment. This feature allows for easier installation by the use of components bored for slip fits without fretting corrosion occurring at the shaft.

INSTALLATION

Flexible sleeve couplings can be installed quickly and easily, because there are no bolts, gaskets, covers or seals. Alignment can be checked with a straight edge placed across the outside of the precision – machined flanges. No special tools are needed for installation, alignment or removal.

MAINTENANCE

The teeth of the sleeve lock into the teeth of the flanges without clamps or screws. Under load they tighten to provide smooth transmission of power. There is no rubbing action of metal against rubber to cause wear. Couplings are not affected by abrasives, dirt, or moisture. This eliminates the need for lubrication or maintenance, provides clean, dependable, quiet performance.

ENGINEERING DATA

P/N ▲	DIMENSIONS D	G(4)	L	X	SHAFT GAP	MAX(3) BORE	WT. (lbs) ■
7S	4-5/8	1	3-15/16	1-5/16	1/4	1-7/8	6-3/4
9S	6-11/32	1-7/16	5-1/16 6	1-3/4	1/4 1-7/16	2-1/2 2-7/8	16 14
10S	7-1/2	1-5/8	5-11/16	2	1/4	3-1/8	25-1/4

▲ Type J couplings supplied with one-piece split JES sleeve
Type S couplings supplied with two-piece E sleeve.

■ Approximate weight for complete coupling.

Notes:

(1) Dimensions given in inches.
(2) Specifications subject to change without notice.
(3) Maximum bore with rectangular key.
(4) "G" dimension represents hub separation not shaft dimension.
(5) Spacer couplings available upon request.

PRODUCT DATA

1 Lamson Street • P.O. Box 4857 • Syracuse, NY 13221 • Ph. 315-433-5500 • FAX 315-433-5451

LAMSON corporation
Dynamic Innovation Since 1880

CENTRIFUGAL AIR SYSTEMS

ACCESSORIES

☒ For Approval ☐ Certified For

AXD Service Industries

LFG Blowers

Project Pelham Bay Landfill

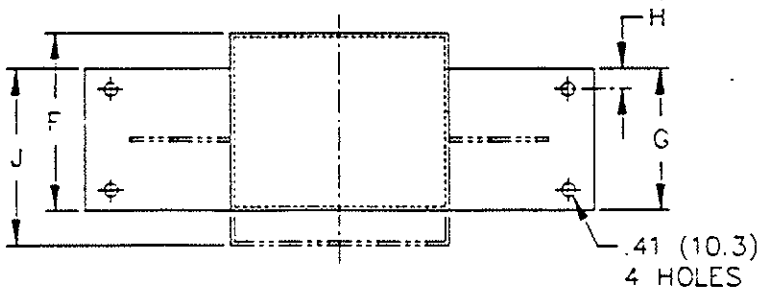
Your Order # AXD-050B

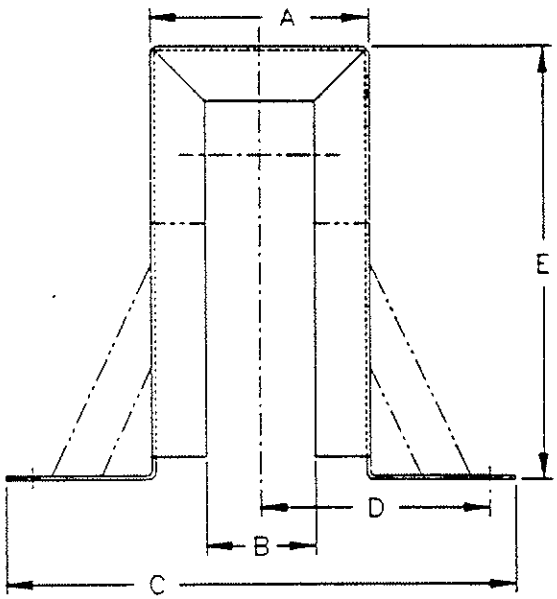
Our Order # 65053 By CS

QUANTITY 2

COUPLING GUARDS

Dimensions in Inches and (mm)





Notes:

1. Material: 12 gauge sheet steel, alternate material available upon request.
2. Gussets on Part Nos. BC4239990000 and BC4239980000 only.
3. Specifications subject to change without notice.

Blower/Exhauster Series	Part Number	A	B	C	D	E	F	G	H	J
310	BC3338990000	5 (127)	3.13 (79.4)	12.25 (311.2)	5.13 (130.2)	12 (304.8)	4.25 (108)	3.88 (98.4)	.5 (12.7)	6.25 (158.8)
400	BC3439010000	6 (152.4)	2 (50.8)	15.5 (393.7)	7 (177.8)	15 (381)	5.75 (146.1)	4.75 (102.7)	.75 (19.1)	– –
510, 550	BC3639010000	8 (203.2)	2.75 (69.9)	17 (431.8)	7.5 (190.5)	18.5 (469.9)	8.5 (215.9)	7.5 (190.5)	1 (25.4)	–
600, [illegible]	BC4039010000	10.25 (260.4)	3 (76.2)	23 (584.2)	8.5 (215.9)	23.38 (593.7)	8.5 (215.9)	7 (177.8)	.88 (22.2)	– –
800, 870, 1210 (250, 1200	BC4239990000 BC4239980000	11 (279.4)	2.75 (69.9)	24 (609.6)	10.75 (273.1)	25.5 (647.7)	7.75 (169.9)	7 (177.8)	1 (25.4)	7.75 (169.9)

For 1210, 1255, 1260 Series, see #3 outlet, outlet driven only.

PRODUCT DATA

1 Lamson Street • P.O. Box 4857 • Syracuse, NY 13221 • Ph. 315-433-5500 • FAX 315-433-5451

LAMSON corporation
Dynamic Innovation Since 1880

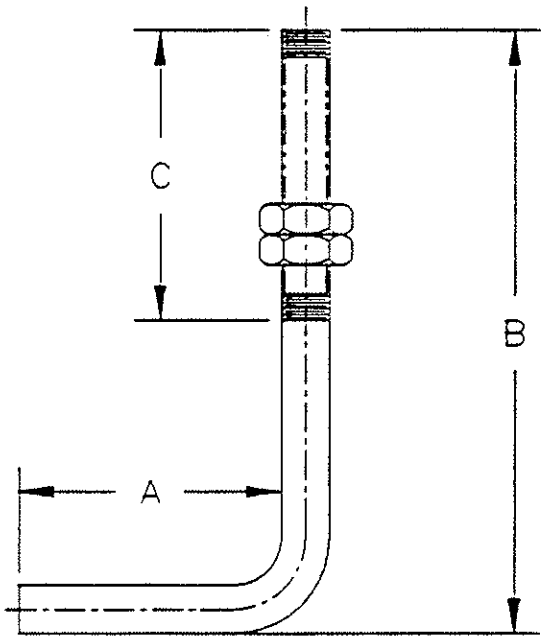
CENTRIFUGAL AIR SYSTEMS

ACCESSORIES

☒ For Approval ☐ Certified For

AXD Service Industries
LFG Blowers
Project Pelham Bay Landfill
Your Order # AXD-050B
Our Order # 65053 By CS

ANCHOR BOLT ASSEMBLY (WITH 2 HEX NUTS)



NOTES:

1. DO NOT TIGHTEN DOWN – USE SECOND NUT TO LOCK IN PLACE.

Part No.	DIMENSIONS				
	Thread	Material	A	B	C
BA1083940000	1/2-7	STN. STL.	2	6-3/4	3 (76.2)
BA1083950000	1/2-7	CARBON STL.	2	6-3/4	3 (76.2)
BA1083960000	3/4-10	STN. STL.	2-1/2	6-3/4	4 (101.6)
BA1083970000	3/4-10	CARBON STL.	2-1/2	6-3/4	4 (101.6)
BA1083980000	7/8-9	STN. STL.	3-1/8	8-1/2	4 (101.6)
BA1083990000	7/8-9	CARBON STL.	3-1/8	8-1/2	4 (101.6)

PRODUCT DATA

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LAMSON corporation
Dynamic Innovation Since 1880

CENTRIFUGAL AIR SYSTEMS

BLOWER EXHAUSTERS

☒ For Approval ☐ Certified For

AXD Service Industries

LFG Blowers

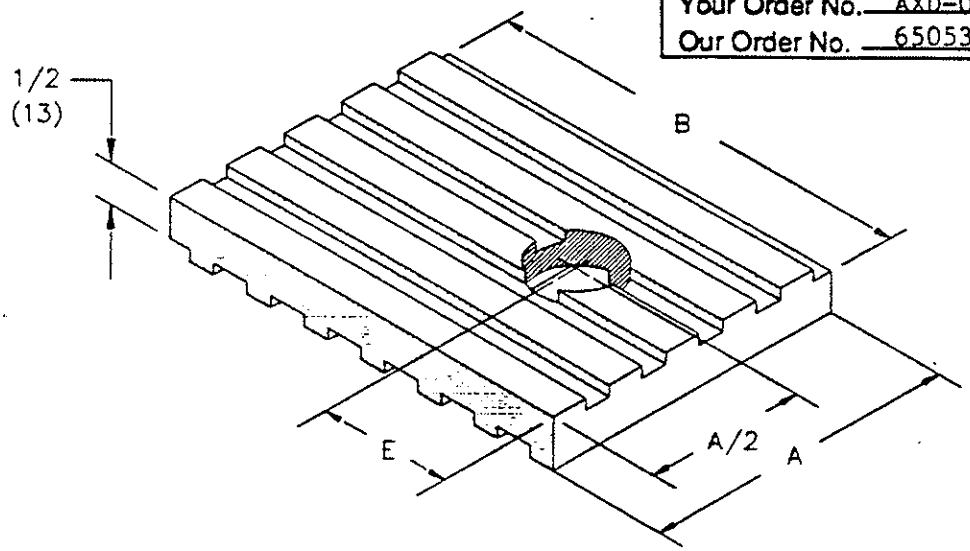
Project Pelham Bay Landfill

Your Order No. AXD-050B

Our Order No. 65053 By CS

12,-BASE PADS

(6 Per Blower)



Part No.	A	B	D Dia.	E
BC3016010000	3/4 (19)	1 (25)	———	———
BC3016020000	1-1/2 (38)	1-1/2 (38)	15/16 (23)	3/4 (19)
BC3016030000	1-1/2 (38)	2 (50)	15/16 (23)	1 (25)
BC3016040000	2 (50)	2 (50)	15/16 (23)	1 (25)
BC3016050000	2 (50)	2 (50)	15/16 (23)	1 (25)
BC3016060000	3 (76)	3 (76)	15/16 (23)	1 (25)
BC3016070000	3 (76)	4 (101)	15/16 (23)	1 (25)
BC3016080000	3 (76)	5 (127)	15/16 (23)	1 (25)
BC3016090000	4 (101)	5 (127)	15/16 (23)	1 (25)
BC3016100000	5 (127)	6 (152)	15/16 (23)	1 (25)
BC3016110000	6 (152)	6 (152)	15/16 (23)	1 (25)
BC3016120000	7 (178)	8 (203)	15/16 (23)	1 (25)

NOTES:

1. Material: Ribbed isolation pad, neoprene, loading 60 PSI to 85 PSI max.
2. Approximate Durometer: 40 ± 5 shore "A" scale.
3. All notations in (parenthesis) are metric.
4. See page 2 for the cast blower/exhauster base pad requirement listing.
5. Specifications subject to change without notice.

CAST BL/EX BASE PAD REQUIREMENT LISTING

UNIT SERIES	SIZE PAD	PART NO.	NO. OF PADS	NO. OF STAGES
200 BD	3/4 x 1	BC3016010000	4	2-3
250F BD	1-1/2 x 1-1/2	BC3016020000	6	3-6
310 DD	1-1/2 x 2	BC3016030000	6	1-6
	2x2	BC3016040000	6	7-11
310 BD	1-1/2 x 2	BC3016030000	6	1-6
	2x2	BC3016040000	6	7-11
400/D/DS/DD	2x2	BC3016040000	6	1-6
	2x3	BC3016050000	6	7-10
400/D/DS/BD	2x2	BC3016040000	6	1-6
	2x3	BC3016050000	6	7-10
510/550 DD	2x3	BC3016050000	6	1-5
	3x3	BC3016060000	6	6-10
510/550 BD	3x3	BC3016060000	6	2-4
	3x3	BC3016060000	9	5-7
600 DD	3x3	BC3016060000	6	1-4
	3x4	BC3016070000	6	5-9
810/850 DD	3x3	BC3016060000	6	1-3
	3x5	BC3016080000	6	4-9
860 DD	3x5	BC3016080000	6	1-5
	4x5	BC3016090000	6	6-10
1210/1250 DD	3x4	BC3016070000	6	1-2
	4x5	BC3016090000	6	3-8
1260 DD	4x5	BC3016090000	6	4-6
	5x6	BC3016100000	6	7-8
1400/1800 DD	4x5	BC3016090000	6	1-3
	5x6	BC3016100000	6	4-5
	6x6	BC3016110000	6	6-8
1850 DD	4x5	BC3016090000	6	1-3
	5x6	BC3016100000	6	4-5
	6x6	BC3016110000	6	6-7
2000 DD	5x6	BC3016100000	6	1-3
	6x6	BC3016110000	6	4-5
	7x8	BC3016120000	6	6-8

COATING SYSTEMS - CHEMICAL PROTECTION

Acid - Solvent - Alkali Resistant Phenolic Coatings for Corrosion and Contamination Resistance

Purpose:

Phenolic coatings can augment our capabilities in gas handling by protecting the iron, steel, and aluminum blower/exhauster components from substances which would otherwise reduce the serviceable life of the machine to an unacceptably short period of time.

These coatings have been developed to produce a protective film with a maximum range of chemical resistance to acids, alkalies and solvents. They are superior to most types of heat reactive coatings in that there is greater resistance to impact shock and thermal shock, being composed of resins of unusually high molecular weight.

Manner of Application:

This material is generally applied in uniform coats of 1.5 to 2 mils dry film thickness by either spraying or dipping, and baked at 300° F for ten minutes between coats to drive off all solvents. Four to six coats may be applied depending on the type and kind of service required. After the full coating system is applied, the work is placed in an oven for 30 minutes to finally cure at temperatures of 375° F to 450° F.

Properties and Characteristics:

The coatings produced being a combination of thermal setting resins, are characterized by extreme smoothness, gloss and chemical insolubility. The films show excellent bonding capability not only to clean, sandblasted iron, steel and aluminum, but to copper and other metals and alloys. They are tough and provide some abrasion resistance.

At the same time, they are relatively flexible for this class of material and will withstand expansion and contraction from thermal change. Films can be built up by a series of coats to a homogenous, continuous film of high dialectric value and low moisture vapor permeability.

The performance of these coatings in offering chemical resistance remains excellent at temperatures from freezing up to 300° F.

Film decomposition does not begin to take place, except to become embrittled, at temperatures reaching 400° F, and in certain applications intermittent service has reached 600° F to 700° F. It must be stated, however, that the coating will not resist all the chemicals at these temperatures that it will at room temperature.

Chemical Resisting Properties:

	Fumes	Spillage or Intermittent Immersion	Continuous Immersion
ACIDS			
Acetic—to 5%	R	R	R
Aqua Regia	R	R	NR
Arsenious (any conc.)	R	R	R
Boric—to 5%	R	R	R
Hydrochloric (comm.)	R	R	R
Hydrofluoric (comm.)	R	R	L
Latic—to 42%	R	R	R
Maleic—aqueous sols.	R	R	R
Maleic—anhydride	R	R	R
Nitric—to 10%	R	R	R
Nitric—to 70%	R	R	L
Oxalic—comm. or sol.	R	R	R
Oleic—comm. or sol.	R	R	R
Phosphoric 10%	R	R	R
Phosphoric 85%	R	R	R
Sulphuric—to 40%	R	R	R
Tannic—comm. or sol.	R	R	R
SALTS AND THEIR SOLUTIONS			
In general, all inorganic salts, acid neutral or basic both dry and in solution.			
There are however a few salts containing nitrogen or halogen groups which in some cases are limited for immersion conditions; for example:			
Cyanide Salts	R	R	R
Hypochlorite Salts of:			
Calcium (Solid) Sodium 16%	R	R	L
Calcium 5% Sodium 5%	R	R	R
Calcium Hydroxide—Sat.	R	R	R

	Fumes	Spillage or Intermittent Immersion	Continuous Immersion
ALKALIS AND BASES			
Ammonium Hydroxide 5%	R	R	R
Ammonium Hydroxide 28%	R	R	R
Calcium Hydroxide (Lat.)	R	R	R
Potassium Hydroxide 50%	R	R	R
Sodium Hydroxide 50%	R	R	R
ORGANIC MATERIALS			
Alcohols (aliphatic)	R	R	R
Chlorinated Hydrocarbons (Ambient Temperature)	R	R	R
At Elevated Temperature	L	L	L
Diesel Fuel, Gasoline, Lubricating Oil—Aromatic	R	R	R
Diesel Fuel, Gasoline, Lubricating Oil—Aliphatic	R	R	R
Formaldehyde—40% sol.	R	R	R
Latex	R	R	R
Phenol	R	R	L
Sour Crude Oil	R	R	R
MISCELLANEOUS			
Hydrogen Chloride, Hydrogen Fluoride, Chlorine, Ammonia:			
Anhydrous	R	R	R
Wet	R	R	R
Dilute (Air)	R	R	R
Hydrogen Sulphide	R	R	R
Hydrogen Peroxide 30%	R	R	L
Hydrogen Peroxide 3%	R	R	R
Sea Water	R	R	R
Tap Water, Mineral Water	R	R	R
Demineralized Water	R	R	R
Boiler Condensate	R	R	R
Detergents	R	R	R
Tanning Solutions	R	R	R

R — Recommended—entirely satisfactory performance.

L — Limited—will perform for a reasonable length of time but will suffer eventual failure due to reaction of chemicals with coating or permeation of film.

NR — Not recommended

ND — No data

Notes:

1. For exceptional applications or service conditions, advise the Syracuse office making reference to temperature, corrosive solutions and concentrations thereof to which the protected area will be exposed. This will enable us to make specific recommendations for the individual problem.

[redacted]

3. Specifications subject to change without notice.

PRODUCT DATA

1 Lamson Street • P.O. Box 4657 • Syracuse, New York 13221 • Ph 315-433-5500 • Fax 315-433-5451

LAMSON corporation
Dynamic Innovation Since 1880

CENTRIFUGAL AIR SYSTEMS

BLOWERS EXHAUSTERS

PAINT SPECIFICATION

CUSTOMER TO SELECT COLOR.

ST-7144 LAMSON ~~GRAY~~ FAST DRY ENAMEL
(Lamson Reference Number MS-100163)

DESCRIPTION

This material is a modified Alkyd with very fast drying properties and an unusually good combination of resistance to many chemicals. Pigmentation is with completely inert colors ensuring excellent color fastness and resistance to leaching etc.. It is free of lead and other toxic ingredients.

PHYSICAL PROPERTIES

Solids Concentration by weight	48.5+/- 1%
Solids Concentration by volume	36.0%
Reduced viscosity #2 Zahn cup	27-32 seconds
Weight per gallon	8.31+/- 0.1 lb.
Reduction	4:1 Xylene
Clean up solvent	Toluol/Xylol

DRY FILM PROPERTIES

Dry to handle	10-15 minutes
Gloss Reading 60 Meter (72 hour air dry)	35-40
Mandrel Bdng 3/8"	Pass
Adhesion Cross Hatch	100%
Impact 30"/lbs Front	Pass
Impact 30"/lbs Rev.	Pass
5% NaOH 1 hour	Recovers
Household Ammonia	Recovers
Perspiration (24 hours)	Pass
Lipstick 1 hour	Removal OK Increase in gloss
Nail Polish	No lifting
Ink (washed with water)	Pass
Ajax Liquid Detergent	Pass

MOISTURE RESISTANCE

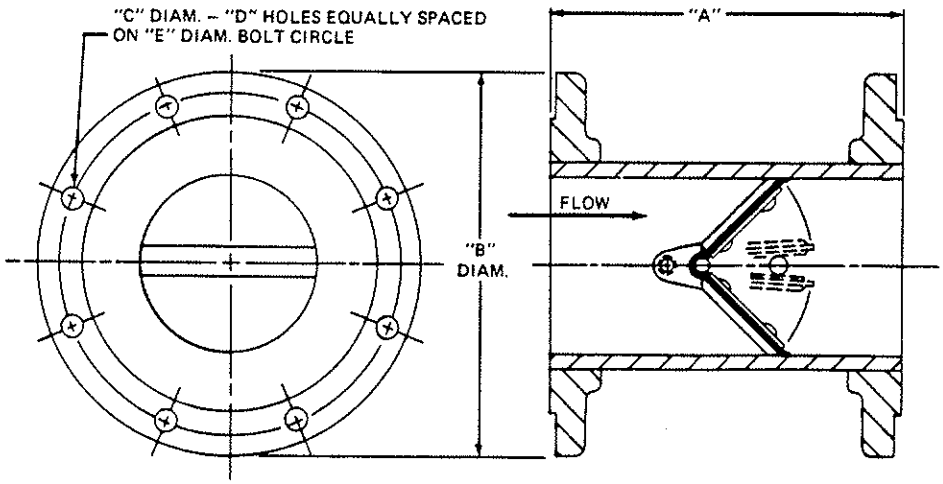
124 Hours - 100% humidity, 100 F	Recovers OK
100 Hours - 5% Salt Fog, ASTM B-117-64	Pass

CONCLUSION

ST-7144 presents an excellent package of rapid drying properties combined with resistance to common chemicals, both acid and alkaline. It is tough, durable and will provide good protection to ferrous metals for long periods of time.

TECHNOCHECK
FULL FLANGED
150 # CLASS

STYLE 5003



GENERAL DIMENSIONS FOR STYLE 5003

VALVE SIZE	"A"	"B"	"C"	"D"	"E"	VALVE SIZE	"A"	"B"	"C"	"D"	"E"
1	3	4-1/4	5/8	4	3-1/8	12	13	19	1	12	17
1-1/4	4-1/2	4-5/8	5/8	4	3-1/2	14	15	21	1-1/8	12	18-3/4
1-1/2	4-1/2	5	5/8	4	3-7/8	16	17	23-1/2	1-1/8	16	21-1/4
2	4-1/2	6	3/4	4	4-3/4	18	19	25	1-1/4	16	22-3/4
2-1/2	5	7	3/4	4	5-1/2	20	21	27-1/2	1-1/4	20	25
3	5	7-1/2	3/4	4	6	24	25	32	1-3/8	20	29-1/2
4	5-1/2	9	3/4	8	7-1/2	30	31	38-3/4	1-3/8	28	36
5	6	10	7/8	8	8-1/2	36	37	46	1-5/8	32	42-3/4
6	7	11	7/8	8	9-1/2	42	43	53	1-5/8	36	49-1/2
8	9	13-1/2	7/8	8	11-3/4	48	49	59-1/2	1-5/8	44	56
10	11	16	1	12	14-1/4						

ALL DIMENSIONS IN INCHES

STANDARD MODELS & MATERIALS

STYLE	BODY	INTERNALS	PSI C.W.P.
5003	STEEL	CADMIUM PLATED STEEL	150
5003-304	304 STAINLESS STEEL	304 STAINLESS STEEL	150
5003-316	316 STAINLESS STEEL	316 STAINLESS STEEL	150
STANDARD ELASTOMER: BUNA-N			

OPTIONAL MATERIAL SELECTION

INTERNAL MATERIALS

- Aluminum
- Bronze
- 304 Stainless Steel
- 316 Stainless Steel
- Cadmium Plated Steel
- Electroless Nickel Plated Steel or Aluminum
- Monel*
- Titanium*
- Hastelloy*

*Non stock item – Available upon request.

SPRING MATERIALS

- 304 Stainless Steel
- 316 Stainless Steel

Monel and Inconel springs available upon request.

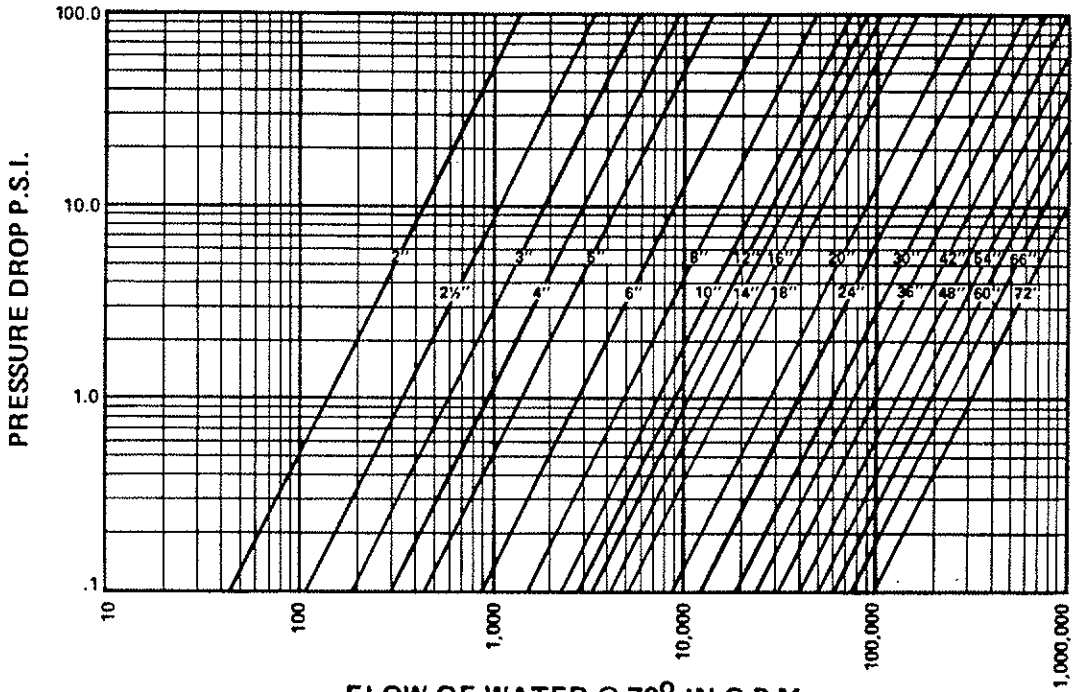
SEALING MEMBER MATERIALS

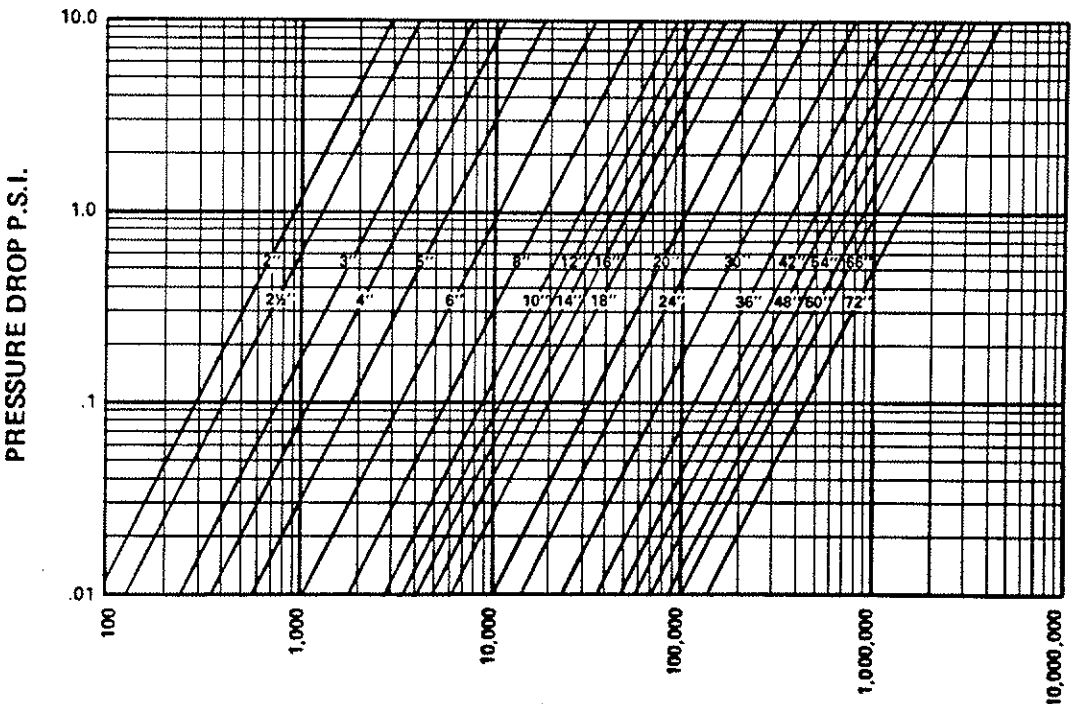
MATERIAL	*TEMPERATURE RANGE
• Buna-N	–60 to 225° F
• Neoprene	–40 to 225° F
• Butyl	–65 to 300° F
• Hypalon	–20 to 300° F
• EPDM	–40 to 300° F
• Viton	–20 to 400° F
• Teflon	–20 to 450° F
• Silicone	–100 to 500° F
• FDA Approved White Neoprene	–40 to 225° F

*This temperature range is for general guidance. The figures may vary with application.

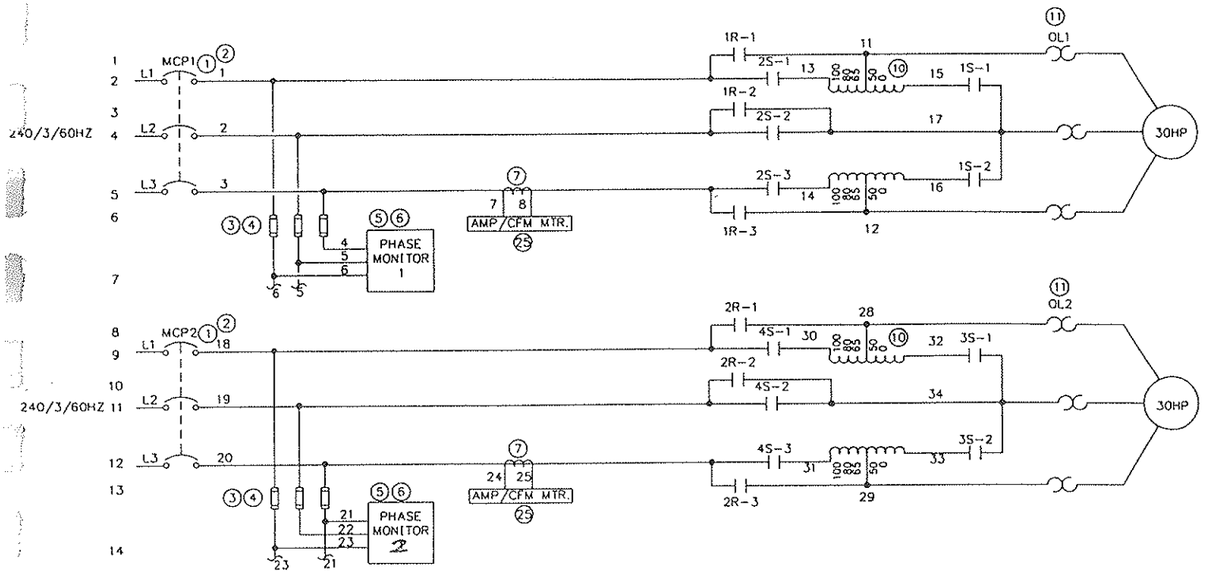
CONSULT FACTORY FOR MATERIALS, SIZES AND PRESSURE RATINGS NOT SHOWN.

PRESSURE DROP CHARTS
FOR WATER AND AIR SERVICE

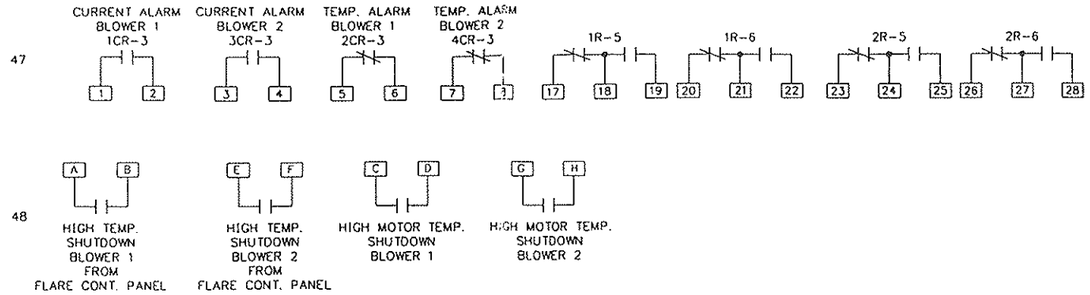


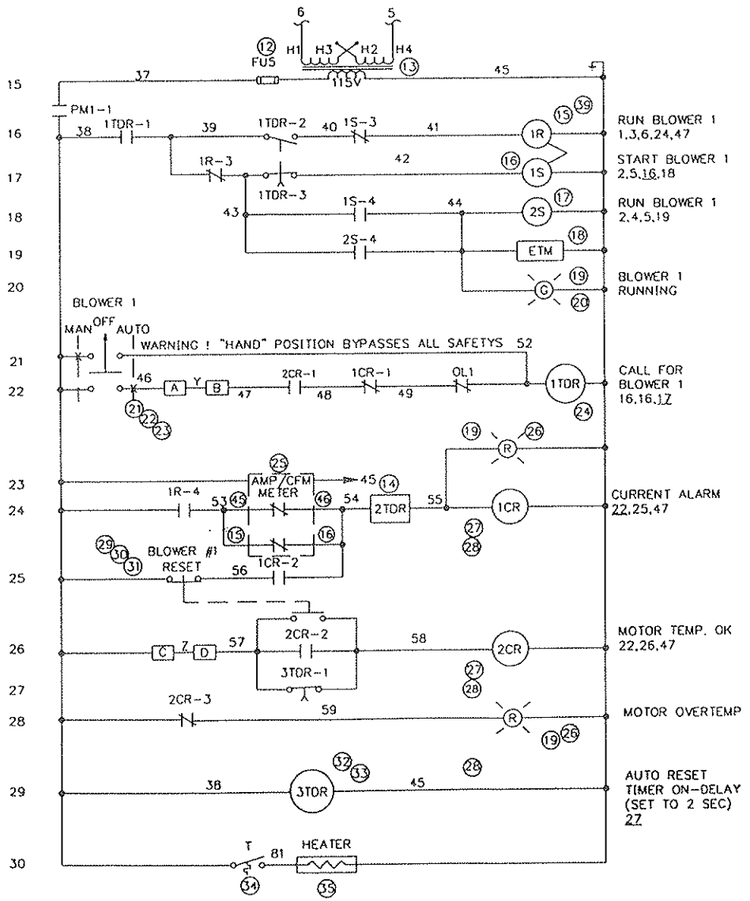


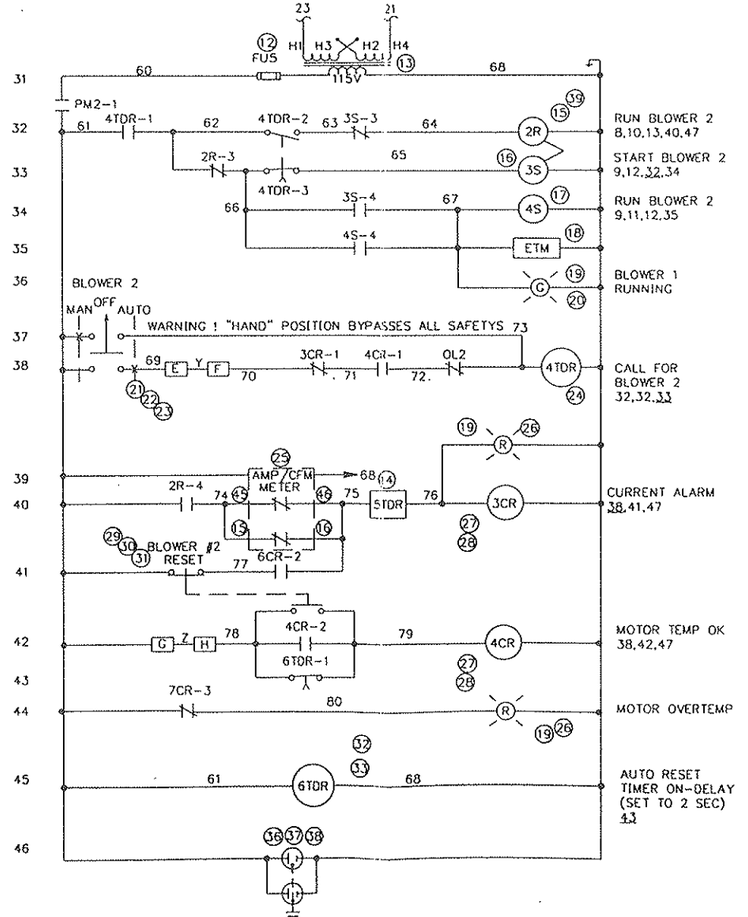
TECHNO CORPORATION
2709 WEST 10TH ST.
P.O. BOX 1416
ERIE, PA 16512
PHONE: 814-838-4561
FAX: 814-838-6963



CUSTOMER CONNECTIONS







WARNING
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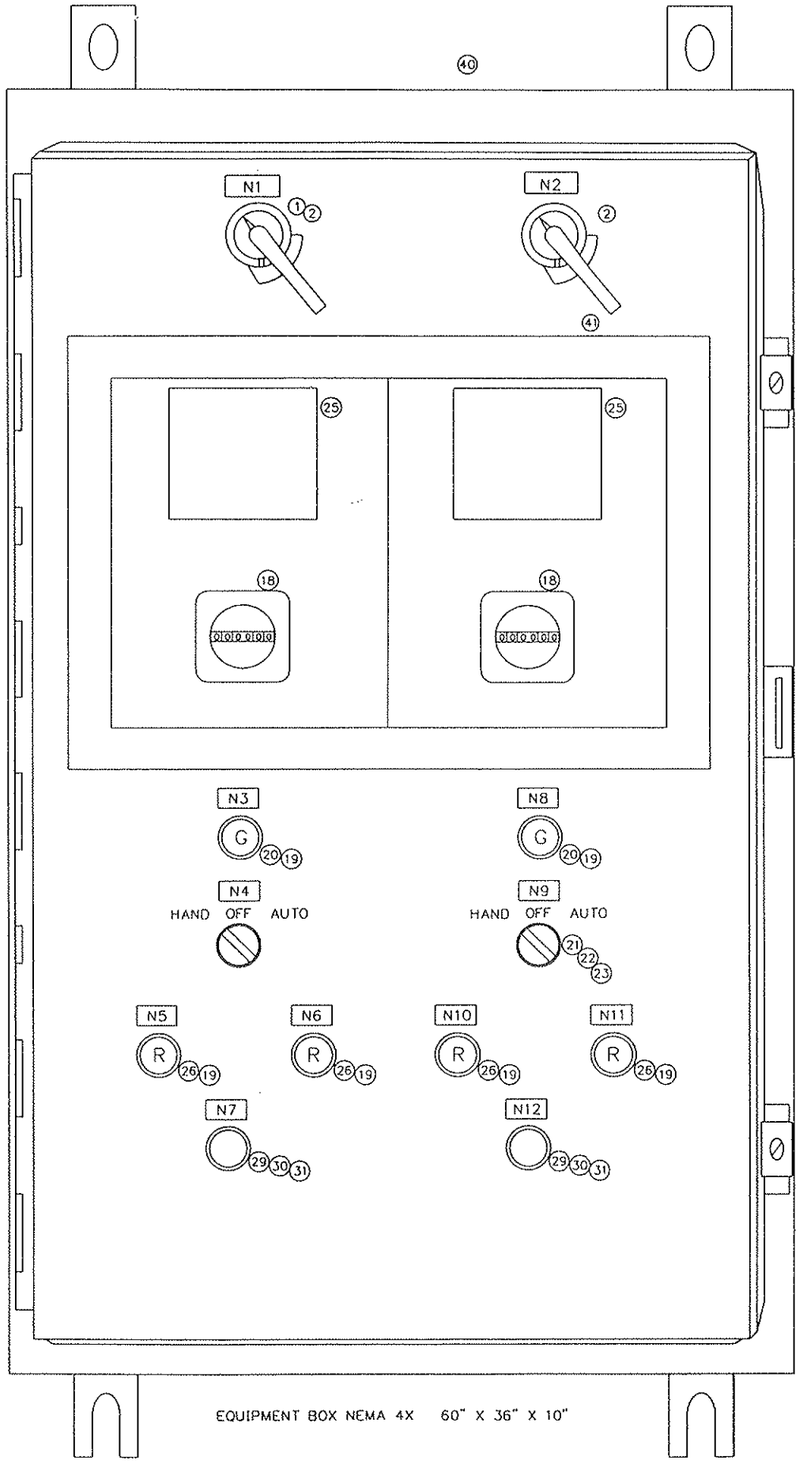
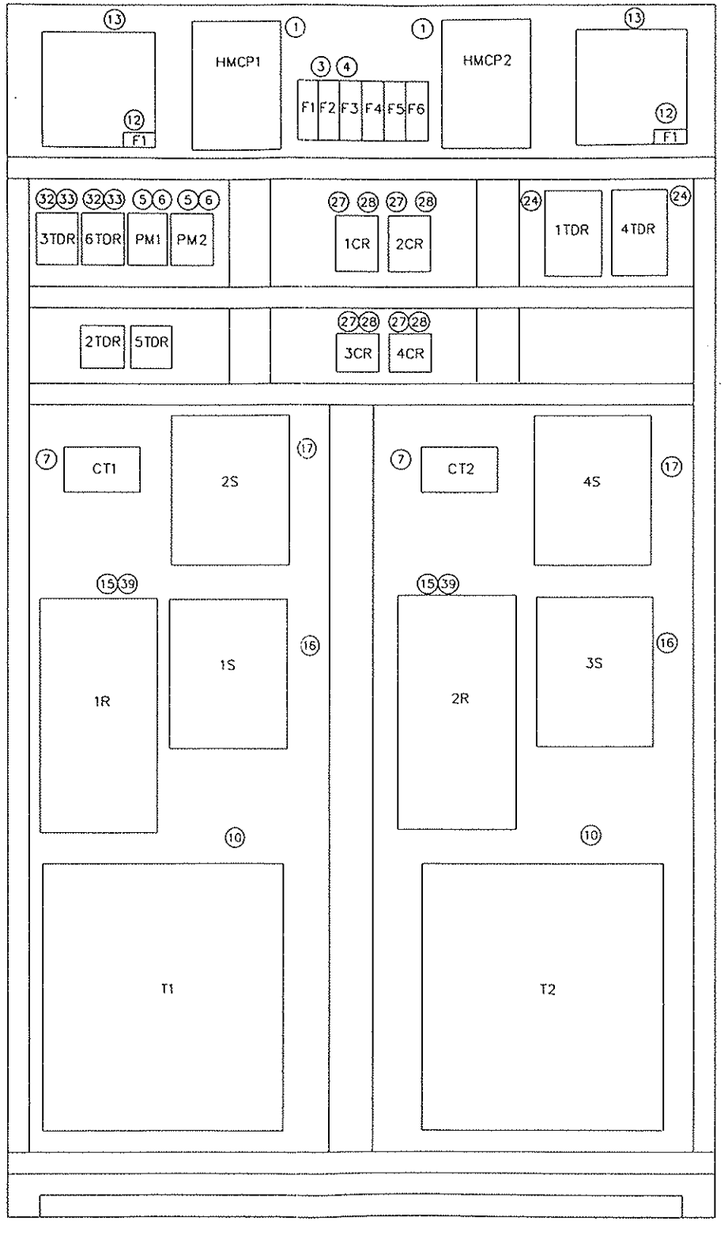
PROJECT: N.Y.C.D.E.P. PELHAM BAY		LINK CONTROL SYSTEMS INC 16 COLT COURT RONKONKOMA, NY 11779 (516) 471-3950 (516) 471-2390 (FAX	
CUSTOMER: AER-X-DUST			
DFTSMN: DLT	ENGR: RJC	CHKD:	S. O. NO: 3-9453 / 9502-16
EQUIP: DUPLEX BLOWER PANEL			DWG. NO: 3-9453-1 / REV: 1
TITLE: ELECTRICAL SCHEMATIC/LAYOUT			DATE: 02/01/95 / 02/03/95





N	LABEL DISCRIPTION
1	DISCONNECT BLOWER 1
2	DISCONNECT BLOWER 2
3	BLOWER 1 RUNNING
4	BLOWER 1
	HAND OFF AUTO
5	BLOWER 1
	CURRENT ALARM
6	BLOWER 1
	HIGH MOTOR TEMP.
7	RESET ALARMS
8	BLOWER 2 RUNNING
9	BLOWER 2
	HAND OFF AUTO
10	BLOWER 2
	CURRENT ALARM
11	BLOWER 2
	HIGH MOTOR CURRENT
12	RESET ALARMS

ITEM	DESCRIPTION	PART NO	MANUFACTURER	QUAN
1	MOTOR CIRCUIT PROTECTOR	HMCP150T4C	WESTINGHOUSE	2
2	MECHANISM	373D958G22	"	2
	HANDLE	504C323G04	"	2
	SHAFT	47A444G37	"	2
3	FUSE BLOCK	3743	BUSS	6
	END SEC	3742	"	2
4	FUSE	FNM4	"	6
5	PHASE MONITOR	A258B240	TIME MARK	2
6	SOCKET 8PIN OCT.	SR2P-06	IDEC	2
7	CURRENT TRANSFORMER	5SFT-500	ELECTRIC METERING	2
8				
9				
10	AUTOTRANSFORMER	52911-071-51	SQUARE D	2
11	OVERLOAD HEATER	CC167	"	6
12	FUSE	FNM5	BUSS	2
13	TRANSFORMER	B350MBT713XK	MICRON	2
14	TIME DELAY RELAY	TDU3000A	SSAC	2
15	MAGNETIC STARTER (2R-1R)	8536 2V02S	SQUARE D	2
16	MAGNETIC STARTER (1S-3S)	8502SEO1V02	"	2
17	MAGNETIC STARTER (2S-4S)	8502SEO2V02S	"	2
18	ELAP. TIME METER	63510063	"	2
19	PILOT LIGHT	FVLU120	CONTROL CONCEPTS	4
20	LENS CAP (GRN)	PLLGNT	"	2
21	SWITCH	SSO3	"	2
22	OPERATOR	SH4-BK	"	2
23	CONTACT	CBNO	"	4
24	TIME DELAY RELAY	9050A012EV02	SQUARE D	2
25	CURRENT/CFM METER	CROMAX-239	AIR-X-DUST	2
26	LENS CAP	PLLRDT	CONTROL CONCEPTS	2
27	RELAY	RH4BUL120	IDEC	4
28	RELAY SOCKET	SH48-05	"	4
29	PUSH-BUTTON	PB4	CONTROL CONCEPTS	2
30	OPERATOR	FC4-BK	"	2
31	CONTACT	CBNC	"	2
32	TIME DELAY RELAY	TDM120VACL	SSAC	2
33	RELAY SOCKET	SR2P-06	IDEC	2
34	TEMP. CONTROL	M7D	MEARS	1
35	HEATER 150W	OT-715	CROMALOX	1
36	DUPLEX. RECEPT	6598-HDI	LEVITON	1
37	HANDY BOX	#420	RACO	1
38	COVER	864	"	1
39	AUX. CONTACT	9999SX8	SQUARE D	4
40	EQUIPMENT BOX	1418N4T10	HAMMOND	1
41	WINDOW KIT	1481W1711	"	1

WARNING
PROPRIETARY AND CONFIDENTIAL: THIS DOCUMENT AND THE INFORMATION CONTAINED HEREIN IS THE PROPERTY OF LINK CONTROL SYSTEMS, INC. AND MAY NOT BE USED FOR ANY PURPOSE NOR DISCLOSED TO ANY PARTY WITHOUT THE PRIORS WRITTEN CONSENT OF LINK CONTROL SYSTEMS, INC.

PROJECT: N.Y.C.D.E.P. PELHAM BAY		LINK CONTROL SYSTEMS INC. 16 COLT COURT RONKONKOMA, NY 11779 (516) 471-3950 (516) 471-2390 (FAX)	
CUSTOMER: AER-X-DUST			
DFTSMN: DLT	ENGR: RJC CHKD:	S. O. NO: 3-9453	9502-16
EQUIP: DUPLEX BLOWER PANEL		DWG. NO: 3-9453-2	REV: 1
TITLE:		DATE: 02/01/95	02/03/95

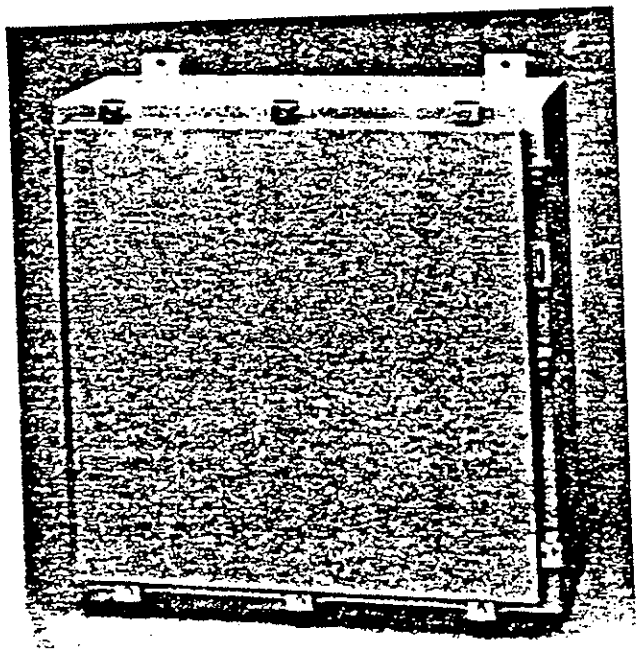
NEMA / EEMAC Type 4, 4X

Single Door Enclosures

1418 N4 Series

Panel Included

B14



Panel Included

Application

- Designed for use as instrument enclosures, electric, hydraulic or pneumatic control housings, electrical junction boxes or terminal wiring enclosures. Provides protection where equipment may be hosed down or otherwise be very wet, or in outdoor applications for full weather protection

Standards

- JIC EGP-1-1967
- IEC 529, IP66

USA

- NEMA / EEMAC Type 12, Type 13, Type 4 and Type 4X
- UL 508 Type 12, Type 4, and Type 4X
- CSA Type 4 and Type 4X

Canada Only

- NEMA / EEMAC Type 12, Type 13 and Type 4
- CSA Type 4

Construction

- Formed 16 gauge steel bodies with 14 gauge steel doors up to sizes 4" x 24". Larger sizes are all formed 14 gauge steel
- Smooth, continuously welded seams, without knockouts, cutouts or holes
- Door and body stiffeners are rovided in the larger enclosures for extra rigidity
- Welded brackets provide for enclosure mounting
- Formed lip on door and enclosure exclude flowing liquids and contaminants
- Stainless steel continuous hinge on door may be removed by pulling the stainless steel hinge pin
- Door is secured with easily operated stainless steel clamps
- Provision for padlocking
- Oil resistant gaskets are permanently secured and mechanically retained
- A removable 12 gauge inner panel is included
- Collar studs are provided for mounting inner panels
- A bonding stud is provided on the door and a grounding stud is provided in the enclosure
- A literature pocket is provided for the inside of the door

Finish

- Cover and enclosure are phosphatized, primed and finished in ANSI / ASA 61 grey
- Removable inner panel is finished in white enamel

Accessories

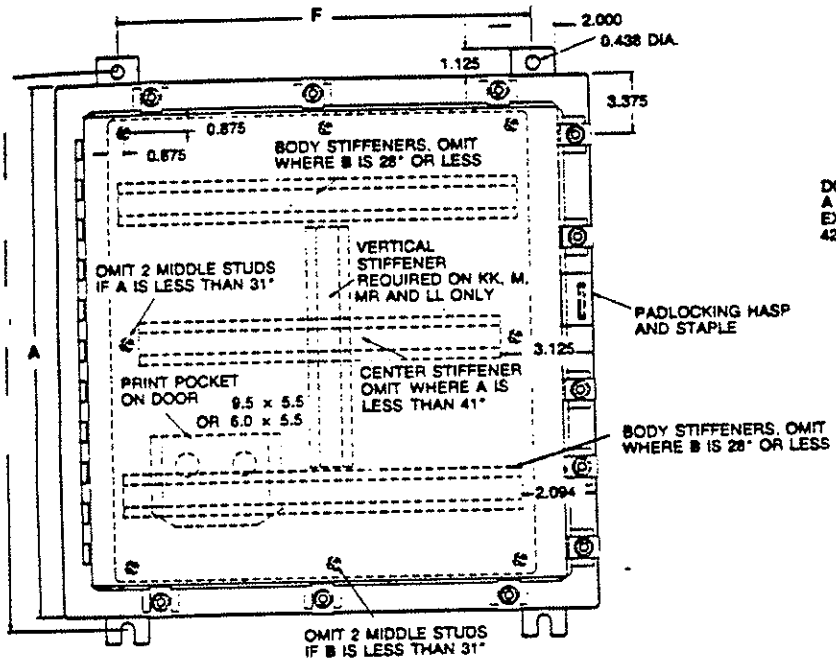
- Air conditioners
- Door stop kit
- Enclosure stabilizers
- Locking handles
- Mounting feet kit
- Quick clamp assemblies
- Spare door clamping hardware
- Spare inner panels
- Terminal kit assembly
- Window kit

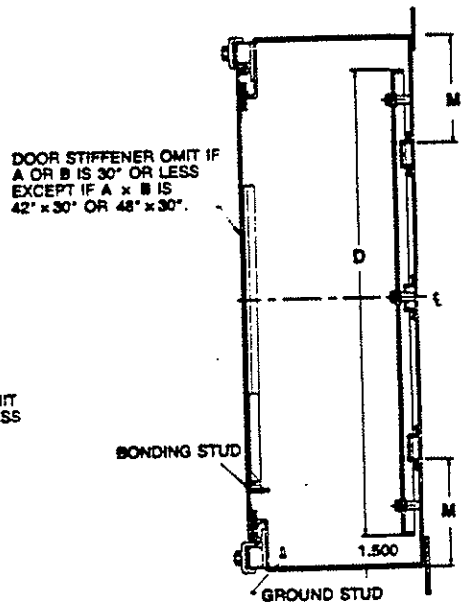
© Hammond Manufacturing Company Ltd

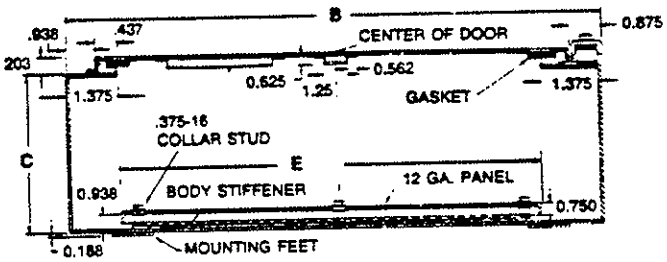
Single Door Enclosures

1418 N4 Series

Panel Included







NOTE:
NUMBER OF DOOR CLAMPS VARIES TO ENCLOSURE SIZE.

When A =	M =
30	7
36	9
42	9.875
48	11.375
60	14.375

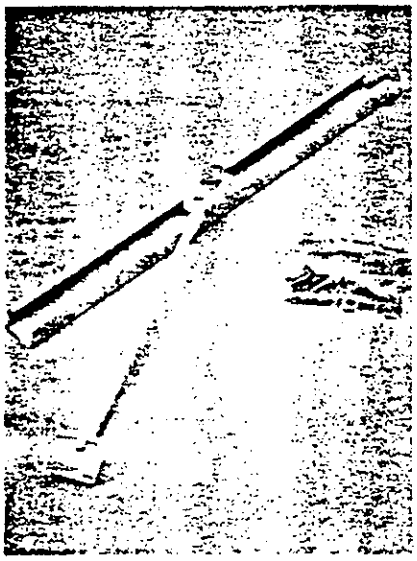
Part No.	A	B	C	Panel Size D	Panel Size E	Mtg. Centers F	Mtg. Centers G	Ship Wt. lbs.
1418 N4 B6†	16	12	6	13	9	9.5	17.25	27
1418 N4 G6†	16	16	6	13	13	10	17.25	34
1418 N4 CR6†	16	20	6	13	17	14	17.25	41
1418 N4 C6†	20	16	6	17	13	10	21.25	40
1418 N4 D6†	20	20	6	17	17	14	21.25	40
1418 N4 AR6†	24	12	6	21	9	9.5	25.25	41
1418 N4 H6	24	16	6	21	13	10	25.25	42
1418 N4 E6	24	20	6	21	17	14	25.25	56
1418 N4 J6	24	24	6	21	21	18	25.25	65
1418 N4 F6	30	20	6	27	17	14	31.25	70
1418 N4 K6	30	24	6	27	21	18	31.25	80
1418 N4 L6	36	24	6	33	21	18	37.25	91
1418 N4 B8†	16	12	8	13	9	9.5	17.25	29
1418 N4 C8†	20	16	8	17	13	10	21.25	44
1418 N4 D8†	20	20	8	17	17	14	21.25	51
1418 N4 ER8	20	24	8	17	21	18	21.25	55
1418 N4 E8	24	20	8	21	17	14	25.25	60
1418 N4 J8	24	24	8	21	21	18	25.25	70
1418 N4 KR8	24	30	8	21	27	24	25.25	74
1418 N4 F8	30	20	8	27	17	14	31.25	79
1418 N4 K8	30	24	8	27	21	18	31.25	88
1418 N4 KK8	30	30	8	27	27	24	31.25	106
1418 N4 L8	36	24	8	33	21	18	37.25	101

Part No.	A	B	C	Panel Size D	Panel Size E	Mtg. Centers F	Mtg. Centers G	Ship Wt. lbs.
1418 N4 M8	36	30	8	33	27	24	37.25	121
1418 N4 D8*	42	30	8	39	27	24	43.25	132
1418 N4 P8*	42	36	8	39	33	30	43.25	177
1418 N4 S8*	48	36	8	45	33	30	49.25	207
1418 N4 T8*	60	36	8	57	33	30	61.25	245
1418 N4 C10†	20	16	10	17	13	10	21.25	47
1418 N4 E10	24	20	10	21	17	14	25.25	66
1418 N4 K10	30	24	10	27	21	18	31.25	91
1418 N4 M10	36	30	10	33	27	24	37.25	125
1418 N4 R10*	48	30	10	45	27	24	49.25	175
1418 N4 S10*	48	36	10	45	33	30	49.25	183
1418 N4 T10*	60	36	10	57	33	30	61.25	252
1418 N4 E12	24	20	12	21	17	14	25.25	71
1418 N4 K12	30	24	12	27	21	18	31.25	95
1418 N4 L12	36	24	12	33	21	18	37.25	106
1418 N4 M12	36	30	12	33	27	24	37.25	136
1418 N4 P12*	42	36	12	39	33	30	43.25	202
1418 N4 S12*	48	36	12	45	33	30	49.25	225
1418 N4 K16	30	24	16	27	21	18	31.25	100
1418 N4 M16	36	30	16	33	27	24	37.25	149
1418 N4 S16*	48	36	16	45	33	30	49.25	290
1418 N4 T16*	60	36	16	57	33	30	61.25	232

Flat panel

All dimensions in inches

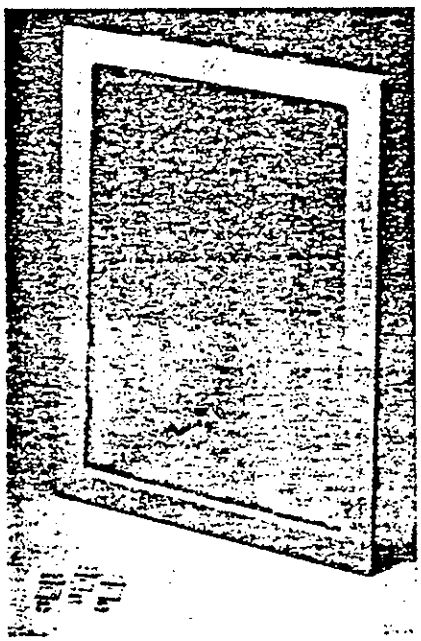
* Do not meet JIC requirements



Door Stop Kit

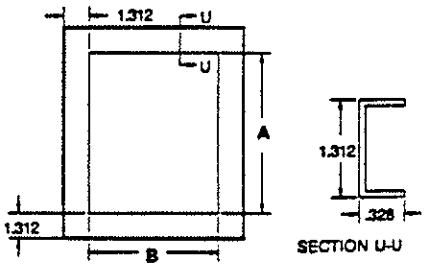
- Designed for use on Hammond 1418, 1422, UD and UHD Series enclosures where the door width is 16 inches or more and is positioned to open horizontally
- Easily installed in the top or bottom of the enclosure
- Adjusts by means of a thumb screw at any desired angle
- Finished in white baked enamel

Part No.
1481 DSK



Steel and Stainless Steel Window Kits

- Designed for use on NEMA 12 and 4 enclosures in indoor applications
- Window is .25 inch thick, clear acrylic
- Frame is heavy gauge steel, or 304 stainless steel with integral weld studs, compression clips and all required mounting hardware
- Oil resistant neoprene gasket ensures a watertight seal
- Finished in grey recoatable enamel or natural brushed stainless steel



Part No.	Description	Window Dim. A x B	No. of Clips	Recommended Cut-out Size	Wt. Lbs.
1481 W0503	Steel	5 x 3	6	6.75 x 4.75	1.4
1481 W0905	Steel	9 x 5.5	10	10.75 x 7.25	2.8
1481 W1303	Steel	13 x 3	10	14.75 x 4.75	2.7
1481 W1308	Steel	13 x 8	14	14.75 x 9.75	4.3
1481 W1705	Steel	17 x 5.5	16	18.75 x 7.25	4.8
1481 W1711	Steel	17 x 11	20	18.75 x 12.75	6.4
1481 W2315	Steel	23 x 15	24	24.75 x 16.75	9.2
1481 W2919	Steel	29 x 19	30	30.75 x 20.75	13.3
1481 W3523	Steel	35 x 23	36	36.75 x 24.75	23.9
1481 WSS0503	Stainless Steel	5 x 3	6	6.75 x 4.75	1.5
1481 WSS0905	Stainless Steel	9 x 5.5	10	10.75 x 7.25	3.0
1481 WSS1308	Stainless Steel	13 x 8	14	14.75 x 9.75	5.1
1481 WSS1711	Stainless Steel	17 x 11	20	18.75 x 12.75	8.0
1481 WSS2315	Stainless Steel	23 x 15	24	24.75 x 16.75	13.1
1481 WSS2919	Stainless Steel	29 x 19	30	30.75 x 20.75	19.4

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Molded Case Breakers

Series C Type HMCP
Motor Circuit Protector

3 to 600 Amperes
600 Volts Ac Max.
3 Poles Only

Underwriters' Laboratories, Inc. Listing
Series C Type HMCP Motor Circuit Protectors (MCPs) are recognized components in UL Listed control assemblies which include contactors and overload relays.

Interrupting Ratings
Testing in combination with a specific contactor and overload relay is required to establish the maximum interrupting capacity of the combined devices.

Application
The HMCP motor circuit protector is designed for application to individual motor circuits in combination with a magnetic motor starter. MCP's operate on the magnetic principle with a current sensing coil in each of the 3 poles to provide short circuit protection. The magnetic trip setting is adjustable from the front of the device.

The MCP is shipped with the adjusting button(s) on the low setting. MCP's are sized to correspond with NEMA starter sizes.

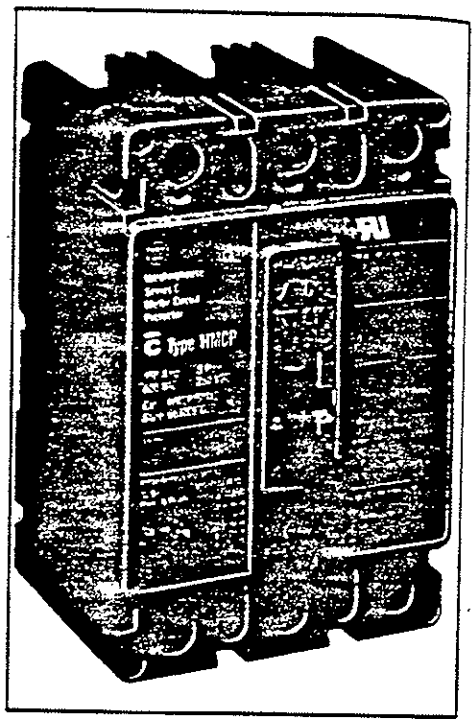
The MCP design permits the fastest tripping time possible on low level faults while offering circuit breaker convenience, quick make-quick break action, dead front safety and protection against single phasing. The size 0-4 Type HMCPs incorporate a unique transient inrush trip suppressor mechanism which allows the MCP to sustain the high transient inrush levels commonly associated with energy efficient motors.

Trip Setting
Determine motor full load current from the motor nameplate data. Refer to the table in Instruction Sheet and determine appropriate trip setting. Depress the adjusting button(s) and turn to selected setting.

For maximum protection, the adjusting button(s) should be turned to successively lower positions until the MCP trips on motor starting. After this position is determined, turn adjusting button(s) to the next higher setting for normal operations. If MCP does not trip at minimum setting leave pointer at this setting.

Current Limiter Attachment (Size 0-4)
Because of the increased interrupting ratings of combination starters using the Series C Type HMCP motor circuit protector, the need for add-on current limiters has been significantly reduced. However, current limiters are available for use with the Type HMCP to provide even higher interrupting capacities. The combination of the Type HMCP plus limiter is covered as a UL recognized component for application in electrical systems with available fault current up to 200,000 amperes at 600 VAC. The current limiters bolt to the load end of the MCP and are provided with terminals suitable for copper or aluminum conductors.

Accessories and Modifications
Accessories and modifications for the MCP include shunt trip, auxiliary switch, alarm switch, undervoltage release, handle locks, line terminal shield, electrical operator and handle mechanisms.



Ratings and Trip Settings

Motor Full Load Current Amperes	MCP Cont. Rating	MCP Catalog Number	Starter Size	MCP Trip Settings								
				A	B	C	D	E	F	G	H	I
.69- 2.5	3	HMCP003A0	0	9	12	15	18	21	24	27	30	....
1.5 - 5.7	7	HMCP007C0	0	21	28	35	42	49	56	63	70	....
3.4 - 12.6	15	HMCP015E0	0	45	60	75	90	105	120	135	150	....
6.9 - 25.2	30	HMCP030H1	1	90	120	150	180	210	240	270	300	....
11.5 - 42.1	50	HMCP050K2	2	150	200	250	300	350	400	450	500	....
16.1 - 59.1	70	HMCP070M2	2	210	280	350	420	490	560	630	700	....
23.0 - 84.5	100	HMCP100R3	3	300	400	500	600	700	800	900	1000	....
34.6 -126.7	150	HMCP150T4	4	450	600	750	900	1050	1200	1350	1500	....
27.0 - 57.2	250	HMCP250A5	4,5	350	400	440	480	525	570	610	660	700
34.7 - 73.5	250	HMCP250C5	5	450	505	565	620	680	735	790	845	900
38.5 - 81.6	250	HMCP250D5	5	500	565	625	690	750	810	875	935	1000
48.1 -102.0	250	HMCP250F5	5	625	700	780	860	940	1020	1090	1170	1250
57.7 -122.4	250	HMCP250G5	5	750	840	935	1030	1125	1220	1315	1410	1500
38.5 - 81.6	400	HMCP400D5	5	500	565	625	690	750	810	875	935	1000
48.1 -102.0	400	HMCP400F5	5	625	700	780	860	940	1020	1090	1170	1250
57.7 -122.4	400	HMCP400G5	5	750	840	935	1030	1125	1220	1315	1410	1500
67.4 -142.8	400	HMCP400J5	5	875	980	1090	1200	1310	1420	1530	1640	1750
77.0 -163.3	400	HMCP400K5	5	1000	1125	1250	1375	1500	1625	1750	1875	2000
86.6 -183.6	400	HMCP400C5	5	1125	1265	1410	1545	1690	1830	1970	2110	2250
96.2 -204.0	400	HMCP400W5	5	1250	1405	1560	1720	1875	2030	2185	2340	2500
115.4 -244.9	400	HMCP400N5	5	1500	1690	1875	2060	2250	2440	2625	2810	3000
134.7 -285.7	400	HMCP400R5	5	1750	1970	2190	2410	2625	2845	3065	3285	3500
153.9 -326.9	400	HMCP400X5	5,6	2000	2250	2500	2750	3000	3250	3500	3750	4000
134.5 -507.7	600	HMCP600L6W	6	1800	2400	3000	3600	4200	4800	5400	6000	....

Typical Specifications

Electrical circuits shall be protected by a 3-pole Series C motor circuit protector (Type HMCP) as manufactured by Westinghouse Electric Corporation, or approved equal. MCPs shall be component-recognized under UL 489 and comply with the applicable requirements of IEC 157-1.

The MCP shall be operated by a toggle type handle and shall have a quick-make, quick-break overcenter switching mechanism that is mechanically trip free from the handle so that the contacts cannot be held closed against short circuits and abnormal currents which cause the MCP to trip. Tripping shall be clearly indicated by the handle automatically assuming a position midway between the manual ON and OFF positions. All latch surfaces shall be ground and polished. All poles shall be so constructed that they open, close, and trip simultaneously.

The MCP status shall be clearly indicated by the handle position and by color-coded flags: Red for ON, Green for OFF and White for TRIP. The on and off positions shall be identified by using the English words On and Off and the international symbols I and 0 respectively.

MCPs must be completely enclosed in a high-strength glass polyester molded case. Ampere ratings shall be clearly visible. Contacts shall be of nonwelding silver alloy. Arc extinction must be accomplished by means of DE-ION® arc chutes, consisting of metal grids mounted in an insulating support.

A manual push-to-trip button shall be provided for manual exercising of the trip mechanism.

Each pole of these MCPs shall provide instantaneous short circuit protection by means of an adjustable magnetic-only element.

The MCP (through 150A) mechanism shall be the transient inrush suppressor type appropriate for the protection of energy efficient motors.

MCPs (through 150A) shall be suitable for use with current limiters, with a built-in trip indicator, that are fully coordinated with the MCP so that the MCP will open all three phases if the limiter operates. Current limiters shall be so constructed that they can only be replaced by an identical or similar limiter having the same interrupting capacity.

MCPs shall be applied in circuits with available fault currents not exceeding those listed by the control manufacturer for the MCP in combination with a contactor and overload relay.

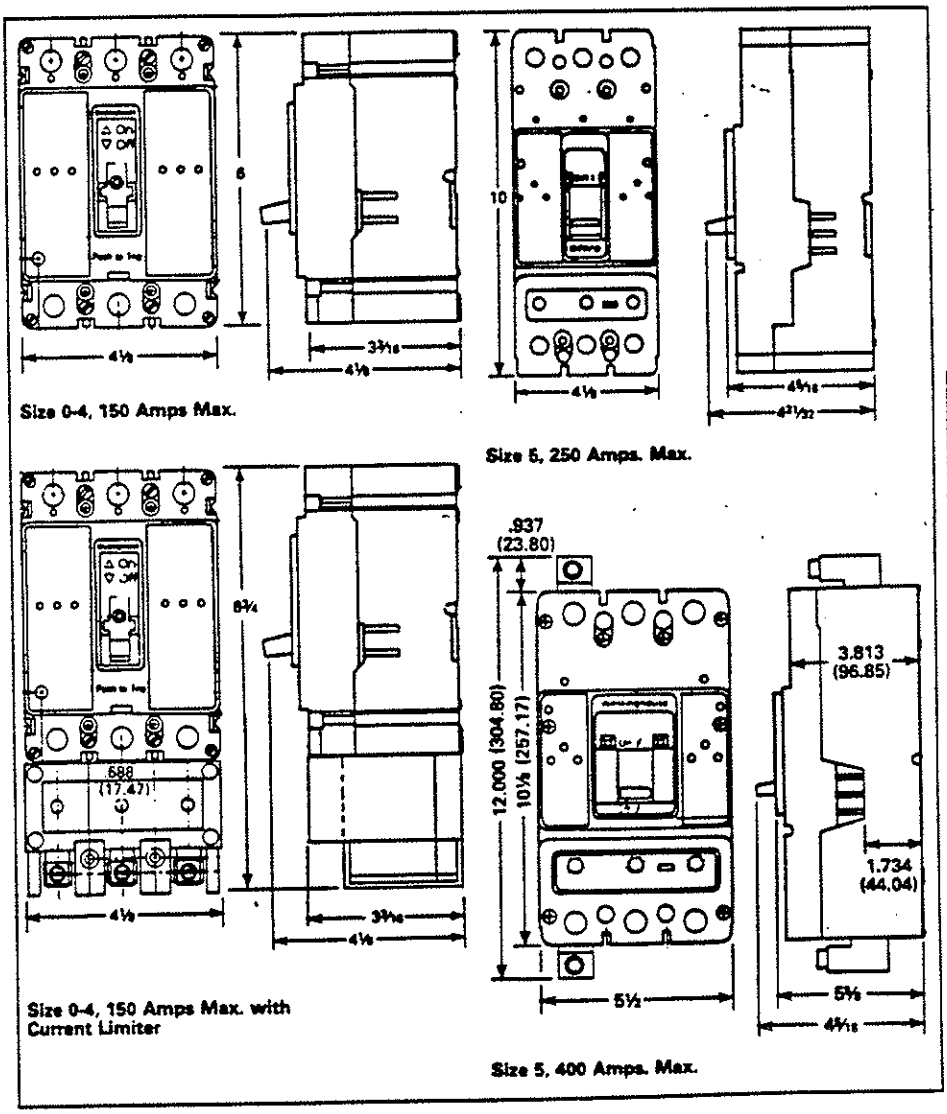
Internally mounted accessories shall be of the plug-in type with pigtail leads or terminal blocks as shown on the drawing.

Provisions shall be available for cross-routing of accessory leads through an integral trough where handle mechanisms obstruct normal exit.

Provisions shall be available for field installation of key interlock and padlocking devices.

MCP ratings, modifications etc. shall be as indicated on the drawings.

Outline Dimensions, Inches
Not to be used for construction purposes unless approved.

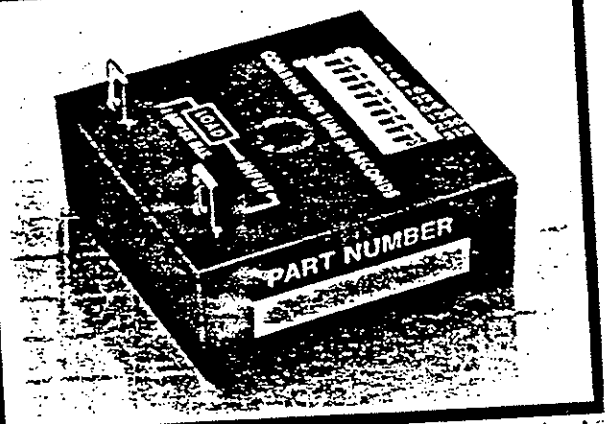


Digi-Set

SOLID STATE TIMER

TDU Series
(Delay On Make)

- ☐ Digital Integrated Circuitry
- ☐ Switch selectable delays from 0.1 seconds to 2.8 hours in specific increments
- ☐ ±0.5% repeat accuracy
- ☐ No first-shot effect
- ☐ Two models operate from 19 to 288 volts AC or DC
- ☐ Full Solid State and Encapsulated
- ☐ UL and CSA Recognized



DIN Track Adaptor available; see *Accessories*, Section I.

DESCRIPTION

Digi-Set timers are a combination of state-of-the-art technology and time proven factors. The result is a control unequalled in performance, features, and reliability.

A. C/MOS digital circuitry that incorporates a stable oscillator and a counting/storage arrangement to provide high repetitive accuracy and stability over a wide range of voltage and temperature. No long first-shot effect or shelf life to consider.

B. Digital selection of time delay by use of ten (10) binary switches. No trial-by-error adjustments or meaningless dials. Set the desired time delay the first time and every time. Provides delays from 0.1 seconds to 2.8 hours.

SPECIFICATIONS

1. **Time Delay**
   - 1.1 Type: C/MOS Digital Circuitry
   - 1.2 Range:
     - a. 0.1 to 102.3 seconds in 0.1 second increments
     - b. 1 to 1023 seconds in 1 second increments
     - c. 10 to 10230 seconds in 10 second increments
   - 1.3 Repeat Accuracy: ± 0.5%
   - 1.4 Tolerance (Factory Calibration): ± 10%
   - 1.5 Recycle Time: 150 milliseconds
   - 1.6 Time Delay vs. Temperature & Voltage: ± 5%

2. **Input**
   - 2.1 Operating Voltage: 19 to 144 volts AC or DC and 80 to 288 volts AC or DC
   - 2.2 Line Frequency: 50/60 Hertz

3. **Output**
   - 3.1 Type: Solid State
   - 3.2 Form: Single pole single throw normally open
   - 3.3 Maximum Load Current: 1 ampere steady state at 60°C. 10 amperes inrush
   - 3.4 Minimum Holding Current: 40 milliamperes
   - 3.5 Voltage Drop: 2.5 volts typical at 1 ampere

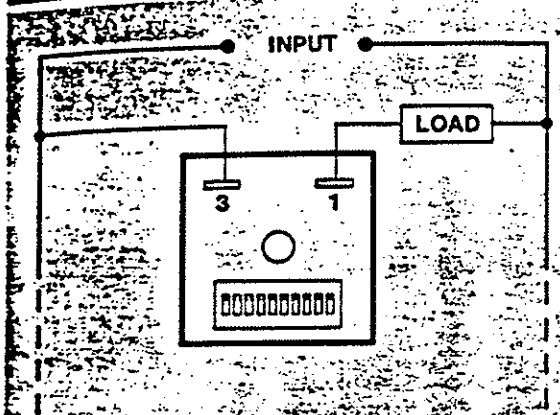
4. **Protection**
   - 4.1 Transient protected
   - 4.2 Dielectric: 1500 volts RMS minimum
   - 4.3 Insulation Resistance: 100 megohms minimum

5. **Mechanical**
   - 5.1 Mounting: Surface with #8 or #10 screw
   - 5.2 Package: Plastic housing with totally encapsulated circuitry
   - 5.3 Termination: 1/4 inch male quick connect terminals

6. **Environmental**
   - 6.1 Operating Temperature: -40°C to +80°C
   - 6.2 Storage Temperature: -40°C to +85°C
   - 6.3 Humidity: 95% relative

SSAC inc P.O. Box 1000 Baldwinsville, NY 13027 (315)638-

CONNECTION



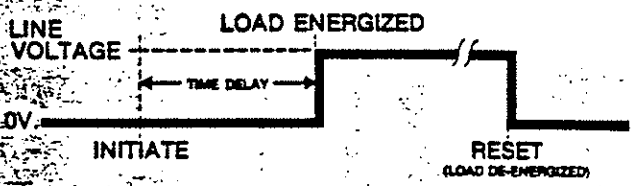
NOTE: The load may operate in either side of line.

OPERATION

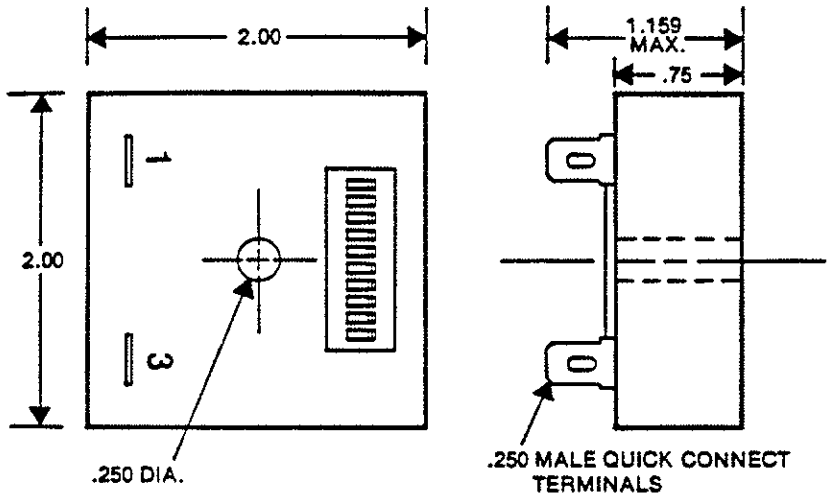
Delay on Make: Upon application of power the time delay is initiated. On completion of the delay period the load becomes energized.

To reset, remove power.

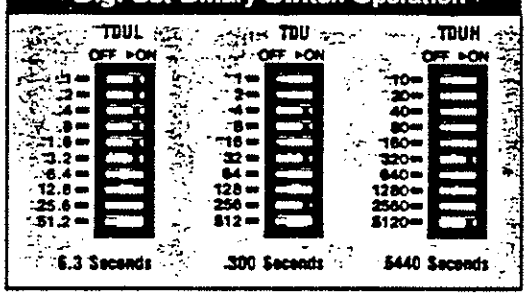
Time Diagram



MECHANICAL



Digi-Set Binary Switch Operation



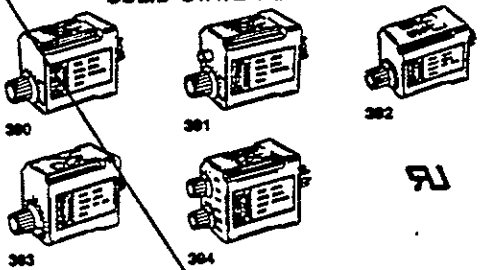
ORDERING INFORMATION

Part Number	Time Range Seconds	Operating Voltage Range AC or DC
TDUL3000A	0.1 to 102.3	19 to 144
TDUL3001A	0.1 to 102.3	80 to 288
TDU3000A	1 to 1023	19 to 144
TDU3001A	1 to 1023	80 to 288
TDUH3000A	10 to 10230	19 to 144
TDUH3001A	10 to 10230	80 to 288

ETI'S AND TIMERS

CRAMER COMPANY

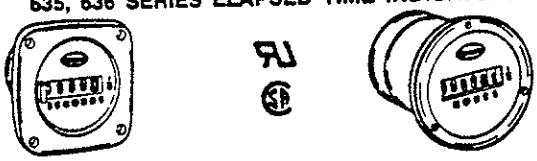
SOLID STATE PLUG-IN TIMERS



Programmable timers with adjustment of delay, interval or cycle timing. Isolated DPDT relay contact output, rated 10A resistive @ 120VAC. 50-60 Hz. Compact 2.813H x 1.750W x 2.375"D (71.45 x 44.45 x 60.32), exclusive of knobs. UL recognized. Potter & Brumfield type 27E122 8-pin socket fits 390, 391 and 394 series timers; Potter & Brumfield type 27E123 11-pin socket fits 392 series timers.

Stock No.	Type	Time Range	1-4
390 SERIES ON DELAY TIMERS, REPEATABILITY ±2%			
55F3118	20003	0.05-2.0 Seconds	$1.35
55F3119	20004	0.1-10 Seconds	$1.35
55F3120	20005	0.3-30 Seconds	$1.35
55F3121	20006	0.6-60 Seconds	$6.17
55F3122	20007	3-300 Seconds	$6.17
55F3123	20008	6-600 Seconds	107.74
391 SERIES EXTENDED ON DELAY TIMERS WITH INDICATOR LIGHT			
55F3124	20009	180-1800 Seconds	151.42
55F3125	20010	300-3600 Seconds	151.42
392 SERIES OFF DELAY TIMERS			
55F3126	20011	0.1-10 Seconds	$7.63
55F3127	20012	0.3-30 Seconds	$7.63
55F3129	20014	3-300 Seconds	109.81
393 SERIES INTERVAL TIMERS			
55F3130	20015	0.05-5 Seconds	$7.63
55F3131	20016	0.1-10 Seconds	$7.63
55F3132	20017	0.3-30 Seconds	$7.63
55F3134	20019	0.3-300 Seconds	109.81
394 SERIES REPEAT CYCLE TIMERS			
55F3135	20020	0.05-5 Seconds	142.33
55F3136	20021	0.1-10 Seconds	142.33
55F3137	20022	0.3-30 Seconds	142.33
55F3138	20023	0.6-60 Seconds	142.33

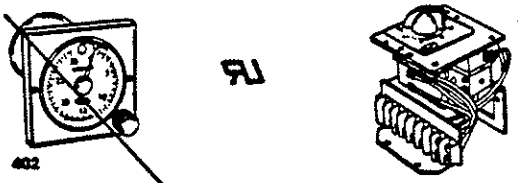
635, 636 SERIES ELAPSED TIME INDICATORS



635 series non-resettable indicators with induction motors for faster starts and stops. Large, six-digit readout. 636 series resettable, with five-digit readout. Both models 115VAC, 60Hz. Case styles: "E" is 3.50"(88.90) round bezel; "S" 3.50"(88.90) square bezel; "X" 2.50"(63.50) round bezel; "Y" 2.50"(63.50) square bezel; "G" 2.50"(63.50) utility type round bezel; "K" 2.50"(63.50) utility type square bezel. UL recognized, CSA certified.

Stock No.	Type	Case Style	Total Count	1-9
635 SERIES SIX-DIGIT ETI'S				
55F4397	10053	E	99,999.9 Minutes	$4.41
55F4399	10055	E	99,999.9 Hours	$4.41
55F3141	10061	S	99,999.9 Minutes	$4.41
55F3143	10063	S	99,999.9 Hours	$4.41
55F3146	10069	G	99,999.9 Minutes	$2.74
55F3148	10071	G	99,999.9 Hours	$2.74
35F3803	10184	K	99,999.9 Minutes	$2.74
35F3805	10186	K	99,999.9 Hours	$2.74
636 SERIES FIVE-DIGIT				
55F4444	10072	X	9,999.9 Seconds	103.23
55F4447	10074	X	9,999.9 Minutes	103.23
55F4450	10075	X	9,999.9 Hours	103.23
55F4460	10076	E	9,999.9 Seconds	103.23
55F4463	10078	E	9,999.9 Minutes	103.23
55F4466	10079	E	9,999.9 Hours	103.23
55F4452	10080	Y	9,999.9 Seconds	103.23
55F4455	10082	Y	9,999.9 Minutes	103.23
55F4458	10083	Y	9,999.9 Hours	103.23
55F4468	10084	S	9,999.9 Seconds	103.23
55F4471	10086	S	9,999.9 Minutes	103.23
55F4474	10087	S	9,999.9 Hours	103.23

402 AND 472 SERIES RESET TIMERS



402 series plug-in model with pilot light feature adjustable interval or delay timing between operation of a control circuit and closing of load circuits. Repeat accuracy: ±0.4%. 115VAC, 60Hz. Power input: motor 3.0 watts, clutch 5 watts. Snap action SPDT switches rated 10A resistive. 3.875" square x 4.156" deep (98.42 x 105.56). UL recognized. 472 series bracket mount models feature external clutch reset and interval or delay timing. Operate from momentary or sustained contact switch. SPDT load switches rated 10A resistive at 125/250VAC. 3.844H x 3.656W x 2.875"D (97.63 x 92.86 x 73.02). UL recognized, CSA certified.

Stock No.	Type	Time Range	1-4
402 SERIES PLUG-IN RESET TIMERS WITH PILOT LIGHT			
35F3806	10006	6 Seconds	223.25
35F3807	20002	15 Seconds	223.25
35F3808	10007	30 Seconds	223.25
35F3809	10008	60 Seconds	223.25
35F3810	10009	5 Minutes	223.25
35F3811	10010	60 Minutes	223.25
35F3812	10011	5 Hours	223.25
472 SERIES BRACKET MOUNT RESET TIMERS			
20F899	10021	5 Minutes	170.00
20F900	10022	15 Minutes	170.00
20F901	10023	30 Minutes	170.00
20F903	10025	5 Hours	170.00
20F904	10026	24 Hours	170.00

241 SERIES PUSHBUTTON RESET INTERVAL TIMERS

- High Visibility 300° Dial
- Silver-Cadmium Load Contacts
- Repeat Accuracy: ±0.25%

Integral start button turns on load and starts timer. Silver-cadmium oxide snap-action load SPDT contacts rated 16A @ 115VAC, 60Hz; 10A @ 250V, non-inductive, 60Hz. Repeat accuracy: ±0.25% except 15 second time range ±0.5%. 3-hole mount 1.687"(42.84) radius. UL recognized, CSA certified.

Stock No.	Type	Time Range	Calibration	1-4
55F351	10000	60 Seconds	1 Second	181.46
35F3800	10001	5 Minutes	5 Seconds	181.46
55F352	10002	15 Minutes	15 Seconds	181.46
55F378	20001	30 Minutes	30 Seconds	181.46
55F353	10003	60 Minutes	1 Minute	181.46
35F3801	10004	5 Hours	5 Minutes	181.46
55F4476	10005	24 Hours	30 Minutes	181.46

561 SERIES PERCENTAGE CYCLE TIMERS

On or off time may be set at any portion of total cycle between 4% and 96%. Continuous repeating; repeat accuracy within 1%. Load switch rated 20A @ 115/220VAC resistive, 50/60 Hz. 3.750" diameter x 3.093" behind panel (95.25 x 78.56). UL recognized.

Stock No.	Type	Time Range	1-4
35F3818	10180	30 Seconds	156.46
35F3819	10181	60 Seconds	156.46
35F3820	10182	5 Minutes	156.46

Digi-Set TIME DELAY RELAY

TDML, TDM, TDMH Series
(Delay On Make)

- ☐ Digital Integrated Circuitry
- ☐ Switch Setable Time Delay
- ☐ Three Time Ranges from 100 Milliseconds to Over 2.8 Hours
- ☐ ±0.1% Repeat Accuracy, No First-Shot Effect
- ☐ ±2% Setting Accuracy
- ☐ DPDT, 10 Amperes Output Contacts
- ☐ LED Indication ☐ UL and CSA

DESCRIPTION

Digi-Set timers are a combination of state-of-the-art technology and time proven factors. The result, a control unequalled in performance, features, and reliability.

A. C/MOS digital circuitry that incorporates a stable oscillator and a counting/storage arrangement to provide high repetitive accuracy and stability over a wide range of voltage and temperature. No long first-shot effect or shelf life to consider.

B. Digital selection of time delay by use of ten (10) binary switches. No trial-by-error adjustments or meaningless dials. Set the desired time delay the first time and every time. Three ranges to choose from.

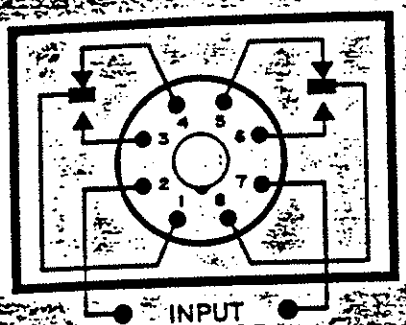
C. Proven electromechanical relay provides isolated double-pole-double-throw output switching. Contacts are 10 ampere silver cadmium oxide that provide millions of reliable operations.

SPECIFICATIONS

1. **Time Delay**
   - 1.1 Type: Digital C/MOS circuitry
   - 1.2 Range: Three ranges (see *Ordering Information*). Selection of the desired time delay is made by means of ten (10) binary switches located at the top end of the unit. To obtain the desired time delay, the time periods for each switch in the ON position are *added* together.
   - 1.3 Repeat Accuracy: ±0.1% or ±8.3 milliseconds, whichever is greater (no first shot effect)
   - 1.4 Setting Accuracy: ±2% or ±50 milliseconds, whichever is greater
   - 1.5 Reset Time: 50 milliseconds maximum
   - 1.6 Recycle Time: 500 milliseconds—TDMH, 300 milliseconds—TDM, and TDML max during timing. 16 milliseconds after timing.
   - 1.7 Time Delay vs. Temperature and Voltage: ±2%
   - 1.8 Indicator: LED indicates during timing
2. **Input**
   - 2.1 Operating Voltage: 12, 24, 120 and 230 volts
   - 2.2 Tolerance: ±20% of nominal
   - 2.3 Frequency: 50 or 60 Hertz
   - 2.4 Power Consumption: 2.25 watts maximum
3. **Output**
   - 3.1 Type: Electromechanical relay
   - 3.2 Form: Double pole double throw
   - 3.3 Rating: 10 amperes resistive at 240VAC
   - 3.4 Life: Mechanical - 10,000,000 operations
     Full load - 1,000,000 operations
4. **Protection**
   - 4.1 Transient: ±1500 volts for 150 microseconds
   - 4.2 Polarity: DC units are reverse polarity protected
   - 4.3 Dielectric Breakdown: 1500 volts RMS minimum at 60 Hertz between input and output terminals
5. **Mechanical**
   - 5.1 Mounting: Plug-in
   - 5.2 Termination: Standard octal plug (8 Pin)
6. **Environmental**
   - 6.1 Operating Temperature: -20° to +65°C
   - 6.2 Storage Temperature: -30°C to +85°C
7. **Panel Mounting Accessory**

BZ1 PANEL MOUNT KIT available for SSAC Plug-in Controls. Also, Octal 8 pin and 11 pin flush mount sockets. See *Accessories*.

CONNECTION

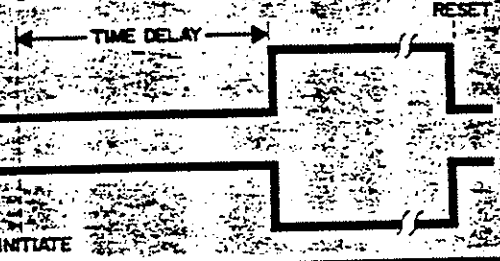


Note: Relay contacts are isolated from input voltage.

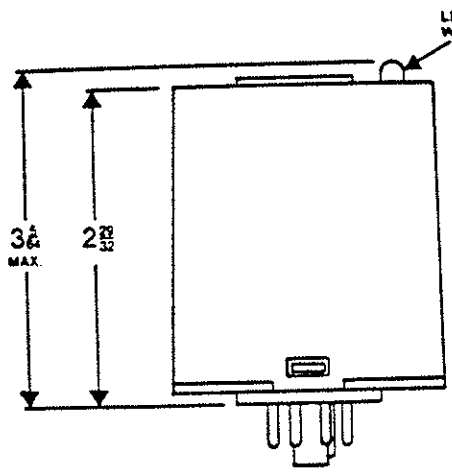
OPERATION

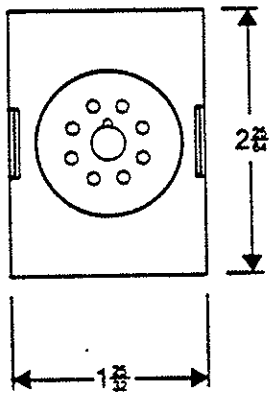
Delay on Make: The Series TDML, TDM and TDMH Time Delay is initiated when power is applied to the input terminals. At the end of the delay period, the output contacts transfer. Reset is accomplished by removal of input power. There is no false output when reset during timing.

Time Diagram: Output Contacts

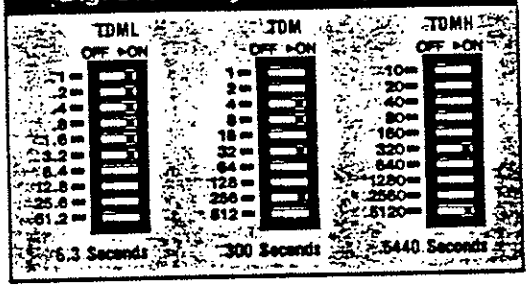


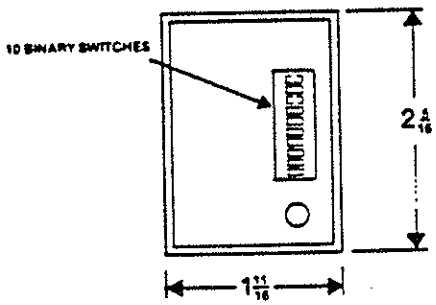
MECHANICAL





Digi-Set Binary Switch Operation





ORDERING INFORMATION

Series/Time Range	Input Voltage	LED Indication
TDML 0.1 to 102.3 seconds in 0.1 second increments	12VDC	
☆ TDM 1 to 1023 seconds in 1 second increments	24VDC/28VDC	
TDMH 10 to 10,230 seconds in 10 second increments	110VDC	
	24VAC	
	☆ 120VAC	☆ L
	230VAC	

☆ **Example Part Number:** TDM120AL is a delay-on-make Digi-Timer, 120 volt AC operating, LED indication and a time range of 1 to 1023 seconds.

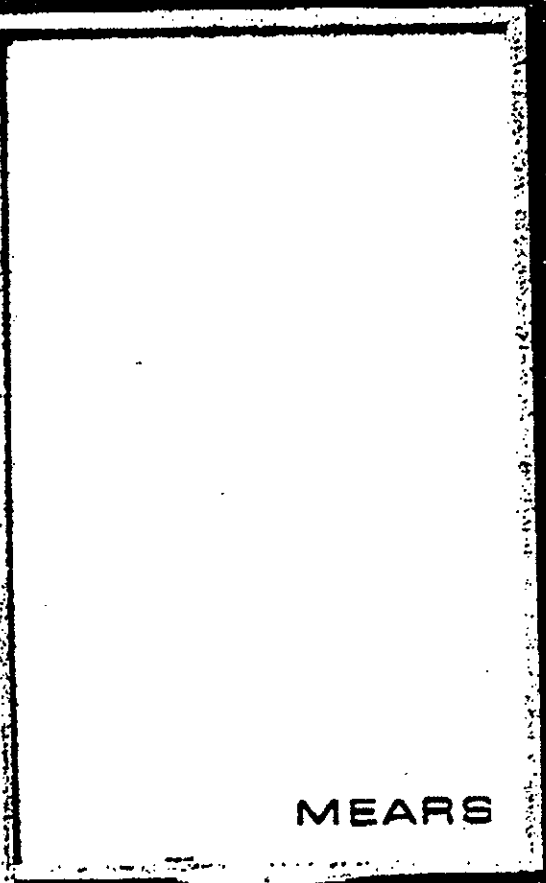
For Application Assistance Call (315)638-1300

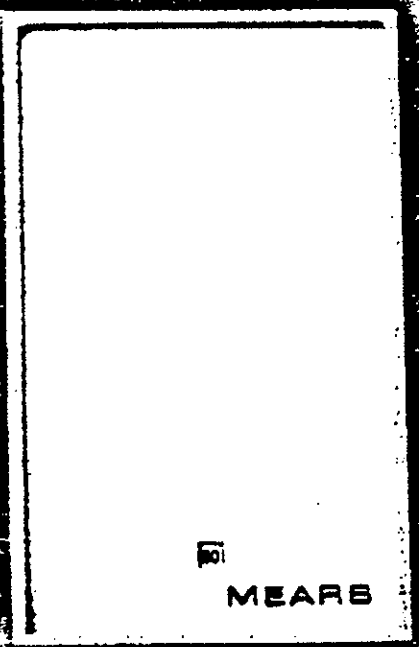
Mears

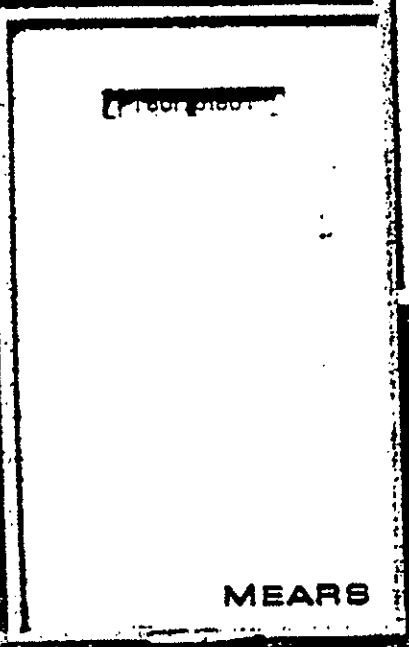
M7 Series

Top quality thermostats designed and engineered for years of dependable temperature regulation.

M7 STANDARD SERIES
Also available with Tamper Proof and Setback design options

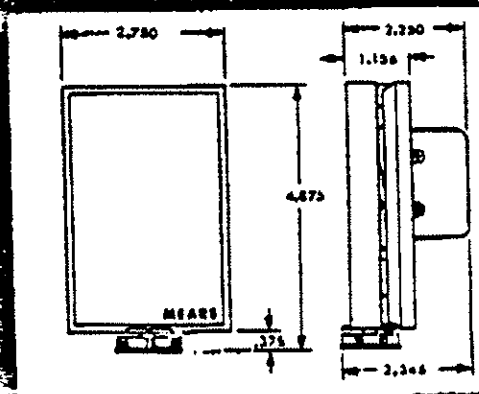






M7 TAMPER PROOF SERIES
Also available with optional thermometer/faceplate

M7 STANDARD SERIES
Shown with 45°F to 75°F range 10 amp rating code where required and optional thermometer/faceplate



All Mears thermostats mount in standard outlet boxes with a recommended volume of 21 cubic inches (344 cc).

EATON

TOTAL P.003

Get the dependable Mears M7 electric heat control you want: Standard, Tamper Proof and Setback designs, plus other options.

Mears M7 Series thermostats combine precision engineering with quality materials and construction to provide outstanding performance and long life. You get efficient snap-action switching that reduces arcing and eliminates TV interference. There's a bimetal sensor that accurately interprets and responds to room temperature conditions. The durable cast metal base resists changes in calibration, and an optional heat anticipator furnishes close, even temperature regulation day in and day out.

M7 Design Options:

Standard M7 Series—designed and built for reliable control of electric heating. Optional limit stops permit limited user temperature selection.

Tamper Proof M7 Series—eliminate tampering by unauthorized persons in schools, hospitals, theaters, other buildings. Adjust setting with a screwdriver after removing faceplate and trim ring with an Allen wrench (provided). Set-point indicator is visible through small window in faceplate.

Setback M7 Series—when thermostats are used in conjunction with setback panels such as the Mears Heatminder System, temperature settings can be regulated from a remote location in schools, motels, hotels, hospitals, rest homes and private residences.

M7 Models:

M7, M7A Single Line Break—Switch breaks only one leg of the circuit—the simplest, most economical electric heating control. M7A model features optional heat anticipation.

M7D Double Line Break—Breaks both legs of circuit in OFF setting. Controls one heating load only; meets all electrical codes.

M7L Load Transfer—For applications where service capacity is limited or demand rates prevail. Used in conjunction with a second thermostat to give priority to one zone of a two-zone heating system.

M7M Modulation (Two Stage)—Reduces input during light load periods. A single thermostat controls two separate heating circuits. Second stage activates when temperature drops to approximately 1½° below first-stage turn-on temperature.

M7S Simultaneous Switching (Double Circuit)—Provides simultaneous control of two heating loads. For use where total load slightly exceeds capacity of a single switch, where two thermostats are impractical, and where the circuit can be divided into equal or nearly equal loads. Both switches are calibrated to operate at approximately the same temperature.

M7C Cooling or Heating—One thermostat controls either cooling or heating, but it cannot be used for combination cooling *and* heating UNLESS an extra switch is installed for the changeover between the cooling circuit and the heating circuit.

Ordering Information:

Orders should include model number and options desired. For 25-amp. switch option, add -25 after model number. For setback option, add -SB. For Tamper Proof option, add -TP. Other options, such as thermometer faceplate or limit/stop option, should also be noted on your order. Tamper Proof and Setback features may be combined on any M7 model.

Specifications:

Temperature range: 40° F to 90° F
45° F to 75° F*
Type of sensor: bimetal.
Type of switch: snap action.
Base material: cast metal.
Listings: UL, CSA.
Electrical ratings:

U.L. listed @
22 amps, 125-250 VAC**
16 amps, 277 VAC**

C.S.A. listed @
17 amps, 125, 240, 277 VAC**

MEARS LINE VOLTAGE THERMOSTATS — MODEL LISTINGS AND OPTIONS

Model Series	With Heat Anticipator		Without Heat Anticipator		Temperature Range				Therm. Cover (Opt.)	Limit Stop (Opt.)	25-Amp. Switch (Opt.)	Specialty Function Options				Setback (Opt.)	Tamper Proof (Opt.)
	SP	DP	SP	DP	90° F max.		80° F max.	75° max. (Code)*				Modulation	Simultaneous	Load Transfer	Cooling/ Heating		
M400	M411	M412	M401	M402			50° F-80° F	45° F-75° F	●	●	●	M400M M400M1	M400S M400S1	M400L	M400C	●	●
M7	M7A	M7D	M7		40° F-90° F			45° F-75° F	●	●	●	M7M	M7S	M7L	M7C	●	●
M21	M21SP	M21DP				50° F-90° F		45° F-75° F		●							

* Mears thermostats are available with a 75° max. temperature range for applications requiring B.O.C.A. code compliance.

** Ratings shown are for non-inductive loads. 25 amp models (available at additional cost) are U.L. rated at 25 amps, 125, 250 VAC and 16 amps, 277 VAC. Loads less than 22 amps are not recommended on 25 amp models.

Eaton Corporation
Controls Division
Beaverton Plant
13725 S.W. Millikan Way
Beaverton, Oregon 97005
Telephone (503) 644-0131

EATON

Printed in U.S.A.
253-02241-00
9-1-88

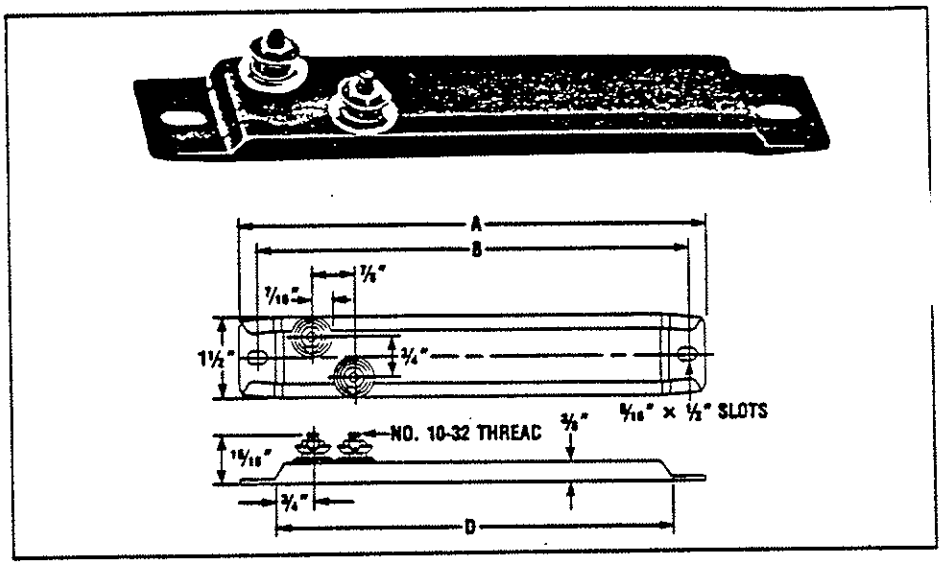
1½" strip

150 to 1250 Watts

2 offset bolt terminals at one end

U.L. Component Recognized and C.S.A. Certified

Type OT



Dimensions — Inches			Rust-resisting Iron Sheath*							Chrome Steel Sheath*							
						PCN		PCN					PCN		PCN		
A	B	D	Watts	W/in²	Catalog No.	120V	Status	240V	Status	Watts	W/in²	Catalog No.	120V	Status	240V	Status	Wt. lbs.
7½	6½	6	150	11	OT-715	129314	S	129322	S	200	15	OT-702	129613	S	129621	S	.5
8	7	6½	150	10	OT-815	129330	S	129349	S	250	17	OT-802	129630	S	129648	S	.56
8	7	6½	175	12	OT-817	129357	S	129365	S	400	27	OT-804	129656	S	129664	S	.56
10½	9½	9	250	10	OT-1025	129373	S	129381	S	350	15	OT-1003	129672	S	129680	S	.75
10½	9½	9	—	—	—	—	S	—	—	400	17	OT-1004	129699	S	129701	S	.88
12	11	10½	250	8	OT-1225	129390	S	129402	S	250	8	OT-1202	129710	S	129728	S	.88
12	11	10½	—	—	—	—	S	—	—	350	14	OT-1203	129736	S	129744	S	.88
12	11	10½	—	—	—	—	S	—	—	500	17	OT-1205	129752	S	129760	S	.88
14	13	12½	300	8	OT-1430	129410	S	129429	S	500	14	OT-1405	129779	S	129787	S	1.0
15¼	14¼	13¾	325	8	OT-1532	129437	S	129445	S	500	12	OT-1505	129795	S	129808	S	1.13
17⅞	16⅞	16⅜	350	6.5	OT-1835	129453	S	129461	S	500	10	OT-1805	129816	S	129824	S	1.38
17⅞	16⅞	16⅜	375	7	OT-1837	129470	S	129488	S	750	15	OT-1807	129832	S	129840	S	1.38
17⅞	16⅞	16⅜	500	10	OT-1850	129496	S	129509	S	1000	19	OT-1801	129859	S	129867	S	1.38
19½	18½	18	350	6	OT-1935	129517	S	129525	S	500	9	OT-1905	129875	S	129883	S	1.5
19½	18½	18	500	8	OT-1950	129533	S	129541	S	750	13.5	OT-1907	129891	S	129904	S	1.5
19½	18½	18	—	—	—	—	S	—	S	1000	18	OT-1901	129912	S	129920	S	1.5
21	20	19½	500	8	OT-2150	129550	S	129568	S	750	12	OT-2107	129939	S	129947	S	1.63
23¾	22¾	22¼	500	7	OT-2450	129576	S	129584	S	500	7	OT-2405	129955	S	129963	S	1.81
23¾	22¾	22¼	750	10	OT-2475	129592	S	129605	S	750	10	OT-2407	129971	S	129980	S	1.81
23¾	22¾	22¼	—	—	—	—	—	—	—	1000	14	OT-2401	129998	S	130008	S	1.81
23¾	22¾	22¼	—	—	—	—	—	—	—	1500	19	OT-2415	129226	S	129234	S	1.81
25½	24½	24	500	6	OT-2550	121005	S	121013	S	750	9	OT-2507	121208	S	121216	S	2.06
25½	24½	24	750	9	OT-2575	121021	S	121030	S	1000	13	OT-2501	121224	S	121232	S	2.0
26¾	25¾	25¼	700	8	OT-2670	121048	S	121056	S	1000	12	OT-2601	121240	S	121259	S	2.19
26¾	25¾	25¼	750	9	OT-2675	121064	NS	121072	S	—	—	—	—	—	—	—	2.19
30½	29⅜	28	750	8	OT-3075	121080	S	121099	S	750	8	OT-3607	121267	S	121275	S	2.38
30½	29⅜	28	—	—	—	—	—	—	—	1000	11	OT-3001	121283	S	121291	S	2.38
30½	29⅜	28	—	—	—	—	—	—	—	1250	13	OT-3012	—	S	121304	S	2.38
33½	32⅜	31	750	7	OT-3375	121101	S	121110	S	750	7	OT-3307	121312	S	121320	S	2.69
35⅞	34¾	33½	1000	9	OT-3610	121128	S	121136	S	1500	13	OT-3601	121339	S	121347	S	2.88
38½	37½	36	800	6	OT-3880	121144	S	121152	S	1000	8	OT-3801	121355	S	121363	S	3.19
38½	37½	36	1000	8	OT-3810	121160	S	121179	S	1500	12	OT-3815	121371	S	121380	S	3.19
42½	41⅜	40	1250	9	OT-4312	121187	S	121195	S	1500	11	OT-4315	121398	S	121400	S	3.38
47⅞	46¾	45⅜	—	—	—	—	—	—	—	1350	9	OT-4813	—	S	121419	S	3.75
47⅞	46¾	45⅜	—	—	—	—	—	—	—	2250	14	OT-4822	—	S	121427	S	3.75

*See page A/6 for maximum sheath temperatures.
Specify: Quantity, catalog no., PCN, watts, volts, strip heaters.
Delivery: S, stock; NS, two weeks.

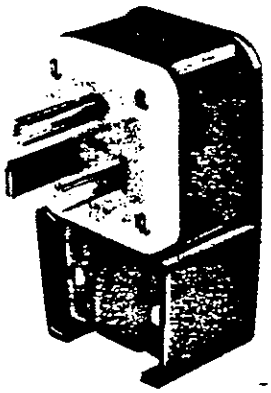
30, 50 and 60 Amp Power Receptacles and Angle Plugs

Flush-mounted power receptacles find widespread use in the industrial environment. Leviton's devices are designed to shrug off impacts and abuse and deliver top performance.

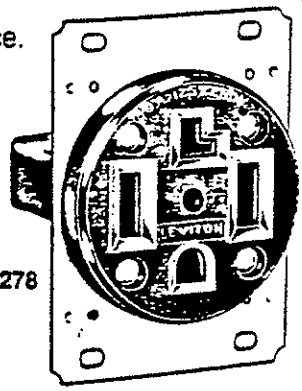
Matching Angle plugs are sturdy and built to last in industrial applications. Rugged cord clamps hold cable securely without tearing conductor jacket.

Power receptacles feature:

- Heavy-gauge double-wipe contacts for maximum conductivity and longevity
- Heavy-gauge steel mounting strap is specially plated to provide outstanding corrosion resistance
- Pressure terminals with 3-point pressure contacts accept up to #4 AWG conductors
- Devices fit standard two-gang wallbox and 4-inch square outlet boxes
- UL Listed, backed by ten-year warranty, Fed. Spec. where applicable



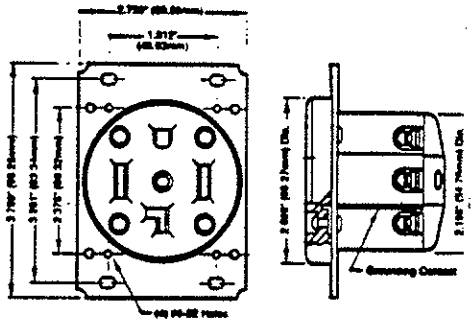
Cat. No. 9550-P



Cat. No. 278

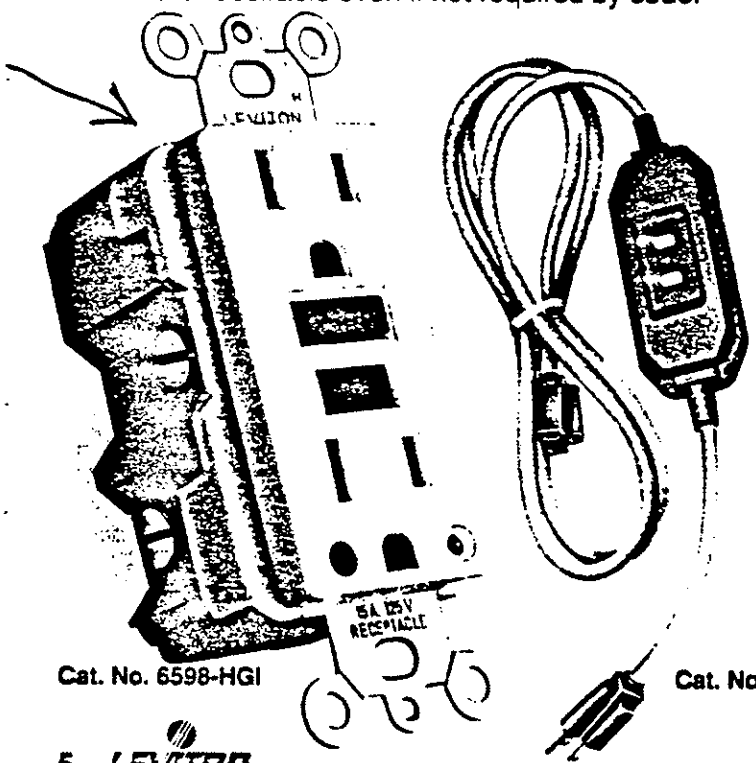
Angle plugs feature:

- Tough, heavy-duty nylon construction for long service life
- Solid brass blades for maximum conductivity
- Broad selection of 17 ratings and NEMA configurations
- UL Listed



GFCI'S

GFCI's are required by the National Electric Code in an increasing number of applications. They are essential in industrial facilities where protection against injury due to ground faults is mandated by the NEC or desirable even if not required by code.



Cat. No. 6598-HGI

Cat. No. 66591

GFCI receptacle features:

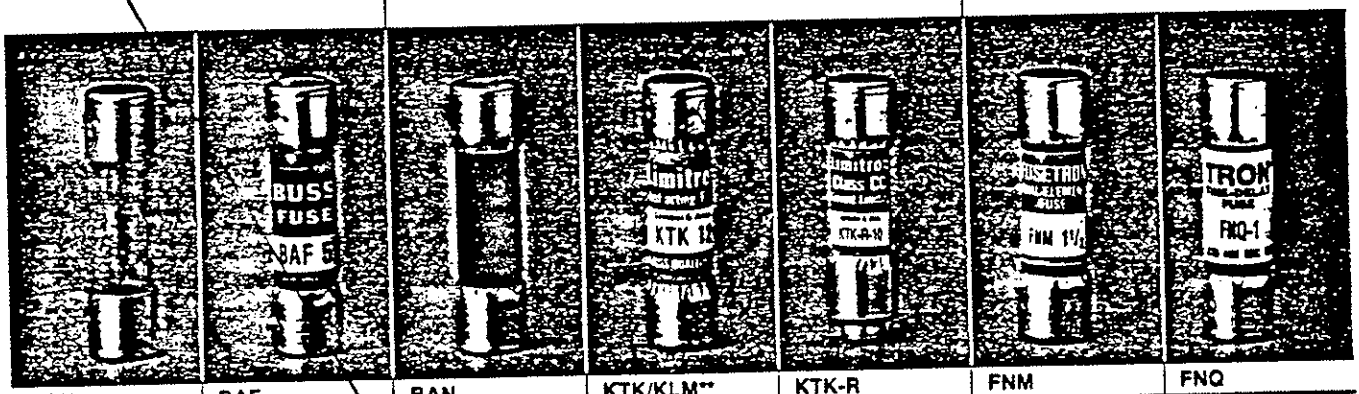
- Available in Brown, Ivory,White and Gray
- Available in UL Listed Hospital Grade
- Conform to UL Standard 943 Class A
- Impact-resistant construction
- Feed-through ready
- Shallow 1 1/8-inch deep body
- Vertically-positioned outlets
- Metal mounting strap with break-off plaster ears
- Silver alloy terminals contacts
- Temperature tolerance level of -31°F to 158°F
- Trip threshold of 5mA

GFCI cord set features:

- Ground fault and open neutral protection
- Equipped with high-visibility yellow 14/3 SJTW-A outdoor cable
- Automatic reset each time the GFCI cord set is plugged in
- Built-in TEST and RESET buttons w/indicator light
- Water resistant enclosure sealed by ultrasonic welding
- Available in 2 ft., 6 ft. and 25 ft. lengths
- Complies with NEC article # 305-6a
- UL Listed

BUSS

Ferrule Fuses

13/32" × 1½" Non-Time Delay		13/32" × 1½" Non-Time Delay			Time-Delay	
						
AGU	**BAF**	**BAN**	**KTK/KLM****	**KTK-R**	**FNM**	**FNQ**
Glass. Formerly 5AG.	Laminated.	Fibre. Formerly 5AB.	Melamine. For circuits having high fault I. 100,000 AIC (KLM's have d-c rating of 500V).	KTK with rejection feature. U.L. Class CC. Branch circuit fuse. 200,000 AIC.	Fusetron. Fibre. For circuits with high inrush currents. 10,000 AIC.	Fibre. For motor control transformers. Circuits with inrush I's. 10,000 AIC. Single element above 3²⁄₁₀A.
(page 3-3-13)	(page 3-3-13)	(page 3-3-14)	(page 3-3-14)	(page 3-3-15)	(page 3-3-16)	(page 3-3-16)
—	—	—	—	—	—	—
—	—	—	KTK/KLM-1/10 600VUC	KTK-R-1/10 600VUC	FNM-1/10 250VUC	FNQ-1/10 500VUC
—	—	—	KTK/KLM-1/8 600VUC	KTK-R-1/8 600VUC	—	FNQ-1/8 500VUC
—	—	—	—	—	FNM-15/100 250VUC	FNQ-15/100 500VUC
—	—	—	—	—	—	—
—	—	—	KTK/KLM-2/10 600VUC	KTK-R-2/10 600VUC	FNM-2/10 250VUC	FNQ-2/10 500VUC
—	—	—	—	—	—	FNQ-3/16 500VUC
—	—	—	KTK/KLM-1/4 600VUC	KTK-R-1/4 600VUC	FNM-1/4 250VUC	FNQ-1/4 500VUC
—	—	—	KTK/KLM-3/10 600VUC	KTK-R-3/10 600VUC	FNM-3/10 250VUC	FNQ-3/10 500VUC
—	—	—	—	—	—	—
—	—	—	—	KTK-R-4/10 600VUC	FNM-4/10 250VUC	FNQ-4/10 500VUC
—	—	—	KTK/KLM-1/2 600VUC	KTK-R-1/2 600VUC	FNM-1/2 250VUC	FNQ-1/2 500VUC
—	BAF-1/2 250VUC	—	—	KTK-R-5/10 600VUC	FNM-5/10 250VUC	FNQ-5/10 500VUC
—	—	—	KTK/KLM-3/4 600VUC	KTK-R-3/4 600VUC	—	—
—	—	—	—	—	FNM-6/10 250VUC	FNQ-6/10 500VUC
AGU-1 250VU	BAF-1 250VUC	BAN-1 250V	KTK/KLM-1 600VUC	KTK-R-1 600VUC	FNM-1 250VUC	FNQ-1 500VUC
—	—	—	—	—	—	—
—	—	—	—	—	FNM-1⅛ 250VUC	FNQ-1⅛ 500VUC
—	—	—	—	—	FNM-1¼ 250VUC	FNQ-1¼ 500VUC
—	—	—	—	—	FNM-1⁴⁄₁₀ 250VUC	—
—	—	—	KTK/KLM-1½ 600VUC	KTK-R-1½ 600VUC	FNM-1½ 250VUC	FNQ-1½ 500VUC
—	BAF-1½ 250VUC	—	—	—	FNM-1⁶⁄₁₀ 250VUC	FNQ-1⁶⁄₁₀ 500VUC
—	—	—	—	—	FNM-1⁸⁄₁₀ 250VUC	—
—	—	—	—	—	FNM-2 250VUC	FNQ-2 500VUC
AGU-2 250VU	BAF-2 250VUC	BAN-2 250V	KTK/KLM-2 600VUC	KTK-R-2 600VUC	FNM-2¼ 250VUC	FNQ-2¼ 500VUC
—	—	—	—	—	FNM-2½ 250VUC	FNQ-2½ 500VUC
—	BAF-2½ 250VUC	—	KTK/KLM-2½ 600VUC	—	FNM-2⁶⁄₁₀ 250VUC	—
—	—	—	—	—	FNM-3 250VUC	FNQ-3 500VUC
AGU-3 250VU	BAF-3 250VUC	BAN-3 250V	KTK/KLM-3 600VUC	KTK-R-3 600VUC	FNM-3⅜₁₀ 250VUC	FNQ-3⅜₁₀ 500VUC
—	—	—	—	—	FNM-3½ 250VUC	FNQ-3½ 500VUC
—	—	—	KTK/KLM-3½ 600VUC	—	FNM-4 250VUC	FNQ-4 500VUC
AGU-4 32V	BAF-4 250VUC	BAN-4 250V	KTK/KLM-4 600VUC	KTK-R-4 600VUC	FNM-4½ 250VUC	FNQ-4½ 500VUC
—	—	—	—	—	FNM-5 250VUC	FNQ-5 500VUC
AGU-5 32V	BAF-5 250VUC	BAN-5 250V	KTK-KLM-5 600VUC	KTK-R-5 600VUC	FNM-5⅝₁₀ 250VUC	FNQ-5⅝₁₀ 500VUC
—	—	—	—	—	FNM-6 250VUC	FNQ-6 500VUC
—	BAF-6 250VUC	BAN-6 250V	KTK/KLM-6 600VUC	KTK-R-6 600VUC	FNM-6¼ 250VUC	FNQ-6¼ 500VUC
—	BAF-6¼ 250VUC	—	—	—	FNM-7 250VUC	FNQ-7 500VUC
—	BAF-7 250VUC	—	KTK/KLM-7 600VUC	KTK-R-7 600VUC	—	—
—	—	—	—	—	FNM-8 250VUC	FNQ-8 500VUC
AGU-8 32V	BAF-8 250VUC	BAN-8 250V	KTK/KLM-8 600VUC	KTK-R-8 600VUC	FNM-9 250VUC	FNQ-9 500VUC
—	BAF-9 250VUC	—	KTK/KLM-9 600VUC	KTK-R-9 600VUC	FNM-10 250VUC	FNQ-10 500VUC
AGU-10 32V	BAF-10 250VUC	BAN-10 250V	KTK/KLM-10 600VUC	KTK-R-10 600VUC	FNM-12 125VUC	FNQ-12 500VUC
—	BAF-12 250VUC	BAN-12 250V	KTK/KLM-12 600VUC	KTK-R-12 600VUC	FNM-15 125VUC	FNQ-15 500VUC
AGU-15 32V	BAF-15 250VUC	BAN-15 250V	KTK/KLM-15 600VUC	KTK-R-15 600VUC	FNM-20 32V	FNQ-20 500VU
AGU-20 32V	BAF-20 125V	BAN-20 250V	KTK/KLM-20 600VU	KTK-R-20 600VUC	FNM-25 32V	FNQ-25 500VU
AGU-25 32V	BAF-25 125V	BAN-25 250V	KTK/KLM-25 600VU	KTK-R-25 600VUC	FNM-30 32V	FNQ-30 500VU
AGU-30 32V	BAF-30 125V	BAN-30 250V	KTK/KLM-30 600VU	KTK-R-30 600VUC		

[U]U.L. Listed; [R]U.L. Recognized under Component Program; [C]CSA Listed.
*Also FNQ-14
**U.L. and CSA Listings applicable only to KTK fuses.

CONTROL CONCEPTS

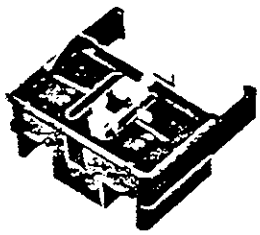
Pushbutton Components

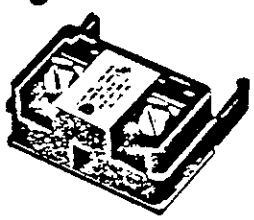
Operators

Operators are available in 2 types to most economically suit the enclosure requirements.

Operator Type	Catalog Number [1]	List Price
NEMA 12 & 13	PB0	$ 8.40
NEMA 3, 3R, 4, 4X	PB4	10.40

Contact Blocks





All contact blocks feature convenient snap-on assembly and are stackable to 4 deep for a total of 8 circuits per operator. Sealed reed and standard blocks may be intermixed. Reed blocks are ideally suited for logic level reliable switching and adverse environments. All blocks are color coded for ready circuit identification.

Mechanical Contact Blocks

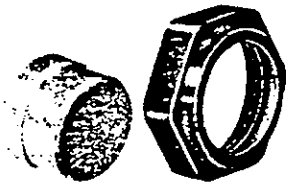
	Contact Description	Contact Symbol	Standard Blocks [2]	Fiber Optic Blocks
Catalog Number List Color Code	Normally Open		CBNO [3] $6.00 Green / Clear	FONO $20.00 Green / Black
Catalog Number List Color Code	Normally Closed		CBNC [3] $6.00 Red / Clear	FONC $20.00 Red / Black
Catalog Number List Color Code	Early Make		CBEM [3] $8.00 White / Clear	FOEM $22.00 White / Black
Catalog Number List Color Code	Delayed Break		CBDB [3] $8.00 Black / Clear	FODB $22.00 Black / Black

Color Caps and Operating Heads [2]

Flush Cap [1]

Color	Catalog Number	List Price
Black	FC-BK	$2.40
Green	FC-GN	2.40
Red	FC-RD	2.40
Yellow	FC-YW	2.40
Blue	FC-BE	2.40
Gray	FC-GY	2.40
Orange	FC-OE	2.40
White	FC-WE	2.40

Extended Cap [1]



Color	Catalog Number	List Price
Black	XC-BK	$2.40
Green	XC-GN	2.40
Red	XC-RD	2.40
Yellow	XC-YW	2.40
Blue	XC-BE	2.40
Gray	XC-GY	2.40
Orange	XC-OE	2.40
White	XC-WE	2.40

Mushroom Cap [1]

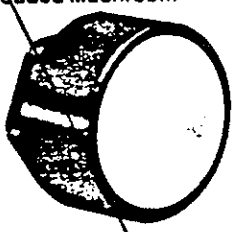
Color	Catalog Number	List Price
Black	MC-BK	$8.00
Green	MC-GN	8.00
Red	MC-RD	8.00
Yellow	MC-YW	8.00
Blue	MC-BE	8.00
Gray	MC-GY	8.00
Orange	MC-OE	8.00
White	MC-WE	8.00

Reed Contact Blocks

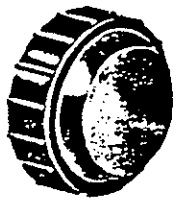
	Contact Description	Logic [5] Reed	Medium [5] Reed	Power [5] Reed
Catalog Number List Color Code	Normally Open	LRNO $17.00 Green / Blue	MRNO $20.00 Green /Yellow	PRNO $33.00 Green
Catalog Number List Color Code	Normally Closed	LRNC $17.00 Red / Blue	MRNC $20.00 Red /Yellow	PRNC $33.00 Red
Catalog Number List Color Code	2 Normally Open			2 PRNO $50.00 Green/Green
Catalog Number List Color Code	2 Normally Closed			2 PRNC $50.00 Red / Red
Catalog Number List Color Code	Normally Open Normally Closed			PRNONC $50.00 Green / Red

Fiber Optic Contact Blocks operate by making (FONO) or interrupting (FONC) a fiber optic light source to provide logic switching signals. As no electricity is used, FO blocks are an ideal application in hazardous locations or very wet remote stations including possible submersion. Blocks use 1/8" SMA905 connectors with screw-on collar and ferrule supplied with cable. Fiber Optic blocks may be intermixed with sealed reed and standard contact blocks.

Color Caps and Operating Heads [7] [11]

	Color	Catalog Number	List Price
Shrouded Mushroom 	Black	SMC-BK	$12.00
	Green	SMC-GN	12.00
	Red	SMC-RD	12.00
	Yellow	SMC-YW	12.00
Jumbo Mushroom [9]	Black	JMC-BK	$10.00
	Green	JMC-GN	10.00
	Red	JMC-RD	10.00
	Yellow	JMC-YW	10.00
Shrouded Jumbo	Black	SJC-BK	$14.00
	Green	SJC-GN	14.00
	Red	SJC-RD	14.00
	Yellow	SJC-YW	14.00
Push-Pull Maintained [12] [9]	Black	PPMC-BK	$24.00
	Green	PPMC-GN	24.00
	Red	PPMC-RD	24.00
	Yellow	PPMC-YW	24.00
Push-Pull Momentary [12] [9]	Black	PPMOM-BK	$24.00
	Green	PPMOM-GN	24.00
	Red	PPMOM-RD	24.00
	Yellow	PPMOM-YW	24.00

NEMA 4-4X Color Caps [9]

	Color	Catalog Number	List Price
NEMA 4X Flush Cap [10] [11]	Black	FC4-BK	$ 8.00
	Green	FC4-GN	8.00
	Red	FC4-RD	8.00
	Yellow	FC4-YW	8.00
NEMA 4X Extended Cap [10] [11]	Black	XC4-BK	$ 8.00
	Green	XC4-GN	8.00
	Red	XC4-RD	8.00
	Yellow	XC4-YW	8.00
NEMA 4X Mushroom Cap [10] [11]	Black	MC4-BK	$12.00
	Green	MC4-GN	12.00
	Red	MC4-RD	12.00
	Yellow	MC4-YW	12.00
NEMA 4X Shrouded Mushroom Cap [10] [11]	Black	SMC4-BK	$16.00
	Green	SMC4-GN	16.00
	Red	SMC4-RD	16.00
	Yellow	SMC4-YW	16.00
NEMA 4-4X Rubber Boot [10] 	Black	RB4-BK	$15.00
	Green	RB4-GN	15.00
	Red	RB4-RD	15.00
	Yellow	RB4-YW	15.00

Contact Block Ratings

- Standard blocks are rated Nema A-600 Heavy Duty, 600 Volt, 10 Amp. continuous, 7200 VA make, 720 VA Break, 250 Volt, 5 Amp. continuos D.C.
- Power Reed blocks are rated 240 Volts A.C. / 220 Volts D.C., 5 Amps. continuous, 1800 VA make, 360 VA break (AC) and 70 VA break (DC).
- Logic Reed blocks are rated 150 Volt, .25 Amps. max., 10 watts D.C..,15 Watts A.C.
- Medium Power Reed blocks are rated 150 Volt, 1.0 Amps. max., 40 Watts D.C., 50 Watts A.C.

Footnotes

[1] All operators accept all color caps listed below and on Page 3. Clamp ring is supplied with color cap.

[2] Standard blocks are rated NEMA A600 heavy duty, 600 volt, 10A continuous, 7200VA make, 720 VA break AC.

[3] Any NC reed blocks should be mounted to operator first.

[4] Gold plated contacts are available on standard blocks. Add suffix "G" to catalog number and increase the price $4.00 list. The cover will be gold (amber) in place of clear. Example—CBNC-G would be $10.00 list.

[7] All caps and heads may be used with either PBO, or PB4 operators.

[9] To substitute 1¾" round aluminum clamp ring in place of standard hexagonal clamp ring, add prefix letter "A" to catalog number and increase price $2.00 list. Example—AFC-BK would be priced at $4.40.

[10] NEMA 4-4X caps provide outfront sealing to prevent entry of foreign material into the operator in hostile environments. Normally PB4 with standard cap(s) would be recommended.

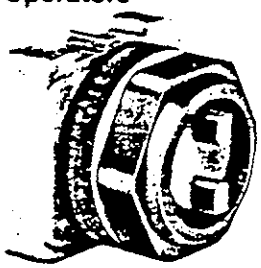
[10] Should be used with PBO operators only.

[11] Also available in blue, gray, orange and white.

[12] Jumbo Mushroom Operating Head also available. Add letter J following PP and add $2.00 List. Example—PPMC-BK would be PPJMC-BK, $26.00 List

Selector Switch Components

Operators



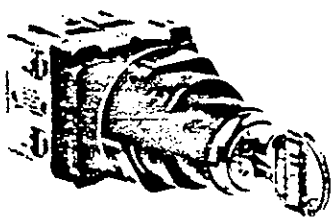
Operators are NEMA 12-13 as standard. They may be converted to NEMA 3, 3R, 4, 4X rating by selecting NEMA 4X handle or lever in place of standard handle or lever in chart on Page 5.

Positions	Operation	Catalog Number	List Price
2	Maintained	SSO2R [1]	$10.00
2	Spring Return—Left to Right	SRO-LR	18.00
2	Spring Return—Right to Left	SRO-RL	18.00
3	Maintained	SSO3	10.00
3	Spring Return—Left to Center	SRO-LC	18.00
3	Spring Return—Right to Center	SRO-RC	18.00
3	Spring Return—Left and Right to Center	SRO-LRC	18.00
4	Maintained	SSO4	10.00
4	Spring Return—Position 4 to Position 3	SRO-43	18.00

Reed Contacts

Logic, Medium, and Power Reed blocks listed on Page 2 may be installed in place of either CBNO or CBNC on standard 2 position selector switches. For 3 position, select operator from Page 5. Any NC Reed blocks should be mounted to operator first.

Key Operators



Key operators are available as NEMA 12-13 and NEMA 4X. All operators feature polyester housings and all locks are premium quality brass for superior corrosion resistance. Keys are extra heavy double bitted brass for long life. Contact sequences are the same as for standard selector switches and should be selected from the tables to the right.

Keyed Different

Up to 250 different key combinations are available. To order locks keyed differently, specify on order and add $28.00 list per operator.

Master Keying

Locks keyed different may also be master keyed. Specify master keying for locks keyed differently on order. Add $28.00 list each to key differently plus $16.00 per set of 2 master keys.

Extra Keys

To order extra or replacement keys add $4.00 per set of 2 keys. When ordering replacement keys, include key number stamped on existing key.

Contact Block Selection
2 Position Selector Switches [1]

Circuit Designation	Handle Position		Block Catalog Number	[2] Mounting Position	List Price
	Left	Right			
G	O	X	CBNO	Either	$6.00
H	X	O	CBNC	Either	6.00

Contact Block Selection
3 Position Selector Switches

Circuit Designation	Handle Position			Block Catalog Number	Mounting [2] Position	List Price
	Left	Center	Right			
A	X	O	O	CBNO	Left	$6.00
B	O	X	O	CBNC	Either	6.00
C	O	O	X	CBNO	Right	6.00
D	O	X	X	CBDB	Left	8.00
E	X	O	X	CBEM	Either	8.00
F	X	X	O	CBDB	Right	8.00

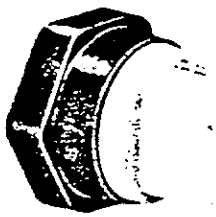
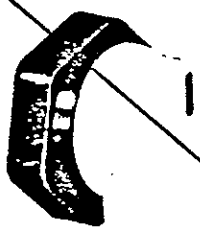
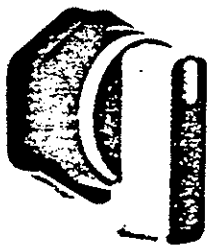
Contact Block Selection
4 Position Selector Switches

Circuit Designation	Handle Position				Block Catalog Number	Mounting [2] Position	List Price
	Left	Left Center	Right Center	Right			
1	X	O	O	O	CBNO	Left	$6.00
2	O	X	O	O	CBNC	Right	6.00
3	O	O	X	O	CBNC	Left	6.00
4	O	O	O	X	CBNO	Right	6.00
5	O	X	X	X	CBDB	Left	8.00
6	X	O	X	X	CBEM	Right	8.00
7	X	X	O	X	CBEM	Left	8.00
8	X	X	X	O	CBDB	Right	8.00

Positions	Operation	Catalog Number	List Price
2	Maintained	KOSS2-[5]	$52.00
2	Spring Return—Left to Right	KOSRLR-[5]	60.00
3	Maintained	KOSS3-[5]	52.00
3	Spring Return—Left to Center	KOSRLC-[5]	60.00
3	Spring Return—Right to Center	KOSRRC-[5]	60.00
3	Spring Return—Left and Right to Center	KOSRLRC-[5]	60.00

Key Removable Position(s)	Catalog Number Suffix
All	-KA
Right Only	-KR
Left Only	-KL
Center Only	-KC
Left and Right Only	-KLR
Left and Center Only	-KLC
Right and Center Only	-KRC

Operating Handles and Levers [1]

	Color	Catalog Number	List Price
Standard Handle	Black	SH-BK	$4.80
	Blue	SH-BE	4.80
	Green	SH-GN	4.80
	Gray	SH-GY	4.80
	Orange	SH-OE	4.80
	Red	SH-RD	4.80
	White	SH-WE	4.80
	Yellow	SH-YW	4.80
NEMA 4X Handle 	Black	SH4-BK	$6.80
	Blue	SH4-BE	6.80
	Green	SH4-GN	6.80
	Gray	SH4-GY	6.80
	Orange	SH4-OE	6.80
	Red	SH4-RD	6.80
	White	SH4-WE	6.80
	Yellow	SH4-YW	6.80
Lever Handle 	Black	SL-BK	$6.80
	Blue	SL-BE	6.80
	Green	SL-GN	6.80
	Gray	SL-GY	6.80
	Orange	SL-OE	6.80
	Red	SL-RD	6.80
	White	SL-WE	6.80
	Yellow	SL-YW	6.80
NEMA 4X Lever 	Black	SL4-BK	$8.80
	Blue	SL4-BE	8.80
	Green	SL4-GN	8.80
	Gray	SL4-GY	8.80
	Orange	SL4-OE	8.80
	Red	SL4-RD	8.80
	White	SL4-WE	8.80
	Yellow	SL4-YW	8.80

Coin Slot Operators Complete [3]

Description	Catalog Number	List Price
2 Position Maintained	CSO-2	$14.80
3 Position Maintained	CSO-3	$14.80

3 Position Reed Operators

Operation	Catalog Number	List Price
Maintained	SSOR3	$10.00
Spring Return—Left to Center	SROR3LC	18.00
Spring Return—Right to Center	SROR3RC	18.00
Spring Return—Left and Right to Center	SROR3LRC	18.00

Reed Contact Block Selection Type LR, MR or PR 3 Position Position Reed Operator

Circuit Designation	Handle Position			Block Suffix	Mounting [4] [2] Position
	Left	Center	Right		
A	X	O	O	NO	Left
B	O	X	O	2-NC	Both Series
C	O	O	X	NO	Right
D	O	X	X	NC	Left
E	X	O	X	2-NO	Both Parallel
F	X	X	O	NC	Right

Footnotes

[1] Spring return left to right operator (Cat#SRO-LR) has contact sequence opposite of standard shown in table. For maintained selector switch with opposite contact sequence, order Cat# SSO2.

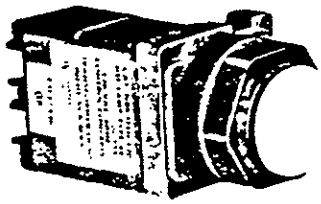
[2] Viewed from front of operator.

[3] To substitute 1⅜" round aluminum clamp ring in place of standard hexagonal clamp ring, add prefix letter "A" to catalog number and increase price $2.00 list. Example ASH-BK would be priced at $6.80.

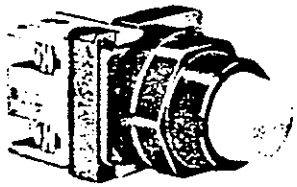
[4] Any NC reed blocks should be mounted to operator before NO blocks are mounted. Position is as viewed from front of operator.

[5] Add key removable suffix from table to right of price list table. If not specified, operators will be supplied with key removable all position for maintained operators and all non-spring return position for spring return operators.

Pilot Lights—All pilot lights and illuminated pushbuttons are rated NEMA 4X as standard.



Transformer Pilot Light Catalog Number TFLU-120-RDL



Illuminated Pushbutton Full Voltage Type Shown With Contact Block Catalog Number FVLU-120-GNC-NO

Unit Complete Less Lens[2][3]				Color Lens or Cap[2][3][4]					Lamp Only[3]		
					Pilot Light Lens		Illum. PB Cap				
Type	Volts	Catalog Number	List Price	Color	Catalog Number	List Price	Catalog Number	List Price	Catalog Number	Manufacturers Type	List Price
Transformer 50/60 Hz	120	TFLU-120	$38.00						FVB6	44 or 1866	$2.00
	240	TFLU-240	38.00								
	480	TFLU-480	38.00								
	277	TFLU-277	42.00								
Full Voltage Type	6	FVLU-6	$18.00	Opaque					FVB6	44	$2.00
	12	FVLU-12	18.00						FVB12	756	2.00
	24	FVLU-24	18.00	Green	PLLGN	$4.80	IPBCGN	$8.00	FVB24	757	2.00
	120	FVLU-120	20.00	Red	PLLRD	4.80	IPBCRD	8.00	FVB120	120MB	4.00
	less lamp	FVLU[3]	16.00	White	PLLWE	4.80	IPBCWE	8.00			
				Yellow	PLLYW	4.80	IPBCYW	8.00	—	—	—
Neon Type[1]	120	FVLU-120N[5]	$18.00	Transparent					FVB120N[7]	—	$2.00
	240	RLU-240N[6]	28.00						FVBN	B2A	2.00
	480	RLU-480N[6]	28.00	Amber	PLLAR	$4.80	IPBCAR	$8.00			
Incandescent Resistor Type	120	RLU-120I	$30.00	Clear	PLLCR	4.80	IPBCCR	8.00			
	240	RLU-240I	30.00	Green	PLLGNT	4.80	IPBCGNT	8.00	FVB55	1835	$4.00
				Red	PLLRDT	4.80	IPBCRDT	8.00	FVB120	120MB	4.00
				Blue	PLLBET	4.80	IPBCBET	8.00			
Dual Input Remote Test[8]	120	RTLU-120	$34.00						FVB55	1835	$4.00
	240	RTLU-240	34.00						FVB120	120MB	4.00
	less lamp	RTLU[3]	30.00						—	—	—

Color Lenses and Caps

Caps and lenses are offered in opaque and transparent colors. Transparent colors are recommended in areas of high ambient light. Transparent colors must be used on neon lights.

To order use catalog number IMC-plus color suffix from table above. List price $12.00. Example—catalog number IMC-RDT would be red transparent.

Illuminated Mushroom Caps

A 1½" diameter mushroom cap is available in place of the standard IPBC cap for use on illuminated pushbuttons and push-to-test lights.

Flashing Lamp

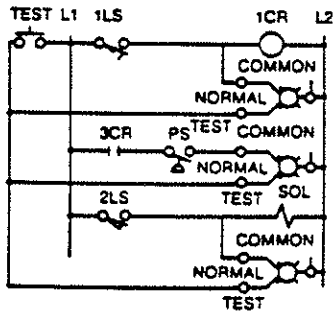
Transformer lights and 6 volt full voltage lights may be supplied with a flashing lamp in place of the standard lamp. To order, add suffix letter "F" to the catalog number and increase the price $4.00 list. Example—catalog number TFLU-120F would be priced at $42.00 list.

Dual Input Pilot Light

This type of pilot light permits testing a number of lights from a single pushbutton. A diode circuit isolates the test supply from the normal supply. The schematic at right represents a typical dual input application.

Schematic Diagram

Dual Input Light



LED Lamps

Transformer lights and full voltage 6, 12, and 24 volt lights can be provided with solid state long life LED lamps in place of the standard incandescent lamps. Control Concepts LED lamps are in a miniature bayonet base for direct interchangeability and feature an ultra bright 4 LED cluster with light output comparable to a standard type 755 incandescent lamp. The 4 LEDs are built into 2 circuits for redundancy and include internal current limiting resistors. Lamps are available in red, green and yellow. To order, add the letter "L" plus the first letter of the color to the light catalog number and add $12.00 list.

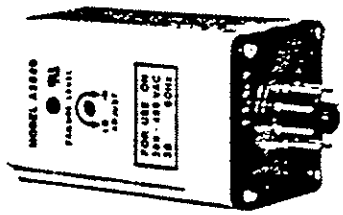
Example—Catalog number TFLU-120LR would be a transformer light with red LED lamp. List price would be $50.00 ($38.00 + $12.00).

LED Lamp Only Price Table			
Voltage	Color	Catalog Number	List Price
6	Red	FVB4CL6RD	$14.00
6	Green	FVB4CL6GN	14.00
6	Yellow	FVB4CL6YW	14.00
12	Red	FVB4CL12RD	14.00
12	Green	FVB4CL12GN	14.00
12	Yellow	FVB4CL12YW	14.00
24	Red	FVB4CL24RD	14.00
24	Green	FVB4CL24GN	14.00
24	Yellow	FVB4CL24YW	14.00

Made with Pride in the U.S.A.

Model 258

3-PHASE POWER MONITOR

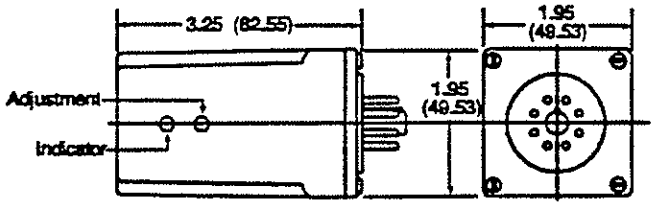


- **Detects phase loss, low voltage, phase reversal and phase unbalance**
- **60 Hz and 50 Hz models**
- **Automatic or optional manual reset**

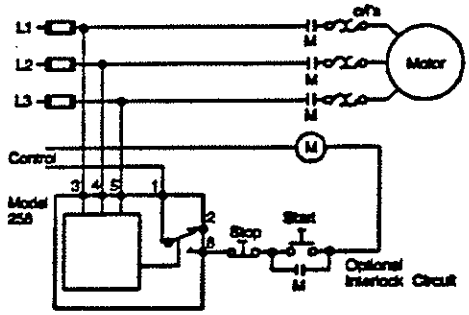
DESCRIPTION

The Model 258 continuously monitors 3-phase power lines for abnormal conditions. When properly adjusted, the Model 258 will detect phase loss on a loaded motor even when regenerated voltage is present. The device consists of a solid-state voltage and phase-angle sensing circuit driving an electromechanical relay. When correct voltage and phase rotation are applied, the internal relay will energize. A fault condition will de-energize the relay; when the fault is corrected the 258 will automatically reset (a manual reset version is available). The 258 does not require a neutral connection and can be used with Wye or Delta systems. Four versions cover 120vac, 208/240vac and 480vac, 60 Hz, and 380vac, 50 Hz. Adjustment ranges are sufficiently wide to allow for proper adjustment to existing conditions. A failure indicator is provided to aid in adjustment and system troubleshooting. Special voltage and frequency ranges are available.

DIMENSIONS



TYPICAL APPLICATION



SPECIFICATIONS

Model No.	B258B	258B	A258B	EX258B
Nominal AC Voltage (phase-to-phase)	120vac	208/240vac	480vac	380vac
Adjustment Range	85-120vac	160-240vac	380-480vac	300-380vac
Frequency	60 Hz	60 Hz	60 Hz	50 Hz
Power consumption	.25 W/ph.	.50 W/ph.	1.5 W/ph.	1.25 W/ph.
Transient protection	2500 VRMS for 10ms			
Repeat Accuracy (fixed conditions)	±0.1% of set point			
Response Time	50 milliseconds			
Reset Time	.05 seconds			
Reset Type	Automatic (optional manual reset)			
Dead Band	2%			
Output Contacts	SPDT			
Contact Rating	Resistive:	15A at 150VAC 10A at 240 VAC 15A at 28VDC		
	Inductive:	4A at 120VAC 2A at 240VAC		
	Pilot Duty:	480VA at 240VAC		
	Tungsten lamp operation:	600W on N.O. contacts 240W on N.C. contacts		
Expected Relay Life	Mechanical:	50,000,000 operations		
	Electrical:	100,000 at rated load		
Operating Temperature	-40° to 55° C			
Humidity Tolerance	97% w/o condensation			
Case Material	ABS plastic			
Mounting	8-pin socket #51X00120-01 (order separately)			
Weight	5 oz. (141.74 grams)			
Agency approval	UL Recognized/CSA Certified condition of acceptability: A258B & EX258B must be used with a UL Recognized, 600 volt socket			

ORDERING INFORMATION

258 ___ ___

- Voltage Code
  - B= 120VAC
  - None= 208/240VAC
  - A= 480VAC
  - EX= 380VAC
- Model No.
- Adjust.
  - A= Fact. set
  - B= screwdriver
- Reset
  - Blank= Auto
  - M= Manual

TIME MARK® CORPORATION

11440 East Pine Street
Tulsa, Oklahoma 74116
Tel:(918)438-1220
FAX (918)437-7584

TITLE: MODEL 258 3-PHASE POWER MONITOR

Dimensions are in inches and millimeters unless otherwise specified. Drawings show no power applied.

© 1991 Time Mark Corp.

FORM 87A123 10/91

Electromechanical Reduced Voltage Starters

Autotransformer Starters

Selection and Pricing

Class 8606

3-Pole Polyphase – 600 Volts AC Maximum – 50-60 Hz

Thermal Units – Prices shown do not include thermal units. Devices require 3 thermal units (Sizes 00-6). Standard trip thermal units are $9. each.

See pages 23-18 – 23-39 for selection.

Motor Voltage (Starter Voltage)	Max. Hp	NEMA Size	NEMA Type 1 General Purpose Enclosure		NEMA Type 4▲ Watertight and Dusttight Enclosure		NEMA Type 12 Dusttight & Drip tight Industrial Use Enclosure		Open Type		O.E.M. Kit	
			TYPE	PRICE	TYPE	PRICE	TYPE	PRICE	TYPE	PRICE	TYPE	PRICE
200 (208)	10	2	SDG1C*	3402	SDW1C*	5262	SDA1C*	4482	SDO1C*	3258	SDK1C*	2859
	15 20 25	3	SEG1D* SEG1E* SEG1F*	4002	SEW1D* SEW1E* SEW1F*	5862	SEA1D* SEA1E* SEA1F*	5142	SEO1D* SEO1E* SEO1F*	3546	SEK1D* SEK1E* SEK1F*	3156
	30 40	4	SFG1G* SFG1H*	7758	SFW1G* SFW1H*	11178	SFA1G* SFA1H*	9198	SFO1G* SFO1H*	7098	SFK1G* SFK1H*	5553
	50 75	5	SGG1J* SGG1L*	12777	SGW1J* SGW1L*	16197	SGA1J* SGA1L*	14397	SGO1J* SGO1L*	11445	SGK1J* SGK1L*	9783
	100 125 150	6	SHG1M* SHG1N* SHG1P*	23805	SHW1M* SHW1N* SHW1P*	28305	SHA1M* SHA1N* SHA1P*	26055	SHO1M* SHO1N* SHO1P*	21669	SHK1M* SHK1N* SHK1P*	17475
230 (240)	10 15	2	SDG1C* SDG1D*	3402	SDW1C* SDW1D*	5262	SDA1C* SDA1D*	4482	SDO1C* SDO1D*	3258	SDK1C* SDK1D*	2859
	20 25 30	3	SEG1E* SEG1F* SEG1G*	4002	SEW1E* SEW1F* SEW1G*	5862	SEA1E* SEA1F* SEA1G*	5142	SEO1E* SEO1F* SEO1G*	3546	SEK1E* SEK1F* SEK1G*	3156
	40 50	4	SFG1H* SFG1J*	7758	SFW1H* SFW1J*	11178	SFA1H* SFA1J*	9198	SFO1H* SFO1J*	7098	SFK1H* SFK1J*	5553
	75 100	5	SGG1L* SGG1M*	12777	SGW1L* SGW1M*	16197	SGA1L* SGA1M*	14397	SGO1L* SGO1M*	11445	SGK1L* SGK1M*	9783
	125 150 200	6	SHG1N* SHG1P* SHG1Q*	23805	SHW1N* SHW1P* SHW1Q*	28305	SHA1N* SHA1P* SHA1Q*	26055	SHO1N* SHO1P* SHO1Q*	21669	SHK1N* SHK1P* SHK1Q*	17475
	250 300	7	SJG1R* SJG1S*	40773	SJW1R* SJW1S*	45273	SJA1R* SJA1S*	43023	—	—	—	—
460 (480) / 575 (600)	10 15 20 25	2	SDG1C* SDG1D* SDG1E* SDG1F*	3402	SDW1C* SDW1D* SDW1E* SDW1F*	5262	SDA1C* SDA1D* SDA1E* SDA1F*	4482	SDO1C* SDO1D* SDO1E* SDO1F*	3258	SDK1C* SDK1D* SDK1E* SDK1F*	2859
	30 40 50	3	SEG1G* SEG1H* SEG1J*	4002	SEW1G* SEW1H* SEW1J*	5862	SEA1G* SEA1H* SEA1J*	5142	SEO1G* SEO1H* SEO1J*	3546	SEK1G* SEK1H* SEK1J*	3156
	75 100	4	SFG1L* SFG1M*	7758	SFW1L* SFW1M*	11178	SFA1L* SFA1M*	9198	SFO1L* SFO1M*	7098	SFK1L* SFK1M*	5553
	125 150 200	5	SGG1N* SGG1P* SGG1Q*	12777	SGW1N* SGW1P* SGW1Q*	16197	SGA1N* SGA1P* SGA1Q*	14397	SGO1N* SGO1P* SGO1Q*	11445	SGK1N* SGK1P* SGK1Q*	9783
	250 300 400	6	SHG1R* SHG1S* SHG1T*	23805	SHW1R* SHW1S* SHW1T*	28305	SHA1R* SHA1S* SHA1T*	26055	SHO1R* SHO1S* SHO1T*	21669	SHK1R* SHK1S* SHK1T*	17475
	500 600	7	SJG1U* SJG1W*	40773	SJW1U* SJW1W*	45273	SJA1U* SJA1W*	43023	—	—	—	—

▲ NEMA Type 4 Enclosures are painted sheet steel. Where required, stainless steel enclosures are available at extra cost. Specify as Form Y56. See "Modifications & Forms" for price adder.

How To Order:

To Order Specify:	Catalog Number			
• Class Number • Type Number • Voltage Code • Form(s) see pg. 12-161–12-169	Class	Type	Line/ Control Code	Form(s)
	8606	SFG1M	V81	S
	Description: 100hp, 480V line, 120V separate control, 60Hz			

* Both line and control voltage must be specified to order this product. Select the appropriate Line/Control Voltage CODE from the table. If control voltage is different than line supply, indicate control configuration by FORM as indicated in table.

Line/Control Voltage Codes (60Hz) ▼

All Coils At Line Voltage

Line	Control	Code	Forms – None Required
208	208	V06	– Standard(common control)
240	240	V03	
380	380	V05*	NOTE: Sizes 6 & 7 - Select voltage code from list below (Sizes 6 & 7 are supplied with a fused transformer with 120Vac secondary as standard.)
480	480	V06	
600	600	V07	

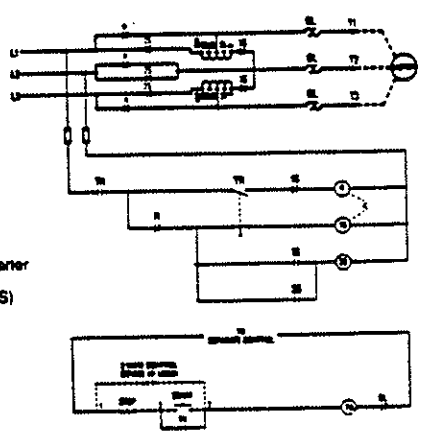
Coils At Different Voltage Than Line Supply

Line	Control	Code	Forms – Select Only One
208	120	V84	— indicate control configuration
240	24■	V82	
240	120	V80	S - Separate control of timing relay only
480	24■	V83	Y195 - Separate control for all coils
480	120	V81	F4T - Fused CPT for timing relay only
600	120	V87	F4T40 - Fused CPT for all coils
other	specify	V99	

▼Refer to Page 12-63 for 50 Hz control voltage code
*Refer to page 12-63 for sizing and pricing of 380V starters
■24 V coils not available on sizes 4 - 7 with form Y195 or F4T40

Note:
Class 8606 starters are supplied with a NEMA rated medium duty autotransformer. Medium duty service includes applications to motors which drive loads such as fans, pumps, compressors, line shafts, etc.
(NEMA Sizes 2 - 5: Autotransformer is rated for 15, 15 second starts per hour)
(NEMA Sizes 6 - 7: Autotransformer is rated for 3, 30 second starts per hour)

Contact Square D Sales Office for applications which require frequent starting, jogging or have extremely high inertia.



Typical Autotransformer Starter
Sizes 2-5
Separate Control (Form S)

CP1 | | Discount Schedule

CURRENT TRANSFORMERS

Model 5

Window Diameter 1.56"

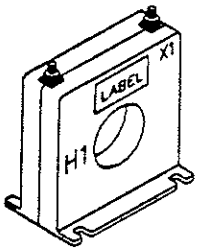
APPLICATION:
With Ammeters, Wattmeters, Relays, and cross current compensation.

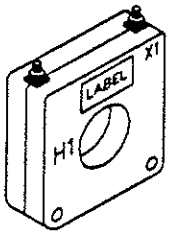
FREQUENCY:
50–400 Hz.

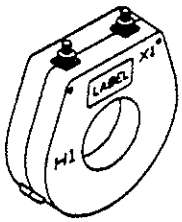
INSULATION CLASS:
0.6 kV. BIL 10 kV. full wave.

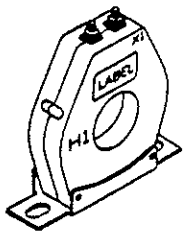
E93779 LR89403

- Flexible leads are UL 1015 105 ° C, CSA approved, #16 AWG, 24 " long.
- Non–standard length to be specified.
- Terminals are brass studs No. 8–32 UNC with one flat washer, lockwasher and regular nut.
- SHT and SFT case styles also available as SHL and SFL with leads.
- Also available as special ratios, i.e. 100:0.2, for use in energy management.
- Mounting bracket kit 0221B00180 when required for Model 5SHT.
- Approximate weight: 1.0 lb.









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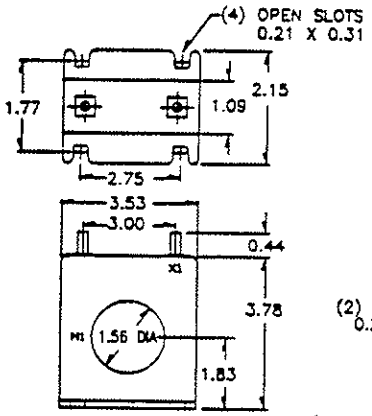

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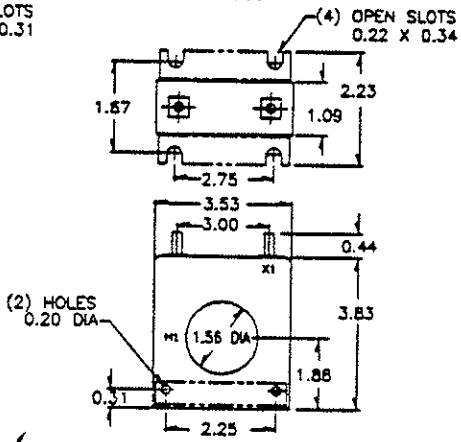

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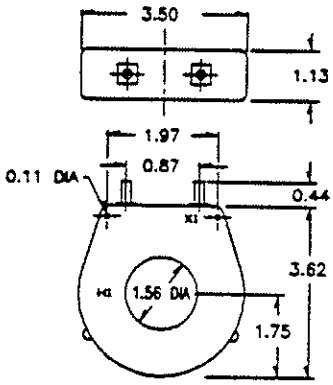

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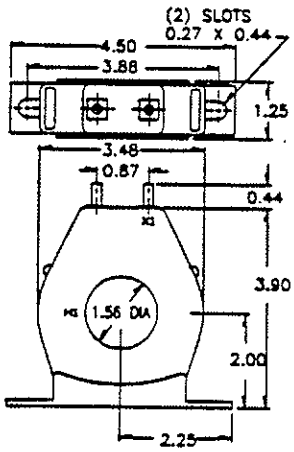

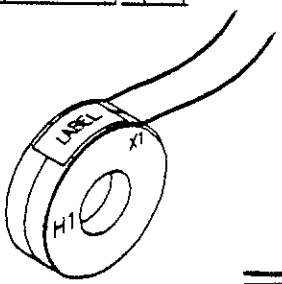

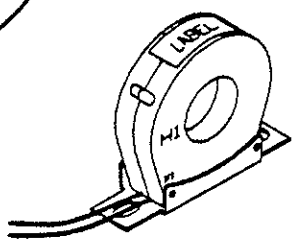

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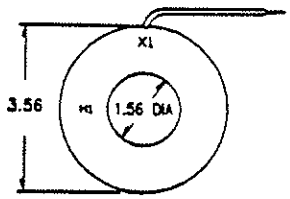

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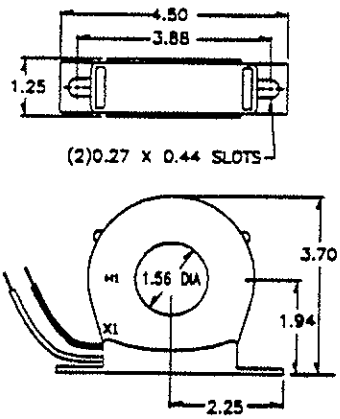

CATALOG NUMBER	CURRENT RATIO	ACCURACY AT 60 Hz	BURDEN VA at 60 Hz
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5 **– 750	75:5	± 2 %	1.5
5 **– 101	100:5	± 2 %	2.0
5 **– 151	150:5	± 1 %	5.0
5 **– 201	200:5	± 1 %	5.0
5 **– 251	250:5	± 1 %	10.0
5 **– 301	300:5	± 1 %	12.5
5 **– 401	400:5	± 1 %	12.5
5 **– 501	500:5	± 1 %	20.0
5 **– 601	600:5	± 1 %	25.0
5 **– 751	750:5	± 1 %	25.0
5 **– 801	800:5	± 1 %	25.0
5 **– 102	1000:5	± 1 %	25.0
5 **– 122	1200:5	± 1 %	30.0

** NOTE: When ordering, prefix Cat No. with model designation required, i.e. 5SFT–500, 5RL–500, etc.

Technical Submittal
Tensar Drainage Composite
Pelham Bay Landfill Closure
Bronx, New York

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- DC4105 & DC4205 Drainage Composite
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3) Installation Suggestions

- Shop Drawings - Overlap Detail

4) QC/QA Manual

5) Samples

TENSAR Environmental Systems, Inc.

5775-B Glenridge Drive
Lakeside Center, Suite 450
Atlanta, Georgia 30328-5363
404 • 250 • 1290
Fax: 404 • 250 • 9056
1 • 800 • 292 • 4459

February 11, 1995

Mr. Brian Dyer
Breco Mechanical Group
870 Nepperhan Avenue
Yonkers, New York 10703

Subject: **Technical Submittal - Tensar Drainage Composite for Pelham Bay Landfill Closure**

Dear Mr. Dyer:

Tensar has reviewed in detail the specification for the above project. This letter and attached documentation represent the required material submittal for the Drainage Composite on the project. The composite is a geonet structure with geotextile materials heat-bonded to both one and two sides. Production capacity is readily available to meet material requirements throughout the expected construction schedule. This letter is formatted to follow the specification and address each specified and implied material requirement for ease of review and approval.

OVERVIEW:

Tensar first introduced the concept of stranded heavy net structures as a planar flow substitute for granular soil drainage layers in 1984. Under a joint development program with EPA, Tensar tested and proved the concept and materials performance resulting in full EPA approval of geosynthetic geonets in landfills across the United States in early 1986. In 1987, Tensar introduced the first drainage geocomposite product to the industry by thermally bonding a filtration geotextile to a geonet. Since then, over 200 million square feet of Tensar Drainage Nets and Composites have been successfully installed in solid and hazardous waste facilities in all fifty states in every application including pore pressure relief, leachate collection, leak detection, gas venting and storm water control *without a single failure.*

SPECIFIC MATERIAL ASSERTIONS

Per paragraph 1.4.E - Samples have previously been submitted for interface friction testing. Additional samples can be provided for transmissivity conformance testing as required by the engineer.

Per paragraph 1.5.A-E - Geocomposite provided to the Pelham Bay Landfill project will be 21' in width if available at the time. Otherwise, our standard 14' wide product will be provided. Standard roll lengths for these products are 225' in length. The geocomposite will be delivered to the jobsite in opaque protective covers and will be marked with product name, lot number, roll number and product dimensions.

Per paragraph 1.6.A - Tensar has in excess of 5 years experience in the manufacture of geonets and geocomposite materials. Attached for your review is a partial listing of projects recently completed by Tensar. (end of section

Per paragraph 2.1.A&B - Corresponding to the change order issued for this project pertaining to the geotextile to be used, Tensar DC4105 and DC4205 geocomposite will be supplied to this project. Each material is manufactured utilizing Tensar NS1405 as the core geonet structure and heat bonding Trevira 011/280 geotextile to either one or both sides of the geonet. The bond between the geonet and the geotextile in both products will exceed a minimum peel strength of 2 pounds per inch per ASTM F904.

Per paragraph 2.2 - Attached for your review is the Material Property Data Sheet for Hoechst Celanese Trevira 011/280 geotextile as requested in the change order.

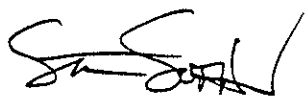
Per paragraph 2.3 - The drainage net core, NS1405, is a three dimensional polyethylene net structure formed by intersecting strands and providing uniform channels, open area and thickness to assure uniform flow throughout the structure. It is crush resistant and has a low compressibility capable of maintaining high transmissivity under a range of loading conditions. The geonet is manufactured with carbon black to provide ultra violet stabilization. Tensar NS1405 meets all material properties listed under geonet properties. Appended hereto is the MPDS for Tensar NS1405.

Per paragraph 3.1.A-J - Tensar has reviewed the placement and handling directions and found them to be in conformance with our suggested procedures. Attached is a copy of our installation guidelines for your review.

Per paragraph 3.3.A-D - The proposed method for overlap and tying of the geonet cores is per our recommended procedures. However, seaming of the geotextile overlaps should not be necessary in this case. Included for your review are detailed drawings outlining the proposed method for overlapping of the geonet cores and geotextile materials.

Tensar looks forward to providing our high quality drainage composite for the Pelham Bay Landfill Closure. We are certain that you will find our materials, delivery and service to be of the highest caliber. Please feel free to contact me directly at (800) 292-4459 if any further information or documentation is required.

Sincerely,
Tensar Environmental Systems, Inc.



Scott Sothen
Sales Engineer

THE TENSAR CORPORATION

COMPANY AND BUSINESS FOCUS

The Tensar Corporation ("Tensar" or the "Company") was founded in Atlanta, Georgia in 1983 as a joint venture investment by Gulf Canada Limited and Netlon Limited of Blackburn, England. Tensar's principal business has been the manufacturing and marketing of high performance, premium quality polymeric products for use in a wide variety of heavy construction, environmental management, fencing and fabrication applications. The Company's unique "Tensar" manufacturing technology produces various polymeric products in a wide range of strengths and grid configurations. Since commercial introduction of these products into The United States and Canadian markets, a large number of applications have been developed, principally in markets related to the highway and heavy construction and environmental management industries. The Company also serves similar markets in Caribbean and South American countries.

In August 1988, the four senior executives of the Gulf/Netlon joint venture purchased the operating assets of the previous company. In addition, the new company entered into a licensing agreement with Netlon Limited to acquire exclusive rights to Tensar technology in the countries of North, Central and South America and the Caribbean Sea. The Company also manufactures and markets products under Netlon process technology through a similar licensing arrangement.

Tensar products are integrally formed grid structures manufactured by precisely perforating thick continuous sheets of high quality polymers which are then heated and stretched. The stretching process causes a high level of orientation of long chain hydrocarbon molecules throughout the apertured sheet, resulting in a finished grid structure with high tensile strength which is continuous through all ribs and junctions of the structure. Both the science and the manufacturing know how involved in manufacturing these products are quite novel, and continue to develop and expand today. The process under which the products are manufactured and certain applications of the products are protected by several patents.

Tensar products provide broad opportunities for innovation and economy in numerous types of reinforcement, support, containment, and enclosure applications. The key features of the products are their high tensile strength, integral grid structure, durability and light weight. Together, these features have created a premium quality product line with no true competitive equivalent in its major applications. The Company's products do compete against conventional construction materials and practices. However, they compete very effectively since customers are provided with significant economic benefits by increasing the availability of feasible building sites; enabling more efficient utilization of difficult building sites; allowing use of lower quality and reduced quantities

of construction fill materials; enabling more efficient utilization of construction labor and equipment; and enabling improvement of the structural performance of earthwork construction to meet increasing regulatory standards.

The Company has continuously expanded and diversified its market presence. In order to meet the varied and unique demands of the many markets served, three marketing subsidiaries have been established to effectively develop markets in three principal sectors.

(a) Tensar Earth Technologies, Inc. ("TET") serves the transportation, property development, resource extraction, and coastal/waterway protection industries. Addressing numerous heavy construction applications in these industries, TET has established a new state of practice in innovative earthwork construction, achieving higher levels of safety, durability, and cost-efficiency than are possible with conventional construction techniques.

(b) Tensar Environmental Systems, Inc. ("TES") serves the waste management industry. Having pioneered the vertical expansion of landfills and the use of low profile polymeric drainage sections in landfills, TES has significantly advanced the technology of containment facility construction to aid in meeting the current national capacity crisis in solid waste disposal while enabling greater levels of structural security and environmental protection in such facilities.

(c) Tensar Polytechnologies, Inc. ("TPI") serves the agricultural, commercial fencing, residential lawn and garden and fabricated products industries. By applying Tensar's proven construction technologies to these markets, TPI has developed alternatives to traditional steel, wood and stone materials which deliver higher levels of efficiency, safety, and productivity to a broad range of industries and markets.

The Company also has an active Corporate Business Development (CBD) group with responsibility for developing additional new markets for the Company's products.

Tensar's opportunities in its major construction markets, are based on three simple trends: the increasing scarcity of quality building sites; the increasing scarcity and cost of quality construction materials; and the increasing cost of construction labor and equipment -- all of which provide a sound, fundamental basis for sustained long-term demand for the Company's products and services. Tensar has been unique in recognizing and pursuing this market vision, and is pursuing it on a national and multi-application basis with significant investment in manufacturing capacity, direct and distributor sales organizations, active technological development programs and an unparalleled technical service capability to serve its rapidly developing markets.

The Company's products, their methods of use, and their methods of manufacture were all unknown in North America prior to establishment of The Tensar Corporation. As a result, the Company has literally established a new industry. Product sales have been dependent upon gaining industry acceptance of both Tensar's products and the innovative engineering

methodologies made possible by use of the products. The Company's marketing strategies in each market sector have involved the conception and development of novel applications and design technologies for its products as well as the support of these applications through a high level of technical service.

The Company markets its products in each end user market group (i.e. via each subsidiary) by utilizing a combination of direct sales staff, marketing support staff and (generally) exclusive distributors. Early in the Company's history, the Company relied more heavily on distributors in order to gain initial market acceptance. Most of these distributors had historically sold conventional products into the markets the Company wished to penetrate. As the Tensar technology has become more accepted, the Company has broadened and diversified its overall distribution network with additional direct sales staff focused on higher profile sales and emerging market opportunities.

The Company's manufacturing and office facility is 172,000 square feet and the Company employs approximately 75 in administrative and marketing functions and 125 in manufacturing. Approximately 50 additional temporary staff are employed in the third and fourth quarters as manufacturing and shipping workloads peak.

PRODUCTS AND SERVICES

The Tensar Corporation manufactures geogrids, geonets, geocomposites, light weight nets and meshes and purchases and resells various ancillary polymeric products. Since establishing each unique product category in the marketplace, and, in fact, creating the industry in most instances, numerous products have been introduced by others to compete with the Tensar product line. The Company's products have, however, remained unmatched in terms of quality and performance capabilities, as have its technical support capabilities. The Company enjoys a significant majority share in its principal markets and maintains attractive margins on its sales.

Geogrids are a member of a growing family of geosynthetics, which are polymeric materials used in earthwork construction. As high performance aggregate/soil reinforcements, geogrids enable higher safety levels, better land utilization and more economical construction. Tensar products have been used, in many thousands of aggregate/soil reinforcement applications throughout North America and in other parts of the world through affiliated companies in the United Kingdom and Japan.

Geonets and geocomposites are used in the leachate collection and groundwater protection systems of landfills and other waste containment facilities as well as in a variety of earthwork structures. Tensar gained acceptance of these products by the EPA in 1985 and thereby created this industry. These products, now manufactured by Tensar and a variety of other competitors, provide reliable and economical drainage channels for these facilities, achieving superior levels of groundwater protection and construction economy than could be achieved by the use of conventional drainage materials (principally sand).

Tensar fencing products are used as safety fencing in the construction industry and as methods of improving productivity in the agricultural sector. They provide a variety of advantages to the producer including improving access to farmland, preventing erosion, reducing weather-induced stress on livestock, and controlling driving snow. Tensar also manufactures and purchases and resells several polymeric products to the home and garden market which assist the homeowner in landscaping, erosion protection, and non-chemical means of weed prevention.

The Company also serves several new and developing markets for OEM/fabrication applications of its products. These are quietly established and grown with limited awareness of such applications in the general marketplace.

All Tensar products are unified by the concept of providing polymeric materials in forms that offer higher levels of safety, productivity, efficiency, or aesthetics to the end user.

MANAGEMENT TEAM

The Company's key management team today includes seven senior executives. Four of the seven have been with the Company since its inception. Mr. Egan joined the Company in 1990. Messrs. Gilbert and Briggs joined the Company in 1993. Brief biographical profiles of each are outlined below. The Company's management, professional, and technical staff also include numerous additional individuals with exceptional qualifications in business and engineering. Numerous employees of the Company have received national awards and recognition and have their work regularly published in national publications.

D. Garry Fehrman - President and Chief Executive Officer

D. G. Fehrman, 51, President and Chief Executive Officer of The Tensar Corporation, has been responsible for The Tensar Corporation's strategic direction and business performance from the inception of the business. While responsible for Gulf Canada Limited's corporate development activities, Mr. Fehrman negotiated agreements with Netlon Limited in 1981 which lead to the formation of The Tensar Corporation. Mr. Fehrman subsequently managed all aspects of implementation of the new business. In 1988, following an acquisition of Gulf Canada Limited by others, he formed a new corporation and led a management buyout of the assets of the prior business.

Mr. Fehrman's corporate development responsibilities with Gulf Canada also included direction of the corporation's strategic business planning, mergers and acquisitions, diversification and divestment activities. In other positions with Gulf Canada, where he was employed for five years, he had overall responsibility for the corporation's research and development and its financial planning and analysis activities. Prior to joining Gulf Canada, he was employed by Ontario Hydro for 12 years. His initial responsibilities were in nuclear engineering and computer systems development. Following these assignments, he held several senior positions in corporate finance.

Born in Ontario, Canada, Mr. Fehrman received a Bachelor's degree in Engineering Physics and a Masters degree in Business Administration from McMaster University in Hamilton, Ontario.

Daniel J. Harrington - Vice President and Chief Financial Officer

Mr. Harrington, 46, holds a graduate Finance degree from Duke University's Fuqua School of Business and a Professional Accounting degree from Northwestern University's Kellogg School of Management. He is also a CPA and was employed by the public accounting firm of Arthur Young & Company from 1975 to 1978. In 1978, he joined Schlumberger, Ltd., a leading oil field service company. Mr. Harrington held several senior financial positions while at Schlumberger, Ltd., both domestically and in Europe. Prior to leaving Schlumberger, Ltd., Mr. Harrington had overall financial responsibility for financial reporting, taxation, treasury and data processing for the Company's oil field service business in Europe. Mr. Harrington joined Tensar in his present capacity in 1984. His responsibilities include all areas of finance, administration, human resources and data processing.

Richard P. Gilbert - Vice President - Operations

Mr. Gilbert, 43, received a Bachelor of Science degree in General Engineering from the U.S. Naval Academy and a Masters of Science degree in Public Administration from George Washington University. Upon completing his Naval Academy training, Mr. Gilbert served six years in the United States Navy. After leaving the Navy, Mr. Gilbert worked for Mobil Chemical Company for eleven years, primarily in the Plastic Packaging Division. Mr. Gilbert's most recent experience prior to joining Tensar was as President and General Manager of Richmond Technology in Redlands, California. Mr. Gilbert joined Tensar as its Vice President - Operations in June 1993.

Robert F. Briggs - Vice President - Administration and General Counsel

Mr. Briggs, 41, received his B.A. degree from the University of Texas and his law degree from American University in Washington, D.C. Upon graduation from law school, he worked as an attorney for Exxon Corporation. In 1980, he joined Schlumberger Limited, a multinational oilfield service company. Beginning as a corporate attorney in Houston, he held several senior positions, both in the U.S. and abroad. Prior to joining Tensar, Mr. Briggs was Schlumberger's General Counsel in Paris, France for all international operations of the company's principal oilfield service group. Mr. Briggs joined Tensar in July 1993.

Robert J. Easterle - President - Tensar Polytechnologies, Inc.

Mr. Easterle, 50, received undergraduate and graduate degrees in Business Administration from Central Michigan University. From 1969 to 1974, he held various marketing, product development, and sales management positions with the General Electric Company. In 1974, he joined the Vallen Corporation, a leading national

manufacturer/distributor of industrial safety equipment, where he held several senior marketing and management positions. In 1982, he was appointed Vice President of Sales and Marketing and an Officer of Encon Manufacturing Company, a division of Vallen. Mr. Easterle joined Tensar as Vice President - Sales & Marketing in 1984 and was appointed President of Tensar Polytechnologies in October 1991.

Philip D. Egan - President, Tensar Earth Technologies, Inc.

Mr. Egan, 43, received a Bachelor of Science degree in Civil Engineering from Bucknell University in Lewisburg, Pennsylvania, and a Masters of Science degree in Geotechnical Engineering from the University of Illinois. Prior to joining Tensar as President of TES in 1988, Mr. Egan was initially employed by Morrison-Knudsen, Inc., and then for several years by The Reinforced Earth Company of Arlington, Virginia as its Vice President - Engineering & Business Development. During the years 1989-1993 Mr. Egan also acted as President of Tensar Environmental Systems, Inc. Mr. Egan was appointed President - Tensar Earth Technologies, Inc. in January 1990.

Dewey E. Tate - President, Tensar Environmental Systems, Inc.

Mr. Tate, 53, received a Business Administration degree from Jacksonville State University. After spending six years in the Textile Fibers Division of E. I. Dupont de Nemours, Inc., where he held several production and personnel management positions. Mr. Tate joined ICI Americas, Inc. For the next 10 years, he held several progressively more responsible positions in Operations Management. He was then hired by Wabash Datatech Inc., a manufacturer of computer data storage devices, as its Vice President - Operations and remained with this company for three years. Mr. Tate joined Tensar as its Vice President -Manufacturing & Engineering in February of 1984. During the years 1986-1989 Mr. Tate also acted as President of Tensar Earth Technologies, Inc. and Tensar Environmental Systems, Inc. He was re-appointed President of Tensar Environmental Systems, Inc. in February 1993.

TENSAR DRAINAGE PRODUCTS REFERENCE LIST

Project List	Contact	Product	Quantity	Date
Croton Point Landfill Croton-On-Hudson, NY	Briarwood Contracting Group Dan Bautista (914) 936-3600	DC3205	1,250,000 s.f.	9/1/93
Babylon Landfill W. Babylon, NY	Tully Construction Co., Inc. Chris Haverstrom (718) 446-7000	DC6205 NS1605	2,700,000 s.f. 175,000 s.f.	3/9/94
BFI-Lorain County Oberlin, OH	BFI-Mid America Region Bruce Schumucker (216) 774-4060	DC3105 NS1305	430,500 s.f. 414,000 s.f.	8/31/93
Dade County Miami, FL	Poly-America Larry Rowold (214) 647-4374	NS1405	340,000 s.f.	8/30/93
Fox Point State Park Wilmington, DE	Contech, Inc. Jackie Haley (413) 283-7611	DC4105	680,000 s.f.	12/21/93
Millersville Sanitary LF Anne Arundel, MD	Heery - Project Manager Jim Trouba (410) 757-1122	DC4205 NS1405	3,600,000 s.f. 1,850,000 s.f.	4/8/94
Michaelsville Michaelsville, MD	Palco Linings Frank Taylor (908) 753-6262	NS1305	2,260,000 s.f.	7/1/93
Tillman Ridge St. Augustine, FL	Hubbard Construction Co. Mike Morris (904) 260-8009	NS1605	365,000 s.f.	1/15/94
Battle Mt. Mining Battle Mt., NV	Serrot Corp. Frank Strnad (702) 566-8600	NS1405	200,000 s.f.	4/27/94
Union County R.R.F. Union County, NJ	Palco Lining Frank Taylor (908) 753-6262	DC4105	600,000 s.f.	1/18/93
Upper Occoquan Centerville, VA	Gundle Lining Systems Kevin Simms (713) 443-8564	DC6205	1,320,000 s.f.	6/7/93
Hassayampa Landfill Hassayampa, AZ	Serrot Corp. Frank Strnad (702) 566-8600	NS1305	410,000 s.f.	5/3/94

(Geonet)

DRAINAGE NET NS1405

The drainage net shall be an integrally formed polyethylene net structure. It shall have uniform channels, open area and thickness to assure uniform flow throughout the structure. It shall have high tensile strength and tear strength to resist installation damage and loading on steep slopes. It shall also have a low compressibility under high loadings to maintain a high transmissivity under a range of loading conditions. The drainage net shall also be resistant to ultraviolet degradation. The drainage net shall conform to the property requirements listed below.

PROPERTY	TEST METHOD	NOTES	UNITS	VALUE
Flow Capacity				
• Gradient of 1				
• Transmissivity @ 500 psf	ASTM 4716	2.2×10^{-3} ft²/s is specified	$x10^{-3}$ ft²/sec (gpm/ft)	21 (9.55)
• Transmissivity @ 10,000 psf		long	$x10^{-3}$ ft²/sec (gpm/ft)	16 (7.24)
• Transmissivity @ 20,000psf		than specified	$x10^{-3}$ ft²/sec (gpm/ft)	8.6 (3.86)
Mechanical Properties				
• Porosity		1		
✓ • Peak Tensile Strength MD	ASTM D5035 D1682	2,5	lbs/foot	0.55-0.60 575 = 48 lb/in
• Compressibility @ 20,000 psf	TTM 2.2	3,4,5	%	50
Material				
✓ • Polyethylene-Specific Gravity	ASTM D792		g/cm³	0.940
✓ • Carbon Black Stabilization	ASTM D4218 D1603		%	2.5
Dimensions				
✓ • Thickness	O.D. Calipered	2,6,7	inches	0.20
• Unit Weight			oz/yd²	29
• Open Area	COE Method Modified		%	58
• Roll Length			ft	300
• Roll Width			ft	14.0
• Roll Weight			lbs	845

Notes:

1. Except where noted all reported test values are nominal.
2. Minimum Value.
3. Compression tests are performed on a 2-inch square sample loaded at a 1mm/minute constant rate of strain.
4. Maximum Value.
5. Tensile Strength and Compressibility properties shall be tested by the manufacturer every 10,000 square yards of products.
6. Thickness is measured by placing the specimen flat on a comparator base and lowering a round 1/2 inch diameter flat end contact surface squarely over a junction.
7. Product thickness shall be measured by the manufacturer every 2,500 square yards of product.

The Tensar Corporation
1210 Citizens Parkway
Morrow, GA 30260
1-800-845-4453

DRAINAGE COMPOSITE DC4205

Trevira 1128

The drainage composite shall consist of a geotextile bonded to each side of a drainage net. The drainage composite shall have a low compressibility in order to maintain high flow capacity over a wide range of confining pressures. The bonding process shall not introduce adhesives or other foreign products. The strength of the bond between the drainage net and the geotextile shall be greater than the friction developed between the geotextile and a soil. The drainage composite shall maintain a high flow under long term loading conditions and shall be resistant to all forms of biological or chemical degradation normally encountered in a soil environment. The drainage composite shall be made from the drainage net and geotextile products whose property requirements are listed below.

PROPERTY	TEST METHOD	NOTES	UNITS	VALUE
Flow Capacity	ASTM 4716	1		
• Gradient of 1				
• Transmissivity @ 500 psf			$x10^{-3}ft^2/sec$	21
			(gpm/ft width)	(9.55)
• Transmissivity @ 10,000 psf			$x10^{-3}ft^2/sec$	16
			(gpm/ft width)	(7.24)
• Transmissivity @ 20,000 psf			$x10^{-3}ft^2/sec$	8.6
			(gpm/ft width)	(3.86)
Mechanical Properties		3,4,5		
• Compression		1,2		
@ 20,000 psf			%	50
• Peak Tensile Strength-MD	ASTM D5035	6	lbs/ft	575
Drainage Net				
• Aperture Size	I.D. Calipered	7	inches	0.3
• Thickness	O.D. Calipered	8,9	inches	0.20
• Polyethylene Polymer				
-Specific Gravity	ASTM D792		g/cm^3	0.940
-Carbon Black Stabilization	ASTM D4218		%	2.5
Geotextile		10		
• Grab Tensile Strength	ASTM D4632		lbs	230
• AOS	ASTM D4751		US Std.Sv.Sz.	70
• Weight	ASTM D1910		oz/sy	8.0
Composite				
• Laminate Bond Strength	ASTM F904	11	g/in	400
• Dimensions - Finished Product				
-Thickness	O.D. Calipered		in	0.24
-Roll Length			ft	225
-Roll Width (Drainage Net)			ft	14
• Roll Weight			lbs	890

Notes

1. Test values are for the core net only.
2. Compression Tests are performed on a 2-inch square sample loaded at a 1mm/minute constant rate of strain.
3. Test values are for drainage net prior to bonding process.
4. All test values are nominal, unless otherwise indicated.
5. MD - Machine (roll) Direction.
6. Minimum value.
7. Inside dimensions in each principal direction are measured by calipers.
8. Outside dimensions in each principal direction are measured by calipers.
9. Thickness is measured by placing the specimen flat on a comparator base and lowering a round 1/2 inch diameter flat end contact surface squarely over a junction.
10. Geotextile splices within each roll of finished goods shall be considered acceptable product. The splicing methods shall include, but are not limited to, stitching or heat bonding. The finished splice shall maintain the continuity of the filtration function of the geotextile. These methods will be considered viable and acceptable unless otherwise specified.
11. Minimum value of a random 5 sample (MD) average between the polyethylene geonet and the needle punched geotextile.

The Tensar Corporation
1210 Citizens Parkway
Morrow, GA 30260
1-800-845-4453

DRAINAGE COMPOSITE DC4105

Trevira 1128

The drainage composite shall consist of a geotextile bonded to one side of a drainage net. The drainage composite shall have a low compressibility in order to maintain high flow capacity over a wide range of confining pressures. The bonding process shall not introduce adhesives or other foreign products. The strength of the bond between the drainage net and the geotextile shall be greater than the friction developed between the geotextile and a soil. The drainage composite shall maintain a high flow under long term loading conditions and shall be resistant to all forms of biological or chemical degradation normally encountered in a soil environment. The drainage composite shall be made from the drainage net and geotextile products whose property requirements are listed below.

PROPERTY	TEST METHOD	NOTES	UNITS	VALUE
Flow Capacity	ASTM 4716	1		
• Gradient of 1				
• Transmissivity @ 500 psf			$x10^{-3}ft^2/sec$	21
			(gpm/ft width)	(9.55)
• Transmissivity @ 10,000 psf			$x10^{-3}ft^2/sec$	16
			(gpm/ft width)	(7.24)
• Transmissivity @ 20,000 psf			$x10^{-3}ft^2/sec$	8.6
			(gpm/ft width)	3.86)
Mechanical Properties		3,4,5		
• Compression @ 20,000 psf		1,2	%	50
• Peak Tensile Strength-MD	ASTM D5035	6	lbs/ft	575
Drainage Net				
• Aperture Size	I.D. Calipered	7	inches	0.3
• Thickness	O.D. Calipered	8,9	inches	0.20
• Polyethylene Polymer				
-Specific Gravity	ASTM D792		g/cm^3	0.940
-Carbon Black Stabilization	ASTM D4218		%	2.5
Geotextile		10		
• Grab Tensile Strength	ASTM D4632		lbs	230
• AOS	ASTM D4751		US Std.Sv.Sz.	70
• Weight			oz/sy	8.0
Composite				
• Laminate Bond Strength	ASTM F904	11	g/in	400
• Dimensions - Finished Product				
-Thickness	O.D. Calipered		in	0.23
-Roll Length			ft	225
-Roll Width (Drainage Net)			ft	14
• Roll Weight			lbs	765

Notes

1. Test values are for the core net only.
2. Compression Tests are performed on a 2-inch square sample loaded at a 1mm/minute constant rate of strain.
3. Test values are for drainage net prior to bonding process.
4. All test values are nominal, unless otherwise indicated.
5. MD - Machine (roll) Direction.
6. Minimum value.
7. Inside dimensions in each principal direction are measured by calipers.
8. Outside dimensions in each principal direction are measured by calipers.
9. Thickness is measured by placing the specimen flat on a comparator base and lowering a round 1/2 inch diameter flat end contact surface squarely over a junction.
10. Geotextile splices within each roll of finished goods shall be considered acceptable product. The splicing methods shall include, but are not limited to, stitching or heat bonding. The finished splice shall maintain the continuity of the filtration function of the geotextile. These methods will be considered viable and acceptable unless otherwise specified.
11. Minimum value of a random 5 sample (MD) average between the polyethylene geonet and the needle punched geotextile.

The Tensar Corporation
1210 Citizens Parkway
Morrow, GA 30260
1-800-845-4453

Hoechst Celanese

Product Description

Trevira® Spunbond Type 011/280

Technical Fibers Group
Hoechst Celanese Corporation
Spunbond Business Unit
Post Office Box 5650
Spartanburg, SC 29304-5650
803 579 5007
Toll Free 1 800 845 7597
Fax 803 579 5830

Trevira® Spunbond Type 011/280 is a 100% continuous filament polyester nonwoven needlepunched engineering fabric. The fabric is resistant to biological and naturally encountered chemicals, alkalies, acids, and ultraviolet light exposure. Trevira® Spunbond Type 011/280 conforms to the property values listed in the following table:

FABRIC PROPERTY	UNIT	TEST METHOD	TYPICAL VALUE[1]	MINIMUM TEST VALUES[2]
Fabric Weight	oz/yd^2	ASTM D-5261	8.5	8.0
Fabric Thickness, t	mils	ASTM D-5199	120	105
Grab Strength (MD/CD)	lbs	ASTM D-4632	320/260	230
Grab Elongation (MD/CD)	%	ASTM D-4632	75/80	60
Trapezoid Tear Strength (MD/CD)	lbs	ASTM D-4533	110/100	80
Puncture Resistance	lbs	ASTM D-4833	125	100
Mullen Burst Strength	psi	ASTM D-3786	435	380
Water Flow Rate	gpm/ft^2	ASTM D-4491	130	90
Permittivity, Ψ	sec^{-1}	ASTM D-4491	1.76	1.20
Permeability, $k = \Psi xt$	cm/sec	ASTM D-4491	.53	.32
AOS	Sieve Size mm	ASTM D-4751	70-120 .210-.125	70 .210
Standard Roll Widths[3]	ft	12.5 and 15.0		
Standard Roll Lengths[3]	ft	300		

MD = Machine Direction CD = Cross Machine Direction

[1] The values listed are average values.
[2] These minimum values represent minimum test values as determined from Quality Control (QC) testing.
[3] Other width and length rolls are available upon request.

011280
November 17, 1993

Hoechst

Drainage Composite Installation Suggestions

Storage and Handling

The drainage composite should be provided in enclosed plastic bags in order to protect the geotextile portion of the material. Once the drainage composite arrives on site, the contractor may choose to store the product under a tarp or inside a storage facility (if available) for extra protection against damage to the drainage composite, mishandling, or contact with blades or sharp tools.

Installation: Placement and Seaming

* The drainage composite should be secured against wind action by sandbags or an equivalent when required.

* On sloping areas (steeper than 10·), drainage composite should be anchored at the top of the slope to prevent it from sliding down the slope.

* Fill material should be placed, spread, and compacted in such a manner to ensure: 1) that the drainage composite is not damaged; 2) minimal slippage of the drainage composite on the underlying geosynthetics; and 3) no excess tensile stresses in the drainage composite.

* The drainage composite should be protected from mud, dirt, dust, wet cement, and similar materials which may affix to the geotextile or core net.

* When connecting the drainage composite rolls side-to-side: 1) the rolls should be butted against each other; 2) the net should be tied approximately every 5 feet; and 3) the geotextile should be overlapped a minimum of 3 inches.

* When connecting the drainage composite rolls end-to-end: 1) the net should be overlapped approximately one foot; 2) the net should be tied approximately every 6 inches across the roll; and 3) the geotextile should be flapped over to cover the net.

* Any damaged geotextile should be covered with extra geotextile before backfilling.

TENSAR Environmental Systems, Inc.
1992

TENSAR DRAINAGE NET INSTALLATION GUIDE

I. DELIVERY

Drainage Nets from The Tensar Corporation are delivered on-site in lightweight, easy to handle rolls. The width of rolls is 6.33 feet; the standard roll lengths are 98.4 feet or 300 feet, however, longer or shorter rolls can be manufactured.

II. STORAGE

Tensar drainage nets have been stabilized for ultraviolet light by adding carbon black to the polyethylene resin. Consequently, they can be stored outdoors without any protection during all the time necessary for construction. Precautions necessary for geotextiles and some geomembranes, such as protection by opaque wrapping, are not required. However, wrapping or sheltering is recommended to keep the net clean. Dirt or dust in the installed net can be transported by the liquid and conveyed by the net and subsequently deposited, which may cause clogging. If plastic net rolls have not been protected during transportation or storage, they should be washed prior to installation. This requirement is similar to washing aggregate prior to use in a drainage layer or trench.

III. GROUND PREPARATION

Drainage nets are never placed in direct contact with the ground. If a net is placed on a geomembrane, there are strict requirements for ground preparation to ensure that the geomembrane will not be punctured but special preparation need be made for the net. If a net is placed on a geotextile, stones likely to puncture the geotextile should be removed.

In most cases it should be possible to find a geotextile strong enough so that a net/ geotextile system could be put on almost any unprepared subgrade or waste surface. However, when the waste or subgrade surface on which a net/geotextile is placed is too irregular, fine soil or waste particles transported by flowing liquids may accumulate in the empty spaces between irregular subgrade of waste surface and geotextile, thereby locally clogging the geotextile.

IV. INSTALLATION STEPS

Due to their flexibility, plastic nets are easy to place. Due to their tensile strength they can be placed on steep slopes, even vertical walls. Recommendations for placement follows:

Placement on Horizontal Area

On a horizontal area, rolls can be pushed by hand and easily unrolled. An alternative consists of placing the roll on a spindle fixed at the rear of a vehicle.

Placement on a Slope

Several alternative methods can be used:

- *The net roll is placed around a fixed spindle at the top of the slope and is unrolled by pulling the end of the net down the slope.*
- *The net roll is unrolled on a flat area near the top or the bottom of the slope and is pulled into position.*
- *The net roll is unrolled down the slope while the end of the net is temporarily secured at the top by workers standing on it. (By doing so, it is difficult to align nets to ensure uniform overlap of adjacent rolls.)*
- *Several net rolls are: (1) unrolled on a flat area near the top of slope; (2) joined laterally; (3) rolled up again to form a single wide roll that is unrolled down the slope while the end of the net is temporarily secured at the top by several workers standing on it. (This method can overcome the alignment problem mentioned above.)*

Unrolling rolls down a slope can be dangerous. The roll lengths must be known prior to pushing the rolls and the path likely to be followed by the roll must be cleared. Accidents have been caused by a geomembrane roll rolling freely down a 2H:1V slope. Net rolls do not roll down slopes as fast as geomembrane rolls and the above described method has been successfully used on a 1.5H:1V slope.

Nets are usually unrolled after the anchor trench at the top of the slope has been excavated. Care should be taken not to entrap in the net channels small stones from the soil excavated in the anchor trench.

If necessary, net rolls can be unrolled horizontally across a slope. For example, in a landfill where a double layer of net is required at the toe of the slope, the first layer of net will be unrolled from the top of the slope, as discussed above, and the second layer will be unrolled across the slope at the toe.

Placement Against a Vertical Wall

A 1.6m (5.3 ft) or 1.9m (6.3 ft) wide roll may be difficult to place against a vertical wall. Rolls can be cut in halves (0.8m, i.e. 32 in., or .95m, i.e. 38 in.) to facilitate placement.

Against vertical walls, placement may be facilitated by using a net-geotextile composite fabricated in advance.

V. ANCHORING

On a Slope

The net should be anchored at the top of the slope to prevent it from sliding along the slope. A convenient way is to place the top end of the ne tin the anchor trench with the geomembrane(s) placed beneath and/or above the net (see Figure 1). The anchor trench presented in Figure 1(d) provides temporary anchorage of the geomembrane while the net is being installed. Similarly, the anchor trench in figure 1(f) provides temporary anchorage of the lower geomembrane and the net.

On a Vertical Wall

Nets can be nailed or secured to the back of a vertical wall using bolted steel or wooden battens. They can also be draped from the top of the wall where they are secured with sand bags until backfill is in place.

VI. SECURING AGAINST WIND ACTION

Nets placed on a horizontal area or on a slope should be secured against wind action by sand bags or reclaimed tires. On a slope it may be necessary to attach sand bags and tires to the top, using ropes. Although nets can be welded to some geomembranes (especially HDPE) this is not recommended because differential movements between nets and geomembranes can tear the geomembrane.

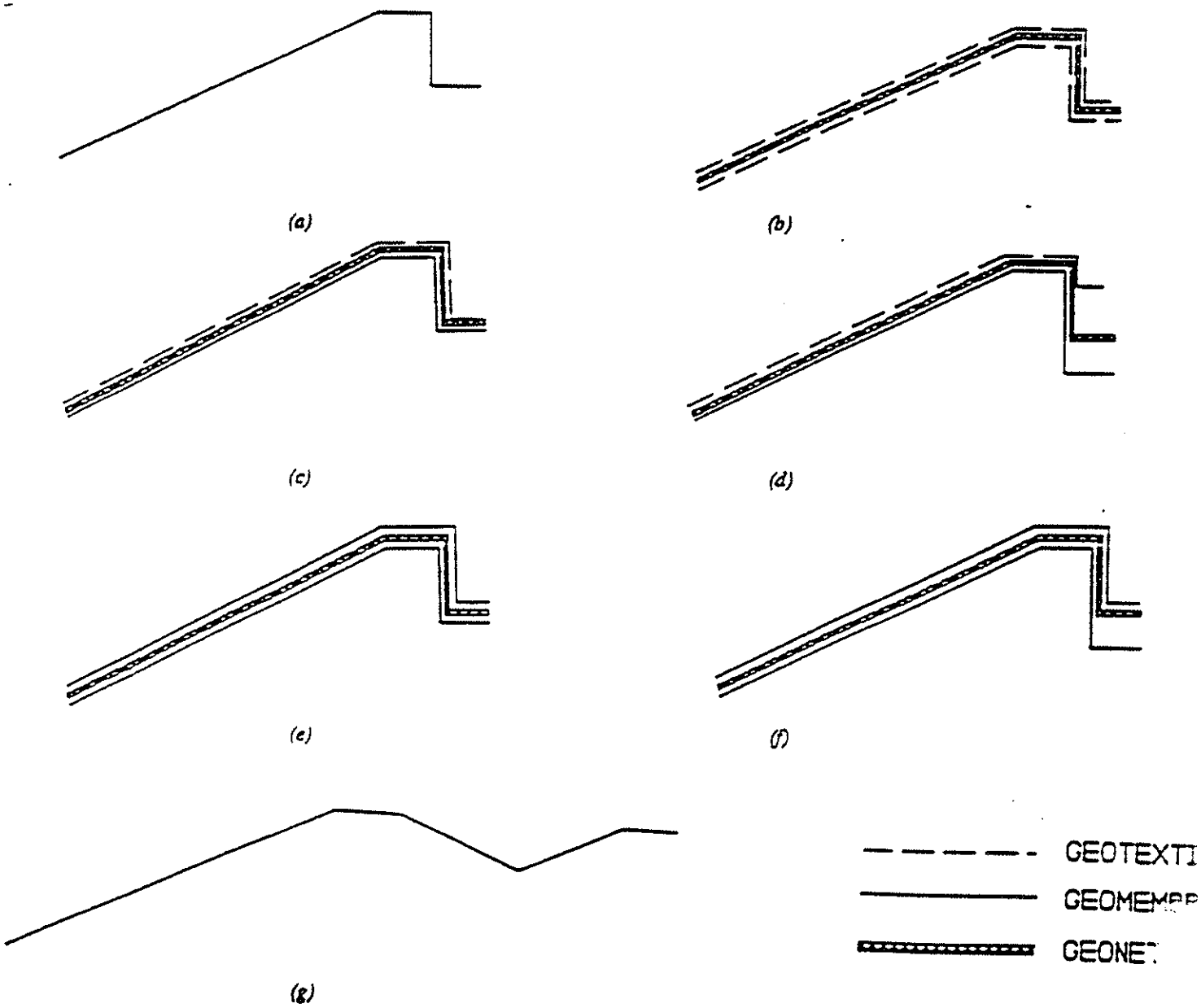


Figure 1:

Cross sections of anchor trenches: (a) traditional anchor trench for a geomembrane; (b) anchorage of geotextile/net/geotextile composite; (c) (d) examples of anchor trenches for leachate collection layer; (e) (f) examples of anchor trenches for a double geomembrane liner with a drainage net used as a leak detection system (Note: it may be useful to vent the air entrapped in the net by making a hole in the top geomembrane liner at the crest; the hole must be sealed after filling the landfill or liquid impoundment); (g) alternate triangular cross-section.

VII. STACKING

When several layers of net are stacked, care should be taken to prevent strands from one layer from penetrating the channels of the next layer, thereby significantly reducing the transmissivity. This cannot happen if stacked nets are placed in the same direction.

In the corners of the side slopes of rectangular landfills or liquid impoundments, nets should be overlapped as indicated in Figure 2. An extra roll of net should be unrolled in the corner, after the placement of the regular nets for the following two reasons:

- flow rate is expected to be higher in corners than elsewhere on the slopes; and
- there is more risk in corners than anywhere else that strands from one layer of nets penetrate channels of the next layer.

VIII. ADJOINING ADJACENT ROLLS

Joining adjacent rolls when the joint is in the direction of flow is achieved by butting or overlapping. When joints are not in the direction of flow, adjacent rolls should be overlapped to ensure continuity of flow. Overlaps should be at least 75mm (3 in.). Connections that are expected to be subjected to tensile stresses (during or after installation of materials adjacent to the net such as geomembrane, geotextile or soil) can be made by spot welding or tying adjacent or overlapping net layers using strings, plastic fasteners or polymer braid, preferably white or colored for easy inspection. Typically, adjacent nets are spot welded every 1.5m (5 ft.). Nets are normally welded or bonded to geomembranes, although geomembranes should not be attached using metallic connections because these connections may damage the geomembrane.

IX. QUALITY CONTROL OF PLACEMENT

Quality control of installation can be carried out at a glance by checking the continuity of the net layer, while quality control of particle size, thickness and cleanliness of sand or aggregate drainage layers is time consuming. Contractor mistakes are minimized because Tensar drainage nets are easy to install.

X. INTERACTION WITH ADJACENT MATERIALS

Connection with Pipes

There are three ways to connect a net to a pipe:

- The net can be wrapped around a slotted or perforated pipe (Figure 3(a).
- The net can be embedded in the aggregate bedding surrounding the pipe (Figure 3(b).
- The net can be inserted into a specially designed pipe (Figure 3(c)

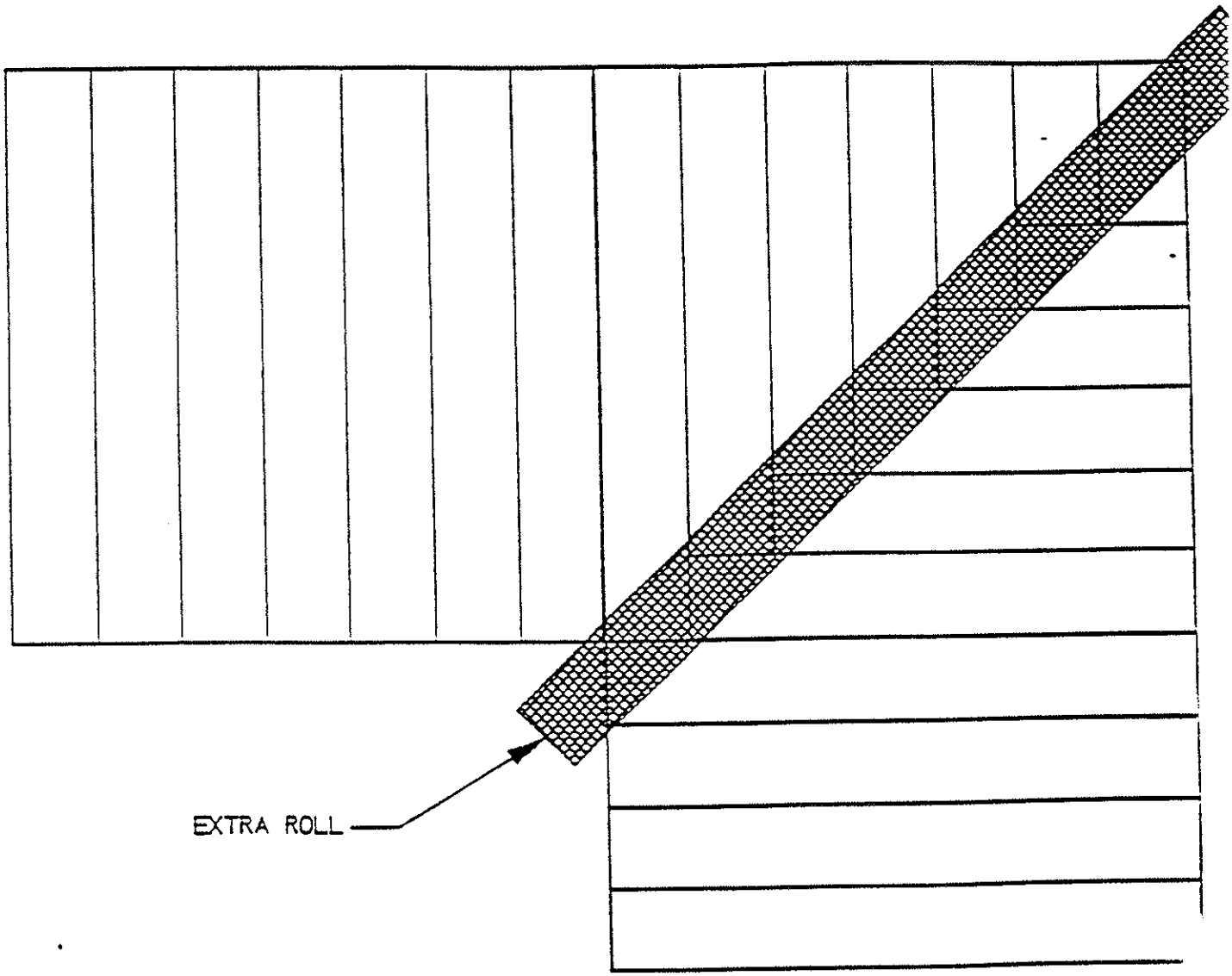


***Figure 2:** Pattern of nets overlapping in the corner of the side slope of a landfill or liquid impoundment.*

Connection with Granular Drainage Layers

Connection of a net with open graded gravel poses no problem. A 0.3m (1 ft) overlap is usually sufficient (Figure 4a). The gravel should be washed prior to placement.

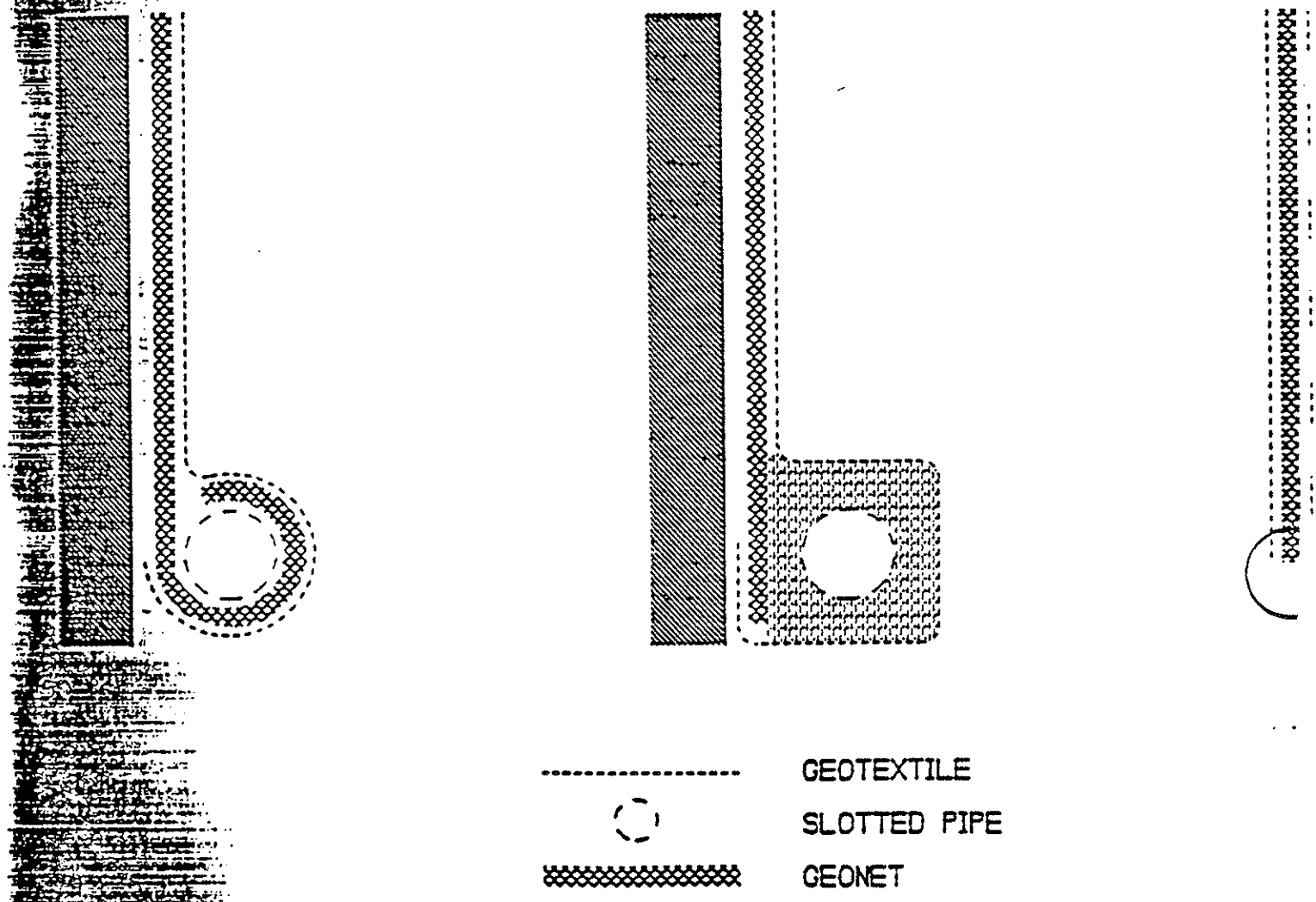
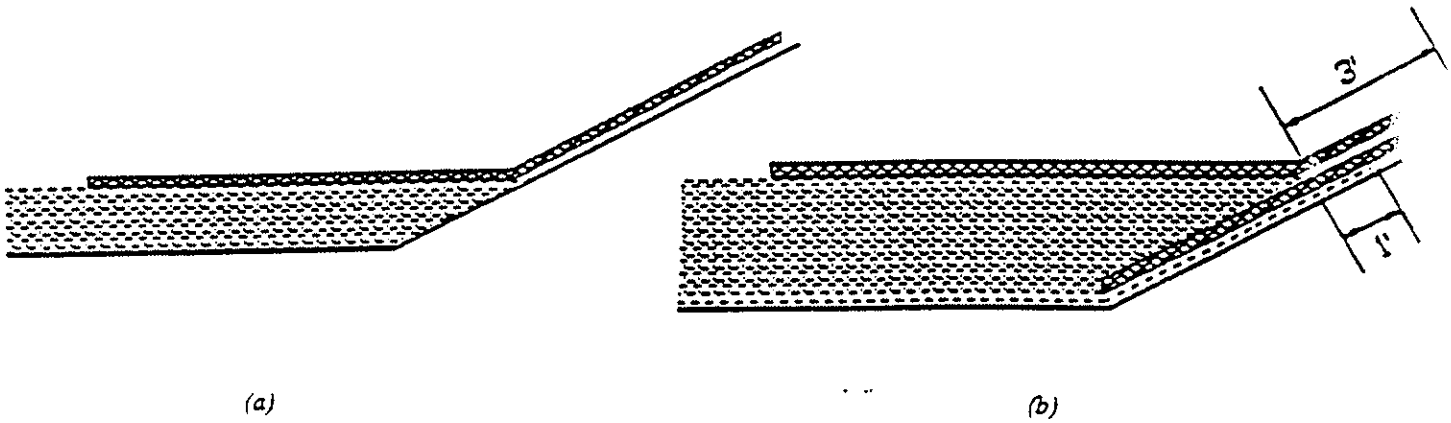


Figure 3: Connection of drainage nets with pipes.



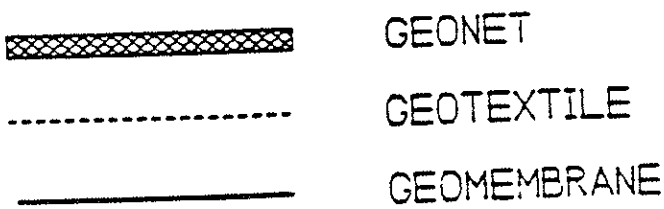
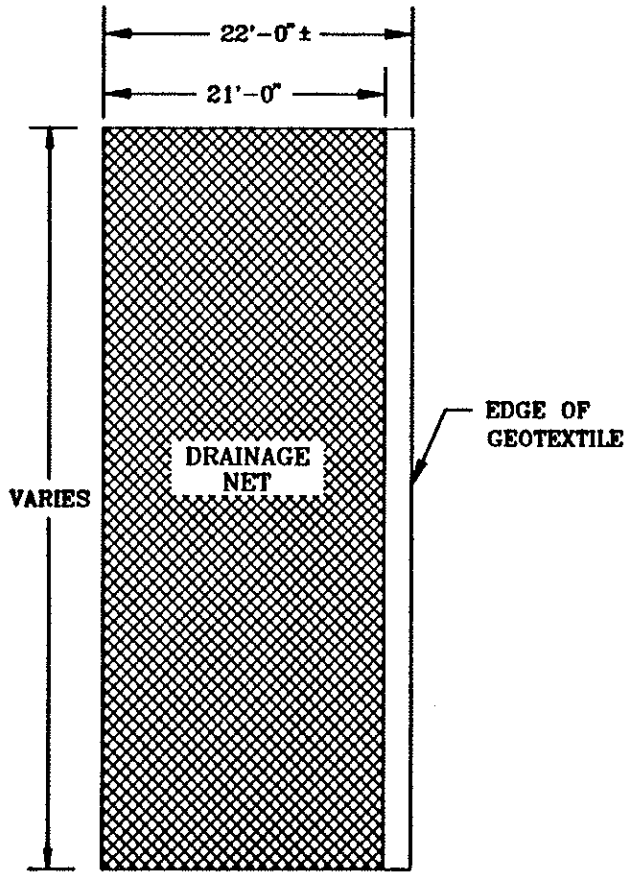
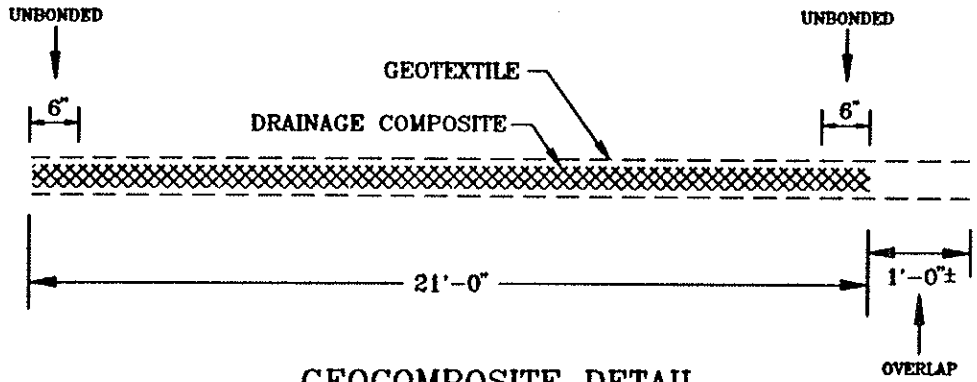


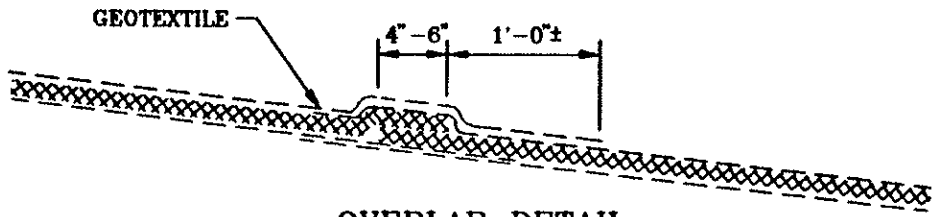
Figure 4: ***Connection of a drainage net with a gravel layer; (a) without a geotextile between gravel and geomembrane; (b) with a geotextile between gravel and geomembrane. In the latter case, an extra layer of net is required because the transmissivity of the net in contact with the geotextile is decreased as compared to its transmissivity in contact with the geomembrane. This extra layer of net can be unrolled across slope.***



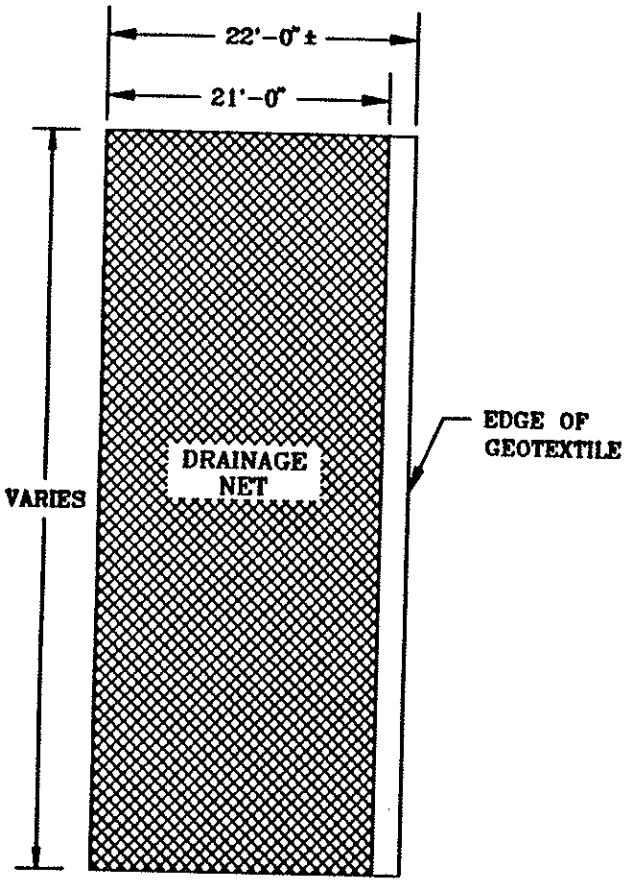
GEOCOMPOSITE DETAIL
(PLAN VIEW)



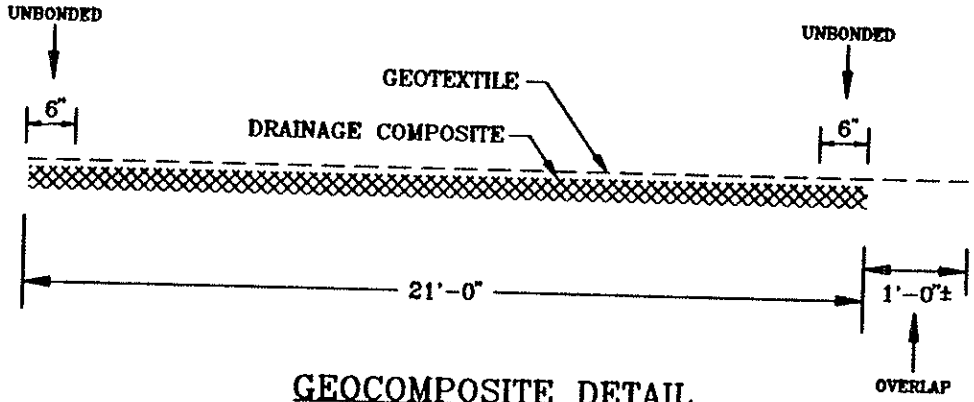
GEOCOMPOSITE DETAIL
(ELEVATION VIEW)



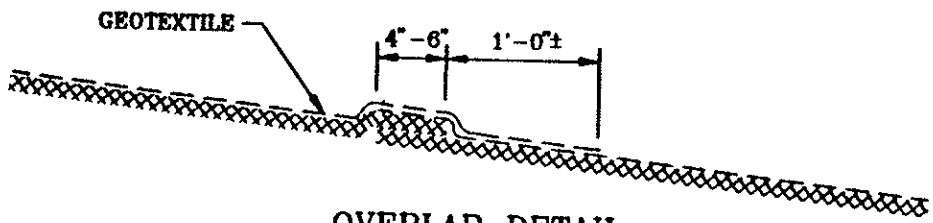
OVERLAP DETAIL



GEOCOMPOSITE DETAIL
(PLAN VIEW)



GEOCOMPOSITE DETAIL
(ELEVATION VIEW)



OVERLAP DETAIL

TENSAR DRAINAGE NET QUALITY CONTROL /

QUALITY ASSURANCE MANUAL

DATE: June 21, 1994
Revision #002

I.

INTRODUCTION

The Quality Control Testing and the Production Testing provide a solid foundation for the assurance that TENSAR DRAINAGE NETS produced by The Tensar Corporation at the Atlanta, Georgia, manufacturing facilities will reliably perform to their design functions.

This manual provides an overview of THE TENSAR CORPORATION DRAINAGE NET PRODUCTS quality assurance program.

II.

QUALITY CONTROL AND PRODUCTION CHECKS

PURPOSE

Allows Operations to improve their capability to maintain a controlled process and to increase production efficiency by routinely monitoring easily measured product characteristics which can be associated with process conditions.

Any production not meeting the measured characteristic's specification is flagged and set aside for further dispositioning by Quality Control personnel.

Quality Control checks and tests are the basis for dispositioning of product, are the source of data for letters of certification, and are checks on Production measurements.

III.

CONTENTS

The information on the following pages is divided into Sections A, B, and C.

Section A details Production quality checks. It lists the product characteristics to be measured or otherwise monitored and the frequency of performing these checks.

Section B details the Quality Control checks and laboratory tests. It lists the measurements and physical tests to be performed on QC samples and the frequency of testing.

Section C is the Appendix. It contains tabulations of the measurements, QC tests, specifications and frequency of tests for typical drainage net products as carried out by Production and by the Quality Control Laboratory of The Tensar Corporation. The chart form provides an easy reference summary to Sections A and B.

SECTION A: PRODUCTION'S QUALITY CHECKS AND SCHEDULE

Rolls will be checked routinely for dimensional and visual parameters felt to be important as factors in preliminary acceptance or rejection of the product. Once in specification, the following scheme will be carried out at a frequency of no less than once per 1,250 square meters of production.

1. Length will be taken from the line's counter and recorded to the nearest 0.1 meter.

2. Weight/Length will be determined from a full width by 1 meter long sample taken directly from the production line.

3. Thickness will be taken from the weight/length sample. The thickness will be taken from each of three areas across the network:

    *) an edge
    *) 1/4 the distance in from an edge
    *) the center

    The sample will be located flatly against the comparator's base with one junction centered under the contact surface of the dial indicator. Three measurements of each area will be taken and an average for each location will be recorded to the nearest 0.01 mm.

4. Mesh Count will also be taken from the weight/length sample and the three values will be recorded individually to the nearest whole mm.

5. Width will be taken from the weight/length sample. Additionally, this parameter is checked many times between scheduled measurements by the use of a scale on the production equipment.

SECTION B: QUALITY CONTROL LABORATORY TESTING AND SCHEDULE

Once a product run has been established as meeting specifications, through Quality Control testing the typical QC sampling schedule as listed will be followed.

Typical QC Sampling Schedule

- Once every 7,440 m^2 of production, a full width by 1 meter long sample is to be taken from the production line to the Quality Control Lab. This sample is to be evaluated for the following:

    1. Tensile Strength (machine direction)
    2. Compressibility
    3. % Weight Carbon Black
    4. Melt Index
    5. Specific Gravity
    6. Appearance
    7. Width
    8. Thickness
    9. Weight per length
    10. Weight per area
    11. Mesh Count on Helix

- Once every 3,720 m^2 of production, a full width by 1 meter long sample is to be taken from the production line to the Quality Control Lab. This sample is to be evaluated for the following:

    1. Appearance
    2. Width
    3. Thickness
    4. Weight per length
    5. Weight per area
    6. Mesh Count on Helix

- Hydraulic Transmissivity testing, although not a Quality Control test, is performed when specifiaclly requested before the production run.

BRIEF DESCRIPTION OF QUALITY CONTROL LAB TEST PROCEDURES

1. Tensile Strength (MD) Network Width (ASTM 5035)

   Five specimens, each being 150mm in the machine direction by 50mm in the cross-machine direction, are individually loaded parallel with the product's machine direction to determine the average maximum strength of the network along the machine direction per meter width.

2. Compressibility (Tensar Method TM2.2)

   a (50 x 50) mm specimen is loaded between flat, parallel surfaces at a rate of 1mm/minute to determine how much the product compresses under given loads. This is an indicator of relative performance regarding transmissivity of the product.

3. % Carbon Black (ASTM D4218-82)

   The % weight of the carbon black additive can be determined by comparing the exact weight of three specimens, before exposure to a high temperature in a muffle furnace, to the weight of their residue.

4. Melt Index (ASTM D1238, Procedure B)

   The rate of extrusion of molten resin through a die of a specified length and diameter at a temperature of 190 degrees centigrade under a load of 2.16 kg is measured via this method and procedure using a melt plastometer meeting the methods requirements.

5a. Specific Gravity (ASTM D792-66)

   The specific gravity is determined via the following ratio:

   $$\frac{\text{the weight, in air, of the melt index extrudate}}{\text{the weight, in IPA, of the melt index extrudate}}$$

   The density of the IPA is determined and accounted for in the actual calculation of the specimen's specific gravity.

BRIEF DESCRIPTION OF QUALITY CONTROL LAB TEST PROCEDURES
(continued)

5b. Density (TM2.5,Foamed Product)

Density of Foamed Product (Tensar TM2.5) is determined by placing a (20 x 200) mm piece of network into a graduated cylinder containing distilled water and dividing the length of the 200mm long specimen, which remains below the water surface, by the 200mm total length.

6. Appearance

Time is taken to ensure that visual aspects remain constant and reflect a quality product.

7. Width (Tensar Method TM2.4)

Network width will be determined while the sample is flat on the floor. Three measurements will be taken, one across each cut end and one across the center. The three measurements will be reported as an average. This value will be recorded to the nearest 1mm.

8. Thickness (Tensar Method TM2.4)

Network thickness is determined by use of a dial gage attached to a comparator stand. Each of the five (2X6)inch tensile specimens are measured at three different sites before the thensile testing is performed. The values are recorded to the nearest 0.01mm.

9. Weight/Length (Tensar Method TM2.4)

Network length will be determined by measuring the sample, while it is flat on the floor, along both edges and along the center. The values will be averaged and reported to the nearest 1mm. The network sample weight is obtained by rolling the product into a tubular configuration applying a 2 inch wide by 16 inch long piece of adhesive tape around this configuration and placing it onto a floor model balance. The weight is divided by the average length and is recorded to the nearest 0.001 lb/m.

BRIEF DESCRIPTION OF QUALITY CONTROL LAB TEST PROCEDURES (continued)

10. Weight/Area (Tensar Method TM2.4)

Network sample weight is divided by the product of its measured average length and its measured average width. The resultant weight/area is recorded to the nearest 0.001 lb/m^2.

11. Mesh Count on Helix (Tensar Method TM2.4)

This is a measurement in the network over a specified number of openings for a given product. This measurement will be determined at the network's edge, center, and 1/4 and 3/4 of the distance across the network from an edge. The locations will be individually reported to the nearest 1mm.

*) Hydraulic Transmissivity (ASTM D4716-87)

Boundaries, gradients, loads are dependent upon customer's needs. Tensar has characterized products using metal boundaries top and bottom. Gradients and loads are listed in published information for each product.

SECTION C: APPENDIX

PRODUCTION CHECKS

NS1405
(Narrow and Wide Product)

PROPERTY	NOMINAL	SPECIFICATION LIMIT(S)	[1]FREQUENCY OF CHECKS (sq. m)	METHOD
Width, m (in)	1.93 4.3	1.91 - 1.95 (75 - 77) 4.26 - 4.45 (167 - 175)	744 1,250	Tensar TM 2.4
Thickness, mm (in)	5.5 (0.216)	5.10 - 5.90 (0.200 - 0.232)	744 1,250	Tensar TM 2.4
Weight/Length, lbs/m	4.00 8.95	3.95 - 4.15 8.90 - 9.10	744 1,250	Tensar TM 2.4
Mesh Count, mm (in) (Over Span of 5 Mesh on Helix)	60 (2.36)	55 - 65 (2.16 - 2.56)	744 1,250	Tensar TM 2.4

1) 744sqm = 1.93width product;1,250sqm = 4.3width product

Q. C. TESTING

NS1405
(Narrow and Wide Product)

PROPERTY	NOMINAL	SPECIFICATION LIMIT(S)	FREQUENCY OF CHECKS (sq. m)	METHOD
Width, m (in)	1.93 4.3	1.91 - 1.95 (75 - 77) 4.26 - 4.45 (167 - 175)	3,720	Tensar TM 2.4
Thickness, mm (in)	5.5 (0.216)	5.10 - 5.90 (0.200 - 0.232)	3,720	Tensar TM 2.4
Weight/Length, lbs/m	4.00 8.95	3.95 - 4.15 8.90 - 9.10	3,720	Tensar TM 2.4
Weight/Area, lbs/m^2	1.93	1.89 - 2.09	3,720	Tensar TM 2.4
Mesh Count, mm (in) (Over Span of 5 Mesh on Helix)	60 (2.36)	55 - 65 (2.16 - 2.56)	3,720	Tensar TM 2.4

Q. C. TESTING

NS1405
(Narrow and Wide Product)

PROPERTY	NOMINAL	SPECIFICATION LIMIT(S)	FREQUENCY OF CHECKS (sq. m)	METHOD
Tensile Strength Kn/m (lbs/ft) width	-----	8.4 minimum (575)	7,440	ASTM [1]D-5035
Compressibility % @ 20,000 psf	-----	50 maximum	7,440	Tensar TM 2.2
% Weight Carbon Black	2.5	2.0 - 3.0	7,440	ASTM D-4218
Melt Index (Grams/10 min)	0.25	0.1 - 1.0	7,440	ASTM D-1238
Specific Gravity (Grams/cc)	0.945	0.940 - 0.950	7,440	ASTM D-792
[2]Hydraulic Transmissivity, X 10-3ft^2/sec	12	-----	As Required	ASTM D-4516

1) Formerly ASTM D-1682

2) Gradient = 1.0;Normal Stress = 500psf;Boundaries = metal plates

$T = 12 \times 10^{-3}$ ft²/sec
$= 1.728$ in²/sec
$= 1 \times 10^{-3}$ m²/s

GUNDLE MATERIAL & INSTALLATION STANDARDS MANUAL

PREFACE

This manual replaces the "Quality Assurance for the Installation of Flexible Membrane Lining Systems" manual currently in circulation. All relevant components of the previous QA/QC manual are incorporated into this document. Additional items have been added as required. The format has been modified for ease of reference and readability.

Limitation of warranty liability: These descriptions are solely for use by engineers as general guidelines in formulating preliminary specifications, and should not be relied upon absent site-specific product testing and manufacturing information. Product designs and specifications are subject to change without advance notice. Any description of the materials contained in this document is for the sole purpose of identifying this material, and no description of the materials has created or amounted to an express warranty that the materials will conform to this description. The materials herein are subject to a printed special material warranty form issued at the time of purchase. This special material warranty supersedes all other warranties, express, implied and statutory, including any implied warranty of merchantability or fitness for a particular purpose.

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QUALITY POLICY STATEMENT

Gundle Environmental Systems Inc. through its operating entities, Gundle Lining Systems, Inc. (GLS) and Gundle Lining Construction Corp. (GLCC), is the leading supplier and installer of quality high and low density polyethylene liner systems for waste containment and other applications. The company has been extremely successful by operating under the philosophy of offering quality products and competitive pricing on a worldwide basis. The company's management is totally committed to its Quality Management System and relies on experienced personnel and "state of the art" processing equipment to achieve the high level of quality in our products and services.

CORPORATE MISSION STATEMENT

The mission of Gundle Environmental Systems, Inc. is to be the world leader in providing innovative, quality barrier systems, products and services to satisfy customer needs in managing and protecting water and other resources.

Gundle Environmental Systems, Inc., through the Quality Management System, will maintain compliance with the requirements of the ISO 9002 Quality System Standard, applicable governmental regulations.

Implementation of the company's Quality Management System will ensure the realization of the following goals:

- Achieving a high degree of customer satisfaction for its products and services,
- Continuous certification under the ISO 9002 Quality System Standard,
- Consistently providing products and services that meet the customer's requirements and expectations,
- Achieving desired product quality through continued process improvement, and
- Continuing growth while maintaining an excellent customer, company, and employee relationship.

POLICY IMPLEMENTATION

Management within Gundle Environmental Systems, Inc. is totally dedicated to achieving these ambitious and challenging goals that will require every employee to share in this total commitment to quality. Management's respect for and recognition of its employees, maintenance of modern processing equipment, and continued commitment to the Quality Management Program will ensure the future success of Gundle Environmental Systems, Inc.

(excerpt from Gundle Environmental Systems, Inc. Quality Assurance Manual, Revision 1).

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1.0 INTRODUCTION

The focus of the company's Quality Management System is to conform to the standards set forth by ISO 9002. As such, the procedures outlined in this document are superseded by any changes made to Gundle's overall Quality Management System. This manual is subject to periodic revision.

1.1 Terms of Reference

1.1.1 Purpose

This manual addresses the quality assurance and quality control of the installation of geomembranes, bentonite blankets and other geosynthetic products used by Gundle Lining Systems, Inc. (GLS) and Gundle Lining Construction Corp. (GLCC) in hazardous and solid waste disposal landfills, municipal solid waste landfills, surface impoundments and other installations as specified by the owner and/or engineer.

This manual reflects the requirements of the Hazardous and Solid Waste Amendments of 1984 to the Resource Conservation and Recovery Act (RCRA), as well as other relevant federal regulations and guidelines.

1.1.2 Quality Assurance and Quality Control

In the context of this manual, quality assurance and quality control are defined as follows:

Quality Assurance - A planned and systematic pattern of all means and actions designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

Quality Control - Those actions which provide a means to measure and regulate the characteristics of an item or service to contractual and regulatory requirements.

In the context of liner production and installation:

- Quality assurance refers to means and actions employed by GLCC and GLS to assure conformity of the lining system production and installation with the project specific Quality Assurance Plan, drawings, and specifications.
- Quality control refers to those actions taken by the manufacturer, fabricator, and installer to ensure that the materials and the workmanship meet the requirements of the plans and specifications.

1.1.3 Lining Materials

The materials comprising the lining systems include geomembranes, geosynthetic clay liners (GCLs) also called bentonite blankets, geotextiles, geonets, and geogrids referred to collectively as geosynthetics manufactured from synthetic polymers.

For purposes of this document, the term "geomembrane" is applied to flexible membrane liners. The term "geomembrane" refers to many liners including polyethylene geomembranes with either smooth surface or textured surface for increased friction. These geomembranes include: 1) high density polyethylene (HDPE) membranes that

are made from resins with a specific gravity greater than 0.935, and 2) very low density polyethylene (VLDPE) membranes that are made from resins with specific gravity less than 0.915 prior to the addition of carbon black and additives.

Geomembranes are utilized either alone or in conjunction with low permeability soils and/or bentonite blankets as composite liners. Geomembranes are the key components of the lining system. Therefore none of the geomembrane requirements contained herein should be compromised in any way. Geotextiles, geonets, and granular soils are utilized in combination for leachate collection systems. Geogrids provide varied structural support interlocking with soil and rock.

The quality assurance of a geosynthetic liner system is addressed herein in its entirety, including all stages from manufacture to installation. The quality assurance of soils is only discussed relative to their interaction with the geosynthetics.

1.1.4 Scope of Quality Assurance and Quality Control

The scope of this manual includes the quality assurance applicable to manufacturing and subject installation of geosynthetics. Full time quality assurance of the installation of geomembranes, bentonite blankets, and of other geosynthetics is essential.

This manual does not address design guidelines, installation specifications, or selection of geomembranes, bentonite blankets, and other geosynthetics (which includes compatibility between geosynthetic and contained material).

This manual does not address the quality assurance of soils except in cases where soil placement may have an influence on the geosynthetics.

1.1.5 Units

In this manual, all properties and dimensions are expressed in U.S. units, with "equivalent" SI units in parentheses. It should be noted that the conversion is typically only accurate within ten percent. In cases of conflict or clarification, the U.S. units shall be deemed to govern.

1.1.6 References

The manual includes references to test procedures of the American Society for Testing and Materials (ASTM), the Federal Test Method Standards (FTMS), the Standards for Flexible Membrane Liners of the National Sanitation Foundation (NSF), Geosynthetic Research Institute (GRI), and other relevant guidelines. Recognizing the fact of technical progress of such standards and the geosynthetic industry at large, this manual is subject to revision.

1.2 Involved Parties

The successful completion of a liner system is dependent on the interaction of many parties. The parties discussed below are those associated with the ownership, design, specification, manufacture, fabrication, transportation, installation, and quality assurance of the liner system. The qualifications of the installer and geosynthetic quality assurance consultant are particularly critical to the successful completion of the lining systems, and must be emphasized in the project specific Quality Assurance Plans.

1.2.1 Designer/Engineer of Record

The designer is responsible for the design, drawings, plans, and specifications of the lining system, foundation materials, and scope of project.

1.2.2 Earthwork Contractor

The earthwork contractor is responsible for the preparation of the supporting soil on which the lining system is to be installed and may also be the party responsible for placing earth and granular materials (if any) over the installed lining system.

1.2.3 Resin Supplier

The resin supplier produces and delivers the resin to the manufacturer (GLS).

1.2.4 Geosynthetic Manufacturer (GLS)

The geosynthetic manufacturer is responsible for the production of finished rolls of geosynthetics from raw material polymer and bentonite as necessary.

1.2.5 Installer (GLCC)

The installer is responsible for field handling, placing, seaming, field testing, temporary securing (against wind), and other aspects of the geosynthetics installation.

1.2.6 Transporter

The transporter conveys the rolls of geomembrane from the manufacturer to the site.

1.2.7 Soils Quality Assurance Consultant

The soils quality assurance consultant is normally a party independent from the owner, manufacturer, fabricator and installer who is responsible for observing, testing, and documenting activities related to the quality assurance of the earthwork at the site. He is also responsible for issuing a subgrade certification report.

1.2.8 Geosynthetic Quality Assurance Laboratory

The geosynthetic quality assurance laboratory is a party responsible for conducting tests on samples of geosynthetics.

1.2.9 Owner

The owner owns, and/or is responsible for, the lined facility. In this manual the term "Owner" shall apply equally to "Operator"; i.e., the party responsible for operating the lined facility.

1.2.10 Project Manager

The project manager is the official representative of the owner. In this manual the term "Project Manager" shall apply equally to "Construction Coordinator"; i.e., the individual in charge of coordinating field activities.

1.3 Meetings

To guarantee a high degree of quality during installation, open channels of communication are essential. Timely and informative meetings facilitate the successful completion of any lining system project.

1.3.1 Pre-Construction Meeting

Following the award of contract for a project, a Pre-Construction Meeting should be held. This meeting should include all parties involved, including the owner, GLCC, the soil quality assurance consultant, the design engineer, and the project manager.

The purpose of this meeting is to begin planning for coordination of tasks, addressing any problems which might cause difficulties and delays in construction, and present the relevant Quality Assurance guidelines to all the parties involved. It is very important that the rules regarding testing, repair, etc., be known and accepted by all.

This meeting should include (but not be limited to) all of the following activities:

- Communicate to all parties any relevant documents;
- Review critical design details of the project. For instance, if a panel layout drawing is required by specification, it should be reviewed at this meeting (this panel layout is usually tentative and may be revised by the Gundle Site Manager with the approval of the field engineer to suit field conditions at the time of installation);
- Review the relevant Quality Assurance guidelines and make any appropriate modifications;
- Make any appropriate modifications to the design criteria, plans, and specifications so that the fulfillment of all design specifications or performance standards can be determined through the implementation of the site specific addendum;
- Reach an agreement on the quality control procedures, especially on methods of determining acceptability of the lining system;
- Assign responsibilities of each party depending on the number of seaming crews and on the type of seaming equipment;
- Establish lines of authority and communication;
- Prepare an approved time schedule for all operations (see Section 4.2.A.1) and any other site specific items pertinent to the lining installation;
- Review the responsibilities of each party;
- Review methods for documenting, reporting, and for distributing documents and reports;
- Establish rules for writing on the geomembrane; i.e., who is authorized to write, what can be written and in which color;
- Outline procedures for packing and storing archive samples;

- Conduct a site walk around to verify that earthwork construction is proceeding on schedule and to review material storage locations;
- Develop a numbering system for panels and seams;
- Finalize field cutout sample sizes;
- Review seam testing procedures;
- Review repair procedures; and
- Review precautions to be taken against clay cracking (subgrade surface desiccation).

The meeting should be documented by a person designated at the beginning of the meeting, and minutes transmitted to all parties.

1.3.2 Progress Meetings

A daily installation progress meeting must be held between the earthwork manager, the GLCC Site Supervisor, the project manager, and any other concerned parties. This meeting is to be used to discuss current progress and any matter requiring action that is raised in this meeting must be reported to the appropriate parties in writing.

1.3.3 Manufacturing Plant Visits

A geomembrane manufacturing plant visit by the owner or his designated agent is welcomed if so desired.

2.0 MANUFACTURING OF GEOSYNTHETIC PRODUCTS

2.1 Raw Materials

2.1.A Polyethylene Geomembranes

The base polyethylene resin will be mixed with 2.0 to 3.0 percent by weight of carbon black and a proprietary additive package of heat stabilizers and anti-oxidants that will not exceed 0.5 percent of the finished product weight.

Raw material resins shall be tested by Gundle for the following physical properties prior to use in the manufacturing process:

a. Melt Index
b. Density

Results of all testing will comply with the specifications outlined in Section 8.0 on Table 8.1.

Raw materials (resin, carbon black, and additive package) may be mixed during the production stage using a "masterbatch" carrier resin containing the carbon black and other additives or during a compounding process prior to production.

2.1.B Gundnet® and Fabri-Net® Products

Gundnet® XL-14 geonet will be made from the same resins used to manufacture Gundle's HDPE geomembranes.

The raw materials will consist of polyethylene resin, 2.0 to 3.0 percent by weight carbon black, and no more than 0.5 percent heat stabilizers and anti-oxidant additives.

Raw material resins shall be tested by Gundle for the following physical properties prior to use in the manufacturing process:

a. Melt index
b. Density

Results of tests will comply with the specifications outlined for HDPE resin in Section 8.0, Table 8.1.

Fabri-Net® products will have a geotextile bonded to one or both sides of the geonet. The geotextiles will be purchased from an outside vendor. The geotextile manufacturer shall furnish quality control documentation demonstrating that the product meets relevant published specifications.

2.1.C Gundseal® Geosynthetic Clay Liner (GCL)

Gundseal® is produced using a Gundle geomembrane and bentonite. The geomembrane will be produced in accordance with the standards for geomembranes outlined within this document.

Bentonite clay is delivered in granular form from a reputable supplier of the product. Each shipment is accompanied by a certificate of compliance from the supplier indicating that the material meets requirements.

Quality control testing is performed on the bentonite for the following physical properties:

a. Moisture Content
b. Filtrate Loss
c. Particle Size
d. Plate Water Absorption
e. Washed 325 Sieve (0.051 mm) Analysis

Testing is carried out at the frequencies outlined in Section 8.0, Table 8.13 and are required to meet the specifications listed in Section 8.0, Table 8.14 to verify that the bentonite meets minimum quality requirements.

2.2 Manufacturing

2.2.A Geomembrane

The production line operator at Gundle's plant will observe the product as it is produced and monitor the equipment to ensure that the material is free of surface defects, holes, and meets the required thickness gauge performance.

To detect the presence of holes in the geomembrane, Gundle employs an electronic hole detecting system on each production line. All liner produced must pass over the spark testing device before it is wound, sampled, and submitted for quality control testing.

A sample will be taken from the end of each roll of geomembrane produced. The sample is then used to perform quality control testing on the finished product in accordance with the test procedures and frequencies as outlined in Section 8.0, Table 8.9.

Test results from the testing are then recorded and evaluated against Gundle standards, or customer specifications.

2.2.B Gundnet® and Fabri-Net®

The production line operator at Gundle's plant will observe the product as it is produced and monitor the equipment to ensure that the material is free of surface defects and meets the required thickness specifications. In the case of Fabri-Net®, the geotextile is inspected to ensure it exhibits even bonding to the geonet.

One sample of Gundnet® will be taken from the end of one roll for every five rolls of Gundnet® product produced. The sample is then used to perform quality control testing on the finished product in accordance with the procedures and frequencies outlined in Section 8.0, Tables 8.10 and 8.11.

Test results are then recorded and evaluated against Gundle standards or customer specifications.

2.2.C Gundseal® Geosynthetic Clay Liner (GCL)

The production line operators insure that the equipment is operating properly and that the bentonite is consistently placed across the width of the roll. Samples are cut across the width of the roll once for every twenty-six rolls produced, (every 91,000 SF) (8,200

SM). The samples are then tested for bentonite layer weight and bentonite layer free swell (GRI GCL-1).

2.3 Documentation

2.3.A Geomembrane

Gundle will provide the following documentation on geomembrane roll goods:

a. Quality control certificate for rolls
b. Test results for raw materials
c. Quality control certificate for resin from the resin manufacturer

Documentation is usually generated and sent out the day after the material is shipped. Examples of provided documentation can be found in Section 10, Exhibits.

2.3.B Gundnet® and Fabri-Net®

Gundle will provide a quality control certificate for every five rolls of product delivered. Documentation is usually generated and sent to the customer the day after the material has been shipped.

2.3.C Gundseal® Geosynthetic Clay Liner (GCL)

The following documentation will be provided:

a. Bentonite certificates from bentonite supplier
b. Bentonite QC test results
c. HDPE Quality Control certificates
d. Gundseal® finished product testing results

3.0 SHIPPING, HANDLING, AND DELIVERY OF PRODUCTS

3.1 Packaging of Roll Goods

3.1.A. Geomembrane

Geomembrane rolls are packaged with a bar coded label placed on the outside of the roll and one within the roll core. Two high strength carrying straps are placed around the outside of the roll to assist in handling the material. The carrying straps are differentiated as to whether they can support 34.5 foot (10.5 m) wide rolls or 22.5 foot (6.86 m) wide rolls.

Labels on the roll contain the following information:

a. Roll number
b. Material type
c. Nominal thickness
d. Line operator
e. Batch number
f. Applicable patent numbers

3.1.B Gundnet® and Fabri-Net®

Gundnet® roll goods are enclosed in a polyethylene bag. Labels are placed on the outside of the wrapping and on the roll inside the packaging. A carrying strap is also provided on fourteen foot (14') (4 m) net to assist in handling the material.

3.1.C Gundseal® Geosynthetic Clay Liner (GCL)

Gundseal® rolls are wrapped with plastic to protect the material from exposure to moisture. The rolls contain labels within the roll core and on the outside of the package. Rolls are also equipped with two cloth straps to assist in handling the material.

3.2 Storage and Handling

3.2.A Geomembrane

Geomembrane rolls should be handled using the attached carrying straps, or if adequately sized equipment is available, with a fork lift stinger inserted through the core. Rolls should be placed on a firm, smooth surface free of large and/or sharp stones. Gundline® HD and VL products are UV stabilized and require no special protection from moisture or sunlight.

3.2.B Gundnet® and Fabri-Net®

Gundnet® rolls should be handled using the attached carrying straps placed on the rolls. Rolls should be stored away from standing water. The plastic bags should be left on the rolls until just prior to deployment. Care shall be taken to avoid damaging the plastic covering protecting the Gundnet® from dirt and moisture.

3.2.C Gundseal® Geosynthetic Clay Liner (GCL)

Gundseal® rolls shall be handled in the same fashion as geomembranes. Gundseal® rolls shall be stored off the ground in areas free of ponding water and consisting of a firm

and level subgrade. Rolls should be covered with a tarp or placed in an enclosed area. Care shall be taken to not damage the wrapping of the individual rolls which protect the bentonite from moisture.

3.3 Shipping of Products

3.3.A Geomembrane

Geomembrane rolls can be shipped on flat bed trucks or open top shipping containers. The loading of rolls in van trailers or open-end containers can be done with special equipment which would also need to be available at the material destination. Standard full load quantities of geomembrane rolls are as follows:

	22.5' (6.8 m) Wide Roll	34.5'(10.5 m) Wide Roll
Flat Bed Truck (45') (14 m)	15	10
40' (12 m) Open Top Containers	16	10

3.3.B Gundnet® and Fabri-Net®

Fourteen foot (14') (2 m) wide rolls are typically shipped on flat bed trucks or open top containers. Six and one-half foot (6.5') (2 m) wide net product rolls are shipped in closed van trailers. Full load quantities of standard geonet products are as follows:

	14' (4.2 m) Wide Roll	6.5' (2 m) Wide Roll
Flat Bed Truck (45') (14 m)	24	--
40' (12 m) Open Top Container	14	60
Closed Van Trailer	--	120*

3.3.C Gundseal® Geosynthetic Clay Liner (GCL)

Gundseal® rolls are shipped on flat bed trucks or open top containers. Rolls should be covered with a tarp during transport and storage. Full load quantities of standard Gundseal® rolls are as follows:

	17.5' (5.3 m) Wide Rolls			
	20 mil	30 mil	40 mil	60 mil
45'(14 m) Flat Bed Truck	11	10	10	11
20' or 40' (12 m) Open Top Container	10	9	10	10
Roll Length	200'	200'	200'	200'

* Varies with weight of geotextile bonded to geonet

4.0 Installation

4.0 GEOSYNTHETIC INSTALLATION

4.1 Anchor Trench Systems

All anchor trench systems will be excavated by the earthwork contractor (unless otherwise specified) in accordance with the lines and widths as shown on the contract drawings, before geosynthetics placement.

If the anchor trench is excavated in clay susceptible to desiccation, no more than the amount of trench required for the geosynthetic to be anchored in one (1) day will be excavated (unless otherwise specified) to minimize desiccation potential of the anchor trench clay soils.

The corners of the anchor trench where geosynthetic enters the trench should be slightly rounded to avoid sharp bends in the geosynthetics. No large rocks or clay lumps will be allowed to underlie the geosynthetic in the anchor trench.

Backfilling of the anchor trench will be conducted according to Section 4.5.

4.2 Geosynthetic Placement

Immediately before installation of any geosynthetics, the subgrade surface will be inspected by Gundle Lining Construction Corp. (GLCC) and the owner or the owner's representative. The decision to repair cracks, if any, will be made by the owner's representative. The subgrade will be walked by GLCC and the project manager for joint approval. GLCC will sign acceptance of the surface condition of the subgrade. The integrity of the underlying soil is the responsibility of the owner/earthwork contractor. (See Exhibits 10.6 and 10.7 in Section 10.0 for example of Pre-start Site Inspection and Subgrade Surface Acceptance Forms.)

Subgrade Preparation Recommendations

No geosynthetic will be placed on surfaces not previously found acceptable by the GLCC Supervisor or his agent.

No sharp stones or other hard objects that could penetrate the liner will be present in the top one inch (1") (2.5 cm) of the surfaces to be covered.

Surfaces to be lined will be smooth and free of all rocks, sharp stones, sticks, roots, other sharp objects, or debris of any kind. The surface should provide a firm, unyielding foundation for the geosynthetic with no sudden, sharp or abrupt changes or break in grade.

4.2.A Geomembrane Placement

4.2.A.1 Installation Schedule

Field panels are placed only after the subgrade has been accepted by GLCC and the project manager. GLCC takes responsibility only for accepting the surface conditions of the subgrade.

Field panels are placed one at a time and each field panel will be seamed immediately after its placement.

4.2.A.2 Location

Field panels are located by the GLCC Field Supervisor in a manner consistent with the specifications and in a manner best suited to existing site conditions (i.e., a field panel is a roll or a portion of roll cut in the field).

4.2.A.3 Field Panel Identification

A field panel is the unit area of geomembrane that is to be seamed in the field.

At the time of installation, the GLCC Field Supervisor will give each field panel an "identification code" (alpha or alphanumeric). This identification code will be agreed upon by the project manager. This field panel identification code will be as simple and logical as possible.

GLCC will record the identification code, roll number, and date of installation of each geomembrane field panel on the Daily Progress Report (see Exhibit 10.8 in Section 10.0). Daily Progress Reports are to be submitted to project manager on a daily basis.

4.2.A.4 Weather Conditions

Neither welding nor placement of geomembrane will take place during any precipitation, in the presence of excessive moisture, blowing dust, or in the presence of high winds (unless wind barriers are provided). In addition, neither placement nor welding will take place in areas of standing water.

4.2.A.5 Method of Placement

GLCC will verify that:

- Any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means;

- The prepared surface underlying the geomembrane has not deteriorated since previous acceptance and is still acceptable immediately before geosynthetic placement;

- Construction equipment used to deploy geomembranes should not create excessive rutting in the subgrade;

- The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);

- If the substrata is a geosynthetic material, deployment may be by hand, by use of small jack lifts on pneumatic tires having low ground contact pressure, or by use of all-terrain vehicles (ATVs) having low ground contact pressure;

- Any geosynthetic elements immediately underlying the geomembrane are clean and free of debris;

- No personnel working on the geomembrane will smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane;

- The method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;

- Adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, or soil is recommended along edges of panels to minimize risk of wind flow under the panels);

- Direct contact with the geomembrane is minimized; i.e., the geosynthetics are protected by geotextiles, extra geomembrane, or other suitable materials in areas where excessive traffic may be expected;

- In the case of high density conductive geomembrane, the electrically conductive layer should be placed conductive side down, and

- GLCC will inform the project manager if the above conditions are not fulfilled.

4.2.A.6 Damage

GLCC will inspect each geomembrane panel for damage prior to seaming. GLCC will advise the project manager what panel or portions of panels should be repaired as required. Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by GLCC. Repairs to geomembrane will be made according to procedures described in Section 4.4.A.

4.2.B Geotextile and Geonet Placement

Geotextile and geonets will be handled in such a manner as to ensure they are not damaged in any way.

On slopes, geotextiles and geonets will be anchored in the anchor trench; then rolled down the slope in such a manner as to continually keep the material in tension.

In the presence of wind, the materials will be weighted with sandbags until final covers are installed.

Care will be taken to assure that any underlying layers are not damaged during placement of geotextiles and geonets.

Care will be taken to assure that stones, mud, and dirt are not entrapped in the geotextile and geonet during placement and seaming operations.

Cutting and trimming of product placed on top of the liner must be done with hooked blade knifes.

4.2.C Geosynthetic Clay Liner (GCL) Placement

The geosynthetic clay liner must be installed in general accordance with the manufacturer's specifications and in such a way as to prevent any damage to the GCL.

One method of installing a GCL is to utilize a piece of equipment such as a front-end loader or forklift that is capable of lifting the GCL. A spreader bar is attached to the lifting equipment, and a core bar is installed through the GCL core. Straps or other types of attachments are looped over the core bar and the spreader bar. The equipment then lifts the GCL above the subgrade soils and while backing away from the initial starting point unrolls the GCL roll. This method can be used to install a membrane-backed GCL with the bentonite side up or side down.

For GCLs with a geomembrane backing, an alternate method for installing the GCL with the membrane facing against the soil is to attach a ten foot (10') long bar clamp to the end of the roll. The upper clamp has a chain attachment that can easily fit over a trailer hitch that is on a truck or other type of equipment. The GCL is then pulled across the subgrade soils. If the membrane is textured, then rub sheets should be used.

Folds in the GCL must be "stretched out" prior to installation of any overlying geosynthetics or soils. If these folds cannot be removed by realignment of the GCL, then these folds must be "cut" from the GCL and patched according to the manufacturer's specifications.

4.3 Geosynthetic Seaming and Joining

4.3.A Geomembrane Seaming

See Section 6 for more guidance.

4.3.A.1 Seam Layout

Seams will be made by overlapping adjacent sheets approximately three inches (3") (2.5 cm) for extrusion welding and approximately four inches (4") (10 cm) for hot wedge welding.

In general, seams should be oriented parallel to the line of maximum slope; i.e., oriented along and not across the slope. For corners and odd-shaped geometric locations, the number of seams should be minimized. Horizontal seams should be a minimum of five feet (5') from the toe of the slope, crest of berms, or areas of potential stress concentrations unless otherwise authorized. When full, a panel does not extend five feet (5') (1.5 cm) past the toe of slope. A cross seam may be welded provided the panel end is cut at an angle greater than forty-five degrees (45°).

A seam numbering system compatible with a panel numbering system will be agreed upon at the Pre-Construction Meeting.

4.3.A.2 Seaming Equipment and Products

The approved processes for field seaming are extrusion welding and hot wedge (fusion) welding. Proposed alternate processes will be documented and submitted to the owner or his representative for approval.

The extrusion welding apparatus will be equipped with gauges giving the temperature of the apparatus at the nozzle and extruder barrel.

The fusion welding apparatus must be an automated device that produces a double seam with an enclosed space or solid seam on thin mil material as specified.

The fusion welding apparatus will be equipped with gauges giving the applicable temperatures and speed settings.

The fusion welding apparatus will also be equipped with gauges giving the nip force on the knurled rollers and the supplied line voltage.

GLCC will verify that:

- Equipment used for seaming is not likely to damage geomembrane;
- The extrusion welder is purged before starting a seam until all heat-degraded extrudate has been removed from the barrel;
- The electric generator if utilized is placed on a smooth base such that no damage occurs to the geomembrane;
- Buffing the geomembrane to remove waxes and oxides will be completed no more than one hour before extrusion welding (buffing is not necessary for hot wedge welding); and
- An insulating plate or fabric is placed beneath the hot welding apparatus.

4.3.A.3 Seam Preparation

GLCC will verify that:

- Before seaming, the area is clean and free of moisture, dust, dirt, and foreign material of any kind;
- Seams are aligned with the fewest possible number of wrinkles and "fishmouths".

4.3.A.4 Seaming In Various Weather Conditions

The high temperature limit for welding is based on two factors: (1) The well-being of the crew. Black lining material will get very hot when exposed to sunlight. It is possible that the elevated sheet temperature in conjunction with immoderate ambient conditions could place the well-being of the crew at risk. (2) Material capability. The highest temperature at which the materials can be properly welded is dependent upon such things as ambient temperature, wind, subgrade conditions, exposure to sunlight, material type, and material thickness to name a few.

Thinner materials and low density products are the most difficult to seam at high liner temperatures. The problem typically is characterized by frequent burnouts (places in the

weld where the rollers lose traction and the machine stops moving causing the wedge to burn through the liner). The number of burnouts can often be reduced by increasing the speed and/or decreasing the wedge temperature until a quality weld with a minimum number of burnouts is attained. The sheet temperature may reach a point at which the supervisor determines there are an excessive number of burnouts at which time the supervisor will order welding to stop.

In some areas of extreme temperature conditions, the supervisor may determine it would be more advantageous to work at night under artificial light, or split the work day to utilize the cooler morning and late evening hours.

The lowest allowable temperature at which welding may be permitted is also dependent upon conditions such as ambient temperature, wind, subgrade conditions, exposure to sunlight, material type, and material thickness. Typically cold weather welding may proceed by reducing welding speeds and/or increasing wedge temperature. Pre-heating the sheet in advance of the welding apparatus may also be done by using a hot air blower. When fusion welding preheat can be accomplished by installing a heater mounted ahead of the hot wedge so that the hot air will be directed between the sheets in the overlap. If the welder mounted blower is to be used as a preheater, the welder control box can no longer be used as a power source for the blower. It is necessary to use a separate power cord.

Whenever temperatures become cold, increased attention should be given to pre-weld destructive samples (Section 4.3.A.5). In cold conditions it is even more critical that these trial welds be performed under the same conditions that will be seen during actual seaming. Quite often a technician will dry the material with a hot air blower before making a trial weld. This may significantly increase the sheet temperature and skew the results of the test. Also, if welding takes place on a frozen subgrade, the trial seams must also be done on frozen subgrade.

The lowest temperature at which welding may take place is the lowest temperature at which consistent passing trial seams can be performed under actual seaming conditions. In order to obtain passing results, it may be necessary to preheat the sheet in advance of the welder and/or shield the welding apparatus and the seaming area from wind.

In all cases, the geomembrane will be dry and protected from wind.

GLCC will verify that these adjustments for various weather conditions are fulfilled and will advise the project manager if they are not. The project manager will then decide if the installation will be stopped or postponed.

4.3.A.5 Trial Seams

Trial seams will be made on fragments of geomembrane liner to verify that seaming equipment and conditions are adequate. Such trial seams will be made at the beginning of each seaming period (start of day, midday, and anytime equipment is turned off and allowed to cool down) for each seaming apparatus used. Trial seams will be made under the same conditions as actual seaming process.

The trial seam sample will be approximately three feet long by one foot wide (3' x 1') wide (1.0 m x 0.3m) for extrusion and six feet long by one foot wide (6' x 1') (2.0 m x 0.3 m) for hot wedge welds with the seam centered lengthwise. Seam overlap will be nominally

three inches (3") (7.5 cm) for extrusion welds and four inches (4") (10 cm) for hot wedge welds.

Two adjoining specimens, each one inch (1") (2.5 cm) wide, will be cut from the trial seam sample by the installer. The specimens will be tested respectively in shear and peel using a field tensiometer, and they should not fail in the seam. If a specimen fails, the entire operation will be repeated. If the additional specimen fails, the seaming apparatus and procedures will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful trial welds are achieved.

4.3.A.6 Seaming Procedure

Unless otherwise specified, the general seaming procedure used by GLCC will be as follows:

- The rolls of membrane will be overlapped by approximately four inches (4") (10 mm) for fusion welding and approximately three inches (3") (7.5 cm) for extrusion welding. Seam strength is not a function of the overlap. The overlap simply needs to be wide enough to weld and test properly.

- "Fishmouths", or wrinkles at the seam overlaps, will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut "fishmouths" or wrinkles will be seamed and any portion where the overlap is inadequate will be repaired in accordance with the repair procedures described in Section 4.4.A.

- Seaming will extend along panel edges into the anchor trench.

- For hot wedge welding on damp or muddy subgrade, a movable protective layer of plastic may be required to be placed directly below the overlapped membranes being seamed. This is to prevent any moisture buildup between the sheets to be welded and/or to provide a more stable base on which the wedge welding device can travel.

4.3.A.7 Non-destructive Seam Testing

GLCC will non-destructively test all field seams over their full length using a vacuum test unit, air pressure testing, or other approved methods where applicable. The purpose of non-destructive tests is to check the seams for leaks. It does not provide information on seam strength or quality of bonding. Non-destructive testing will be carried out as the seaming progresses, not at the completion of a job.

4.3.A.7.1 Vacuum Testing

The equipment will be comprised of the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a gauge to indicate chamber vacuum;

- A steel vacuum tank and pump assembly equipped with a vacuum gauge and pipe connections;
- A rubber pressure/vacuum hose with fittings and connections;
- A bucket and wide brush, mop or spray assembly; and
- A soapy solution.

The following procedures will be followed:

- Energize the vacuum pump;
- Wet a strip of geomembrane approximately twelve inches by forty-eight inches (12" x 48") with the soapy solution;
- Place the box over the wet area;
- Close the bleed valve and open the vacuum valve;
- Ensure that a leak tight seal is created;
- For a period of approximately five (5) to ten (10) seconds, examine the geomembrane through the viewing window for the propagation of soap bubbles;
- After ten (10) to fifteen (15) seconds, close the vacuum valve and open the bleed valve, move the box over the adjoining area with a minimum three inches (3") overlap, and repeat the process;
- All areas where soap bubbles appear will be marked and repaired in accordance with Section 4.4; and
- Vacuum tested seams are recorded on Daily Progress Reports (see Exhibit 10.8 in Section 10.0).

4.3.A.7.2 Air Pressure Testing (For Double Hot Wedge Seam Only)

The equipment will be comprised of the following:

- An air pump (manual or motor driven) equipment with pressure gauge capable of generating a pressure between 25 and 40 psi (173 and 276 kPa);
- A rubber hose with fittings and connections; and

- Hollow needle and clamp assembly as shown in Figure 6.3, Section 6, or other approved pressure feed device.

The following procedures will be followed:

- Seal one end of the seam to be tested;
- Insert needle or other approved pressure feed device into the tunnel created by the fusion weld;
- Energize the air pump to a pressure between 25 and 40 psi (173 and 276 kPa), close valve, and hold pressure for approximately five minutes;
- If loss of pressure exceeds the values listed below, or does not stabilize, locate faulty area and repair in accordance with Section 4.4.A.
- Release air pressure by puncturing seam at opposite end of where pressure is applied to assure there is no blockage in the air channel and verify that the full seam has been pressurized;
- Remove needle or other approved pressure feed device and seal; and
- Pressure tested seams are recorded on Daily Progress Reports (see Exhibit 10.8 in Section 10.0).

PRESSURE TEST SPECIFICATIONS FOR DUAL TRACK HOT WEDGE WELDS IN HDPE AND VLDPE
Test Pressure (After 5 Min.) PSI (kPa)

Sheet Thickness	Min.	Max.	Pressure Drop Allowed
30 mil (.75 mm)	24 (166)	40 (276)	3 PSI (21 kPa)
40 mil (1.0 mm)	24 (166)	40 (276)	3 PSI (21 kPa)
60 mil (1.5 mm)	27 (186)	40 (276)	3 PSI (21 kPa)
80 mil (2.0 mm)	27 (186)	40 (176)	3 PSI (21 kPa)
100 mil (2.5 mm) & thicker	30 (207)	40 (276)	3 PSI (21 kPa)

4.3.A.7.3 Spark Testing Conductive Liner

Background

Spark testing was originally developed to inspect coatings on steel pipe. In this application, a high electrical potential (voltage) of negative polarity (ground) is applied to the metal pipe. A wand or brush of opposite positive polarity is passed over the coating and any voids in the coating establish electrical continuity and allow a spark to pass between the metal pipe and the wand.

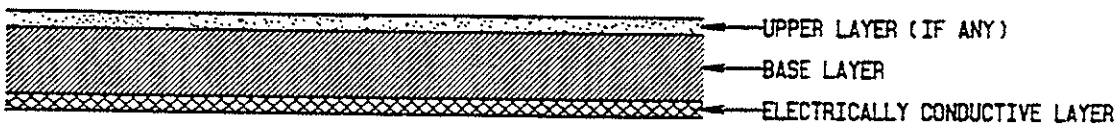
This same technology is now used to test synthetic liners for defects. Synthetic liners made of plastic materials such as high density polyethylene are nonconductors just as coatings on metal pipes. In order to spark test a synthetic liner, an electrically conductive material must be in "intimate contact" with the liner.

"Intimate contact" is critical for a valid test because air is also a good electrical insulator. Typically, 1,700 to 2,000 volts per millimeter is required to establish an electrical arc across a nonconductor. Therefore, to bridge a 1-inch air gap, a 35,000 to 50,000 volt potential would be required. To bridge a 4-inch air gap, 140,000 to 200,000 volts would be required.

If the conductive layer was the earth itself, wrinkles, bridged areas, or any condition separating the liner and the earth would invalidate the test.

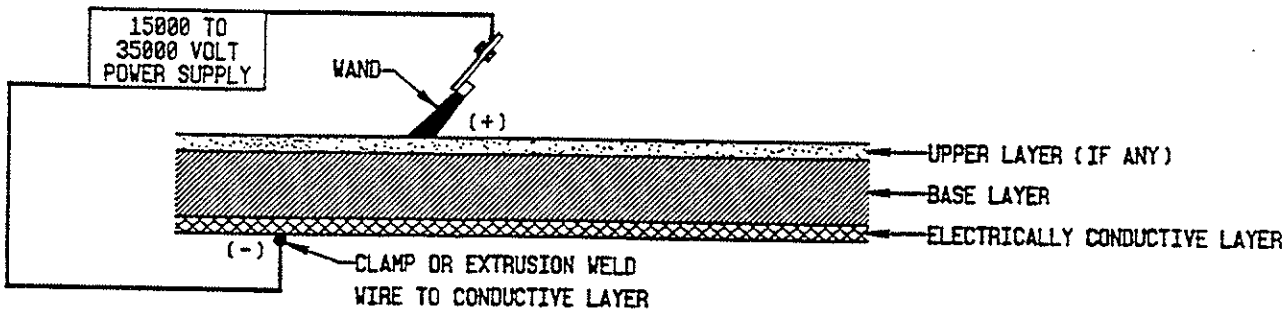
The Gundle Approach

Gundle has solved this problem by co-extruding a thin layer (minimum 2 mil) of liner material with elevated concentrations of high purity carbon black on one side of the liner. The special carbon black makes this layer electrically conductive and at the same time retains the performance characteristics of the base liner. Since the conductive layer is co-extruded, it is an integral part of the base liner and cannot be torn or damaged such that it fails to perform its basic duty. In cross-section the conductive liner is as shown below:

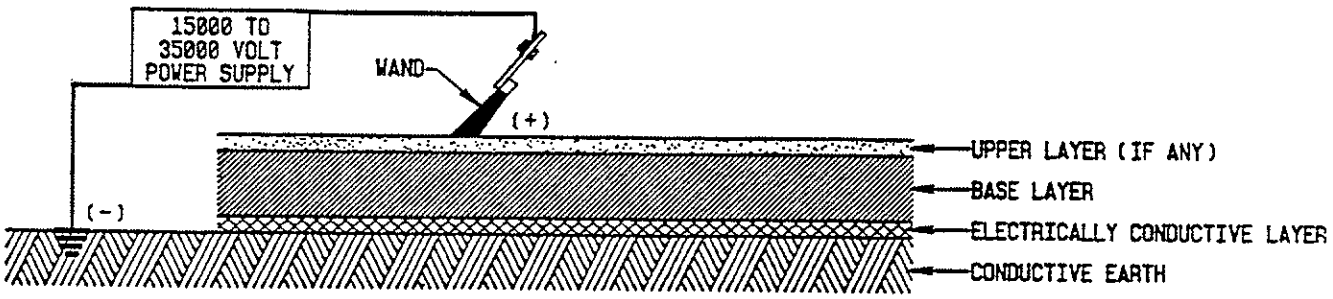


A high voltage potential (15,000 to 35,000 volts) source for spark testing can be connected to the liner in one of three ways.

1. Direct connection to the conductive layer:



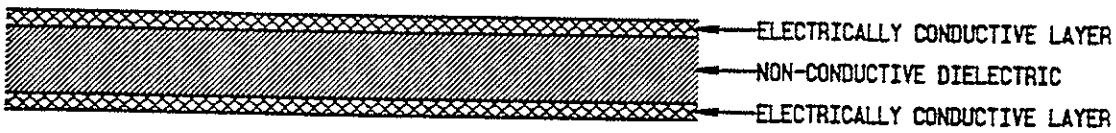
2. Through an Earth Ground:



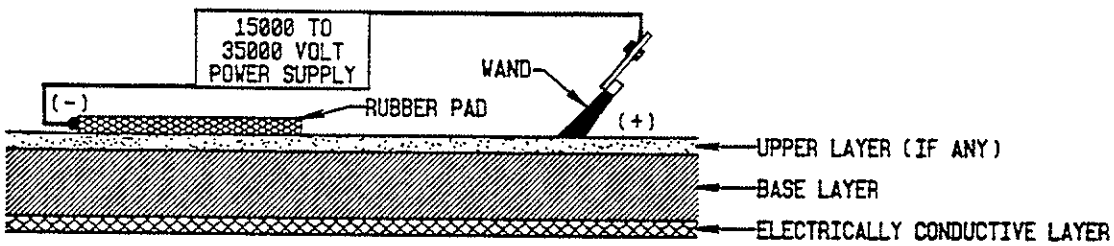
Both methods above require an electrical lead from the power supply to the wand, therefore, in a large lined area, thousands of feet of cable would be required which would in itself be cumbersome.

3. The Electrical Capacitance Effect: Gundle's Procedure with Co-extruded Conductive Layered Liner

It is possible to take advantage of the electrical property of capacitance and eliminate the long electrical lines. A capacitor is an electrical device in which two electrically conductive materials are separated by a dielectric (or non-conductive) material as shown below:



A capacitor will store an electrical charge in each conductive material when attached to a power source. We take advantage of electrical capacitance by placing an electrically conductive rubber pad on top of the liner and inducing a potential in the conductive layer of the co-extruded conductive liner through electromagnetic induction. The rubber pad moves with the test unit.



Once the conductive liner layer has been energized by one of the methods above, the wand is passed over the upper surface of the liner. Any defect or pinhole which penetrates the liner to the conductive layer will allow a spark to pass through the liner to the wand. This spark is clearly visible and triggers an audible alarm on the testing unit. Gundle uses both hand held units and ATV trailer mounted units to spark test 100% of the area lined with conductive layered geomembrane under observation by the owner's representative, repairing all holes detected per Section 4.4.

4.3.A.8 Destructive Testing

4.3.A.8.1 Introduction

Destructive testing of seams is important because it provides direct evaluation of seam strength and bonding efficiency which indicates seam durability.

Destructive testing involves two techniques: 1) shear testing, and 2) peel testing. Shear testing applies a tensile stress from the top sheet through the weld and into the bottom sheet. Peel testing, on the other hand, peels the top sheet back against the overlapped edge of the bottom sheet in order to observe how separation occurs. The peel test

indicates whether or not the sheets are continuously and homogeneously connected through the seam.

4.3.A.8.2 Location and Frequency

Destructive seam tests will be performed at randomly selected locations. The owner and/or owner's representative will select locations where destructive samples will be cut.

A frequency will be agreed upon by GLCC and the project manager at the Resolution and/or Pre-Construction Meeting. Unless otherwise specified, destructive samples should be pulled at intervals of one (1) sample for every 500 linear feet of weld.

The seaming technician will not be informed in advance of the locations where the seam samples will be taken.

4.3.A.8.3 Sampling Procedure

Samples will be cut by GLCC as seaming progresses. When cutting samples above an existing geomembrane, hook blade knives should be used.

A number shall be assigned to each sample which is to be based upon seam and sample number and mark it accordingly (see Exhibit 10.9 in Section 10.0, example of sample sticker);

Destructive sample locations will be recorded on daily report and on the as-built drawing; and

All holes in the geomembrane resulting from destructive seam sampling will be immediately repaired in accordance with repair procedures described in Section 4.4.

4.3.A.8.4 Size of Samples

At a given sampling location, two coupons for field testing should be taken. Each of the coupons will be one inch wide by twelve inches (1" x 12") (0.25m x 0.3m) long with the seam centered parallel to the length. The distance between these two (2) coupons will be 42 inches (107 cm).

If both coupons pass the field test described in Section 4.4.A.8.5, a sample will be cut between the two coupons. This sample will be cut into three (3) parts and distributed as follows:

- One portion to the Installer (GLCC) for testing, 18 inches x 12 inches (.45 m x .3 m);
- One portion for geosynthetic quality assurance laboratory testing if applicable, 12 inches x 12 inches (4.8 cm x 4.8 cm); and
- One portion to the owner for archive storage, 12 inches x 12 inches (4.8 cm x 4.8 cm).

Final determination of the sample sizes will be made at the Pre-Construction Meeting.

4.3.A.8.5 Field Testing

Electric or hand tensiometer destructive testing is to be carried out in the field. Testing procedure is as follows:

- Two (2) one inch (1") (2.5 cm) wide strips will be tested in the field for peel and shear and will not fail in the seam. If seam strengths are being evaluated, samples should be cut with a die to provide proper geometry.

- If any field test sample fails to pass, then the procedures outlined in 4.3.A.8.7 will be followed.

- If the initial sample coupon test passes with a Film Tearing Bond (FTB) (see Figures 6.6 and 6.7 in Section 6.0), the sample qualifies for further testing to obtain quantitative results per Table 4. If it fails, the seam should be repaired in accordance with Section 4.4.

4.3.A.8.6 Gundle Laboratory Test Procedures

Gundle standard testing procedure is as follows:

- If there is a failure in either peel or shear, then five (5) total coupons are tested. If more than one coupon fails, then the sample fails. This is a modified ASTM method. The ASTM method used is D4437.

- The Film Tear Bond (FTB) is very important (see Figures 6.6 and 6.7 in Section 6). With a fully integrated, continuous connection through the seam, no weld bead/sheet or sheet/sheet interface exists, and the specimen tears the sheet as it pulls apart (FTB). Such an interface might eventually be separated by absorbed chemicals, causing failure of the seam.

- In addition to the FTB criterion, a minimum stress level is specified. This is important in order to protect against FTB tearing of a thin portion of polymer in the weld (as might occur if the weld is off center).

- The minimum stress levels are necessarily lower than tensile yield strengths of the parent sheet because of the different configuration of the test specimens during destructive testing. Bending moments come into play along with tensile stresses, especially as the sheets are bent back in peel. These bending moments depend on the shape of the welds which vary even within the same welding technique. The minimum stress values are based on the averaged performance values of passed weld specimens tested in the laboratory.

Table 4

SPECIFICATION FOR SEAM STRENGTH
(Meets NSF 54 - 1993 Standards)

Type of Material	No. of Coupons		Minimum Values Required ppi (N/cm)			
	Peel	Shear	Peel Extrusion	Peel Fusion	Shear Extrusion	Shear Fusion
HDPE						
30 Mil (0.75 mm)	2	1	35 (61)	49 (86)	63 (110)	63 (110)
40 Mil (1.0 mm)	2	1	48 (84)	67 (117)	86 (151)	86 (151)
60 Mil (1.5 mm)	2	1	70 (123)	98 (172)	126 (221)	126 (221)
80 Mil (2.0 mm)	2	1	92 (161)	130 (228)	166 (291)	166 (291)
100 Mil (2.5 mm)	2	1	115 (201)	143 (250)	207 (362)	207 (362)
HDT						
40 Mil (1.0 mm)	2	1	42 (74)	60 (105)	76 (133)	76 (133)
60 Mil (1.5 mm)	2	1	63 (110)	88 (154)	113 (198)	113 (198)
80 Mil (2.0 mm)	2	1	84 (147)	118 (207)	151 (264)	151 (264)
100 Mil (2.5 mm)	2	1	105 (184)	143 (250)	189 (331)	189 (331)
VLDPE						
30 Mil (0.75 mm)	2	1	30 (53)	30 (53)	33 (58)	33 (58)
40 Mil (1.0 mm)	2	1	40 (70)	40 (70)	44 (77)	44 (77)
60 Mil (1.5 mm)	2	1	60 (105)	60 (105)	66 (116)	66 (116)
80 Mil (2.0 mm)	2	1	72 (126)	72 (126)	80 (140)	80 (140)
100 Mil (2.5 mm)	2	1	88 (154)	88 (154)	100 (175)	100 (175)
VLT						
40 Mil (1.0 mm)	2	1	40 (70)	40 (70)	44 (77)	44 (77)
60 Mil (1.5 mm)	2	1	60 (105)	60 (105)	66 (116)	66 (116)
HD/VL/HD						
30 Mil (.75 mm)	2	1	30 (53)	30 (53)	33 (58)	33 (58)
40 MIL (1.0 mm)	2	1	40 (70)	40 (70)	44 (77)	44 (77)
60 Mil (1.5 mm)	2	1	60 (105)	60 (105)	66 (116)	66 (116)
80 Mil (2.0 mm)	2	1	72 (126)	72 (126)	80 (140)	80 (140)
HDT/VL/HDT						
30 Mil (.75 mm)	2	1	30 (53)	30 (53)	33 (58)	33 (58)
40 MIL (1.0 mm)	2	1	40 (70)	40 (70)	44 (77)	44 (77)
60 Mil (1.5 mm)	2	1	60 (105)	60 (105)	66 (116)	66 (116)
80 Mil (2.0 mm)	2	1	72 (126)	72 (126)	80 (140)	80 (140)

4.3.A.8.7 Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test. GLCC has two options:

1. Reconstruct the seam between any two passed destructive test locations.

2. Trace the welding path to an intermediate location ten feet (10') (3 m) minimum from the point of the failed test in each direction and take a small sample coupon for an additional field test at each location. If these additional samples pass the field test, then full samples are taken. If these samples pass the tests, then the seam is

reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

All acceptable seams must be bounded by two (2) locations from which samples passing destructive tests have been taken.

GLCC will document all actions taken in conjunction with destructive test failures; e.g., capping of failed seam area.

4.3.B Geotextiles, Geonets and Fabri-Net® Joining

4.3.B.1 Geotextiles

Geotextiles may be installed by overlapping, by thermally bonding on a spot or continuous basis, or by sewing as specifications dictate.

If sewing is required, the thread used will be a polymeric material with chemical resistance similar to the geotextile.

4.3.B.2 Geonets

Geonets may be butt joined or lapped if specified. Nylon/plastic cable ties will be applied to the net edge at five foot (5') (1.5 m) intervals along the edge.

End splices will be made as follows: On slopes, the ends will overlap two feet (2') (0.6 m) with uphill panels on top and two (2) rows of cable ties applied. In flat areas, the ends will overlap a minimum of two inches (2") (50 mm) and one row of three (3) cable ties applied.

4.3.B.3 Fabri-Net®

Geocomposites can be overlapped with the net portion tied and and the geotextile portion thermally bonded or seamed as required by the project specifications.

4.3.C Geosynthetic Clay Liner (GCL) Joining

Seaming of GCLs is achieved by simply overlapping the GCL panels. Care must be taken in order to determine if any loose bentonite should be spread between the overlap. When placing a GCL with a membrane backing with the bentonite side down, it is necessary to place tape along the seam in order to prevent intrusion of overlying cover soils into the overlap. Alternately, the geomembrane backing can be welded in accordance with the membrane and GCL manufacturer specifications.

4.4 Geosynthetic Repair Procedures

4.4.A Defects and Repairs of Geomembranes

4.4.A.1 Identification

All seams and non-seam areas of the geomembrane will be examined by GLCC for identification of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

Defective/damaged materials will be identified via a deficiency report, either separately or on the Daily Progress Report. Actions taken to resolve or correct the problem will also be recorded on a similar form.

Defects, holes, blisters, undispersed raw materials, signs of contamination by foreign matter, unacceptable welds in geomembranes, and other unsatisfactory conditions will be identified. The repair/corrective action to repair the area will be recorded.

Work will not proceed with any materials which will cover these areas until they are repaired in accordance with Section 4.4.A.3.

4.4.A.2 Repair Procedures

Any portion of the geomembrane failing a destructive or non-destructive test will be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be agreed upon between the project manager and GLCC. The procedures available include:

- Patching - used to repair large holes, tears, and contamination by foreign matter;
- Buffing and re-welding - used to repair small sections of extruded seams;
- Spot welding or seaming - used to repair pinholes, or other minor localized flaws;
- Capping - used to repair large lengths of failed seams; and
- Topping - used to repair areas of inadequate seams which have an exposed edge;

In addition, the following provisions will be satisfied:

- Surfaces of the geomembrane which are to be repaired will be abraded no more than one hour prior to the repair;
- All surfaces must be clean and dry at the time of the repair;
- All seaming equipment used in repair procedures must be approved;
- The repair procedures, materials, and techniques will be approved in advance of the specific repair by the project manager and GLCC; and
- Patches or caps will extend at least six inches (6") (15 cm) beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least three inches (3") (8 cm).

4.4.A.3 Repair - Non-destructive Testing

Each repair will be non-destructively tested using the methods described in Section 4.4 as appropriate. Repairs which pass the non-destructive test will be taken as an indication of an adequate repair. Failed tests indicate that the repair will be redone and re-tested until a passing test result is obtained.

4.4.B Geotextile, Geonets and Fabri-Net® Repairs

Any holes, tears, or burn throughs from thermal seaming in geotextiles will be repaired by patching with the same geotextile. The patch will be a minimum of twelve inches (12") (30 cm) larger in all directions than the area to be repaired and will be spot bonded thermally.

Any holes or tears in geonets will be repaired by patching with the same geonet. The patch will be a minimum of twelve inches (12") (30 cm) larger in all directions than the area to be repaired. The patch will be tied in place using a minimum of four (4) nylon cable ties.

4.4.C Geosynthetic Clay Liner (GCL) Repair Procedures

GCLs will be inspected for cuts, tears, or areas of bentonite loss.

The area to be repaired (patched) must be free of contamination by foreign matter. Patches must have a twelve inch (12") (30 cm) overlap around the damaged area. For fabric-encased GCLs, the patch is to be tucked into place with excess bentonite poured over the overlap. Simple overlapping of hte patch is sufficient for geomembrane backed GCLs. However, temporary attachment of patches is required to ensure that the patch is not dislodged by covering with a geomembrane or soil.

4.5 Backfilling of Anchor Trench

The anchor trench, if any, will be adequately drained by owner/earthwork contractor to prevent ponding or softening of the adjacent soils while the trench is open. The anchor trench will be backfilled by the earthwork contractor or as outlined in the specifications and bid documents.

Since backfilling the anchor trench can affect material bridging at toe of slope, consideration should be given to backfilling the liner at its most contracted state; preferably during the cool
of the morning or extended period of overcast skies. Care will be taken when backfilling the trenches to prevent any damage to the geosynthetics.

4.6 Lining System Acceptance

The geosynthetic lining system will be accepted when:

- The installation of all materials are deployed and welded; and
- Verification of the adequacy of all seams and repairs including associated testing is complete.

4.7 Soils in Contact with the Geosynthetics

Important points for quality assurance of soils in contact with geomembranes include:

- A geotextile or other cushion approved by the designer may be installed between angular aggregate and the geomembrane.

- Equipment used for placing soil will not be driven directly on the geomembrane.

- A minimum thickness of one foot (1') (0.3 m) of soil is recommended between a light dozer (such as a CAT D-3 or wide track caterpillar D-6 or lighter) and the geomembrane.

- In areas of heavy traffic such as access ramps, soil thickness should be at least two (2) to three (3) feet (0.6-0.9 m).

Soil/Earth Cover on Top of Geomembrane

Placement of soil (sand or other types of earth) cover on top of the liner will not be performed until all destructive and non-destructive testing has been performed and accepted.

Placement should be performed to minimize wrinkles. Equipment operators should be briefed on method and timing of soil placement to deal with thermal expansion and contraction of the liner. Soil placement during cooler parts of the day minimizes wrinkle problems.

Material placed on top of the liner should be back-dumped on liner and, in order to avoid the formation of wrinkles, efforts should be made to load the soil so that it comes down on top of the liner rather than being pushed across the sheet. This is done by 1) using a front-end loader to place soil ahead of spreading soil cover, and 2) spreading soil by building a mound at the edge of soil, then pushing soil up and over the mound causing it to come down on the liner.

If a wrinkle forms, every effort should be made to walk the wrinkle out.

Minor folding over of wrinkles is acceptable providing an even transition occurs at the tail of the wrinkle. If excessive stress points are created at the tail of the wrinkle, the wrinkle should be cut out and repaired per Section 4.4.

5.0 Engineered Applications

5.0 ENGINEERED APPLICATIONS

PREFACE

Geomembranes, together with the geosynthetic industry as a whole, have made tremendous strides in terms of technological progress and wide acceptance from federal and state regulators. Their popularity now extends far beyond the traditional uses in landfills, ponds, and leach pads.

Geomembranes are now a common construction material, both for new facilities and the repair or upgrading of existing ones, in the following additional applications:

- Tank Linings (both secondary and primary containment)
- Floating Covers
- Vertical Cutoff Walls
- Tunnel Linings
- Dam Facings
- Foundation Liners
- Sump Liners
- Canals and Raceways

To provide the complete service our company is known for, Gundle has segmented the more nontraditional lining construction applications into an area we call Engineered Applications. These applications are governed by the criteria and standards set forth in this manual, but generally involve a more complicated installation and make use of the special construction methods and testing procedures described in this section.

5.1 Tank Linings

5.1.A Vacuum Testing

5.1.A.1 Foreword

Pulling a vacuum from tank structures lined with synthetic liner can assure a tight fit of the installed material and provide a means to check for leaks in areas inaccessible to conventional vacuum boxes.

When an excessive gap between liner and subgrade is present ("bridging"), hydrostatic pressure (during tank use) can induce a proportional amount of stress on the seams adjacent to the bridging point and possibly lead to failure. Pulling a vacuum will identify these areas and remedial work can be pursued.

Equipment required:

1. Adapter connecting the vacuum hose and liner;

2. Vacuum truck or portable pump with hoses;

3. Sound detection device; and

4. Soap solution.

5.1.A.2 Procedure

Install the adapter in a manner to create a tight seal with the liner. A vacuum is pulled with either a vacuum truck or portable pump until all air behind the liner has been removed (expelled) or when a tight fit has been achieved. The length of time and amount of vacuum pulled will depend on the type of material, vacuum equipment, size and condition of lined surface, and seal around the liner perimeter. Once a sufficient vacuum is achieved, areas with excessive bridging can be marked for future repair and panels and seams can be checked for leaks using a directional microphone (sound detection device) and/or a soap solution.

Additionally, hard to reach corners or other areas are tested for leaks by the use of a sound detection device or by soaping. After areas requiring remedial work have been identified, the vacuum apparatus is turned off and the liner is relieved of any pressure. Then appropriate repairs are made. The test is now complete. The hole on the liner left after removal of the adapter shall be patched and tested with a vacuum view box.

5.1.B Spark Testing

(For Tanks Using Conductive Liner as Primary or Secondary Containment)

Spark testing of electrically conductive geomembrane can provide a method to test the entire lined installation for defects. The seams, panels, and complex configurations (i.e., corners, pipe boots) which are difficult to test non-destructively can also be tested with this system.

Spark testing is described in Section 4.3.A.7.3.

Damage leading to leaks in complex installations can easily be overlooked. Spark testing, however, can detect these areas immediately and prevent costly subsequent repairs. Repeat testing year after year can be performed to confirm continual leak-free performance if desired.

5.2 Floating Covers

Floating covers are primarily used for waste water lagoons, anaerobic digesters, and potable water reservoirs. The construction can be done under dry (empty) or wet (full impoundment) conditions.

A dry condition will follow the same installation and quality control guidelines as described elsewhere in this manual and as is done for standard pond installations. When the cover is constructed dry over an impermeable liner, pulling a vacuum, as described in Section 5.1.A, can be employed after the standard methods of non-destructive testing (i.e., air pressure and vacuum testing) are completed. Another method that can be used in lieu of or in addition to pulling a vacuum is partial flooding of the impoundment. Remedial work can then be started.

Installation under wet conditions, on the other hand, is accomplished by constructing a barge especially designed to accommodate liner construction over the liquid surface to be covered. The entire process, from deployment to quality control and seam testing per Sections 4.3.A.7 and 4.3.A.8, is accomplished for each geomembrane panel before the barge/platform is moved to the next area to be deployed. The barge can only move in the direction of not-yet-covered liquid surface and cannot go back to an area already enclosed. Once the area has been completely covered, the barge is removed and the final closure of the system can take place.

5.3 Quality Control Test For Fabricated Boots (See Drawing)

"Boots" are comprised of "skirt" and "sleeve" of synthetic liner welded together on both sides of the skirt (see drawing).

Procedure A - Water Submersion Test

The sleeve is extended initially by one foot (1') (0.3 m) so that the sleeve can be welded shut for pressurizing in the test. The boot is then clamped around the skirt with batten strips to polyethylene sheet pressurized with air and submerged under water. If no leak is indicated by air bubbles in the water, the boot is removed and marked TESTED/PASSED. After successful testing, the clamps are released and the sleeve is reopened by cutting off the extra one foot (1') (0.3 m) section.

If the boot does not pass, the area of leakage is marked, repaired with heat seaming, and retested in the same manner.

Procedure B - Electrical Spark Test

Alternatively, all seams are provided with copper wires properly embedded in the seam and grounded. A high-voltage (15-30 kv) electrical current is then applied to the wire area using a high voltage detector (similar to Tinker and Razor Holiday Detector, Model AP-W), and any leakage to ground is detected by sparking.

5.4 Vertical Cutoff Wall (Gundwall®)

5.4.A Project Conditions

The work site is to be clear of all surface debris and obstacles which may interfere with the installation of the barrier.

All overhead obstacles up to a height of sixty feet (60') (18 m) must be removed or relocated in a timely manner so as not to delay the progress of the installation.

All underground utilities and other obstacles shall be located and their position marked along the path of the installation with three foot (3') (1 m) stakes. In addition, the installer will be supplied with three (3) sets of detailed drawings showing the location, type, and depth of each obstruction.

If the location of utilities is unknown or uncertain, then a backhoe will be used to excavate an exploratory trench along the path of installation. The trench will be excavated to a depth of no less than ten feet (10') (3 m) and suitable precautions taken to prevent damage to any utilities encountered.

When installing panels in an open trench, the trench will not have any protrusion from the trench walls which could damage the panels or inhibit installation.

5.4.B Installation Procedure

5.4.B.1 Preliminary Considerations

Gundle shall fabricate the barrier panels to the desired lengths in the factory or designated fabrication facility. Sheet panels, interlock sections, and bottom anchors will be assembled using either wedge or extrusion welding.

Additional materials for the manufacturing of closure panels and the repair of damaged sections will be available for field use.

The Gundle Supervisor will walk the installation path with the engineer or his representative prior to beginning any work. Starting and stopping points, utility locations, and overhead obstructions will be discussed and checked against the drawings.

5.4.B.2 Vibratory Installation Procedures

The installation mast designed by Geotechnics America, Inc. and Gundle Lining Construction Corp or any other system acceptable to the architect/engineer will be utilized for the installation of each panel.

The initial panel is to be installed with the male section of the panel interlock oriented in the direction of installation.

The interlock seal will be fed into the female section as each panel is installed. The seal will be monitored during installation to ensure that it is being fed into the lock at the same rate as the panel installation. If the progress of the seal comes to a halt during the installation and the seal cannot be restarted, then the panel being installed will be removed and the seal replaced. Installation can then continue as before. If during an insertion the plate comes to a complete halt prior to reaching the installation depth, then the plate will be withdrawn and a trench excavated along the path of installation to ascertain the nature and extent of the obstruction. If the obstruction is removed, the excavation will be back-filled and the installation continued. If the obstruction is not removed, the installation plan will be modified as approved by the architect/engineer.

5.4.C Destructive Testing of Panel Interlocks

5.4.C.1 Introduction

Destructive peel and shear tests will be performed on the membrane/interlock interface (see Section 4.3.A.8). The purpose of these tests is to check that welds are fully integrated with each other and to evaluate seam strength. Seam strength testing will be done as work progresses, not at the completion of all fabricated panels.

5.4.C.2 Frequency

Destructive samples will be taken at intervals of one sample for each side of the Gundwall® panel (male and female) for every 1,000 linear feet (1,000') (300 m) (or less) of weld.

5.4.C.3 Sampling Procedure

Samples will be cut by Gundle Fabrication as the seaming progresses. Gundle Fabrication will:

Cut samples; and

Assign a number to each sample which is to be based upon panel number.

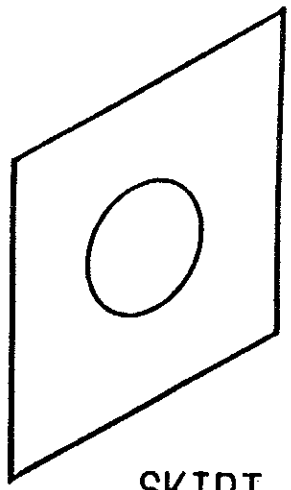
5.4.C.4 Sample Size and Testing

At a given sampling location, two (2) samples from each side (male and female) of the panel will be taken.

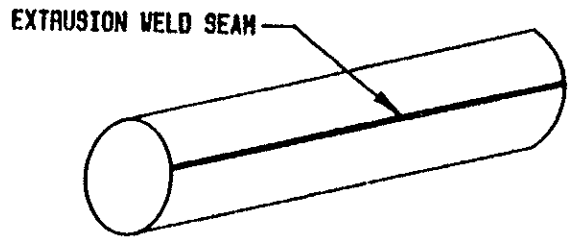
Both samples are destructively tested and will pass according to the values provided in Section 4.3.A.6. If any samples fail to pass, the panel will be refused.

Destructive test samples at Gundle's Fabrication Facility will be delivered to Gundle's Laboratory.

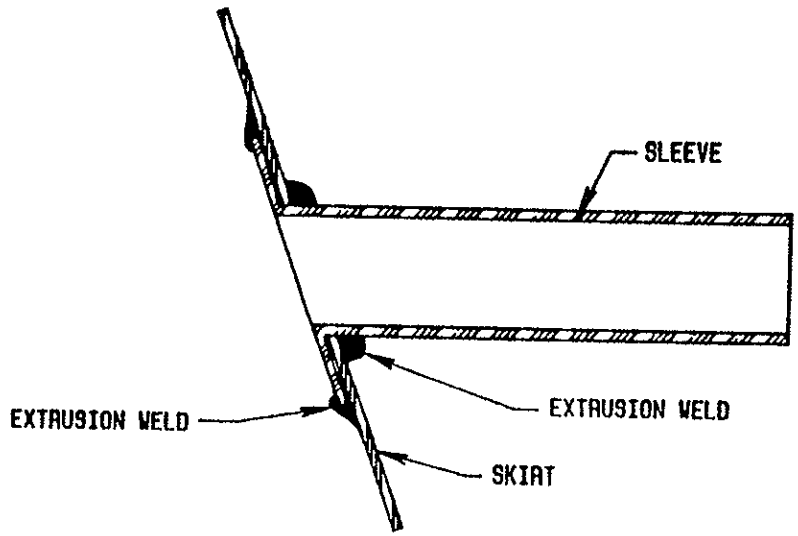
Gundle's Laboratory will provide verbal results no more than 24 hours after they receive the samples. Written results will follow within one week.



SKIRT



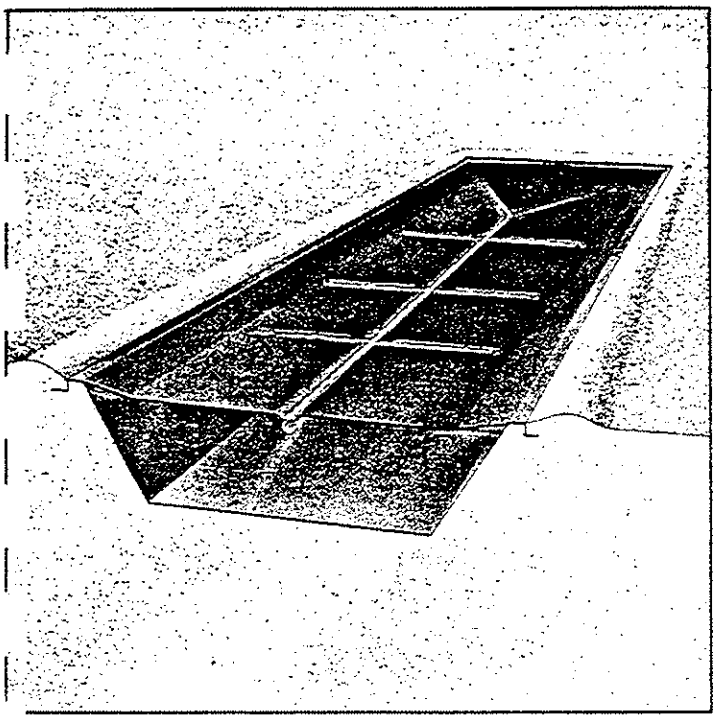
SLEEVE



PREFABRICATED HDPE BOOT

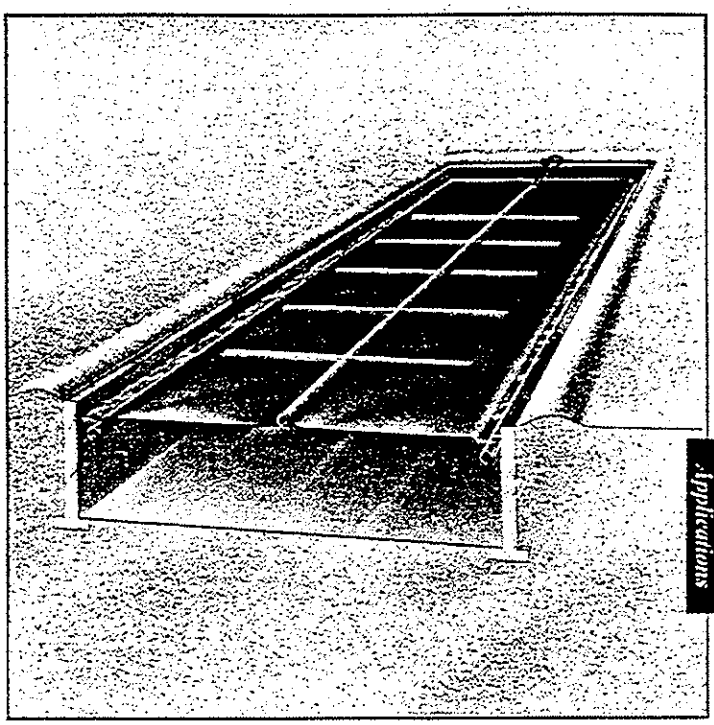
DRAWING #1:

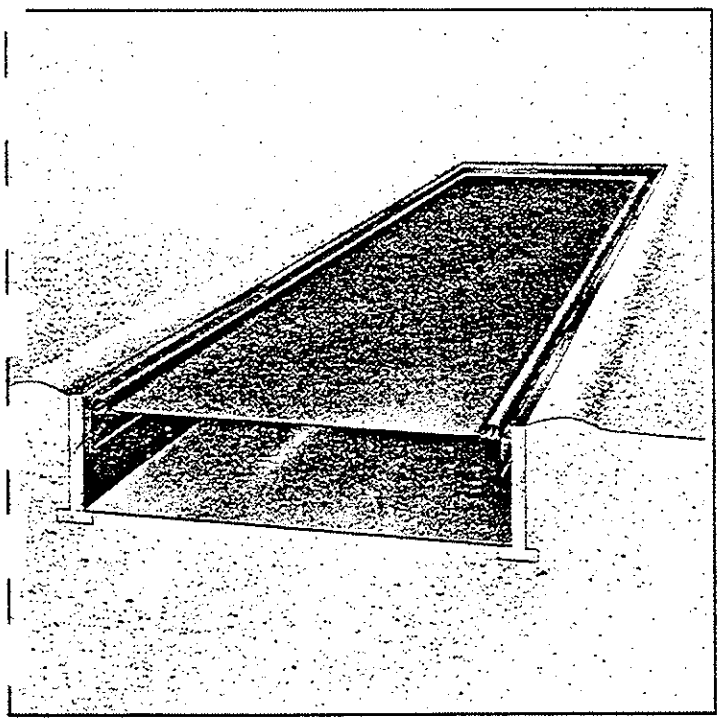
This design provides for quick, cost effective construction and is suitable for both potable water and anaerobic waste reservoirs. It is most applicable for shallow earthen lagoons.



DRAWING #2:

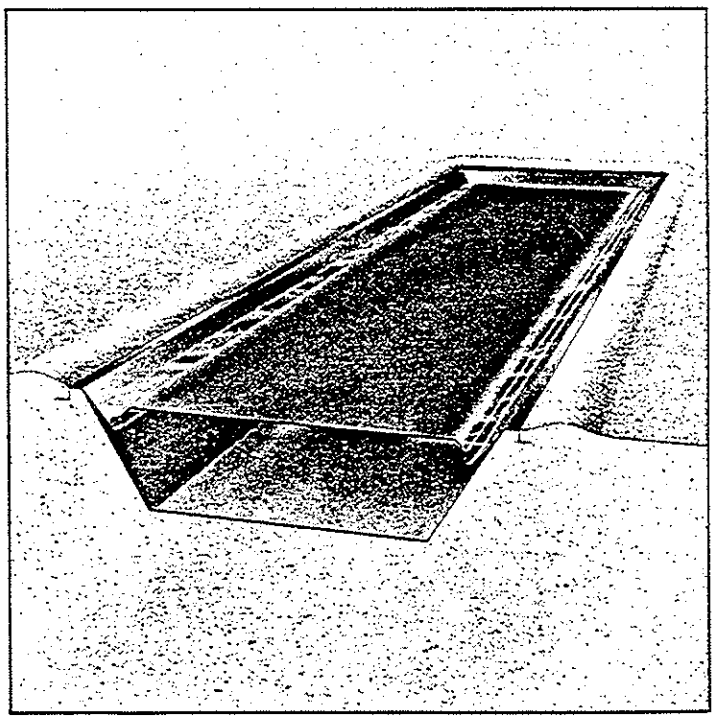
This cover design is most suitable for large reservoirs used for either anaerobic digestion or potable water storage. The design allows for the efficient removal of stormwater and, with modifications, gas collection if necessary.





DRAWING #3:

The system above is strictly applicable for anaerobic waste lagoons with vertical walls. This cover allows for efficient gas extraction and is capable of being insulated.

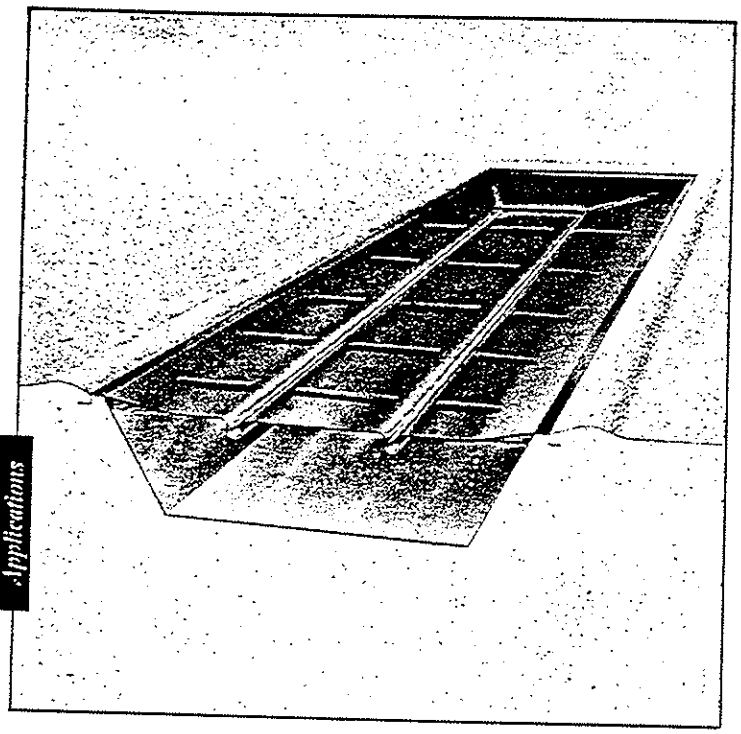


DRAWING #4:

This system is applicable for potable water reservoirs, prevention of algae blooms and odor control. This cover is easily constructed and cost effective.

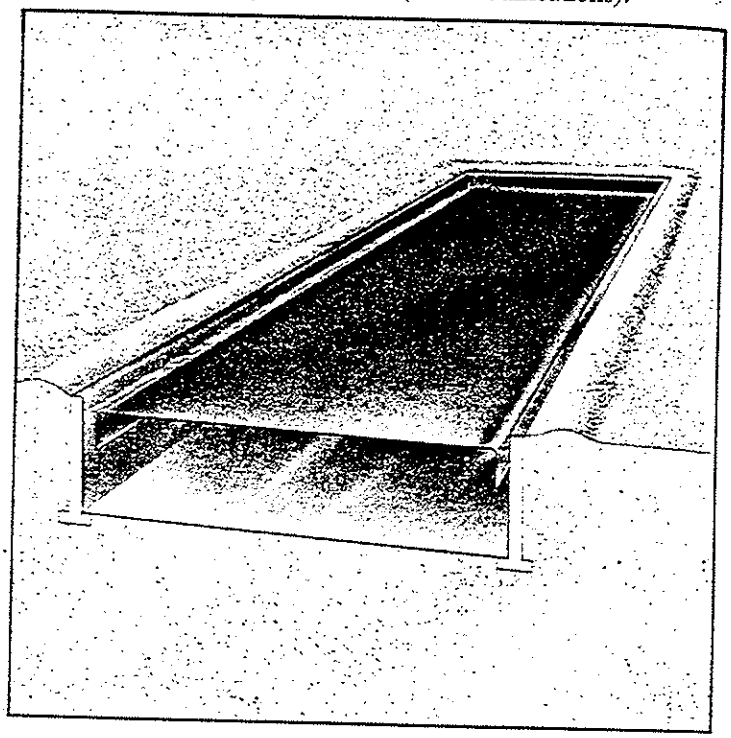
DRAWING #5:

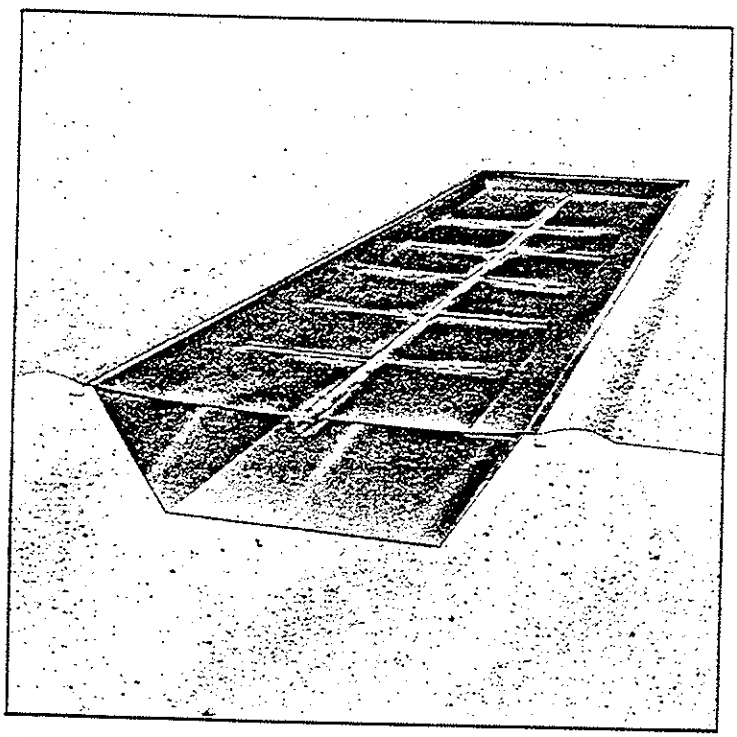
This is a totally sealed potable water cover that is best suited for large, deep reservoirs with steep slopes. This system is both cost effective and easy to construct.



DRAWING #6:

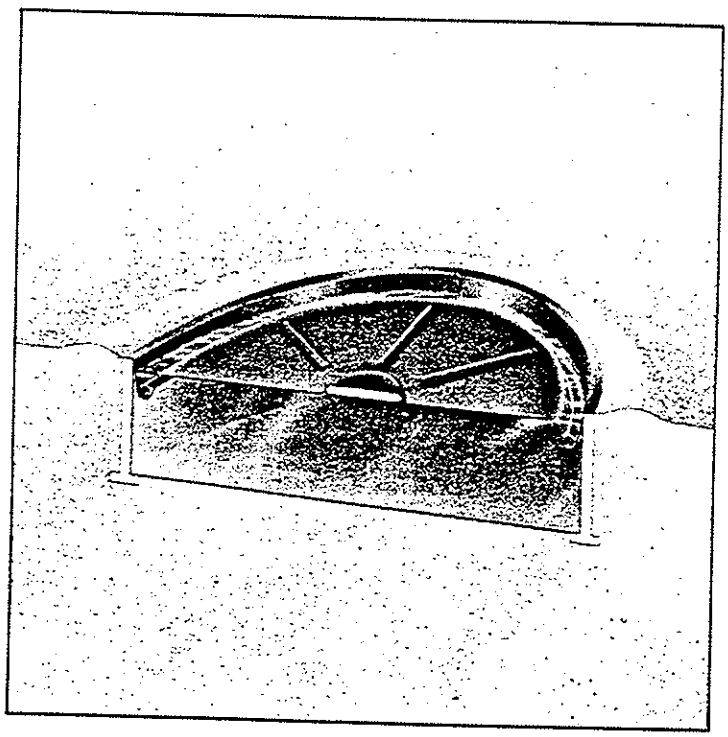
This design is most applicable for small lagoons with vertical walls. The system is efficient for either algae bloom prevention, odor control or gas collection (with modifications).





DRAWING #7:

The above design is similar to Drawing #1, but is typically used in deeper lagoons with steeper slopes. This cover allows for efficient stormwater removal and gas collection.

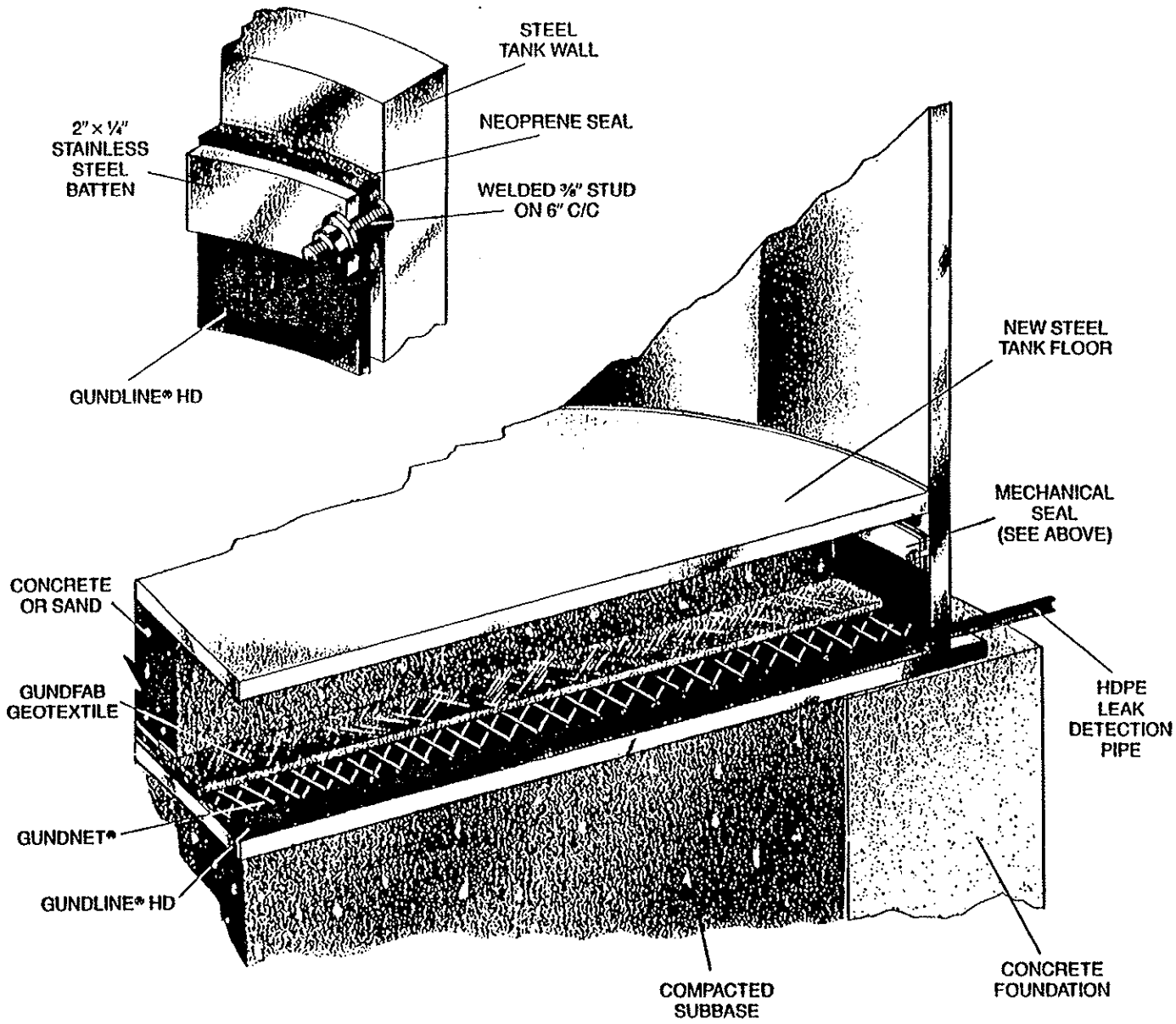


DRAWING #8:

Shown here is a design strictly used for potable water reservoirs. This cover configuration can be easily suspended for internal maintenance.

DR[illegible]NG [illegible] TAN[illegible] EAK [illegible]EC[illegible] LIN[illegible] RET[illegible]IT [illegible] KIST[illegible] ST[illegible] TAN[illegible]

Sh[illegible]n th[illegible] [illegible]ail d[illegible] g is a cross-section of the floor for a steel tank which has been retrofitted with a leak detection system and a new tank bottom. Typically, the tank is cleaned and a liner is installed over the entire floor area. At the vertical facing, the liner is mechanically attached with a stud and batten strip system that provides a hydraulically secure seal. The HDPE leak detection pipe system is installed in pre-drilled holes on approximately 50' centers around the perimeter of the tank. A composite of Gundnet®/ Gundfab liquid transmission flow zone is then installed on top of the liner. This system is capable of transmitting ten gallons per minute of liquid across each foot of the composite to the detection pipe in the event of a leak. Either a weak mix of concrete or a permeable fill is then installed over the liquid transmission system and a new floor is welded in place. Enlarged for quick reference is the mechanical seal showing the welded stud and stainless steel batten attachment.



Drawing #4 in a series of 8 drawings.

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5.0 Engineered Applications

SYSTEM A: System A depicts a typical "hit anchor" mechanical attachment system in which a 2" by ⅛" 304 stainless steel or other metal batten strip and a ¼" × 2" neoprene strip is affixed to the wall on 12" centers. This method sets a bolt through the steel and into the concrete by drilling and hammering, securing the liner-batten system to the concrete. Advantages of this system include its quick placement and cost effectiveness.

SYSTEM B: System B depicts a typical "expansion anchor" system in which a ¼" by 2" neoprene strip is attached to the concrete surface with a stainless steel batten strip 2" by ¼" using a ⅜" by 3½" stainless steel expansion anchor. The expansion anchors are typically set at 6" centers providing a hydraulically secure seal that prohibits leakage from passing down behind the liner. This system offers a very sound and secure mechanical attachment.

SYSTEM C: System C is called the "Gundlock® system." Installation begins by attaching the Gundlock strip to the inside of the wood forms with a small nail before the concrete is poured. When the forms are removed, the Gundlock facing will be exposed and flush with the surface of the concrete. Liner attachment is then made by means of extrusion welding.

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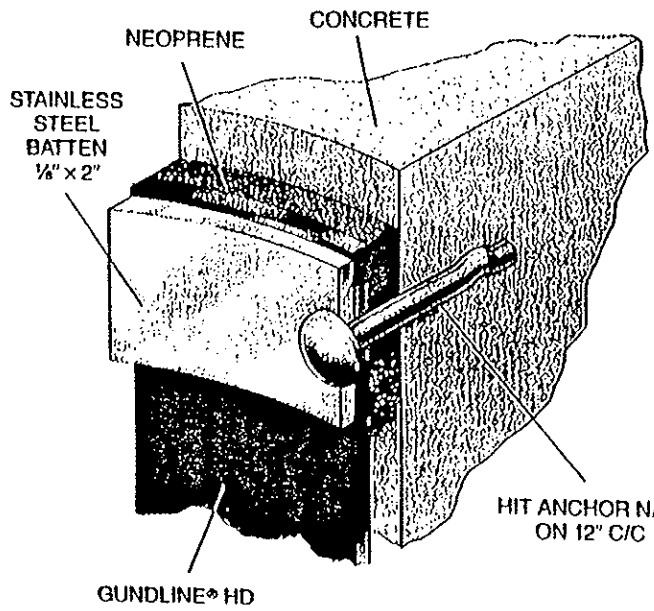
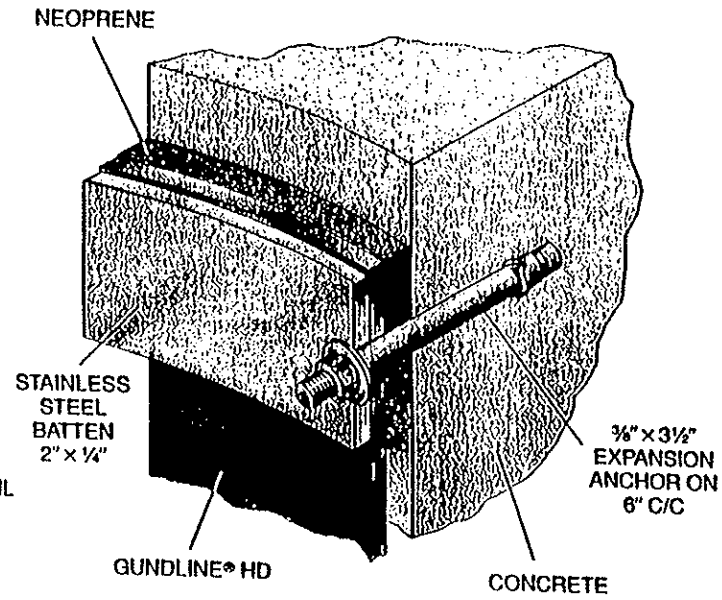
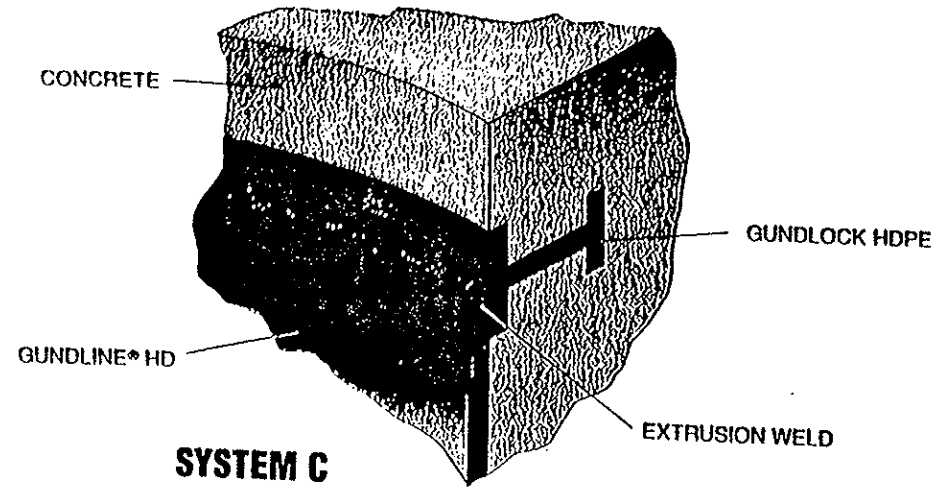
DRAWING #5: TANK LEAK DETECTION LINER/MECHANICAL ANCHORING SYSTEMS

SYSTEM A



SYSTEM B





SYSTEM C

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Drawing #5 in a series of 8 drawings.

GUNDLOCK INSTALLATION GUIDE

Gundlock is a High Density Polyethylene (HDPE) extruded shape designed to provide a mechanical anchor attachment for Gundline HD (High Density Polyethylene liner). Gundlock is designed to be embedded in any face of new cast-in-place or precast concrete construction and can be fabricated to maneuver around shapes and corners.

Any thickness of Gundline® HD can be welded to the Gundlock. If unexpectedly high tensile loads are experienced by the liner, the liner is designed to yield before the Gundlock yields or pulls out of the concrete. The Gundlock profile is detailed in Figure 1.

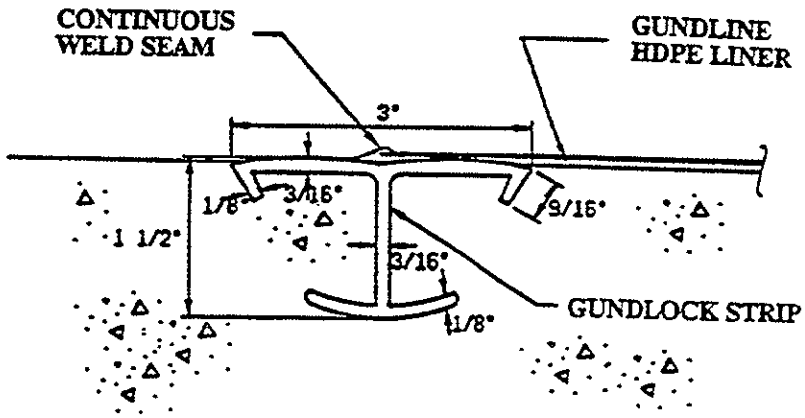

FIGURE 1

Attachment of Gundline HD to Gundlock is performed by grinding the Gundlock and Gundline HD and then extrusion welding the Gundline HD to the Gundlock.

Gundlock should not be used as a waterstop for most installations although it may be utilized as such in special applications. (Please consult Gundle Lining Construction for further information.)

Proper installation techniques must be observed to insure a secure embedment of the Gundlock and a sound weld to the Gundline HD sheeting.

GUNDLOCK INSTALLATION

Gundlock must be cut and butt-welded together to fit corners and shapes. (Figures 2 and 3). This cutting and welding, if performed correctly, will provide continuous support for the liner and secure a seal. Corners and "T" connections can be supplied prefabricated.

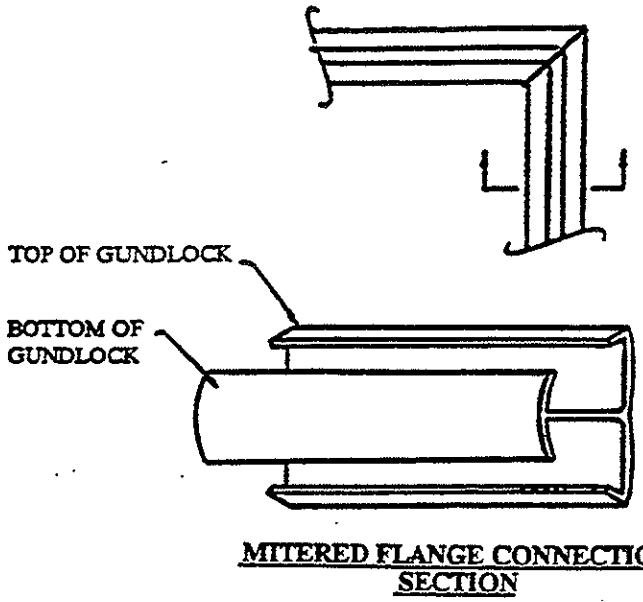

FIGURE 2

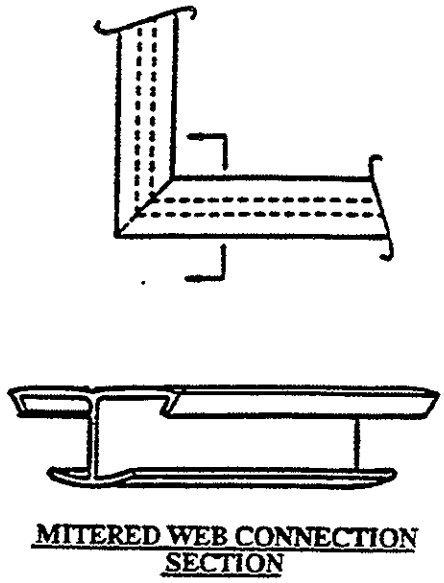

FIGURE 3

ATTACHMENT OF GUNDLOCK TO FORMS

Gundlock is attached to the inside of a concrete form with finishing nails prior to concrete placement (Figure 4). The size of the finishing nails must be no longer than 1". The nails must be driven flush with the back of the Gundlock to allow for their easy removal when the forms are "wrecked." The Gundlock should be attached at sufficient points to insure a flush fitting with the form. Alternate methods of attachment are staples or shot-in anchors.

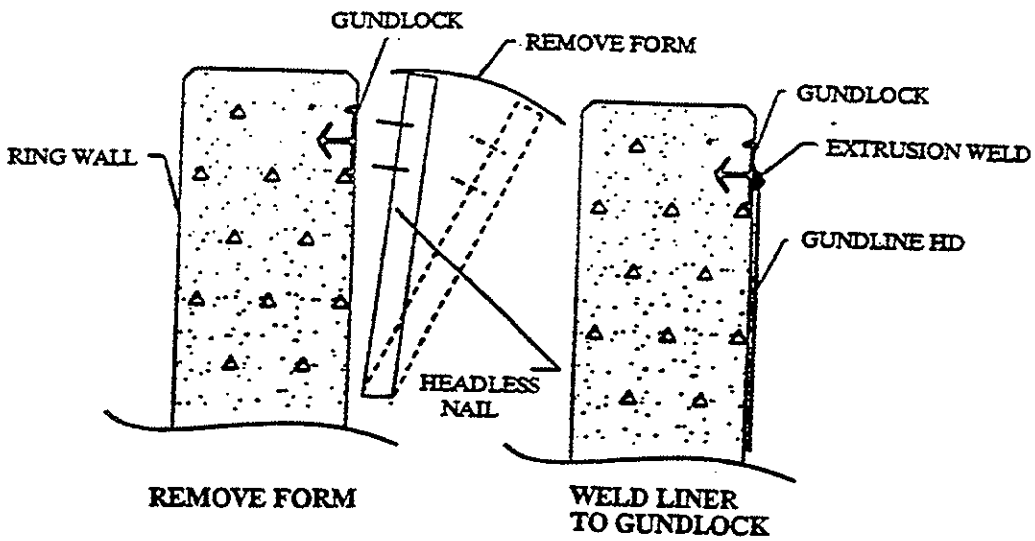

FIGURE 4

EMBEDMENT OF GUNDLOCK

Proper embedment of the Gundlock requires careful attention. The "T" shape of the section can entrap air if sufficient consolidation of the concrete is not achieved. Concrete placed around Gundlock must be properly vibrated to ensure the concrete fills void spaces. Caution: If the concrete surrounding the Gundlock is not consolidated (vibrated), the Gundlock cannot develop the full pull-out strength of the lock.

GUNDLOCK PREPARATION

After the concrete has set and the forms are "wrecked", the finishing nails, staples, or anchors can be removed. Occasionally concrete will seep between the Gundlock and the form and must be chipped away to reveal the Gundlock. The sharp edges thus created by the chipping back of the concrete must be beveled to prevent possible cutting or puncturing of the liner.

HEAT FUSION WELDING OF GUNDLOCK - SUGGESTED METHOD:

The recommended method of butt welding HDPE Gundlock is the heat fusion welding method which yields a continuous strip of material. The following is a list of tools and procedures required to perform the heat fusion welding methods:

1. Carpenters' power chop saw or any saw which can cut material squarely. (Note: A handsaw or hacksaw will not cut it squarely.)
2. Utility knife
3. 110V leister triac
4. 135MM welding mirror

There are eight steps to fusion welding which must be followed to create a strong continuous weld.

1. Cut ends of Gundlock to be welded. This cut should be square and smooth with no nicks or gouges in the surface.
2. Use a utility knife to remove any burrs or shavings from the edges and check that a smooth surface exists.
3. Clean ends with a clean cotton cloth to remove dirt, water, grease and other foreign materials.
4. Check line-up of ends to see that there is a square and complete fit over the entire surface to be fused.
5. Insert clean welding mirror plate between ends (be sure mirror is pre-heated) and bring ends firmly in contact with plate but do not apply pressure while achieving melt pattern. Allow ends to heat and soften until a melt bead of approximately 1/8" appears.
6. Carefully move the ends away from the mirror plate and remove the plate. (If the softened material sticks to the mirror plate, discontinue the joint. Clean the mirror

plate, re-square ends and start over.) Never drag or slide the plate across the melted end.

7. Bring melted ends together rapidly. Do not slam. Apply enough pressure to form a double roll-back bead to the body of the material (approximately 1/8"). Pressure is necessary to cause the heated material to flow together.

8. Allow the joint to cool and solidify properly. This occurs when the bead feels hard and the joint is cool to touch. (Which means your finger can remain comfortably on the bead.) Inspect joint for completeness and continuity. Following these procedures will produce continuous HDPE Gundlock material which can then be installed in a precast or cast-in-place structure.

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ıent " inst " As n, the spill containment liner would slope towards a sump which would remove rain water and/or spill material that has accumulated. The berm can either be constructed from soil, in which case a three-to-one slope is typical, or a concrete perimeter wall, which would require a mechanical seal.

Permeable fill is installed over the liner for protection from mechanical damage and wind uplift. Typically, the spill containment area will safely contain 1.5 times the tank volume.

Options for mechanical attachment to the tank ring wall and perimeter concrete wall are shown on Drawing #5.

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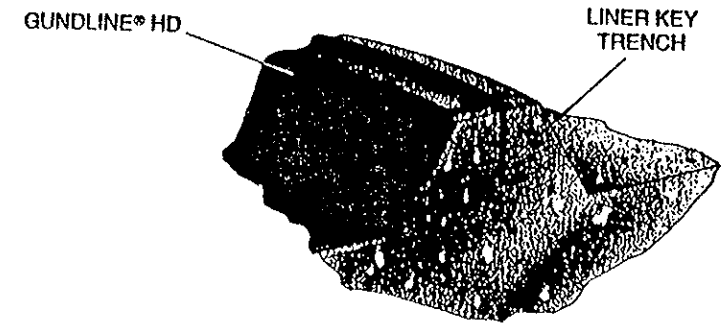
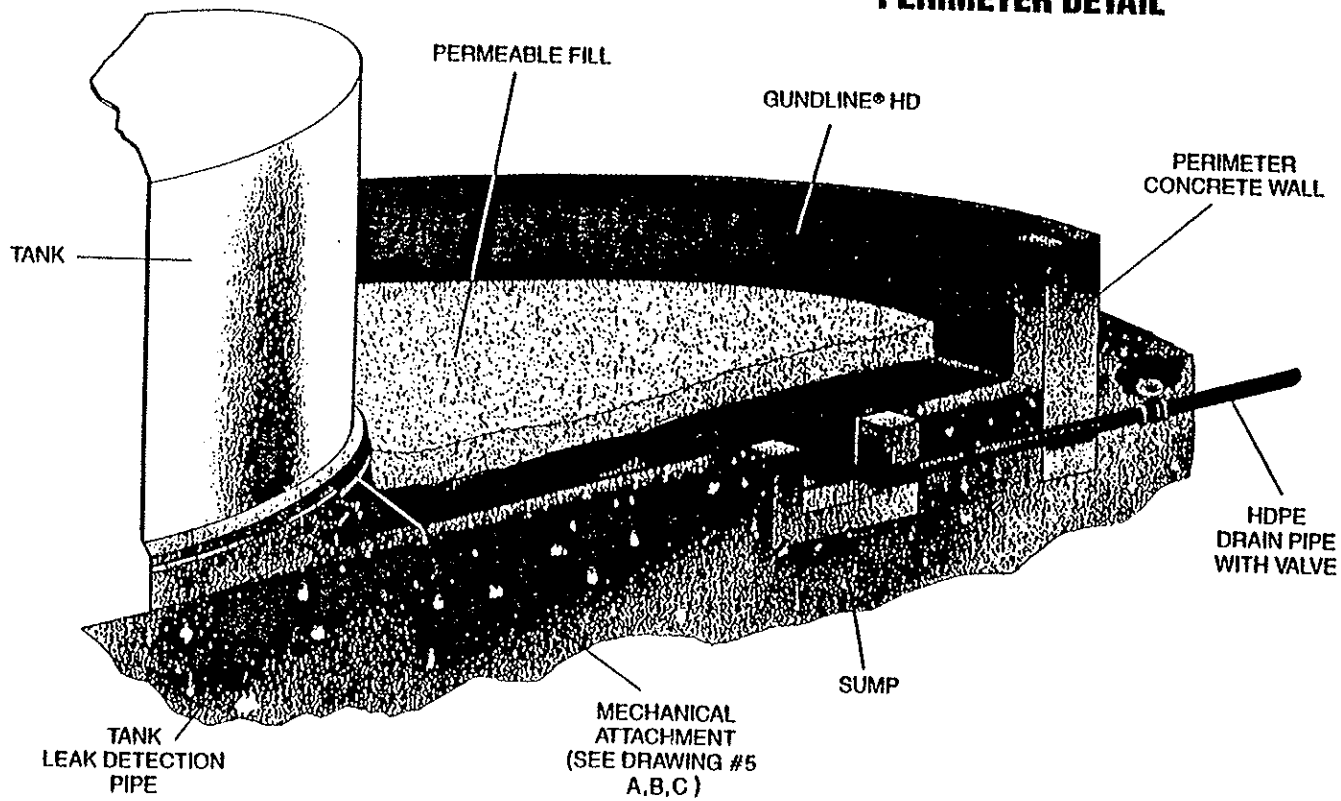


ALTERNATE BERM PERIMETER DETAIL



Drawing #6 in a series of 8 drawings.

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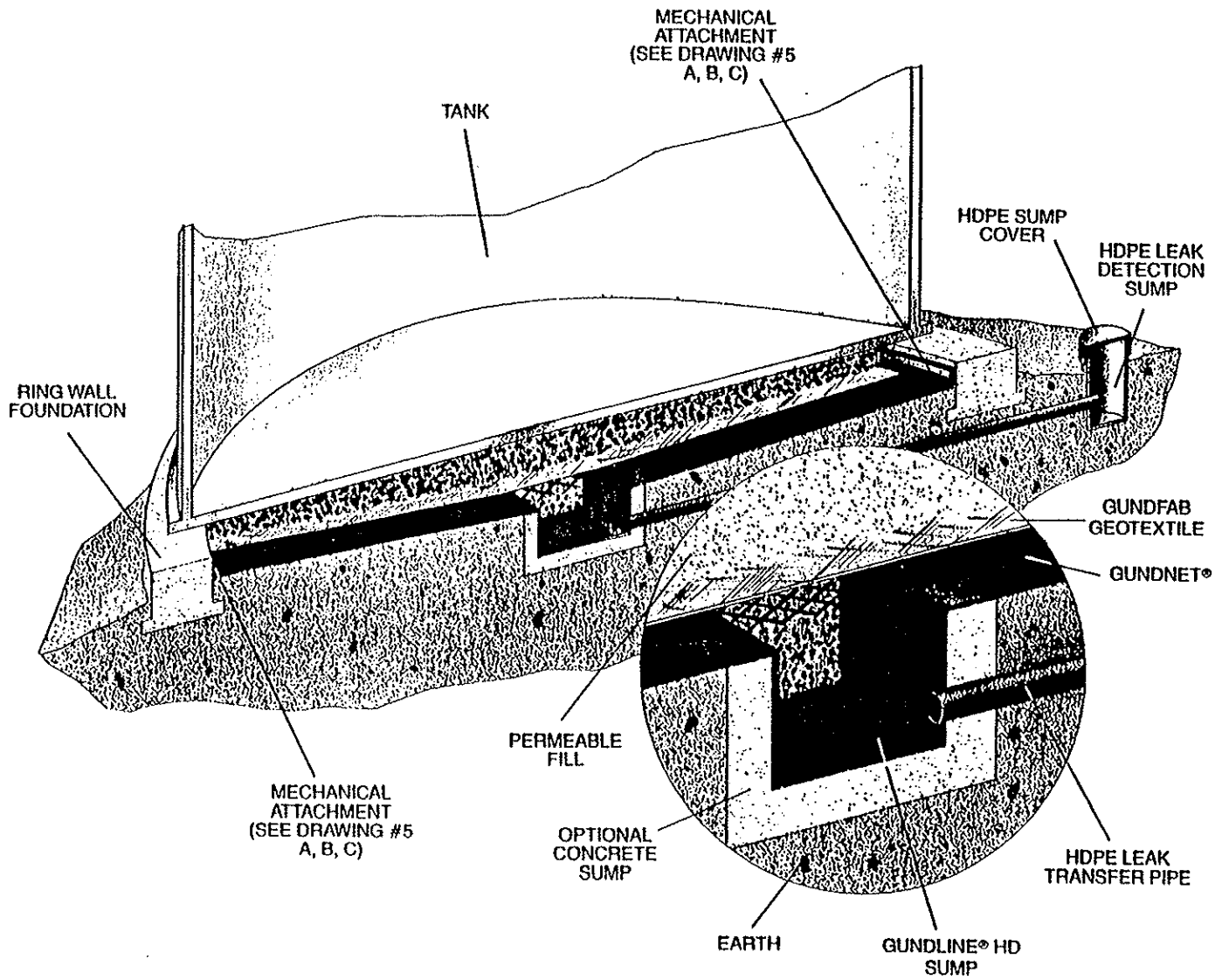
5.0 Engineered Applications

DRAWING #7: TANK LEAK DETECTION LINER WITH CENTRAL SUMP

This drawing depicts a steel tank on a ring wall foundation. Before construction of the tank begins, a sump is constructed in the center of the ring wall with a detection pipe leading to a perimeter observation point. The subgrade within the ring wall is graded to a cone-down configuration to allow drainage to reach the central leak detection sump. Leakage from the tank will travel through the permeable fill to the central sump via the Gundnet®/ Gundfab composite. The central sump is connected by HDPE piping to a perimeter leak detection sump for continuous monitoring. This detailed system is a variation of Drawing #1.



Drawing #7 in a series of 8 drawings.

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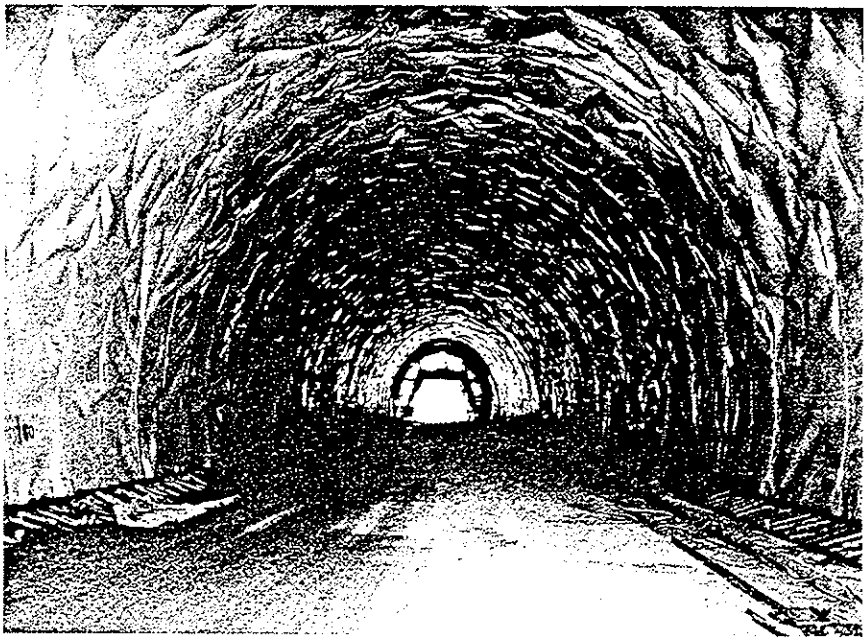
Gundle Waterproofing Membranes - The Industry Standard.

The demanding requirements of today's tunnel designs include sophisticated waterproofing membrane materials that are nonporous, chemically inert and completely waterproof. Full encapsulation of tunnels with such materials will ensure the tunnel remains dry at all times, thereby allowing for continued construction activities and an extended useful life. Waterproofing membranes are referred to in the industry as "membranes" while the term "liner" more closely associated with concrete liners such as shotcrete, segmental or slipformed liners.

Although a variety of tunnel membrane materials are available from Gundle, the preferred membrane is Gundline® VL, a special co-polymer very low density polyethylene (VLDPE) based geomembrane. For greater elasticity and elongation properties, Gundline VL is a proven performer. As one of the most widely used tunnel lining membranes produced by Gundle, Gundline VL is renowned for its high performance characteristics such as its exceptional flexibility without the use of plasticizers and exceptional resistance to puncturing, chemicals, rodents, and microorganisms.

Gundline® HD is also utilized as a tunnel membrane providing a smooth uniform surface on segmental tunnel installations. Gundline HD is manufactured from the highest quality pipe grade HDPE resins, carbon black, anti-oxidants and heat stabilizers, making the sheet strong and chemically inert. Superior resins that make up Gundline VL and Gundline HD are especially important in tunnel lining applications since underground deposits of hydrocarbons and



methane gas can break down many other membranes.

You can combine the strength and the chemical resistance of Gundline HD with the flexibility and elongation of Gundline VL in a versatile Gundle product: Gundline® HD/VL/HD. This co-extruded, fully integrated composite membrane features a VLDPE inner core sandwiched between two outer surface layers of HDPE, giving the membrane extremely good chemical resistance and flexibility combining the best of both Gundle worlds.

To ensure every sheet meets Gundle's high standards of quality and performance, a battery of tests are conducted on the resins as well as the finished product before shipping. These Quality Control Tests include density, melt flow index, oxidative induction times, tensile testing, stress cracking tests and multi-axial burst testing. All results are recorded on Quality Assurance Certificates that accompany each roll when delivered to the site. Widths of Gundline HD and Gundline VL rolls are standard 6.86m (22.5 ft.) and a wider 10.52m (34.5 ft.), ranging in thickness from 0.51mm (20 mils) to 3.5mm (140 mils) and available in a variety of colors.

Gundline® VLW- A White Surface Enhances Inspection.

Co-extrusion technology is behind another Gundle innovation that vastly improves visual inspection: Gundline VLW. This state-of-the-art synthetic membrane combines a UV stabilized white layer of approximately 0.13mm (5 mils) thick with durable impermeable carbon black stabilized material in manufactured thicknesses from 0.75mm (30 mils) to 3.5mm (140 mils). The result is a homogeneous membrane that boasts all the advantages of our VLDPE membranes while bringing substantial benefits to the tunnel engineer.

Damage detection is probably the most significant advantage. With Gundline VLW, the black backing underneath the thin white surface makes holes, slits, score marks and punctures from above or beneath more visible than with conventional membranes. The result is an extra measure of leak

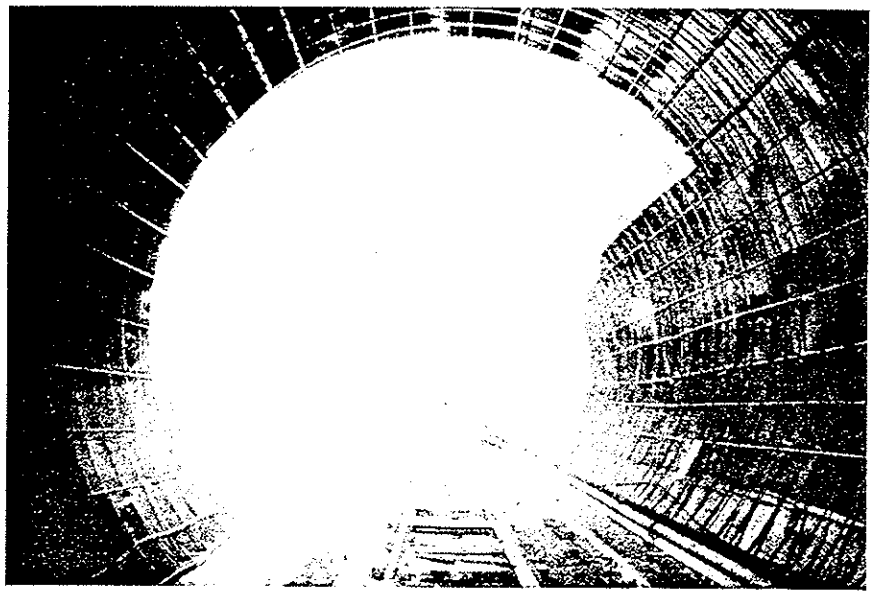
prevention assurance. This is especially meaningful to regulators, inspectors and environmental groups concerned with the integrity of the membrane.

Another outstanding characteristic of Gundline VLW's white surface is its reflective qualities which come into play in exposed, open cut and subsurface installations.

One of the few problems experienced with polyethylene membranes in open cuts is their tendency to wrinkle up when exposed to solar heat. Gundline VLW reflects the heat of the sun and thereby reduces the expansion and contraction of the membrane. Reinforcing steel can be installed and concrete can be placed without interference from wrinkles. The cooler membrane in open cut applications provided by Gundline VLW also lowers moisture content beneath the sheet. The drier surface lessens the possibility of mildew, surface rotting and dampness within the tunnel environment.

When Gundline VLW is installed inside tunnels, the white surface acts as a light enhancer, reflecting all artificial light within the tunnel. In any application, the uniform nature of Gundline VLW adds to the quality and aesthetics of the installation.

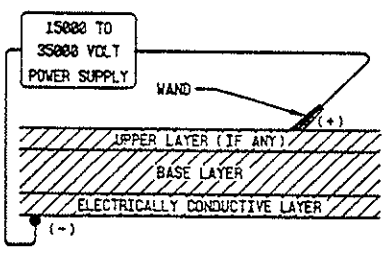
Gundline VLW meets all the material specifications of Gundline VL. This innovative white surfaced waterproofing membrane technology is also available in combination with HDPE, spark testable electrically conductive membrane, textured surfaces and other non-black colors.



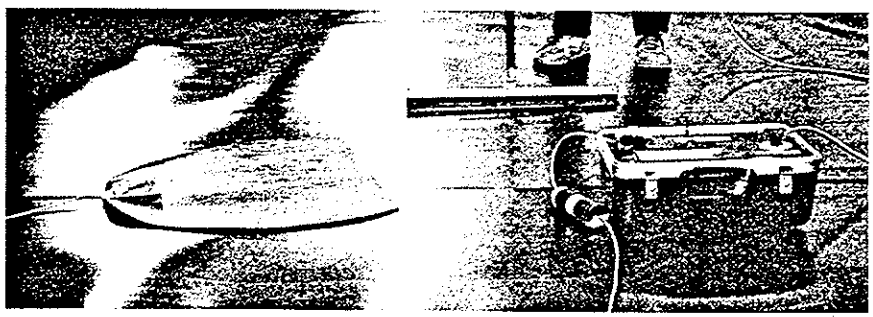
Gundline® VLC- A Revealing Revolution.

Gundle's co-extrusion technology made textured and multi-colored membranes a reality. Now, that same manufacturing technique has produced our most innovative new product yet: Gundline VLC. This remarkable waterproofing membrane uses electricity for leak detection that has proven to be 100% effective. The system is based on spark (or holiday) testing and utilizes Gundline HD or Gundline VL waterproofing membranes, either smooth, textured, or white-surfaced. Employing advanced 3-layer co-extrusion technology, a thin [approximately 0.13mm (5 mil)] electrically conductive layer is added underneath using electrically conductive carbon black. A brass or neoprene wand is passed over the non-conductive layers on top. Even a pinhole in the membrane will immediately transmit a spark, accompanied by an audible alarm signal. So the exact location of the breach is detected for repair. Although Gundline VLC is relatively simple in concept and function, it provides considerable advantages for tunnel membranes:

- The extremely high voltage eliminates the need for a conductive fluid such as water to penetrate the defect and provide a current path to ground, so even the most minute leaks will be detected.
- Utilizing high voltage and low current, the system generates no heat and is safe for all personnel during inspections.
- Water puddles and dirt have no effect on the test.
- Primary membranes can be tested as easily as secondary or ground contact membranes.
- Repairs can be retested quickly and easily.
- Since the conductive layer is an integral part of the membrane, there are no areas where the electrical potential does not exit.



CONDUCTIVE LINER-LEAK DETECTION



Typical Tunnel Lining Systems.

All of today's modern tunnels utilize lining systems with waterproofing membranes. The most widely used configuration, concrete/membrane/concrete, is employed for almost any type of tunnel construction. During construction the outer layer of concrete holds the tunnel open until the waterproofing membrane can be installed. The inner layer of concrete, which acts as the main structure of the tunnel, is then placed over the membrane. Although there are several tunneling methods used that can employ this typical layered configuration, two types are most common.

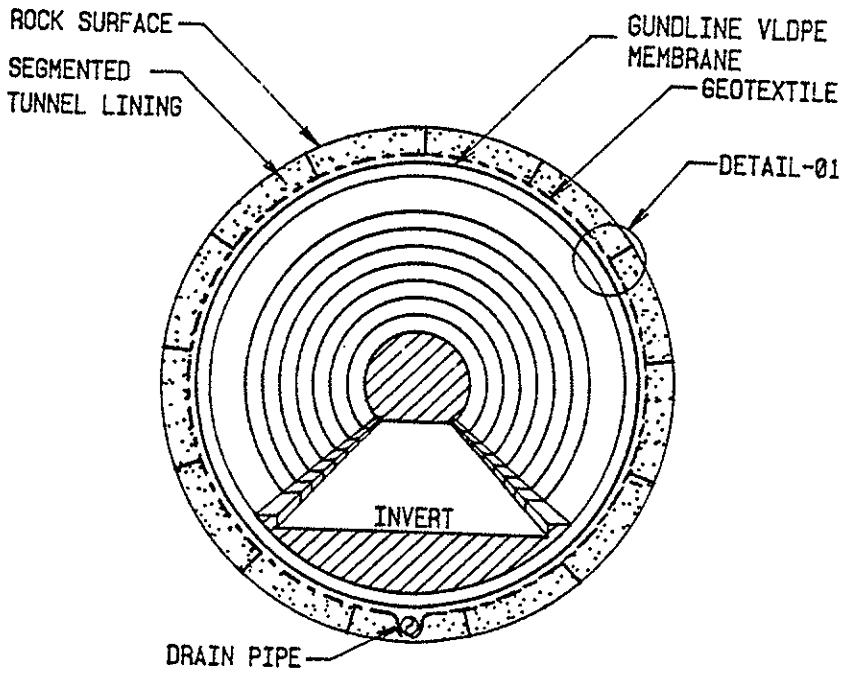
The first is the segmental tunnel lining system which is normally constructed in round tunnels by standard tunneling methods or by TBM (Tunnel Boring Machine). Standard tunneling methods utilize simple age-old excavation/blasting techniques that yield a rough cut surface onto which preformed or precast interlocking concrete panels are placed. The TBMs normally yield a smooth bore surface where the interlocking segments are easily assembled. The segments are installed at the tail of the TBM as the machine moves forward.

In all precast concrete segment supported tunnels, the waterproofing membrane is typically installed along the invert first, on top of the precast tunnel segments. After the invert slab is poured and has cured, the membrane is installed in the arch of the tunnel, usually utilizing a rolling scaffolding called a jumbo.

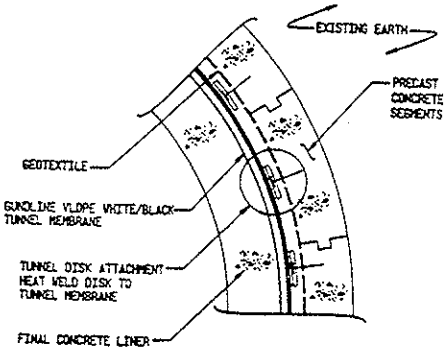
The most common jumbos hold one roll of membrane material on one or both sides. The material is pulled over the top of the framework from one side to the other. Hydraulic jacks or manpower are employed to push the membrane against the arch. Mechanical attachments that are individually welded to the membrane hold it in place.

The next step involves welding the membrane deployed over the arch to the tail of the membrane protruding from both sides of the invert slab. The waterproofing system is now sealed and ready for placement of the concrete inner liner. During all phases of construction, extreme care must be taken not to puncture the membrane with reinforcing steel or other materials within the tunnel. The membrane must be held securely to the arch until the internal concrete lining is placed.

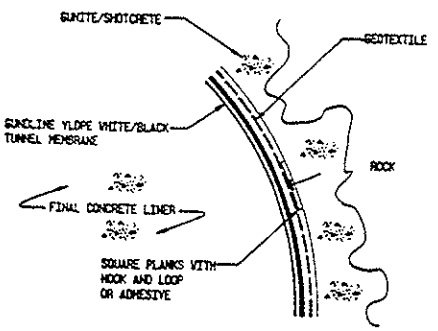
A second type of tunneling method is the shotcrete lining system that has its origins in NATM (New Austrian Tunneling Method, also known as the Shotcrete Method). NATM is normally constructed by sequentially digging parallel arched tunnels by conventional methods then shotcreting the bore surfaces. When the individual tunnels are completed, the area between the tunnels is excavated and the new shotcreted lining tied into the existing tunnel shotcrete linings. NATM depends upon the existing in situ strength of the surrounding earth to hold itself open until the shotcrete is applied.



TYPICAL TUNNEL-PRECAST SEGMENTAL



DETAIL-01
TYPICAL INSTALLATION UTILIZING LABOR INTENSIVE DISKS



DETAIL-02
IMPROVED INSTALLATION METHOD

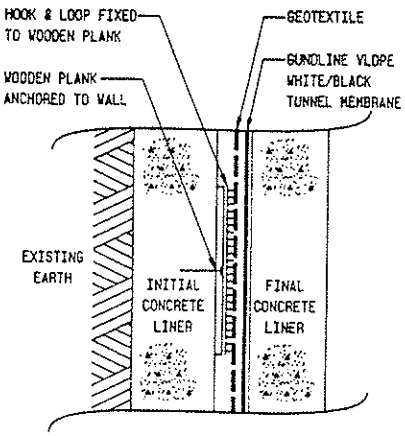
In most instances a steel reinforced shotcrete shell with rock anchors is installed to provide any necessary additional support. Successful NATM construction depends upon highly trained and extremely experienced engineers and contractors, as each meter of tunnel length can require differing support requirements. NATM tunnel construction normally results in rough cut tunnel bores. Lining of NATM tunnels may require a membrane in the invert but most certainly will require a membrane for the outvert. Again, like the segmental tunnel membrane system, mechanical attachments are required to support the waterproofing membrane.

Typical methods of membrane attachment and support for all waterproof membranes are plastic discs that are anchored to the wall and then welded to the back of the membrane, or anchors with washers that penetrate the membrane and are then individually capped with membrane material.

In either case these two attachment methods are inherently labor intensive, requiring several construction steps before the membrane can even be held up to be attached.

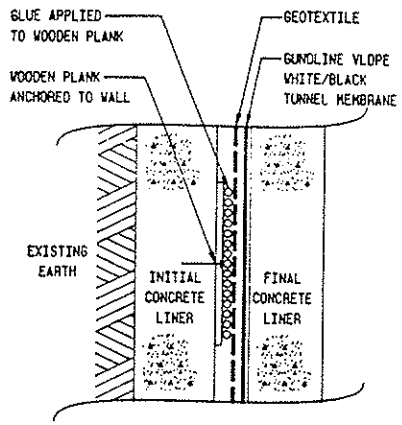
Preferred Attachment Method.

Existing methods of membrane attachment rely on a direct connection between the membrane and the wall by welding the membrane to fixed discs or anchors penetrating the membrane. There are, however, new methods available that allow for the hanging of membrane with less labor and no



HOOK & LOOP ATTACHMENT

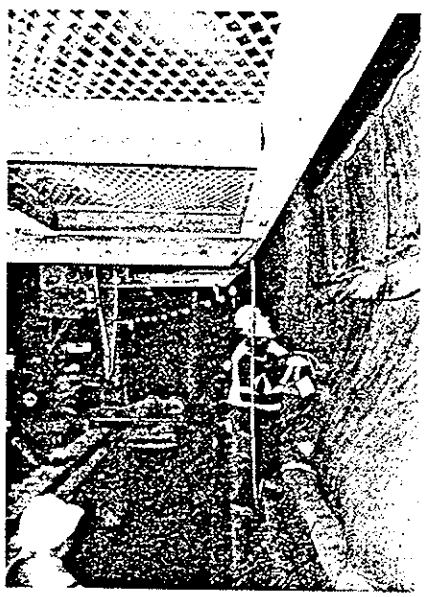
potential leaks at attachment points. The new approach is to indirectly attach the membrane to the wall. By gluing a geotextile fabric continuously across one side of the membrane, a new surface is presented that more readily lends itself to mechanical attachment than with the membrane alone. By anchoring a hook and loop sheet or placing a layer of waterproof adhesive to the tunnel walls at regular intervals, the composite membrane/geotextile can be pressed against the attachment points securing it in place. The hook and loop method is basically a "Velcro system" in which the hook surface is fixed to the tunnel bore surface with wooden squares, while the glue is simply applied to the wall or spread over a previously attached wooden square. All that is necessary to attach the membrane is to press the geotextile side against the hook surface, where it automatically attaches via the "Velcro" effect, or onto the glued areas where it sticks. Because the



GLUE ATTACHMENT

membrane is now held by the geotextile rather than by penetrating nails or other fasteners that may potentially penetrate the membrane, there are no holes to patch and no patches that might leak. Plus, the absence of fasteners beneath the overlap allows the hot wedge type fusion method to be used for seaming.

Segmented tunnels are perfect for these new attachment methods. The NATM method which normally yields a rough cut tunnel bore surface will find the hook and loop attachment method the preferred method for speed and ease of installation.



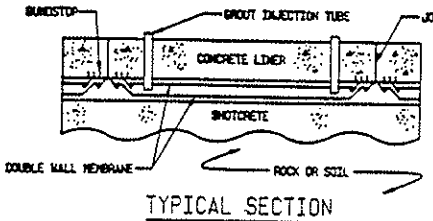
Innovative Grid System Design Eliminates Leak Chasing.

No matter what precautions are taken, waterproofing membranes for tunnels are invariably punctured or damaged during the installation process. While most holes are detected during the quality control stage of membrane deployment, it simply isn't realistic to assume that a 100% leak free system will be found. Gundle has created a unique double walled grid system to isolate membrane sections and focus damage detection in a confined area of the system.

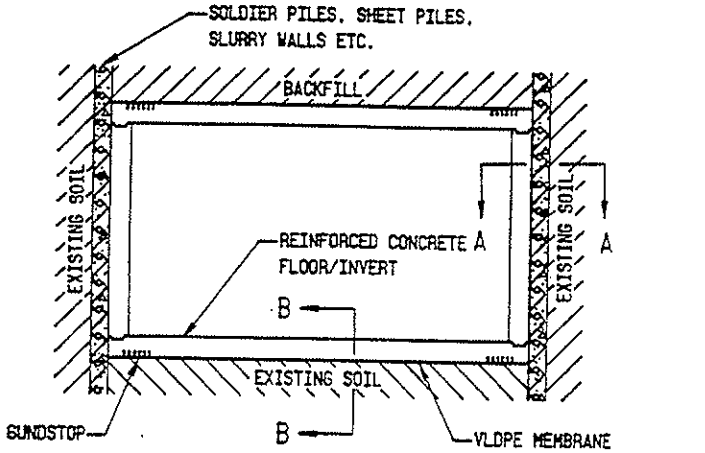
Each grid is made from strips of HDPE or VLDPE cut in 150mm to 200mm (6 in. to 8 in.) widths, each with six rows of raised ribs that run the entire length of the strip. The grids themselves can be any size but are typically at 15m (50 ft.) centers around the circumference of the tunnel. Each strip is welded to the double walled waterproofing membrane. Two grout pipes per grid area are installed on opposite ends of the compartmentalized area before the concrete lining is placed. As the wet concrete is placed for the internal concrete liner the ribs become imbedded cutting off any water migration from a potentially leaking adjacent grid.

So if a leak should appear, the imbedded strips will indicate that the hole in the membrane is somewhere within the compartmentalized area and not hundreds of feet from where the water appears through the concrete liner. Any leaks, once located, can then be sealed by pumping a chemical out through one of the grout pipes in the compartment. The grout will travel behind the concrete liner and between the two membranes in the double walled system thus sealing the leak.

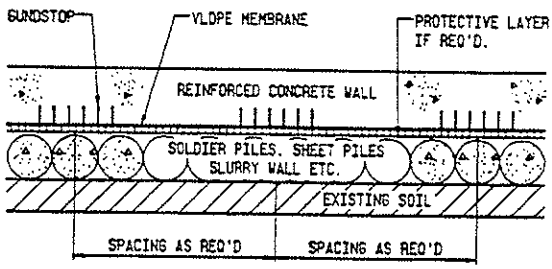
The grid system can also be applied to square or rectangular open cut work. Gundle provides quality tested membrane materials and installation systems with multiple inspection and testing methods that confirm the continuity of the membrane for its intended purpose and allow for leak repair if a leak develops.



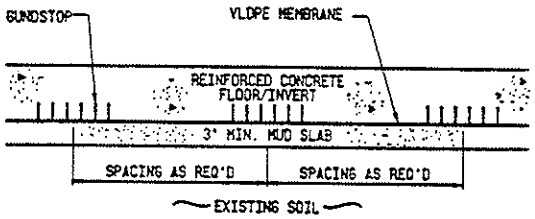
TYPICAL SECTION
DOUBLE WALL SYSTEM
IN CONJUCTION W/GRID SYSTEM



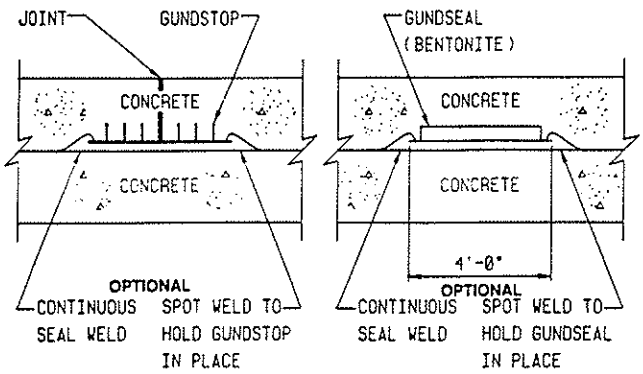
SECTION THRU CUT & COVER INSTALLATION
WATERPROOFING SYSTEM



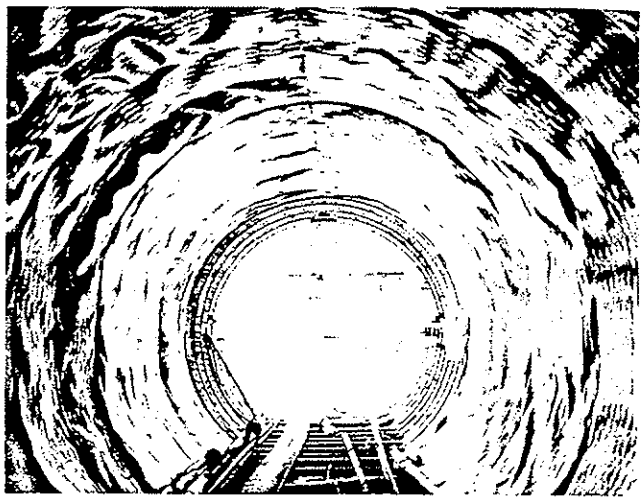
SECTION A-A
GRID SYSTEM - WALL



SECTION B-B
GRID SYSTEM - FLOOR/INVERT



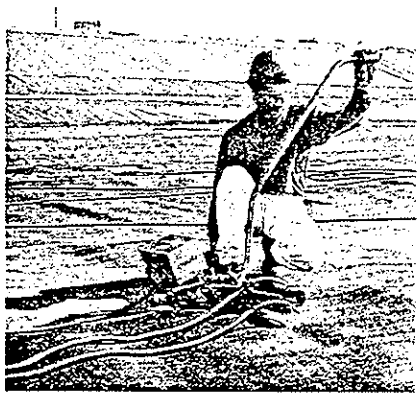
WATERSTOP OPTIONS FOR GRID SYSTEM



Hot Wedge Welding Ensures Sheet Continuity.

Gundle combines the most reliable membranes with the industry's state-of-the-art seaming method. Known as hot wedge welding, this proven technique consists of melting opposing surfaces of membrane using a hot metal wedge. The hot wedge passes between the sheets, followed by pressure rollers which press the molten sheets together. The wedge is automatically positioned at the edge of the top sheet. The pressure roller gap, in turn, is automatically adjusted to accommodate different sheet thicknesses. These features enable the hot wedge welder to achieve welding speeds of up to 4.5 m (15 ft.) per minute for thinner sheets.

Nondestructive testing is also made more efficient because of air pressure testing for the "split" or "dual" wedge of the Gundle system. The dual wedge system leaves a space between two separate weld tracks which is then pressurized with air. Continuity through the air space is ensured by releasing the pressure from the opposite end to which the air was introduced.



Gundle Is On A Roll For Lined Tunnels.

Gundle's history is epitomized by some of the lining industry's most celebrated technical advances, boldest innovations and impressive success stories. It is not surprising then that Gundle has brought these same achievements to the complex business of membrane lining of tunnels. From standard-setting membrane materials and inventive leak detection systems to proven installation techniques and welding procedures, Gundle has emerged as the world leader in total tunnel membrane expertise and experience. And as our commitment to excellence continues to expand to new frontiers, look for Gundle to remain at the forefront of tunnel membrane technology.

Gundle Lining Systems Inc

Gundle®

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6.0 WELDING SYSTEM DETAILS

6.1 Details of Hot Wedge Welding System

6.1.A Introduction

The hot wedge welding system is the primary seaming system for geomembrane installation and the extrusion welding system is utilized for repairs and detail work.

The hot wedge welding apparatus (typically called a fusion welder) is self propelled and produces a double seam with an enclosed air channel for testing. A single wedge may be made available for very thin materials on special request (certain lead times in obtaining this equipment may apply).

The wedge itself contains two cartridge style heaters and its temperature is controlled by a closed loop feedback controller using a thermocouple positioned in the wedge. This maintains the wedge temperature typically to within ±10 degrees Centigrade (10° C) of the setpoint temperature during welding.

Closed loop feedback is also used to control the speed of the machine. This is critical as changes in line voltage and in grade will otherwise affect the rate of seaming. Also, when using a simple potentiometer to control the speed of the machine, there may not be any correlation between the settings from one machine to the next. Closed loop speed control is accomplished by having a speed sensor that monitors the actual motor speed between the motor and reduction gears (the higher RPM at this point assures a more accurate rendering). The speed sensor provides continuous feedback to the speed control unit which is constantly adjusting the DC voltage supplied to the drive motor to maintain constant speed.

The welder is equipped with a voltmeter in the control box capable of determining the supply voltage. It is important to be aware of the actual voltage supplied to the heaters to assure they are operating at their full capacity. Many factors on the job site can affect the supply voltage and if the voltage drops below 115 volts, the wedge may not be able to maintain the setpoint temperature during welding. The welder is also equipped with a sensor to determine the nip force on the rollers. The force can be read on a meter in units of pounds force. The meter is also capable of displaying actual wedge temperature as determined by the same thermocouple used by the temperature controller.

In addition to these electronic devices, a great deal of care has been taken to assure that the mechanical design is as self-adjusting and trouble free as possible. The wedge for example is free floating and pivots about the same axis as the drive rollers. This means that no wedge position adjustments must be made for welding materials of different thicknesses. Also, the drive system consists of totally enclosed gears and shafts which need no adjustment and are protected from the environment.

6.1.B Geomembrane Preparation

- Correct performance of the welder requires that the geomembrane be brought to its exact plan position for final installation and seaming.
- The two geomembrane panels to be joined must be properly positioned such that approximately three inches (3") (8 cm) of overlap exists.

- If the overlap is insufficient, lift up the panel to allow air beneath it and "float" it into proper position. Avoid dragging sheets, particularly when they are on rough soil subgrades since scratches in the material can create various stress points of different depths and orientations.

- There should not be excessive undulations (waves) along the seams during the seaming operation. When excessive undulations are present, they often lead to the undesirable formation of "fishmouths" which must be trimmed, laid flat, and reseamed via a patch.

- There will generally be slack in the geomembranes depending on ambient temperature, length of exposure time, etc.

- The sheets which are overlapped for seaming must be clean.

- The sheets which are overlapped for seaming must be completely free of moisture in the area of the seam. Air blowers are used in addition to rags because sufficiently dry rags are usually not available to keep the geomembrane dry enough to be suitable for seaming.

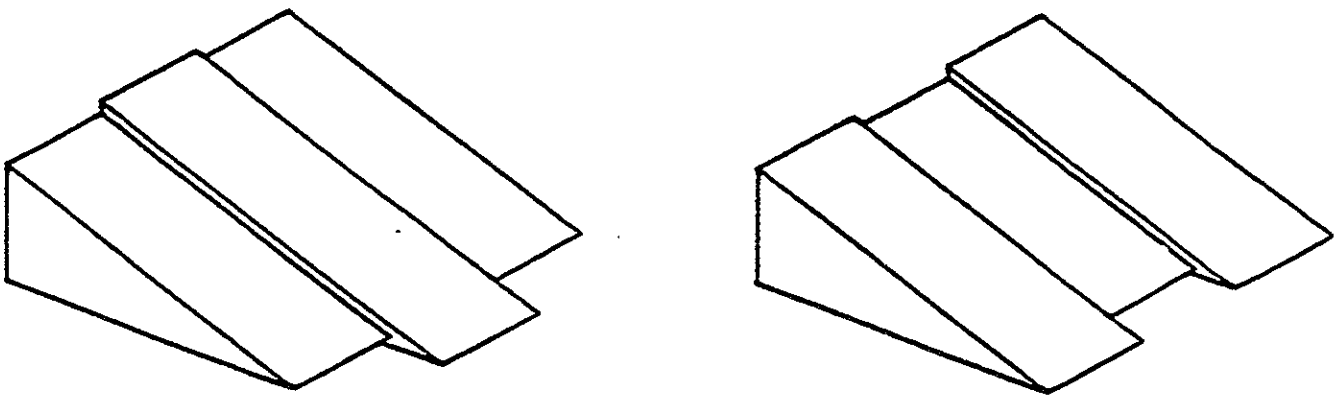

Figure 6.1

- Seaming is not allowed during rain or snow, unless the seam is covered with an enclosure.

- The soil surface beneath the geomembrane panels cannot be saturated because the heat of seaming can draw water into the region to be joined. Ponded water on the soil's surface beneath the sheet is never allowed.

- The soil beneath geomembranes cannot be frozen. The heat of seaming will thaw the frost allowing water to be drawn into the region to be joined. Seaming over frozen soil, however, can be accomplished with rub sheets of geomembrane directly under seam edges.

- Ambient temperatures for seaming should be above freezing; i.e. thirty-two degrees Fahrenheit (32° F) (0° C). However, heat seaming below thirty-two degrees

Fahrenheit (32° F) (0° C) can proceed with caution as stated in the next item and in Section 4.3.A.4.

- For cold weather seaming, it may be advisable to preheat the sheets with a hot air blower, use a shield of some sort to prevent heat losses during seaming, and to prepare more test welds in order to determine appropriate seaming conditions (e.g. equipment temperatures should be set higher and seaming rates slowed down during cold weather seaming). (Further guidance in Section 4.3.A.4)

6.1.C Equipment Preparation

- A working and properly functioning small electric generator must be available within close proximity of the seaming region and with adequate extension cords to complete the entire seam. The generator must be rubber tired, or placed on a smooth plate such that it is completely stable so that no damage can occur to the geomembrane. Fuel (gasoline or diesel) for the generator must be stored off the sheet.

- As the hot wedge method is one of melting the opposing surfaces of the two panels to be joined, no grinding of sheets is necessary, nor allowed.

- Tacking of the geomembrane panels as done in fillet extrusion seaming is not needed.

- The heated wedge itself should be inspected to see that it is uniform and reasonably tapered. Various types are currently available. Some are smooth surfaced while others have patterned ridges in the direction of the seam. The taper dimensions vary according to different types of machines. The major point for inspection is that no sharp edges should exist where sheet surfaces must pass.

- Nip rollers for applying pressure on the sheets and driving the device (most often knurled rollers) follow the wedge. They should be inspected for sharp surfaces or excessive wear.

- For a dual or split hot wedge seam, the recessed space for the air track should be examined.

- As the geomembrane panels pass through the machine, they must properly come in contact with the wedge. Gundle hot wedge welding machines are equipped with pressure shoes which assure contact between the sheet and the wedge as the material passes through the machine. Once the welding machine has been set up for a particular thickness, further field adjustments are not required.

- The front part of the seaming device should be inspected for sharp corners and irregular details which may damage the geomembrane.

- Temperature controllers on the wedge device should be checked periodically.

6.1.D Seaming Process

- The principle of the hot wedge is that both surfaces to be fused come into intimate contact with the hot wedge. The wedge lifts up both overlapped panels off the subgrade and fusion is brought about by compressing the two molten surfaces of the sheet together, causing an intermingling of the polymers.

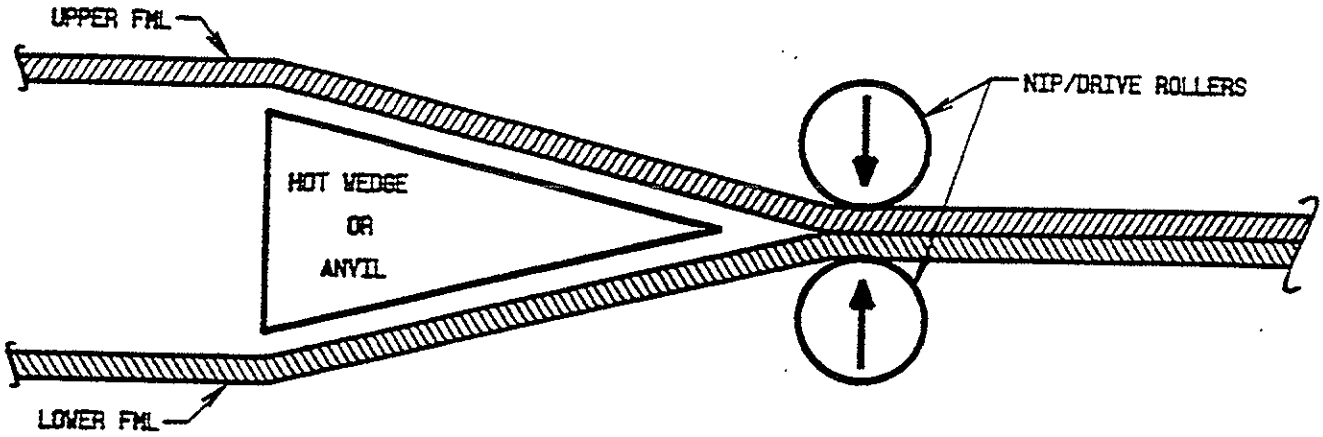

Figure 6.2

- Temperature, speed, and nip force setting will vary according to the geomembrane thickness and material being installed.

- Ambient factors such as clouds, moisture, and hot sun may require the temperature and/or speed setting of the wedge to vary. A test strip should be run before welding begins, which will enable the operator to find the proper settings for the particular conditions that day. See Section 4.3.A.5.

- After placing the machine into the overlapped sheet of material, pick it up a few inches loading the bottom sheet first, and then the top sheet between the wedge and respective pressure shoe. When top and bottom sheets are loaded, engaging the nip rollers will secure the position of sheet and wedge and start the welding.

- It is necessary that the operator keep constant visual contact with temperature controls and the completed seam coming out of the machine. Occasional adjustments of speed may be necessary to maintain a consistent weld.

- Occasionally on some soils the wedge tends to "bulldoze" into the ground as it travels. This causes soil to enter the weld, making the seam weak and unacceptable. To overcome this, it is recommended that the operator take some of the weight off the front of the machine by lifting it slightly. Alternatively, some type of base for the machine to travel on can be provided. Strips of geotextile or geomembrane ("rub sheets") have proven effective to prevent this bulldozing effect.

6.1.E After Seaming

- A smooth insulating plate or heat insulating fabric is to be placed beneath the hot welding apparatus after use.

- A slight amount of "squeeze-out" or "flashing" in the weld is a good indicator that the proper temperatures were achieved. Some melted polymer laterally extruded out of the seam zone indicates a proper seam.

- For geomembranes 40 mil (1.0 mm) thick or less, a long, low wave-length pattern in one direction of the seam on its top surface is indicative of a proper weld. If the wave peaks are too close together, the machine speed should be increased until a

satisfactory pattern is present. The absence of this wavelength pattern indicates that the machine speed should be decreased. Geomembranes 40 mil (1.0 mm) thick or less require considerable visual inspection. There will be no wavy pattern for geomembranes greater than 40 mil (1.0 mm) thick due to the inherent stiffness of the thicker material.

- Nip/drive roller marks will always show on the surface and will be just barely evident to the touch.

- The hot wedge device requires only a few adjustments, but it is very important that they be checked daily. Cleaning of the machine should be done frequently, and at least daily.

6.1.F Dual Track Hot Wedge Air Pressure Testing

General

Gundle Lining Systems' unique automatic hot wedge seaming machine creates two distinct seams. These two seams are separated by a void or air space. This seam design is intentional for two reasons. First, it allows a very positive test for leak integrity, and second, the double weld seam offers both a primary and a secondary seal for the seam.

Air Pressure Test Procedure (More information in Section 4.3.A.7.2)

1. Seal one end of the seam by applying heat to the end of the seam via hot air gun until "flow temperature" is achieved.

2. Clamp off end using hand vise gripper.

3. A pressure gauge/needle assembly is inserted into void or air chamber.

4. Air pressure is then applied into the air chamber with the use of an air pump per the following schedule:

Initial Pressure Schedule

Material	Field Testing Minimum PSI (kPa)	Maximum PSI (kPa)
30 mil (0.75 mm)	24 (166)	40 (276)
40 mil (1.0 mm)	24 (166)	40 (276)
60 mil (1.5 mm)	27 (186)	40 (276)
80 mil (2.0 mm)	27 (186)	40 (276)
100 mil (2.5 mm)	30 (207)	40 (276)

5. Pressure test seams according to the initial pressure test schedule. Hold test for five minutes. If no pressure drop is greater than the maximum allowable pressure drop, the seam is judged leak free.

SEAM AIR PRESSURE TEST
FOR HOT WEDGE WELD

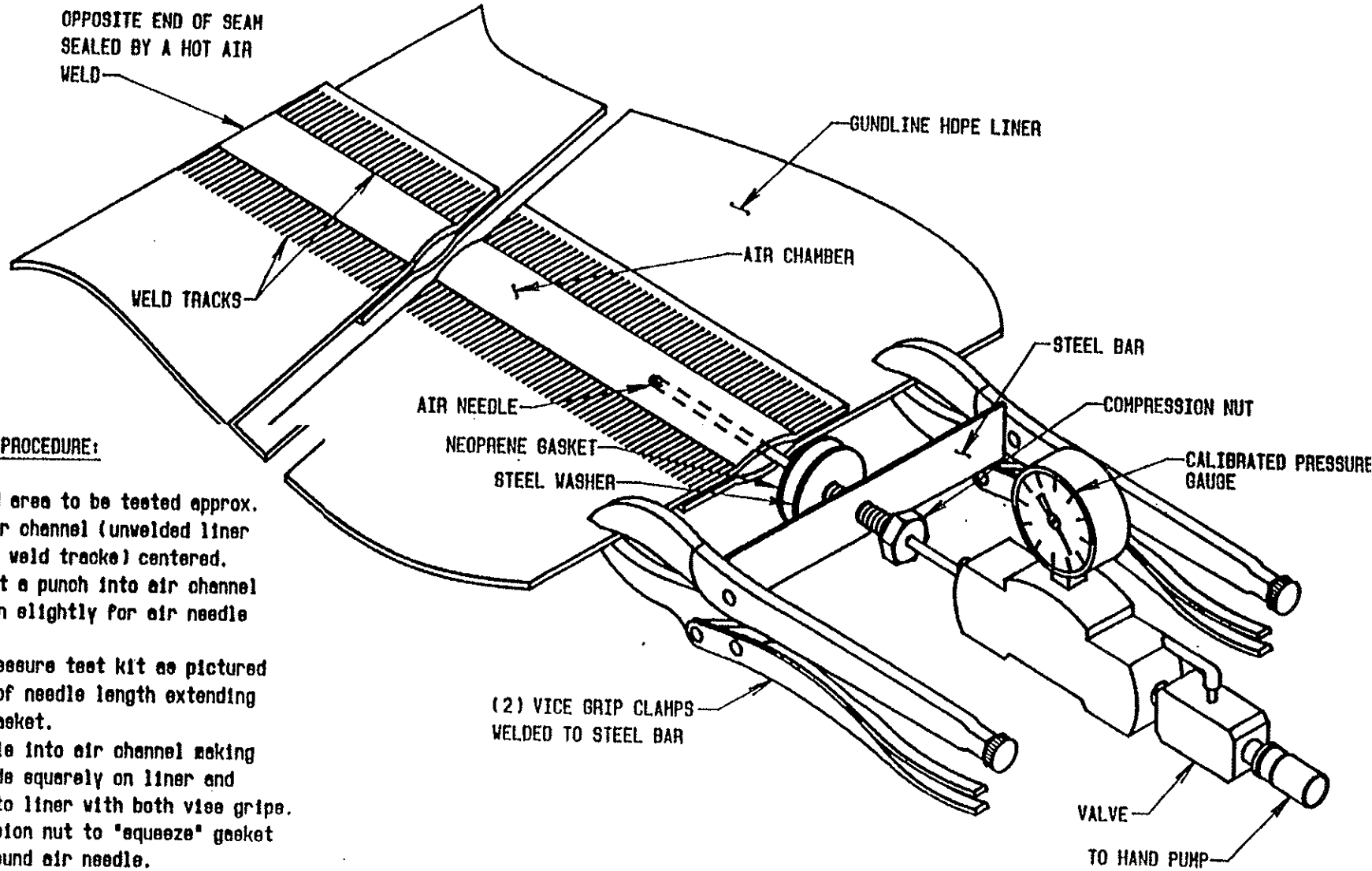

Figure 6.3

AIR PRESSURE TEST PROCEDURE:

1) Square out weld area to be tested approx. 6" long with air channel (unwelded liner between the two weld tracks) centered.
2) Carefully insert a punch into air channel about 3" to open slightly for air needle entry.
3) Assemble air pressure test kit as pictured with about 1/2 of needle length extending past neoprene gasket.
4) Insert air needle into air channel making sure gasket lands squarely on liner and clamp test kit to liner with both vise grips.
5) Tighten compression nut to "squeeze" gasket to liner and around air needle.
6) Pump air briskly through air channel with an observer at the other end of the weld to verify a clear air passage.
7) Seal off open end of air channel with hot air weld and pressurize to check for leaks.

Maximum Allowable Pressure Drop

Material	Field Test (after 5 minutes)
30 mil (0.75 mm)	3 PSI (21 kPa)
40 mil (1.0 mm)	3 PSI (21 kPa)
60 mil (1.5 mm)	3 PSI (21 kPa)
80 mil (2.0 mm)	3 PSI (21 kPa)
100 mil (2.5 mm)	3 PSI (21 kPa)

Note: At all times before heat sealing the end of the seam, the operator should insure that the void or air channel is free of obstruction. This is determined by allowing air pressure to travel freely to the opposite end of the pressure gauge/needle assembly.

6. On completion of the test, the air channel at the end of the seam away from the pressure source should be cut open. The pressure gauge reading should immediately drop to zero indicating that the air channel was continuous and unblocked.

FIELD SEAM FAILURE

Should failure occur through excessive leak down over the scheduled time period, check both ends of seam to insure proper seal and re-test. Should failure reoccur, check the top fusion seam by applying a constant flow of air pressure to void or air channel. Mix a strong solution of liquid detergent and water and apply an ample amount to the top fusion weld. Any failure or leak will be indicated by continuous bubbles appearing.

If no failure appears in the top fusion seam area, check systematically by isolating random sections of the seam. This should be done in one hundred and fifty foot (150') (45 m) long sections of seam. Then re-test each section by pressure testing until the leak is located. Repair failed seam area by extrusion welding the outside edge of the top fusion weld between areas of failure. Then vacuum test repaired seam. All repairs are in accordance with Section 4.4.A.

6.1.G Peel Test For Hot Wedge Seam Weld

For more information see Section 4.3.A.8.

Procedure

1. Cut specimen approximately one inch wide by approximately six inches long (1" x 6") (25 mm x 150 mm).

2. Only the inner weld track is peeled apart in this destructive test. The outer track (directly at sheet edge) is for the purpose of air pressure testing capabilities.

3. Clamp bottom tabs into the testing machine (field or lab tensiometer). Turn on machine and pull the seam.

4. All testing of destructive samples of fusion seam will be in accordance with ASTM D4437 which references ASTM D413 for peel.

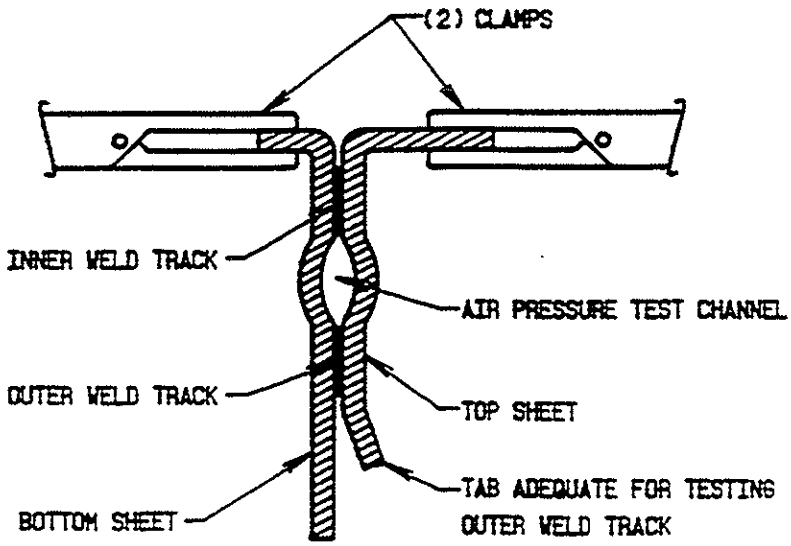

Figure 6.4

6.2 Details of Extrusion Welding System

6.2.A Introduction

The hot wedge welding system is the primary seaming method for geomembrane installation. The extrusion welding system is utilized for repairs and detail work. The extrusion welding system produces a seam quality equal to the hot wedge weld (peel strengths are less only because of different geometrics) and has the advantage that all welds are applied on top of the geomembrane which allows its use at "T" intersections and in irregular seam areas such as pipe boots.

The extrusion welder shall have two independent heating zones, each with its own closed loop temperature control system. These two zones are typically referred to as the nozzle and the extruder. The nozzle thermocouple is positioned approximately one inch (1") (2.5 mm) from the end of the steel nozzle which rides on the sheet giving good control over the temperature of the molten polymer as it contacts the sheet.

The extruder and nozzle shall be insulated to prevent excessive heat loss in cold and/or windy conditions as well as to provide a safe working environment for the operator.

The extrusion welder is equipped with two counter-rotating tips in the nozzle to provide mixing of the extrudate at the zone of contact with the sheet.

When tested in peel, the numerical values for weld strength of an extrusion weld will be lower than for hot wedge welds (see Section 4.3.A.8). The lower value is the result of the weld bead on top of the liner changing the geometry of the load application in the tensile test and not an indication of inferior weld quality.

6.2.B Geomembrane Preparation

Geomembrane preparation is the same as described for the hot wedge weld, Section 6.1.B.

6.2.C Equipment Preparation

- A working and properly functioning small electric generator must be available within close proximity of the seaming region and with adequate extension cords to complete the entire seam. The generator must be rubber tired, or placed on a smooth plate such that it is completely stable so that no damage can occur to the geomembrane. Fuel (gasoline or diesel) for the generator must be stored off the liner.
- The Gundle extrusion welder is a completely self contained system which requires no adjustments after it has been set up for a particular geomembrane thickness.
- An initial inspection of the extrusion welder should be made before it is heated to confirm that the electrical cords, insulation and covers are in good condition and that the welding nozzle is correct for the geomembrane to be seamed.
- The welding machine should be connected to a proper power supply and heated to the correct welding temperature for the geomembrane to be seamed.
- After the unit has reached correct operating temperature, clean and dry welding rod should be inserted and the unit operated for several minutes to confirm that temperature controllers are operating properly and that the welding rod feed system and rotating tips are operating properly.
- The flow of extrudate from the test run will force the rotating tips to their outermost position and they can then be checked for proper setting with depth calipers.
- The Teflon shoes at the nozzle should be checked for excessive wear and replaced if necessary. The Teflon shoes must be trimmed for proper control of the weld bead configuration.

6.2.D Seaming Process

- Geomembrane to be extrusion welded must have low molecular weight polymer (waxes) and surface oxidation removed by lightly grinding the weld surface with an 80 grit disc. The grinding is performed parallel to the seam and controlled such that grinding marks do not extend more than 0.25 inches (6 mm) outside the area of the weld bead. Grinding should precede the actual welding as closely as possible but in no case should grinding precede welding by more than one hour. Sixty (60) mil (1.5 mm) or thicker liners should have the edge of the top sheet beveled by grinding to approximately a 45 degree (45°) angle.
- The geomembrane to be extrusion welded must be temporarily bonded to hold the material in place until the extrusion weld bead cools and attains full strength. Automatic or hand-held hot air tack welds are therefore applied prior to extrusion welding.
- The extrusion welder barrel should be purged of all degraded polymer prior to the start of seaming.

- The welding operation should be observed to assure that the weld bead is centered over the edge of the top overlapped sheet and that weld bead appearance is smooth and uniform.

- All extrusion welds should be non-destructively tested by vacuum testing as described in Section 4.3.A.7.1. Areas which cannot be non-destructively tested should be capped or welded with excess extrudate.

- Destructive tests, per Section 4.3.A.8 and Figures 6.5 and 6.7, are conducted when seam lengths are adequate.

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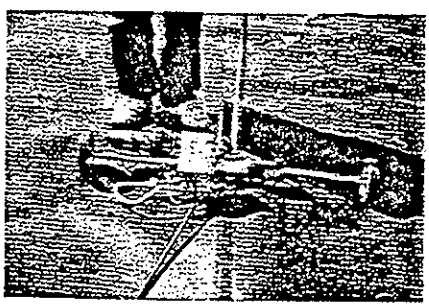
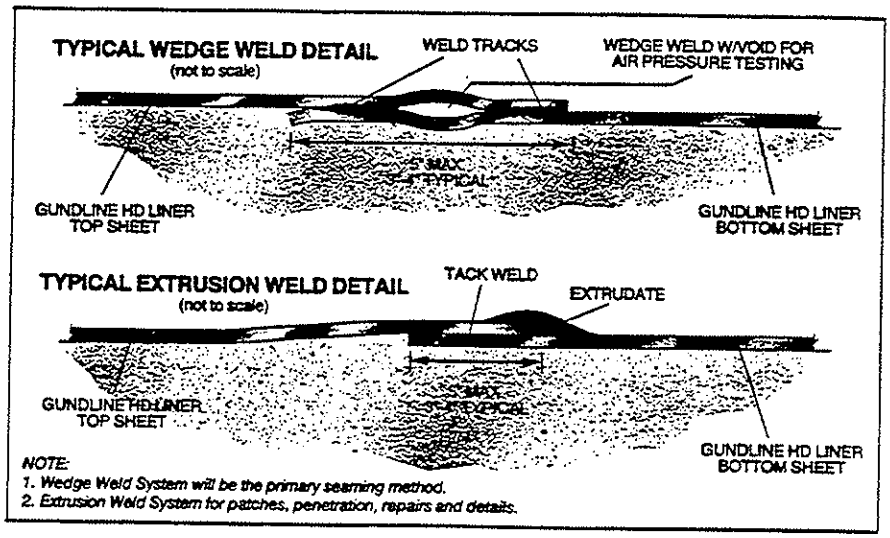
The Gundle Hot Wedge Weld: Effective And Efficient

Gundle's new generation hot wedge welders add versatility, speed and performance to Gundle's seaming capabilities. Together with the patented "mixing tip" fillet extrusion welders, Gundle offers the most advanced systems available today.

The Gundle hot wedge welder offers a number of important advantages over traditional seaming methods. As the welder propels itself along the sheets it draws a hot wedge between them. The heated sheets are then fed between a set of pressure rollers, creating a dual track seam. The Gundle hot wedge welder automatically adjusts the roller gap and wedge position to accommodate different sheet thicknesses. An air blower, mounted on the welder, directs a stream of air ahead of the path of the wedge to blow away dust particles. This air can be heated to dry or preheat the sheet during extreme cold. The Gundle welder also positions the wedge accurately at the edge of the top sheet for ease of non-destructive seam testing.

These features enable the Gundle hot wedge to weld sheets from 20 mil to 140 mil at speeds of up to 15 feet per minute. The welder has enough power to weld vertical seams, and yet, with its modern materials and innovative design, is 40% lighter than other welders, reducing operator fatigue and errors. Using appropriate temperature and speed settings, the hot wedge welded seams provide excellent results in peel and shear destructive tests.





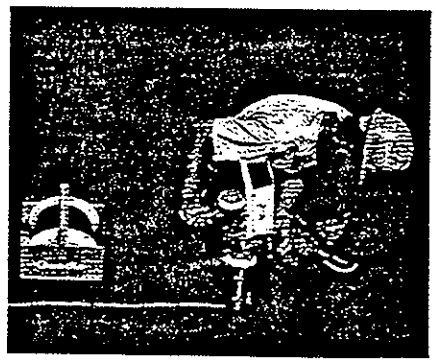
The Gundle hot wedge welder is a precision-machined assembly in which all drive components are totally enclosed and sealed from site dirt. This compact machine hardly lifts the upper sheet, which minimizes the formation of "fish mouths." Fish mouths are often caused by bulkier welding machines which stretch the top sheet. These features, together with automatically controlled temperature and speed, result in extremely consistent welds while reducing operator adjustments to an absolute minimum.

Since fillet extrusion welding is always necessary at penetrations and when patching, Gundle's hot wedge welder used alongside Gundle's patented extrusion welder with mixing action provides Gundle customers with the finest combination of welding technology available.

The Gundle Extrusion Weld: Improved Heat Transfer For Top Quality Extrusion Welding

Gundle Lining Systems' patented extrusion weld provides the combination of heating, extrudate deposition, and mixing action that results in a truly homogeneous bond between liner sheets.

Gundle's special extrusion welding gun stirs the molten extrudate against and into the liner. This mixing action greatly improves heat transfer and blends the extrudate bead into both sheets, creating a homogeneous weld. The result is a fully integrated connection through the seam. Since there is a continuous connection through the seam, and because the extruded bead is as thick as the liner sheet, the resulting seam is as strong as the sheet itself. Due to the extremely efficient heat transfer of Gundle's



patented mixing action, installations welded at 15°F have provided the same high quality test results as installations welded at 70°F.

The Gundle extrusion welder extrudes the identical polymer mix from which Gundline® HD sheet is made. The high quality pipe grade HDPE extruded to form the seam, therefore, has the same excellent resistance to a wide range of waste solutions. These include metal hydroxides, salts, acids, alkalis, oils, and hydrocarbon solvents including most chlorinated hydrocarbons (along with many other chemicals). The extrusion weld system must be used for patches, penetrations, repairs, and detail work.

Both the Gundline extrusion weld and the Gundle hot wedge weld result in a truly homogeneous bond between the liner sheets. Therefore, there is no interface between the sheets which could be disrupted by absorbed solvents. Both Gundle seams offer the same chemical resistance as Gundle sheets and both can be used with Gundline HD, Gundline® HDT, Gundline VL, and Spectraline.

Destructive Testing At The Lab And On-Site

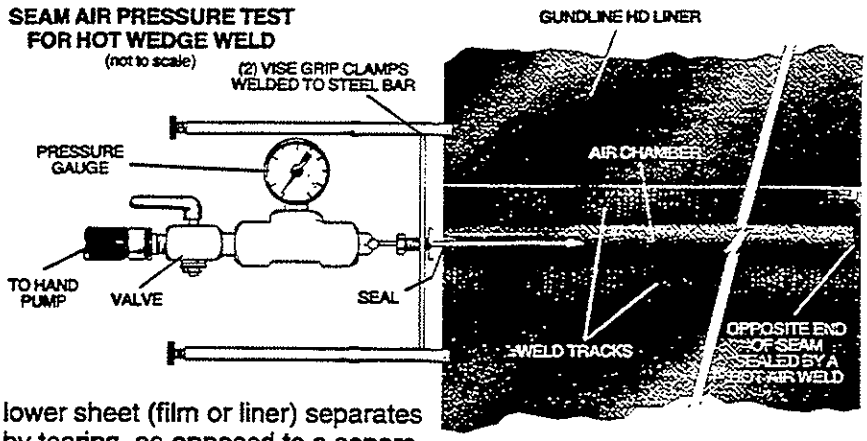
All Gundle seams are subjected to destructive testing. Samples cut from site welds are tested in the laboratory according to ASTM D638 (shear test) and ASTM D413 (peel test). These tests prove the quality of the Gundle welds.

Shear testing applies a tensile stress from the top sheet through the weld and into the bottom sheet. Peel testing peels the overlapped edge of the bottom sheet away from the top sheet in order to observe if separation occurs. The peel test indicates whether or not the sheets are continuously and homogeneously welded at the seam.

The important criterion in the peel test is that the test sample demonstrates what is called a Film Tear Bond (FTB). This means that as the weld is tested, the upper or lower sheet (film or liner) separates by tearing, as opposed to a separation between the top surface and bottom surface of the seam itself. A Film Tear Bond test result means the seam is good; a fully integrated weld.

Weld samples are sent by Express Mail to Gundle's laboratory in Houston from project sites. The Gundle Lab provides 24-hour turnaround for results on destructive test samples.

Gundle regularly conducts destructive seam tests at the jobsite too. This is to properly set welding conditions prior to start-up each morning and after work each work break, as well as to augment the official Gundle Lab testing of destructive seam samples.



Non Destructive Air Pressure Testing

The standard procedure for Gundle installations is to test 100% of the seam footage for leaks. With the Gundle hot wedge welder, non-destructive testing is made more efficient by air pressure testing of the gap between the "dual" wedge weld tracks on all welds 30 mils and greater. A single weld track is used on 20 mil, and an air lance or probe is used for non-destructive testing. The gap is pressurized by air injected through a needle inserted into the gap between weld tracks. Possible leaks are indicated by a loss of pressure over 5 minutes after the gap has been pressurized by a hand pump, and sealed by a valve. Very long sections of seam (up to 500 ft.) can be quickly tested for leaks, resulting in very efficient installation QC. Note that after a seam has passed a pressure test, pressure is released at the seam end opposite the pump/gauge assembly. This ensures that the seam is continuous and has been 100% tested.

Non Destructive Vacuum-Box Testing

Where air pressure testing is not applicable, Gundle technicians use a vacuum chamber to test 100% of the seamed footage. This test also confirms that no leaks are present in the seams. To perform a vacuum test, a soap solution is sprayed on top of the seam. Then a rectangular plexiglass-faced vacuum box is placed on the seam and a 5 psi vacuum is pulled in the box.

Visual inspection of Gundle extrusion welds, which are on top of the sheet, is also an important part of quality control on all Gundle installations.

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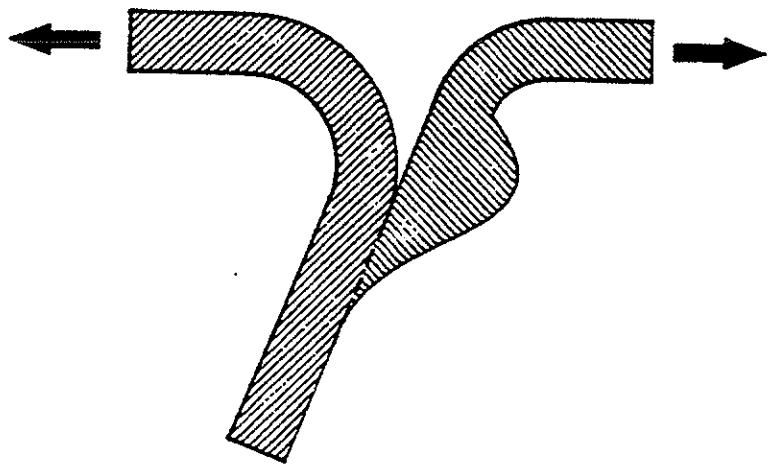
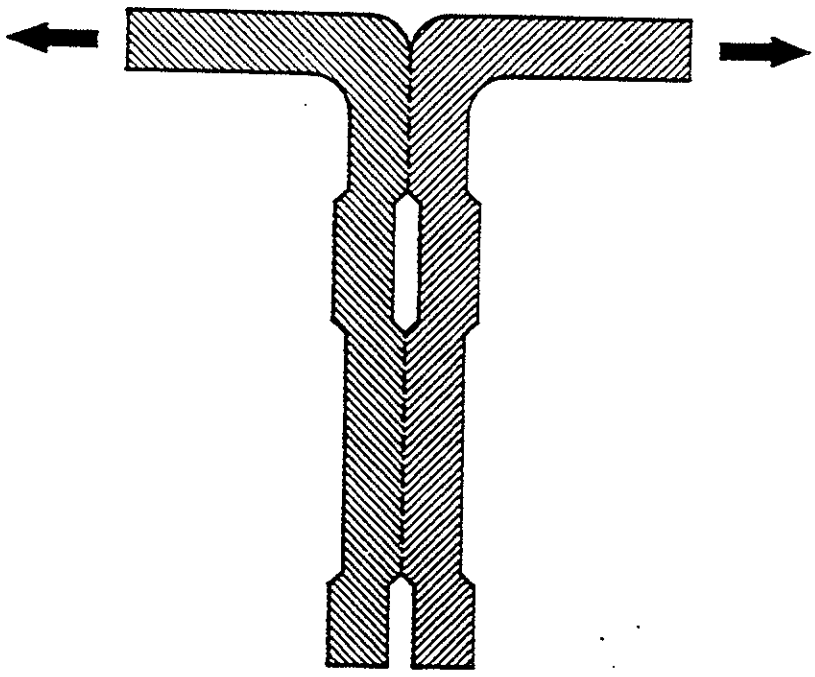
PEEL TEST CONFIGURATION



EXTRUSION WELD

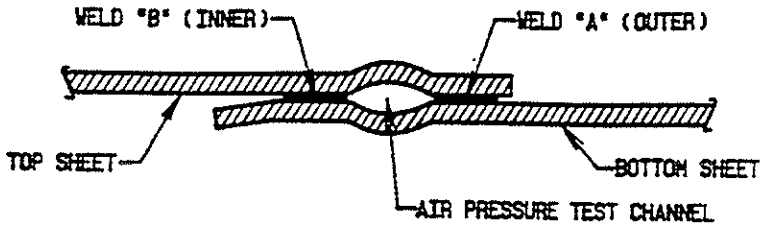


HOT WEDGE WELD

Figure 6.5

DESTRUCTIVE TESTING OF DUAL HOT WEDGE WELD

Figure 6.6

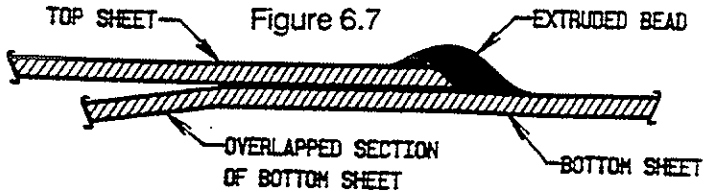


TEST STRIP	RESULTS	
	(PASS)	* FTB IN BOTTOM SHEETING
	(PASS)	* FTB IN TOP SHEETING
	(PASS)	* FTB IN BOTTOM SHEETING AT INNER EDGE OF SEAM
	(PASS)	* FTB IN TOP SHEETING AT INNER EDGE OF SEAM
	(FAILURE)	* FTB IN BOTTOM SHEETING OF SEAM AFTER SOME ADHESION FAILURE
	(FAILURE)	* FTB IN TOP SHEETING OF SEAM AFTER SOME ADHESION FAILURE
	(FAILURE)	FAILURE IN ADHESION

* FTB = Film Tear Bond

VARIETIES OF SEAM FAILURES DURING DESTRUCTIVE TESTING OF EXTRUSION WELD

Figure 6.7



TEST STRIP		RESULTS
	(PASS)	* FTB SEPARATION IN BOTTOM SHEET AFTER SOME DELAMINATION.
	(PASS)	* FTB SEPARATION IN TOP SHEET AT SEAM EDGE.
	(PASS)	* FTB SEPARATION IN TOP SHEET.
	(PASS)	* FTB SEPARATION IN BOTTOM SHEET.
	(PASS)	* FTB SEPARATION IN BOTTOM SHEET AT OUTSIDE SEAM EDGE.
	(PASS)	* FTB SEPARATION IN WELD (IF RECORDED STRESS MEETS SPEC)
	(PASS)	* FTB SEPARATION IN WELD (IF RECORDED STRESS MEETS SPEC)
	(FAILURE)	SEPARATION IN ADHESION
	(FAILURE)	SEPARATION IN ADHESION

* FTB = FILM TEAR BOND

7.0 GUNDLE ENVIRONMENTAL SYSTEMS, INC. SAFETY POLICY

7.1 SAFETY CREED

Management and employees of Gundle Environmental Systems, Inc. believe that while risks exist:

- Accidents and injuries are preventable
- Each employee has a personal responsibility for his/her safety and the safety of others, both on and off the job.
- No business objective is so important that it will be pursued at the sacrifice of safety.
- Safe conduct of operations is a condition of employment at Gundle Environmental Systems, Inc.
- A job is well done only if it is done safely.
- Gundle Environmental Systems, Inc. will have the best safety performance in the industries in which we do business.

7.2 GENERAL

Safety is of primary importance in Gundle's operations. Each employee has the responsibility to make the safety of himself/herself and his/her co-workers a basic concern. This objective is fundamental to employee well being as well as to the efficient operation of Gundle's business. With few exceptions, every safety rule or practice in this manual has evolved from experience and knowledge gained over many years in the prevention of accidents and injuries.

Yet, as helpful as they are, safety rules alone cannot prevent accidents. The indispensable ingredients of a safe working environment are: management commitment, a knowledgeable supervisory staff, an involved safety leader, and a conscientious work force, where each individual is dedicated to the principle that accident prevention is an essential part of the planning and efficient execution of every job.

Gundle management recognizes its responsibility to provide healthful and safe working conditions, safe working rules based upon experience and safety knowledge, and competent work direction.

Every employee has the responsibility to prevent accidents and injuries by observing established working rules, by following the directions of supervisors, by practicing the principles taught in safety training, and by providing ideas on how our safety efforts might be further strengthened. Gundle and its employees have the responsibility to comply with all federal, state, and local regulations related to safety and health programs. An effective safety program extends beyond normal working hours and, accordingly, safety in employees' and their families off-the-job activities is encouraged.

Contractors performing work on Gundle premises shall be required to comply with health and safety laws and regulations and to adopt safety practices equivalent to those applicable to Gundle employees.

7.3 SAFETY TRAINING

- Forty (40) hour Hazwaste Training (CFR 1910.120)
- Eight (8) hour Confined Space Entry Training (CFR 1910.146)
- Twenty-four (24) hour MSHA Training (Mine Safety)
- First Aid/CPR Training
- Blood Borne Pathogen Testing
- Defensive Driving/D.O.T. Training
- Base Line Physical
- Respirator Fit Testing
- Pulmonary Function Testing
- Equipment Training (Loader, Forklift or Lull, Jiglift)
- Repetitive Motion Training
- Back Injury Prevention Training
- Emergency Response
- Personal Protection Training (Hard Hats, Safety Glasses, Cut Protection Gloves, Wrist Support, Etc.)

8.0 PROPERTIES AND TESTING

Definition of Minimum Average Roll Value (MARV)

Key to Co-extruded Product Descriptors

Property and Testing Tables

8.1 Resin Suppliers, Properties, and Testing

8.2 Smooth HDPE Liner Properties

8.3 Textured HDPE Liner Properties

8.4 Smooth VLDPE Liner Properties

8.5 Textured VLDPE Liner Properties

8.6 Smooth HD/VL/HD Liner Properties

8.7 Textured HD/VL/HD Liner Properties

8.8 Gundguard Liner Properties

8.9 Quality Control Testing Frequency of Geomembranes

8.10 Gundnet® and Fabri-Net® Properties

8.11 Gundnet® and Fabri-Net® Testing Frequencies

8.12 Gundle Welding Rod Properties and Testing

8.13 Delivered Bentonite Quality Verification

8.14 Bentonite Quality Daily Production Verification

Providing Certified Minimum Average Roll Values

ıimum Average Roll Values

there is always some variation in the procedure for any nthetic test, the actual property values for any given roll .aterial is determined by the average results of a number ests on that roll as defined by the specific test procedure. ıinimum average roll value is the *minimum* average anticipated for 95 percent of the rolls in the lot.

Certified minimum property values ARE NOT "typical" erage" property values, where as much as 50 percent of .oduct may not meet the *minimum* specs.

provide a level of confidence that products will meet sign requirements, the manufacturers belonging to the .rial Fabrics Association International (IFAI) have ed that certified *minimum* average roll values are neces- maintain the industry credibility. Statistically, minimum e roll values are equal to the average minus something .nan two standard deviations, such that there is a 95 per- t confidence level that a lot of product sampled according M D-4354-89, and tested and evaluated according to D-4759-88 will be accepted.

ndard Deviation

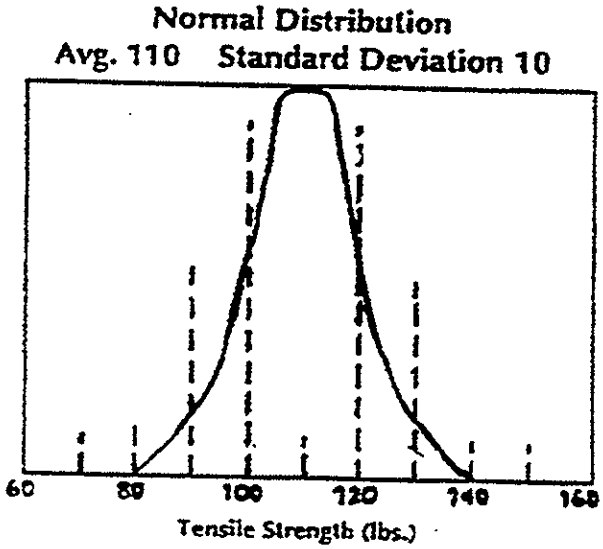
y given material tested, some variation in test results is .ed. The measure of the deviation between the average value and value tested is commonly referred to as the rd deviation.

.tistically, standard deviation is defined as follows:

> The square root of the arithmetic mean of the squares of the deviation of each of the class frequencies from the arithmetic mean of the frequency distribution.

ne significance of standard deviation lies in the variation material properties that it can reflect. One Standard Deviation (O_1) from the mean will include 67 percent of all measured values. Two standard deviations (O_2) include more than 95 percent of all measured value.

Example: If the minimum average roll value specification is 90 pounds, and the process has a standard deviation of 10 pounds, the process must be centered at 110 pounds or higher. For a normal bell curve (see diagram), 97 percent of the total product population will exceed the minimum average roll value for normal distributed populations.



Note: For statistical accuracy, we recommend that manufacturers limit their test data to products created using current production processes and practices.

nglish—SI/SI—English Unit Conversion Chart

ngth

- meter = .0394 in.
- ter = 3.28 ft.
- nch = 25.4 mm
- = 1000 mils
- = .305 m
- = .001 in.

- m = .0353 oz.
- dlogram = 2.20 lb.
- ce = 28.3 g
- nd = .454 kg

- ter² = 1.195 yd.²

Area (continued)

1 yard² = .836 m²

Force

1 newton = .225 lb.
1 pound = 4.45 N

Stress, Pressure

1 pound per square inch = 6.89 kPa
1 kilopascal = .1451 psi

Transmissivity

1 meter²/second = 4.83 gal./min./ft.
1 gal./min./ft. = .207 m²/S

U.S. Sieve Designation	Opening Size (mm)	U.S. Sieve Designation	Opening Size (mm)
200	.075	25	.710
170	.090	20	.850
140	.106	18	1.00
120	.125	16	1.18
100	.150	14	1.40
80	.180	12	1.70
70	.212	10	2.00
60	.250	8	2.36
50	.300	7	2.80
45	.355	6	3.35
40	.425	5	4.00
35	.500	4	4.75
30	.600		

KEY TO CO-EXTRUDED PRODUCT DESCRIPTORS IN SPEC TABLES

HD	=	High Density Polyethylene (HDPE)
VL	=	Very Low Density Polyethylene (VLDPE)
W	=	White Surface
C	=	Conductive Undersurface
T	=	Textured (double sided)
TS	=	Textured (single sided)

RESIN SUPPLIERS, PROPERTIES, & TESTING

RESIN SUPPLIERS AND PRODUCT CODES

Type of Polyethylene	Supplier Name	Product Code	
		Fluff/Flake	Pelletized
HDPE	Phillips 66	TR-400GF	TR-400G
HDPE	Chevron	8644	9642
HDPE	Quantum	LP0510-00	LP5101-00
HDPE	Union Carbide		DEDA2400NT
HDPE	Solvay		XF-836
VLDPE	Union Carbide		DFDB1506

RESIN PROPERTIES OF VIRGIN RESIN

Property	Test Method	Units	Testing Frequency	HDPE Value	VLDPE Value
Density	ASTM D1505 Condition A	g/cc	Four Samples Per Railcar	0.935 - 0.941	0.900 - 0.915
Melt Index	ASTM D1238 (190° C/2.16 kg)	g/10 min.	Four Samples Per Railcar	0.05 - 0.30	0.10 - 0.60

RESIN PROPERTIES OF COMPOUNDED RESIN (FROM FLUFF/FLAKE RAILCARS ONLY)

Property	Test Method	Units	Testing Frequency	HDPE Value	VLDPE Value
Density	ASTM D1505 Condition A	g/cc	Every Two Hours	0.940 min.	n/a
Melt Index	ASTM D1238 (190/2.16)	g/10 min.	Every Two Hours	0.05 - 0.30	n/a
Carbon Black Content	ASTM D1603	%	Every Two Hours	2.0 - 3.0	n/a

Table 8.1

SMOOTH GUNDLINE® HD, HDW, AND HDC

Minimum Average Roll Values (MARV) Except When Designated Minimum, Maximum, or Range of Values

Property	Test Method	Unit	40	60	80	100
Thickness	ASTM D751	Mils (mm)	36-46 (0.9-1.15)	54-69 (1.35-1.73)	72-92 (1.8-2.3)	90-120 (2.25-3.0)
Density	ASTM D1505	g/cc	0.94 min.	0.94 min.	0.94 min.	0.94 min.
Melt Flow Index	ASTM D1238 Condition E (190°C,2.16 kg.)	g/10 minutes	0.3 max.	0.3 max.	0.3 max.	0.3 max.
Carbon Black %*	ASTM D1603	%	2-3	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D3015	Rating	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1
Tensile Properties	ASTM D638 Type IV, gauge length 2" break, 1.3" yield Dumb-bell @ 2 ipm					
Strength at Yield		PPI (N/mm)**	95 (17)	140 (25)	185 (32)	230 (40)
Strength at Break		PPI (N/mm)**	160 (28)	240 (42)	320 (56)	400 (70)
Elongation at Yield		%	13	13	13	13
Elongation at Break		%	700	700	700	700
Tear Resistance	ASTM D1004 Die C	Pounds (N)	30 (134)	45 (200)	60 (267)	75 (334)
Puncture Resistance	FTMS 101B Method 2065	Pounds (N)	52 (231)	80 (356)	105 (467)	130 (579)
Environmental Stress Crack	ASTM D1693 10 % Igepal, 50°C	Hours	1500 min.	1500 min.	1500 min.	1500 min.
Dimensional Stability	ASTM D1204 100° C 1 Hr.	% change	±2 max.	±2 max.	±2 max.	±2 max.
Thermal Stability OIT	ASTM D3895 130°C, 800 PSI 0_2	Minutes	2000 min.	2000 min.	2000 min.	2000 min.
Low Temperature Brittleness	ASTM D746 Procedure B	Degree F (° C)	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.
Coefficient of Linear Thermal Expansion	ASTM D696	$x10^{-4}$ cm/cm°C	2.0 max.	2.0 max.	2.0 max.	2.0 max.
Hardness Type D	ASTM D2240		50 min.	50 min.	50 min.	50 min.
Volatile Loss	ASTM D1203	%	0.3 max.	0.3 max.	0.3 max.	0.3 max.
Water Absorption	ASTM D570	%	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Hydrostatic Resistance	ASTM D751	PSI (kPa)	200 (1380)	400 (2760)	500 (3450)	600 (4140)
Water Vapor Transmission	ASTM E96	g/m^2/day	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Seam Strengths	ASTM D4437					
Peel Strength (wedge)		PPI (N/cm)	67 (117)	98 (172)	115 (201)	143 (250)
Peel Strength (extrusion)		PPI (N/cm)	48 (84)	70 (123)	92 (161)	115 (201)
Shear Strength		PPI (N/cm)	86 (151)	126 (221)	166 (291)	207 (362)

* Gundline® HDC may have an overall carbon black percentage above 3.0% due to the high carbon black concentration in the conductive layer.
** Approximate corresponding stress specifications are; Yield, 2300 psi (16 N/mm^2); Break, 4000 psi (28 N/mm^2).

Table 8.2

TEXTURED GUNDLINE® HDT, HDWT, HDTS, HDWTS, AND HDCTS

Minimum Average Roll Values (MARV) Except When Designated Minimum, Maximum, or Range of Values

Property	Test Method	Unit	40	60	80	100
Thickness	ASTM D751	Mils (mm)	36-46 (0.9-1.15)	54-69 (1.35-1.73)	72-92 (1.8-2.3)	90-120 (2.25-3.0)
Density	ASTM D1505	g/cc	0.94 min.	0.94 min.	0.94 min.	0.94 min.
Melt Flow Index	ASTM D1238 Condition E (190°C,2.16 kg.)	g/10 minutes	0.3 max.	0.3 max.	0.3 max.	0.3 max.
Carbon Black %*	ASTM D1603	%	2-3	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D3015	Rating	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1
Tensile Properties	ASTM D638 Type IV, gauge length 2" break, 1.3" yield Dumb-bell @ 2 ipm					
Strength at Yield		PPI (N/mm)**	95 (17)	140 (25)	185 (32)	230 (40)
Strength at Break		PPI (N/mm)**	50 (9)	75 (13)	100 (18)	125 (22)
Elongation at Yield		%	13	13	13	13
Elongation at Break		%	150	150	150	150
Tear Resistance	ASTM D1004 Die C	Pounds (N)	30 (134)	45 (200)	60 (267)	75 (334)
Puncture Resistance	FTMS 101B Method 2065	Pounds (N)	52 (231)	80 (356)	105 (467)	130 (579)
Environmental Stress Crack	ASTM D1693 10 % Igepal, 50°C	Hours	1500 min.	1500 min.	1500 min.	1500 min.
Dimensional Stability	ASTM D1204 100° C 1 hr.	% change	±2 max.	±2 max.	±2 max.	±2 max.
Thermal Stability OIT	ASTM D3895 130°C, 800 PSI O_2	Minutes	2000 min.	2000 min.	2000 min.	2000 min.
Low Temperature Brittleness	ASTM D746 Procedure B	Degree F (° C)	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.
Coefficient of Linear Thermal Expansion	ASTM D696	$x10^{-4}$ cm/cm°C	2.0 max.	2.0 max.	2.0 max.	2.0 max.
Volatile Loss	ASTM D1203	%	0.3 max.	0.3 max.	0.3 max.	0.3 max.
Water Absorption	ASTM D570	%	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Hydrostatic Resistance	ASTM D751	PSI (kPa)	200 (1380)	350 (2415)	450 (3105)	550 (3795)
Water Vapor Transmission	ASTM E96	g/m^2/day	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Seam Strengths	ASTM D4437					
Peel Strength (wedge)		PPI (N/cm)	60 (105)	88 (154)	115 (201)	143 (250)
Peel Strength (extrusion)		PPI (N/cm)	42 (74)	63 (110)	84 (147)	105 (184)
Shear Strength		PPI (N/cm)	76 (133)	113 (198)	151 (264)	189 (331)

* Gundline® HDCTS may have an overall carbon black percentage above 3.0% due to the high carbon black concentration in the conductive layer.

** Approximate corresponding stress specifications are; Yield, 2300 psi (16 N/mm^2); Break, 1250 psi (8.6 N/mm^2).

Table 8.3

SMOOTH GUNDLINE® VL, VLW, AND VLC

Minimum Average Roll Values (MARV) Except When Designated Minimum, Maximum, or Range of Values

Property	Test Method	Unit	30	40	60	80
Thickness	ASTM D751	Mils (mm)	27-35 (0.67-0.88)	36-46 (0.93-1.15)	54-69 (1.35-1.73)	72-92 (1.8-2.3)
Density	ASTM D1505	g/cc	.910-.929	.910-.929	.910-.929	0.910-.929
Melt Flow Index	ASTM D1238 Condition E (190°C,2.16 kg.)	g/10 minutes	0.6 max.	0.6 max.	0.6 max.	0.6 max.
Carbon Black %*	ASTM D1603	%	2-3	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D3015	Rating	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1
Tensile Properties	ASTM D638 Type IV, 2" gauge length Dumb-bell @ 2 ipm					
Strength at Break		PPI (N/mm)**	95 (17)	126 (22)	190 (33)	250 (44)
Elongtion at Break		%	900	900	900	900
Tear Resistance	ASTM D1004 Die C	Pounds (N)	14 (62)	18 (80)	27 (120)	33 (160)
Puncture Resistance	FTMS 101B Method 2065	Pounds (N)	51 (227)	64 (285)	78 (347)	95 (423)
Environmental Stress Crack	ASTM D1693 10% Igepal, 50°C	Hours	1500 min.	1500 min.	1500 min.	1500 min.
Dimensional Stability	ASTM D1204 212°F 1 hour	% change	±3 max.	±3 max.	±3 max.	±3 max.
Thermal Stability OIT	ASTM D3895 130°C, 800 PSI O_2	Minutes	2000 min.	2000 min.	2000 min.	2000 min.
Low Temperature Brittleness	ASTM D746 Procedure B	Degree F (° C)	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.
Coefficient of Linear Thermal Expansion	ASTM D696	$x10^{-4}$ cm/cm°C	2.0 max.	2.0 max.	2.0 max.	2.0 max.
Hardness Type D	ASTM D2240		40 min.	40 min.	40 min.	40 min.
Volatile Loss	ASTM D1203	%	0.3 max.	0.3 max.	0.3 max.	0.3 max.
Water Absorption	ASTM D570	%	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Hydrostatic Resistance	ASTM D751	PSI (kPa)	100 (690)	140 (966)	180 (1242)	220 (1518)
Water Vapor Transmission	ASTM E96	g/m^2/day	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Seam Strengths	ASTM D4437					
Peel Strength		PPI (N/cm)	30 (53)	40 (70)	60 (105)	72 (126)
Shear Strength		PPI (N/cm)	33 (58)	44 (77)	66 (116)	80 (140)

* Gundline® VLC may have an overall carbon black percentage above 3.0% due to the high carbon black concentration in the conductive layer.
** Approximate corresponding stress specifications are 3125 ppi (22 N/mm^2).

Table 8.4

TEXTURED GUNDLINE® VLT, VLTS, VLWT, VLWTS, AND VLCTS

Minimum Average Roll Values (MARV) Except When Designated Minimum, Maximum, or Range of Values

Property	Test Method	Unit	30	40	60	80
Thickness	ASTM D751	Mils (mm)	27-35 (.067-0.88)	36-46 (0.9-1.15)	54-69 (1.35-1.73)	72-92 (1.8-2.3)
Density	ASTM D1505	g/cc	.910-.929	.910-.929	.910-.929	.910-.929
Melt Flow Index	ASTM D1238 Condition E (190°C,2.16 kg.)	g/10 minutes	0.6 max.	0.6 max.	0.6 max.	0.6 max.
Carbon Black %*	ASTM D1603	%	2-3	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D3015	Rating	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1
Tensile Properties	ASTM D638 Type IV, 2" gauge length Dumb-bell @ 2 ipm					
Strength at Break		PPI (N/mm)**	56 (10)	84 (15)	112 (20)	169 (30)
Elongation at Break		%	400	400	400	400
Tear Resistance	ASTM D1004 Die C	Pounds (N)	14 (62)	18 (80)	27 (120)	33 (147)
Puncture Resistance	FTMS 101B Method 2065	Pounds (N)	51 (227)	64 (285)	78 (347)	95 (423)
Environmental Stress Crack	ASTM D1693 10 % Igepal, 50°C	Hours	1500 min.	1500 min.	1500 min.	1500 min.
Dimensional Stability	ASTM D1204 100°C 1 hour	% change	±3 max.	±3 max.	±3 max.	±3 max.
Thermal Stability OIT	ASTM D3895 130°C, 800 PSI 0_2	Minutes	2000 min.	2000 min.	2000 min.	2000 min.
Low Temperature Brittleness	ASTM D746 Procedure B	Degree F (° C)	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.
Coefficient of Linear Thermal Expansion	ASTM D696	$x10^{-4}$ cm/cm°C	2.0 max.	2.0 max.	2.0 max.	2.0 max.
Volatile Loss	ASTM D1203	%	0.3 max.	0.3 max.	0.3 max.	0.3 max.
Water Absorption	ASTM D570	%	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Hydrostatic Resistance	ASTM D751	PSI (kPa)	100 (690)	140 (966)	180 (1242)	220 (1518)
Water Vapor Transmission	ASTM E96	$g/m^2/day$	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Seam Strengths	ASTM D4437					
Peel Strength		PPI (N/cm)	30 (53)	40 (70)	60 (105)	72 (126)
Shear Strength		PPI (N/cm)	33 (58)	44 (77)	66 (116)	80 (140)

* Gundline® VLCTS may have an overall carbon black percentage above 3.0% due to the high carbon black concentration in the conductive layer.

** Approximate corresponding stress specifications are 1860 psi (13 N/mm^2).

Table 8.5

SMOOTH GUNDLINE® HD/VL/HD, HDW/VL/HD, HD/VL/HDC, AND HDW/VL/HDC

Minimum Average Roll Values (MARV) Except When Designated Minimum, Maximum, or Range of Values

Property	Test Method	Unit	30	40	60	80
Thickness	ASTM D751	Mils (mm)	27-35 (0.67-0.88)	36-46 (0.9-1.15)	54-69 (1.35-1.73)	72-92 (1.8-2.3)
Density	ASTM D1505 Condition A	g/cc	.91 min.	.91 min.	.91 min.	.91 min.
Melt Flow Index	ASTM D1238 Condition E (190°C,2.16 kg.)	g/10 minutes	0.6 max.	0.6 max.	0.6 max.	0.6 max.
Carbon Black %*	ASTM D1603	%	2-3	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D3015	Rating	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1
Tensile Properties	ASTM D638 Type IV, gauge length 2" break, 1.3" yield Dumb-bell @ 2 ipm					
Strength at Yield		PPI (N/mm)**	33 (6)	45 (8)	70 (12)	90 (16)
Strength at Break		PPI (N/mm)**	108 (19)	144 (25)	216 (38)	288 (50)
Elongation at Yield		%	151	151	151	151
Elongation at Break		%	850	850	850	850
Tear Resistance	ASTM D1004 Die C	Pounds (N)	15 (67)	20 (89)	30 (134)	40 (178)
Puncture Resistance	FTMS 101B Method 2065	Pounds (N)	40 (178)	55 (245)	78 (347)	95 (423)
Environmental Stress Crack	ASTM D1693 10 % Igepal, 50°C	Hours	1500 min.	1500 min.	1500 min.	1500 min.
Dimensional Stability	ASTM D1204 100°F 1 hour	% change	±3 max.	±3 max.	±3 max.	±3 max.
Resistance to Soil Burial	ASTM D3083 Using ASTM D 638	% change	±10	±10	±10	±10
Thermal Stability OIT	ASTM D3895 130°C, 800 PSI 0_2	Minutes	2000 min.	2000 min.	2000 min.	2000 min.
Low Temperature Brittleness	ASTM D746 Procedure B	Degree F (° C)	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.
Coefficient of Linear Thermal Expansion	ASTM D696	$x10^{-4}$/ cm/cm°C	2.0 max.	2.0 max.	2.0 max.	2.0 max.
Hardness Type D	ASTM D2240		50 min.	50 min.	50 min.	50 min.
Volatile Loss	ASTM D1203	%	0.3 max.	0.3 max.	0.3 max.	0.3 max.
Water Absorption	ASTM D570	%	.1 max.	0.1 max.	0.1 max.	0.1 max.
Hydrostatic Resistance	ASTM D751	PSI (kPa)	100 (690)	140 (966)	180 (1242)	220 (1518)
Water Vapor Transmission	ASTM E96	g/m^2/day	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Seam Strengths	ASTM D4437					
Peel Strength		PPI (N/cm)	30 (53)	40 (70)	60 (105)	72 (126)
Shear Strength		PPI (N/cm)	33 (58)	44 (77)	66 (116)	80 (140)

* Gundline® HD/VL/HDC and HDW/VL/HDC may have an overall carbon black percentage above 3.0% due to the high carbon black concentration in the conductive layer.

** Approximate corresponding stress specifications are; Yield, 1100 psi (8 N/mm^2); Break, 3600 psi (25 N/mm^2).

Table 8.6

TEXTURED GUNDLINE® HDT/VL/HDT, HDT/VL/HD, HDWT/VL/HDT, HDWT/VL/HD, HDT/VL/HDC, AND HDWT/VL/HDC

Minimum Average Roll Values (MARV) Except When Designated Minimum, Maximum, or Range of Values

Property	Test Method	Unit	30	40	60	80
Thickness	ASTM D751	Mils (mm)	27-35 (0.67-0.88)	36-46 (0.9-1.15)	54-69 (1.35-1.73)	72-92 (1.8-2.3)
Density	ASTM D1505 Condition A	g/cc	0.910 min.	0.910 min.	0.910 min.	0.910 min.
Melt Flow Index	ASTM D1238 Condition E (190°C,2.16 kg.)	g/10 minutes	0.6 max.	0.6 max.	0.6 max.	0.6 max.
Carbon Black %*	ASTM D1603	%	2-3	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D3015	Rating	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1
Tensile Properties	ASTM D638 Type IV, gauge length 2" break, 1.3" yield Dumb-bell @ 2 ipm					
Strength at Yield		PPI (N/mm)**	33 (6)	45 (8)	70 (12)	90 (16)
Strength at Break		PPI (N/mm)**	56 (10)	84 (15)	112 (20)	169 (30)
Elongation at Yield		%	15	15	15	15
Elongation at Break		%	400	400	400	400
Tear Resistance	ASTM D1004 Die C	Pounds (N)	15 (67)	20 (84)	30 (134)	40 (178)
Puncture Resistance	FTMS 101B Method 2065	Pounds (N)	40 (178)	55 (245)	78 (347)	95 (423)
Environmental Stress Crack	ASTM D1693 10 % Igepal, 50°C	Hours	1500 min.	1500 min.	1500 min.	1500 min.
Dimensional Stability	ASTM D1204 212°F 1 hour	% change	±3 max.	±3 max.	±3 max.	±3 max.
Thermal Stability OIT	ASTM D3895 130°C, 800 PSI O_2	Minutes	2000 min.	2000 min.	2000 min.	2000 min.
Low Temperature Brittleness	ASTM D746 Procedure B	Degree F (° C)	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.
Coefficient of Linear Thermal Expansion	ASTM D696	$x10^{-4}$ cm/cm°C	2.0 max.	2.0 max.	2.0 max.	2.0 max.
Volatile Loss	ASTM D1203	%	0.3 max.	0.3 max.	0.3 max.	0.3 max.
Water Absorption	ASTM D570	%	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Hydrostatic Resistance	ASTM D751	PSI (kPa)	100 (690)	140 (966)	180 (1242)	220 (1518)
Water Vapor Transmission	ASTM E96	g/m^2/day	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Seam Strengths	ASTM D4437					
Peel Strength		PPI (N/cm)	30 (53)	40 (70)	60 (105)	72 (126)
Shear Strength		PPI (N/cm)	33 (58)	44 (77)	66 (116)	80 (140)

* Gundline® HDT/VL/HDC and HDWT/VL/HDC may have an overall carbon black percentage above 3.0% due to the high carbon black concentration in the conductive layer.

** Approximate corresponding stress specifications are; Yield, 1100 psi (8 N/mm^2); Break, 1860 psi (13 N/mm^2).

Table 8.7

GUNDGUARD LL/VL/LL

Minimum Average Roll Values (MARV) Except When Designated Minimum, Maximum, or Range of Values

Property	Test Method	Units	12	20	30
Thickness (Nominal)	ASTM D751	Mils (mm)	12 (0.3)	20 (0.5)	30 (0.75)
Density	ASTM D1505	g/cc	0.90 min.	0.90 min.	0.90 min.
Melt Index	ASTM D1238 Condition E (190° C,2.16 kg.)	g/10 min.	1.0 max.	1.0 max.	1.0 max.
Carbon Black %*	ASTM D1603	%	2-3	2-3	2-3
Tensile Properties	ASTM D638 Type IV Dumb-bell 2 ipm, 2" gauge length				
Strength at Break		lbs./in. (N/mm)**	35 (6)	60 (11)	95 (17)
Elongation at Break		%	700	700	700
Puncture Resistance	FTMS 101B Method 2065	lbs. (N)	20 (89)	32 (142)	46 (205)
Tear Resistance	ASTM D1004	lbs. (N)	4 (18)	6 (27)	10 (45)
Dimensional Stability	ASTM D1204 100° C, 1 hr.	% change	±3 max.	±3 max.	±3 max.
Low Temperature Brittleness	ASTM D746 Procedure B	Degree F (° C)	-107 (-77) max.	-107 (-77) max.	-107 (-77) max.
Resistance to Soil Burial	ASTM D3083 Using ASTM D638	% change	±10 max.	±10 max.	±10 max.
Environmental Stress Crack	ASTM D1693 10% Igepal, 50° C	Hours	1500 min.	1500 min.	1500 min.

* The overall carbon black content of thin non-black surfaced material may be lower due to the absence in the white surfaced layer of any carbon black.

** Approximate corresponding stress specifications are 2900 psi (21 N/mm^2).

Table 8.8

QUALITY CONTROL TEST FREQUENCY OF LINER

Test	Method	Routine
Thickness	ASTM D751	Every Roll

The thickness of geomembrane samples is tested using a dead weight digital thickness indicator. The constant pressure applied by the mass of the spindle and apparatus is preferred to the varying pressures which can be applied by a hand micrometer. To measure smooth geomembranes, the spindle and anvil of the thickness indicator are equipped with convex surfaces. For textured geomembrane, the contact points are tapered rods with a 1/32 inch (0.8 mm) diameter point. The thickness of a roll is measured approximately every eight inches (8") (20 cm) across the width of the roll.

Density	ASTM D1505	Twice Per Day
Melt Flow Index	ASTM D1238 Condition E	Twice Per Day
Carbon Black Content	ASTM D1603	Four Times Per Day
Carbon Black Dispersion	ASTM D3015	Twice Per Day
Tensile Properties	ASTM D638 Modified	Every Other Roll
Tear	ASTM D1004, C	Every Other Roll
Puncture	FTMS 2065, 101B	Every Other Roll
✓ Environmental Stress Crack	ASTM D1693 Condition B	Once Per Resin Batch
✓ Dimensional Stability	ASTM D1204	Once Per Line Per Week
✓ Modulus of Elasticity	ASTM D638 Modified	Upon Request
OIT Oxidative Induction Time	ASTM D3895	Once Per Resin Batch
Differential Seaming Calorimeter DSC	ASTM D3417	Upon Request
Thermogravimetric Analyzer TGA		Upon Request
Tensile Impact	ASTM D1822	Upon Request
✓ Rersistance to Soil Burial	ASTM D3083	Upon Request
Multi-Axial	GRI-GM4	Upon Request

Table 8.9

SPECIFICATION FOR GUNDNET® XL-14 DRAINAGE NET

Test	Method	Units	Gundnet XL-14
Mass Per Unit Area		lbs./sq.ft. (kg/sq.m)	0.16 (0.73)
Thickness	Micrometer Measurement at Strand Intersection	mils (mm)	200 mil - 265 mil .200 in. - .265 in. (5 - 6.6)
Density	ASTM D1505 Condition A	g/cc	0.940
Melt Flow Index	ASTM D1238	g/10 min.	0.3 max.
Carbon Black Content	ASTM D1603	%	2 - 3
Tensile Strength at Break	ASTM D751 (2" x 5"		
Machine Direction	Specimen Pulled	PPI (N/cm)	25 min. (44)
Cross Direction	Apart at 2 in./min.)	PPI (N/cm)	15 min. (26)
Transmissivity (Minimum)	ASTM 4716 10,000 psf compressive load Between Two Layers of Gundline® HD; 0.25 Hydraulic	gal/min/ft. or m^2/sec.	10 or 2×10^{-3}

SPECIFICATION FOR FABRI-NET® DRAINAGE COMPOSITE

Property	Method	Units	Requirements
Ply Adhesion*	ASTM F904 2" x 5" 2 ipm	g/in.	Polyester Geotextile 550 min. 900 avg. Polypropylene Geotextile 250 min. 450 avg.
Transmissivity (Minimum)	ASTM 4716 10,000 psf compressive load Two-Sided 8 oz./sq.yd. Geocomposite Between Two Layers of Gundline® HD; 0.25 Hydraulic	m^2/sec.	3.0×10^{-4}

Specification of net portion of composite is identical to the drainage net specification. Fabric specifications are dependent on customer specifications.

* Specifications will vary for other types of geotextiles.

Table 8.10

QUALITY CONTROL TEST FREQUENCY OF

GUNDNET® XL-14 DRAINAGE NET

Test	Method	Routine
Thickness	Micrometer at Strand Junction	Once Per 5 Rolls
Density	ASTM D1505 Condition A	Twice Per Day
Melt Flow Index	ASTM D1238 Condition E	Twice Per Day
Carbon Black Content	ASTM D1603	Four Times Per Day
Tensile Properties	ASTM D751 2 ipm, 2" x 5" Specimens	Once Per 5 Rolls
Transmissivity	ASTM D4716	Reference Only or Upon Request

QUALITY CONTROL TEST FREQUENCY OF COMPOSITE

Test	Method	Routine
Ply Adhesion	ASTM F904 2" x 5" 2 ipm	Once Per 5 Rolls
Transmissivity	ASTM D4716	Upon Request

Testing of net portion of composite is identical to drainage net testing frequency. Testing of fabric is performed by supplier.

Table 8.11

SPECIFICATION FOR WELDING ROD

Property	Method	Units	HDPE	VLDPE
Thickness	Micrometer	Mils (mm)	195 - 205 (4.9 - 5.1)	195 - 205 (4.9 - 5.1)
Density	ASTM D1505 Method A	g/cc	0.94 min.	0.90 min.
Melt Flow Index	ASTM D1238 Condition E	g/10 min.	0.3 max.	1.10 max.
Carbon Black Content	ASTM D1603	%	2 - 3	2 -3

QUALITY CONTROL TESTING FREQUENCY OF WELDING ROD

Method	Test	Routine
Thickness	Micrometer	Twice Per Day
Density	ASTM D1505	Twice Per Day
Melt Flow Index	ASTM D1238 Condition E	Twice Per Day
Carbon Black Content	ASTM D1603	Twice Per day

Table 8.12

DELIVERED BENTONITE QUALITY VERIFICATION

	Test Method	Every 5th Truck (300,000 lbs.)	Every 10th Truck (600,000 lbs.)
Moisture Content	ASTM D2216	X	
Filtrate Loss	API 13A, Section 4	X	
Particle Size	ASTM C136	X	
Plate Water Absorption	ASTM E946-83		X
Washed 325 Sieve (0.051 nm)	API 13A, Section 4		X

Table 8.13

BENTONITE QUALITY DAILY PRODUCTION VERIFICATION

Moisture Content	ASTM D2216
Filtrate Loss	API 13A, Section 4
Free Swell	(USP-NF-XVII)

Table 8.14

9.0 PRODUCT INFORMATION

9.1. **Gundline® HD** - High Density Polyethylene (HDPE) Liner

9.2 **Gundline® VL** - Very Low Density Polyethylene (VLDPE) Liner

9.3 **Gundline® HDT and VLT** - Textured Surfaced HDPE and VLDPE Liners

A. Air Space Capacity Savings Calculations Using Textured Liners

B. Tensile Break Properties of Gundline® HDT

C. Textured Sheet Cross-Sections

9.4 **Gundline® HDW** - White-Surfaced Liner

A. What Constitutes a Significant Defect or Score Mark in HDPE?

9.5 **Gundline® HDC** - Electrically Conductive Liner to Spark Test 100% of Lined Surface for Leaks After Installation

9.6 **Gundline® HD/VL/HD** - Three layer Co-extruded HDPE/VLDPE/HDPE Liner to Combine the Advantages of Both Materials

9.7 **Prefabricated Products** - Sheet Panels, Sumps, Boots, Manholes, and Pipe

9.8 **Gundguard** - Prefabricated Flexible Liner for Self-Installation

9.9 **Gundnet® and Fabri-net®** - Fluid Drainage HDPE Net and Fabric/Net Composite

A. Air Space Capacity Savings Calculations Using Geosynthetic Drainage Products

9.10 **Gundseal®** - Geomembrane Supported Geosynthetic Clay Liner (GCL)

A. GCLs vs CCLs (Compacted Clay Liners)

B. Gundseal® vs Fabric-Supported GCLs

C. Air Space Capacity Savings Calculations Using Gundseal®

9.11 **Gundwall®** - HDPE Vertical Barrier Wall Construction

9.12 **Hydrotite™** - Hydrophilic Neoprene Water-Sealing System

9.13 **Sensor™ Damage Detection System** - Electrical Sensors Allowing Computer Software to Map Leak Locations

9.14 **Geogrid** - Oriented HDPE Grid for Structural Support in Geotechnical Applications

Gundline® HD

9.0
Product
Information

GUNDLINE® HD is a high quality formulation of High Density Polyethylene containing approximately 97.5% polymer and 2.5% of carbon black, anti-oxidants and heat stabilizers. The product was designed specifically for exposed conditions. It contains no additives or fillers which can leach out and cause embrittlement over time.

GUNDLINE® HD

PRODUCT DESCRIPTION

JOINING SYSTEMS

Critical to the success of any flexible membrane liner is the joining system. Gundle's Hot-Wedge Welding System and patented Extrusion Welding System are used to join individual panels of GUNDLINE HD. Request your copy of Gundle's Welding Brochure for complete details.

SUPPLY SPECIFICATIONS

The following describes typical roll dimensions for GUNDLINE HD.

THICKNESS		WIDTH		LENGTH		AREA		ROLL WEIGHT	
mil	mm	ft	m	ft	m	ft²	m²	lb	kg
30	0.75	22.5	6.86	840	256	18,900	1756	2800	1272
40	1.0	22.5	6.86	650	198	14,625	1359	2800	1272
50	1.25	22.5	6.86	500	152	11,250	1043	2800	1272
60	1.5	22.5	6.86	420	128	9,450	878	2800	1272
80	2.0	22.5	6.86	320	98	7,200	670	2800	1272
100	2.5	22.5	6.86	250	76	5,625	522	2800	1272
120	3.0	22.5	6.86	210	64	4,725	439	2800	1272
140	3.5	22.5	6.86	180	55	4,050	377	2800	1272

THICKNESS		WIDTH		LENGTH		AREA		ROLL WEIGHT	
mil	mm	ft	m	ft	m	ft²	m²	lb	kg
30	0.75	34.5	10.5	840	256	28,980	2688	4400	2000
40	1.0	34.5	10.5	650	198	22,425	2079	4400	2000
50	1.25	34.5	10.5	500	152	17,250	1596	4400	2000
60	1.5	34.5	10.5	420	128	14,490	1344	4400	2000
80	2.0	34.5	10.5	320	98	11,040	1029	4400	2000
100	2.5	34.5	10.5	250	76	8,625	798	4400	2000

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GUNDLINE HD is rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Custom lengths available on request.

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THE DURABILITY OF GUNDLINE HD

"How long will liners last and retain their barrier properties?" This is a very important question in waste containment, especially considering the many different environmental actions which can impact liners (see Figure 2). Clay liners are known to lose much of their barrier properties due to chemical action, weathering, root growth, and the difficulties of proper installation. Durability problems may also affect synthetic liners. Therefore the question of durability becomes very important. This newsletter will begin a series of discussions on each of the following categories of durability:

1. Thermal-oxidative degradation
2. Ultraviolet light degradation
3. Chemical degradation (including ozone attack)
4. Environmental stress cracking
5. Biological degradation (plant and animal effects)

Gundline HD is designed to provide superior durability in all of the above categories.

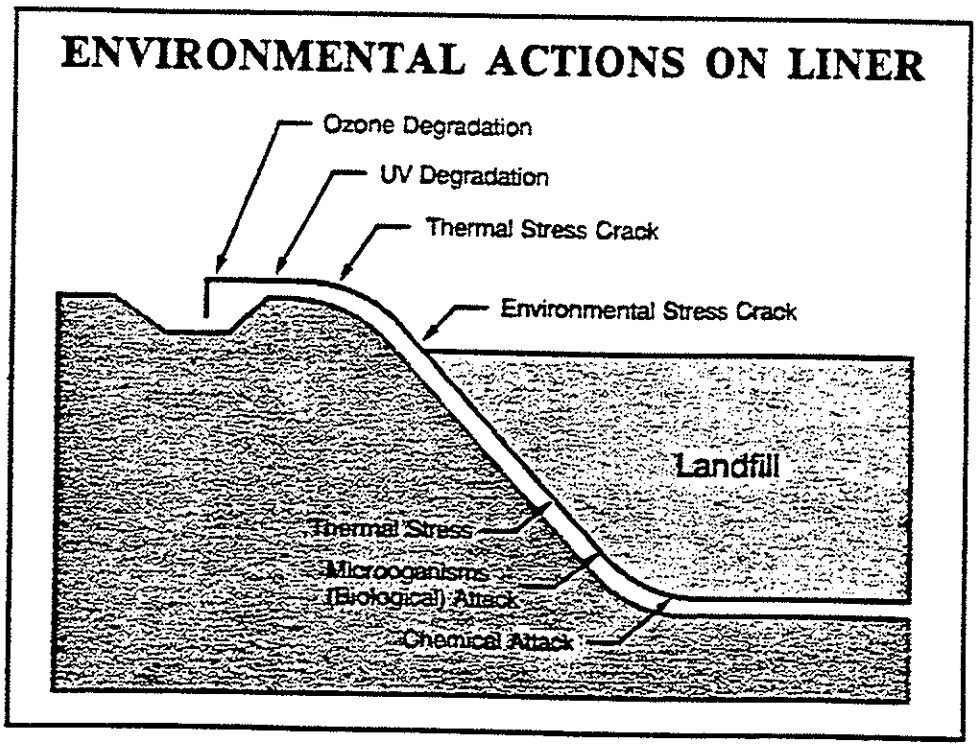

FIG. 2

Product Information

THERMAL-OXIDATIVE DEGRADATION

onsidering that temperature increases of F have been correlated to 80% reductions in polymer life expectancies (1), it mes clear that thermal-oxidative degrad n of HDPE is a very important consideration in the estimation of polymer durability. Liner temperatures can be elevated by 1) radiation on the black plastic (temperas as high as 75° C have been measured), anaerobic fermentation of wastes in con ent (60° C temperatures are common), ntainment of plant process wastes at evated temperature, and 4) smoldering ndfill fires. Therefore, thermal-oxidative tests are and have always been an portant test protocol for liner durability. In the lining business a couple of oven tests have been used to test for al-oxidative degradation: ASTM D573 d ASTM D1349. These tests involve suspending tensile specimens in an oven at up to 110° C and monitoring changes in tensile strength and elongation. The problem is that these existing methods for the accelerated aging of synthetic liners are generally unsatisfactory with regard to reproducibility and length of test. The forced-air oven aging test, for example, suffers from the following weaknesses: 1) the endpoint of the test is not distinct, 2) the test requires many months, even years, and 3) precise temperature control is critical, but difficult to maintain in all parts of a forced-air oven. Other tests such as oxygen uptake tests also suffer from a lack of reproducibility, long test periods, and in addition have limited sample capacity. **Differential scanning calorimetry is therefore a very attractive technique for examining thermal-oxidative degradation via oxidative induction times (OIT).**

an, M.G., Gilroy, H.M., and Martin, W.M., Longterm Aging Properties of Pololefins, iety of Plastics Engineers Inc., Regional Technical Conference, Houston, TX (1984).

TABLE I
OMPARISON OF OIT FOR DIFFERENT HDPE LINERS
ASTM D3895 @ 130 DEG. C, 800 PSI O_2

E...	WIDTH (m)	FACTORY SEAMS	OIT (MINUTES)
dline HD	6.9	No	2600
C U K)	2.5	No	300
s t - Monarflex	4.0	No	810
sheet - Blackline	4.0	No	875
			479
o l Seal	4.6	No	340
ue	7.3	Yes (every 2.4 m)	925
uw	2.0	No	743
	5.0	No	961
rg	2.0	No	857
pio	11.0	Yes (every 0.5 m)	925
	6.8	No	1058
	2.0	No	783

I... OIT'S LISTED ARE FOR TYPICAL SAMPLES OF THE INDICATED LINER. THESE ARE NOT MINIMUM SPECIFICATIONS.

OXIDATIVE INDUCTION TIMES

At Gundle we are actively using Differential Scanning Calorimetry (DSC) to characterize liner materials and define the limits of performance of liners. DSC measures heat energy released or absorbed by a small sample of material. The instrument can thus be used to scan the melting region, calculate heats of fusion, (which relate to % crystallinity), and calculate oxidative induction times.

Oxidative Induction Times (OIT) reflect the capacity of a liner to withstand degradation over time. Once degradation is initiated — by heat, light, radiation, or chemical attack — oxidation can cause polymer bonds to break in a chain reaction. The time at which these reactions occur in a run-away fastion is visible on a DSC as heat released by the destructive reactions. **The OIT is a measure of the time it takes to reach this run-away state of degradation.**

Both high temperatures and (of recent development) high oxygen pressures can be used to accelerate polymer degradation. The high pressure makes tests at lower temperatures than normal possible for OIT testing (130° C vs. 210° C). The lower temperatures are much closer to field temperatures (sometimes 75° C or more), and provide a better indication of resistance to aging due to conditions in the field. This is important because when OIT temperatures are too high, completely different mechanisms of degradation and stabilization can be in effect.

Resistance to oxidation, the principle mechanism behind the aging of any material, is much higher for Gundline HD than for other polyethylene liners, especially at 130° C testing (see Table 1). Our OIT specification for Gundline HD is a minimum of 2000 minutes at 130° C and 800 psi of oxygen. The superior performance reflects attention to low thermal stress during manufacturing, high quality resin, and stabilizer selection. While extrapolation to actual lifetimes in field application is impossible, OIT results along with our attention to the other important areas of durability make Gundline HD more durable than its competitors.

UV - RESISTANCE OF GUNDLINE® HD

Ultraviolet light exposure resistance is of major importance in determining the weatherability of lining materials. In the case of polyethylene products, we have the background of many successful applications in an outdoor environment which date back to the 1940's. The most common of these applications for polyethylene have been in outdoor wire coatings and irrigation pipe. Thus, over the years, much has been learned about the stabilization of polyethylene.

To protect polyethylene against UV radiation, finely dispersed carbon black is added to the raw material. Test results from various sources have shown that a carbon black content greater than 1% in sheet made of HDPE with a wall thickness greater than 1 mm is absolutely sufficient to guarantee maximum UV resistance.

In 1941, an early sample of polyethylene containing only 1% of carbon black was put on exposure racks in Florida by AT&T Research Labs. Although there was a small, initial decrease in mechanical strength, the formulation then showed almost no further loss and remains on test at the exposure site. Modern practice now specifies from 2.0 to 3.0% of carbon black for optimum protection. Expert opinion on carbon black stabilized polyethylene is that properly stabilized material should last over 100 years in even the most intense belts of solar radiation.

The specification for outdoor UV exposure is that the carbon black should be: 1) an optimum particle size, 2) be properly dispersed, and 3) be added in the right amount. At Gundle we test according to the following guidelines:

Property	Specification	Method
Carbon Black Content	2 - 3%	ASTM D1603
Carbon Black Dispersion	A-1, A-2, B-1	ASTM D3015 with analysis by ASTM D2663

The degree of additive dispersion by the Gundle process is excellent. An indication of this is the consistently obtained rating of A-1 — A-2 in the carbon black dispersion test. These are the highest rating levels possible on the ASTM chart.

In addition to carbon black, a proprietary stabilization package is compounded with the resin at a very small overall percentage. This package includes primary and secondary antioxidants known to work synergistically with the carbon black, and which also add protection against thermal degradation.

THE CHEMICAL RESISTANCE OF GUNDLINE® HD

The chemical resistance of HDPE is due to its fundamental molecular structure; primarily the tightly ordered arrangement of polymer chains (crystallinity) along with the simplicity of its building block, ethylene, which is completely free of reactive functional groups.

High Density Polyethylene is naturally inert to a wide range of different chemicals, including acids, bases, heavy metals, hydrocarbons, inorganic salts, detergents, natural fats and oils, chlorinated hydrocarbons, and others. HDPE does not degrade in the presence of most corrosive and reactive chemicals. Its chemical resistance is proven by a large amount of testing in many different industries.

Chemical resistance tests include EPA Method 9090 and ASTM D543. The data base of test results from these and other methods or chemicals and chemical waste mixtures in contact with HDPE has become very large. The results demonstrate the inert character of HDPE in contact with a very wide range of chemicals.

With Gundle's many years of experience, we have tested the chemical resistance of Gundle HD against a wide variety of chemicals. Any of the chemical compatibility reports appearing below are available to you.

CHEMICAL COMPATIBILITY TEST DATA
(Reports Available)

Report Number	Type of Chemical
105	Stripped Gas Liquor (70° C)
109	Sulphuric Acid (97.3%) (25° C)
111	Metal Hydroxide Waste Water Sludge
156*	E-2 Sludge
185	No. 6 Fuel Oil
197*	Sludge E-1; Sludge T-1; Flyash E-2; Neutralized T-1
208	Contaminated Water Samples
210	Kerosene
216	Hydrochloric Acid; Methanol; Diethylbenzene
227	Aromatic Waste Containing Inorganics
234	Creosote Emulsion
251	Potato Plant Wastewater
298	Escaid 100 (Kerosene)
334	Kerosene (Jet Fuel)
425*	Wastewater - Synthetic & Rutile Ore; Petroleum Coke; Sand & Grid; Hydroxides; oxides; iron; chromium; calcium carbonate; manganese, arsenic; nickel; salts; calcium sulfate
451	Shop dust leachate' pickle liquor sludge leachate
533	Leachate solution
553	Fuel Oil (Automotive Fuels)
563	Leachate Solution (PVC); 3300 Polylefin
567	Metals Leachate (black mud slurry waste)
629	Creosote
644	Petroleum Waste Sludge
656	Black Liquor (Hypalon)
667	Aromatic Leachate
671*	Trichloroethylene
690	Synthetic Leachate (Gundnet; Gundfab: Gundflex 300)
730*	Boiler Blow-down Waste; Brine Concentrate
731	Aromatic Hydrocarbons
763	Leachate generated from air pollution sludge; flue dust
796	Herbicides & Metals Leachate
914	Exposure to Metal Leachate after One Year
962	Nitric Acid (10% & 50%)
1118	Chemical Waste (Organic & Acidic/Basic)
1119	Cholorinated Hydrocarbon Leachate
1195	Dichlorobenzene
1196	Dichlorobenzene Plus Water
1197	Dichloroethylene
1198	Dichloroethylene Plus Water
1315	Ethylene Dichloride Solution (2-3%)
1316	Resin Waste Containing Methyl Methacrylate (40 Days)
1327	Typical Landfill Leachate
1370	Landfill Leachate
1371	Synthetic Hazardous Waste Mixture
1374	Municipal Landfill Leachate (PVC)
1375	Municipal Landfill Leachate (Driline)
1376	Nacl Solution

* Chemical Analysis Included

1448	Pond Water
1449	Methyl Methacrylate (120 Days)
1450	Oil Retention Pond Waste
1519	Synthetic Leachate/Neutralization Sludge
1520	Spent Carbon
1521	Mill Waste
1522	Flame Retardant
1523	Municipal/Residual Waste
1524	Chemical Waste Solution from NUS Corp.
1525	Municipal Landfill Leachate
1584	Brominated Hydrocarbon Solution (ALRS)
1617	Treated Sludge (Dust)
1705	Phosphate Leachate
1775	Wastewater Leachate
1785	Cyanide
1824	Heavy Metals Leachate
1825	Landfill Leachate
1870	Waste Water
1952	Creosote Emulsion
1953	Flume Wastewater
1954	Solvent/Pesticide Waste (Casmalia)
1989	Ground Wastewater (Aromatic Hydrocarbon Waste)
2043	Paint Reducer & Paint Thinner
2044	Creosote Emulsion (LDPE & HDPE)
2098	Chlorinated Pesticide
2114	Metals Leachate
2148	Waste Sludge
2214	Dichlorobenzene
2277	Toluene
2357	Nitric Acid
2817*	Metal Salts, Hydrocarbons & Halogenated Compounds
2901*	Landfill Leachate
3183*	Toluene, Ethylbenzene
3600*	Dichloroethane & Miscellaneous Organic Solvents
3601*	Incinerator Ash Sludge
4214*	Chlorinated Hydrocarbon Waste, Ketones, Alcohols
4215*	Phenolic Landfill Leachate
5081*	Heavy Metal Leachate
5771*	Aromatic & Phenolic
5812*	Phenolics, Aromatics, Sulfates, Nitrates
5815*	Chromate Copper Arsenate (Wood Preservative)
5882*	Anthraquinones (Aromatic Solvent)
5969*	Aromatics, Phenolics

Product Information

OL 001*	Chemical Compatibility Testing of HDPE Chevron Resin
OL 002*	Chemical Compatibility Testing of HDPE Union Carbide Resin
OL 003*	Chemical Compatibility Testing of HDPE Solvay Resin
OL 004*	Chemical Compatibility Testing of HDPE Geomembrane
OL 005*	Chemical Resistance of Jet Fuel–TRI Test Results (80mil)
OL 006*	Chemical Resistance of Jet Fuel–TRI Test Results (60mil)
OL 007*	Chemical Compatibility Testing of HDPE Quantum Resin

*** Chemical Analysis Included**

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SPECIFIC GUIDELINES FOR GUNDLINE HD CHEMICAL RESISTANCE

	Gundline HD Resistance
Alcohols -	resistant to 100% concentration
* Aldehydes -	resistant to 100% concentration
Amines -	resistant to 100% concentration
* Aromatic and Aliphatic Hydrocarbons without Functional Groups -	resistant to 100% concentration
Detergents and Other Cleaning Products -	resistant to 100% concentration
Esters -	resistant to 100% concentration
* Ethers -	resistant to 100% concentration
* Halogenated Hydrocarbons -	resistant to 100% concentration
-	aromatic halogenation resistant to 1% concentration
Inorganic Acids -	nitric acid resistant to 10% concentration
-	chlorosulphonic acid resistant to 5% concentration
-	other acids resistant to 95%
Inorganic Bases -	resistant to 100% concentration
Inorganic Salts -	resistant to 100% concentration
* Ketones -	resistant to 100% concentration
Natural Fats and Oils -	resistant to 100% concentration
Organic Acids -	resistant to 100% concentration

* These materials are significantly absorbed by the liner causing some "softening" but no degradation. Concentrations in liquid next to the liner should be prudently limited to 1500 ppm for long term containment. Concentrations in soils may, however, be higher.

Note 1: This information is for containment at 23 $^{+}$ 5^{o}C. Higher temperatures would increase reactivity, especially of the inorganic acids.

Note 2: This data does not apply to the mixture of certain chemicals, e.g., a strong acid and base would react releasing much heat and possible rupture of the liner at "hot spots".

Actual report data can be obtained from Gundle by requesting the chemical resistance reports index. Other specific data is available from independent laboratory testing and from polyethylene manufacturers. Please call if you have questions.

T-068

LINER DURABILITY: STRESS CRACK RESISTANCE

There are two approaches in testing for environmental stress cracking: 1) constant strain (e.g., bent strip testing, ASTM D1693), and 2) constant stress (e.g., ASTM D2552). The most frequently conducted test is the bent strip test, ASTM D1693 (see Figure 1). This test simulates the bending and folding stresses that can be left in a liner.

Immersed in a surfactant solution and held at elevated temperature cracks should not occur in the bent strips of ASTM D1693. Stress is induced across a "notch" (a razor blade slit placed in the strips) by the bending of the strips of polymer. With time, the polymer strips relax (i.e. assume the "U" shape) and the stress is relieved. Hence, Environmental Stress Crack Resistance (ESCR) values cited in excess of 1000 hours are of questionable value. It is for this reason we do not cite ESCR values greater than 1500 hours for ASTM D1693.

ASTM D2552, on the other hand, applies a constant tensile stress in the liner and prevents relaxation of the liner specimen. This does not reflect the vast majority of stress conditions in the field. Field stress conditions are caused primarily by deformation of the liner. In cases of deformation, the polymer molecules can conform to the new "deformed" position and relax.

PROPER INSTALLATION

Constant stress-type stresses in the liner may occur in exposed liners in cases of extreme and long-term thermal contraction. Since field seams may behave similar to a lab test "notch", severe thermal contraction which results in tension across seams can produce cracks at seams in exposed liners. However, proper installation and design can eliminate these stresses. Installation of exposed liners during hot weather must mean deploying excess material to compensate for thermal contraction which will occur as temperatures decrease. Proper installation also means that seams should always run parallel to the slope direction. In addition, slopes must be designed to be less than the friction angle between the liner and subgrade in order for loads on the liner to be transferred through to the subgrade. Compressive loads should, by design, not be allowed to become tensile stresses in the liner.

MODERN PIPE-GRADE POLYETHYLENE

But most importantly, many modern polyethylene resins have excellent resistance to stress cracking. And they are getting better all the time. Phillips slurry process copolymer HDPE resins, in particular, demonstrate superior resistance to stress cracking. This is confirmed by Prof. Norman Brown of the University of Pennsylvania, one of the worlds top experts on stress crack growth rates in polyethylene. Prof. Brown says that Phillips TR 400 resin remains the top performer in stress crack growth resistance. He notes, in particular, that TR 400 has improved in the last few years. The stress crack growth rates of 1988 resin are 7 times better than the 1985 resin. TR 400 and its licensed equivalent, Chevron 9642, are resins Gundle uses to make Gundline HD.

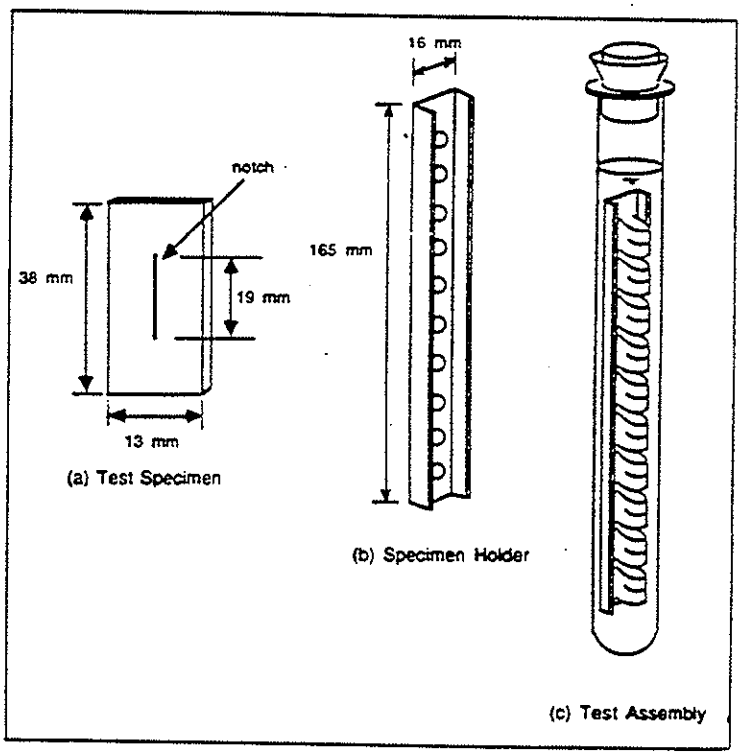
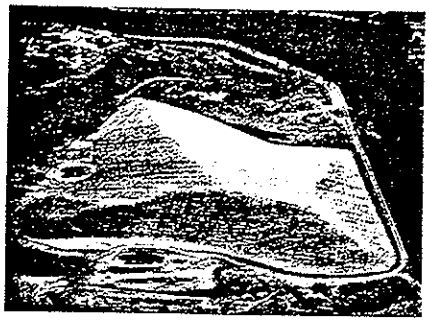


Fig. 1. - Test Setup for ASTM D-1693 Bent Strip Test

Gundline® VL

9.0
Product
Information

Gundline® VL (VLDPE) Lining System.



Now, there's a proven, cost-effective solution to flexibility requirements in many of your liner applications ... Gundle's Gundline® VL Very Low Density Polyethylene Liner (VLDPE). This high-performance polyolefin (also known as "FLEXOMER") has exceptional elastic properties. So, in applications such as landfill caps, tunnel lining, and potable water containment, where flexibility and elongation are more important than

chemical resistance, Gundline VL is ideal. Gundline VL also offers many of the traditional advantages of Gundline® HD liner such as: low temperature resistance; microorganisms, insect, and rodent resistance; 22.5-foot or 34.5-foot seamless widths and effective heat-seaming techniques.

The Alternative Choice for Landfill Caps and Closures

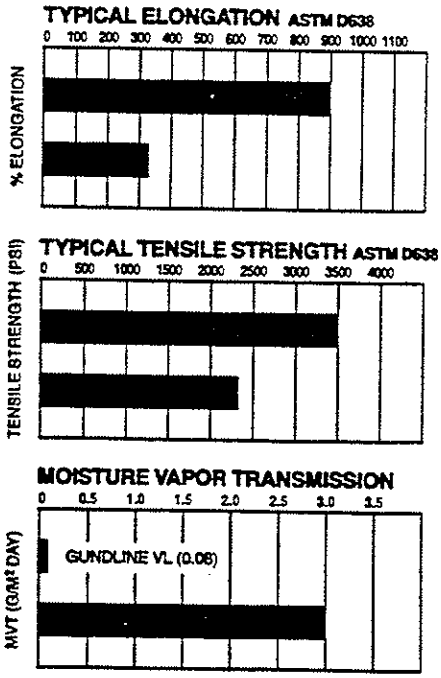
Landfill cap design usually presents unique problems, especially potential differential settlement of the landfill. Gundline VL, with its excellent multiaxial elongation, offers tremendous insurance against problems due to settling. Clay liners, on the other hand, are known to lose much of their barrier properties due to the absence of elasticity, difficulties of proper compaction, weathering, and root growth.

Not only does the lining have excellent elasticity, but Gundline VL also offers excellent barrier properties to rainwater from outside the landfill while acting as a collector of gas from inside the landfill. Because of its flexibility, Gundline VL conforms very well to non-uniform surfaces. It "hugs" these surfaces tightly, providing good slope stability and puncture resistance over the closures.

A Gundline VL cap also promotes

good vegetative growth in the topsoil cover of the closure by blocking the seepage of landfill gas through the vegetation. This enhances slope stability even further and provides better erosion control for the final closure.

Gundline® VL Liner Compared to PVC.



Polyvinyl Chloride (PVC) has been used in applications where flexibility is more important than chemical resistance. But the material achieves its flexibility from the addition of plasticizers. Present in PVC liners at 30% weight or more, plasticizers are low molecular-weight compounds such as monomeric fats.

These low molecular-weight additives can leach out because of heat, soil chemicals, and stresses in the liner, causing the liner to become brittle later on. Plasticizers are also food for rodents and microorganisms.

Gundline VL, on the other hand, contains no plasticizers. It achieves all of its flexibility and elongation from its inherent polymer structure. The natural strength and durability of polyethylene is combined with exceptional flexibility and elongation in Gundline VL. Gundle's co-extrusion technology can manufacture Gundline VL in one color or in layers of different colors, including a white reflective surface/(Gundline VLW) for control of expansion/contraction and improved visual inspection for damage. Gundline VL can also be given an electrically conductive undersurface for built-in spark test capability for leaks after installation over 100% of its area.

SUPPLY SPECIFICATIONS

THICKNESS		WIDTH		LENGTH		AREA	
mil	mm	ft.	m	ft.	m	ft.	m
20	0.5	22.5	6.86	1250	381	28,125	2613
30	0.75	22.5	6.86	840	256	18,900	1756
40	1.0	22.5	6.86	650	198	14,625	1359
60	1.5	22.5	6.86	420	128	9,450	878
80	2.0	22.5	6.86	320	98	7,200	670
100	2.5	22.5	6.86	250	76	5,625	522
20	0.5	34.5	10.5	1250	381	43,125	4006
30	0.75	34.5	10.5	840	256	28,980	2688
40	1.0	34.5	10.5	650	198	22,425	2079
60	1.5	34.5	10.5	420	128	14,490	1344
80	2.0	34.5	10.5	320	98	11,040	1029
100	2.5	34.5	10.5	250	76	8,625	798

GUNDLINE VL is rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Custom lengths available upon request.

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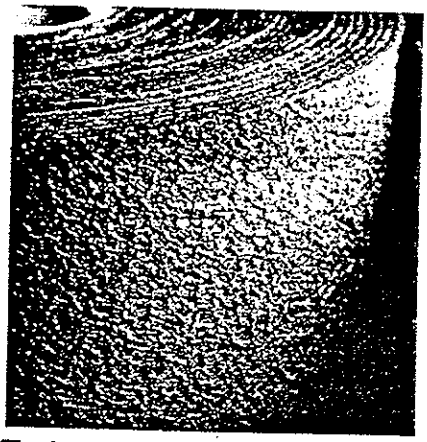
Gundline® HDT
Gundline® VLT

9.0
Product
Information

Textured Gundline® HDT Maximizes Slope Stability

Gundle Lining Systems has developed a method for adding a rough texture to the surface of our durable High Density Polyethylene (HDPE) liners. The result is a high performance product called Gundline HDT which increases slope stability in engineered landfills and other lining applications.

Gundline HDT's special textured surface dramatically improves slope stability by increasing friction between the synthetic liner and soils, geotextiles, and other geosynthetics. Cover soils are held on the liner with the greatly increased friction, and safety-conscious engineers can improve factors of safety on slopes of varying steepness. Table 1 lists the improvements in friction angle for Gundline HDT, determined by direct shear box testing.



The innovative friction surface of Gundline HDT is manufactured simultaneously with extrusion of the solid barrier portion of the liner as opposed to being added after extrusion. It's a rough surface, fully integrated with the sheet during the molten phase of manufacture. As a result, it has excellent abrasion resistance and remains intact regardless of chemicals contacting the sheet surface.

TABLE I: DIRECT SHEAR BOX FRICTION ANGLES*

SLIDING SURFACE	*FRICTION ANGLE (DEGREES)* *POLYETHYLENE*	*TEXTURED*
Gundline/H.R. Clay	16	24
Gundline/Ottawa Sand	17	26
Gundline/Geotextile (Nonwoven)	11	29

*Note: Friction angles for the products listed are typical only and may vary with local soil conditions. Accordingly, engineers must test friction angles for the product using site specific soil composition for all designs incorporating the product.

Gundline HDT Retains The Important Advantages Of Gundline® HD.

Manufactured in 22.5 foot wide seamless rolls and in thicknesses ranging from 40-100 mils of barrier wall, Gundline HDT features the same important qualities that have made Gundline HD the world's leading lining system. Tensile strength before yielding, biaxial elongation, tear resistance, puncture resistance, ultraviolet light resistance, chemical resistance, dimensional stability, heat resistance, and stress crack resistance are all excellent. So is resistance to microorganisms and rodent damage.

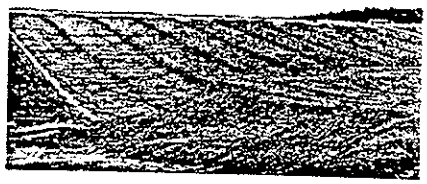
As with Gundline HD, Gundle manufactures Gundline HDT with only the top performing pipe grade HDPE resin. The superior high grade resin creates an ideal structure to the finished sheet.

HDPE resin and carbon black used in manufacturing.

Gundline® VLT

Gundline VLT combines the exceptional elongation and elastic properties of Gundline® VL (Very Low Density Polyethylene Liner) with the outstanding friction characteristics and slope stabilizing qualities of Gundline® HDT! The combination makes the liner ideal for landfill closures and other applications where elongation, flexibility, and slope stability are important. The excellent multi-axial elongation of Gundline VLT accommodates differential settlement while the textured surface provides long term slope stability.

Gundline HDT Provides Solutions To Difficult Applications.



A recent problem at Islip, New York illustrates the effectiveness of Gundline HDT. It began when the city's municipal landfill neared capacity. The problem was then compounded by the lack of available land for expansion. But Gundle provided the solution. After considering all available options, it was decided to expand vertically—a process dubbed "piggybacking." A new cell would be created to sit atop the existing closed and capped landfill. However, it was critical to establish slope stability for the new, steep slopes of this 80-foot high addition. So Gundle manufactured and installed 1.2 million square feet of Gundline HDT and successfully increased the friction angle between the liner and the sand over sixty percent.

Today, not only does Islip have 1.8 million cubic yards of new refuse disposal capacity, but they also have peace of mind knowing it's lined with the industry's most stable and durable liner.

SUPPLY SPECIFICATIONS

The following describes typical roll dimensions for Gundline HDT and VLT.

NOMINAL THICKNESS		WIDTH		LENGTH		AREA	
mil	mm	ft.	m	ft.	m	ft. 2	m2
30	0.75	22.5	6.86	625	190	14,063	1306
40	1.0	22.5	6.86	600	183	13,500	1254
60	1.5	22.5	6.86	420	128	9,450	878
80	2.0	22.5	6.86	320	97	7,200	669
100*	2.5	22.5	6.86	250	76	5,625	522

* 100 mil is only available in HDT

GUNDLINE HDT and GUNDLINE VLT are rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Custom lengths available upon request.

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SIDE SLOPES AND FRICTION ANGLES

FRICTION SURFACES

Sliding Surfaces	Angle of Friction (Degree)	
	Gundline HD	Gundline Textured HD
Gundline HD/H.R. Clay	15°	24°
Gundline HD/Ottawa Sand	17°	26°
Gundline HD/Concrete Sand	23°	29°
Gundline HD/Geotextile	11°	29°

SLOPE	ANGLE OF FRICTION
8:1	7.1°
6:1	9.5°
5:1	11.3°
4:1	14.0°
3.5:1	15.9°
3:1	18.4°
2.5:1	21.8°
2:1	26.6°
1.5:1	33.7°
1:1	45.0°

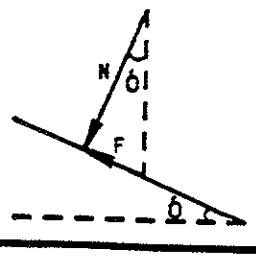
DEFINITION OF FRICTION ANGLE

μ = coefficient of friction (dimensionless)

δ = angle of friction (degrees)

$\mu = \tan \delta = F/N$

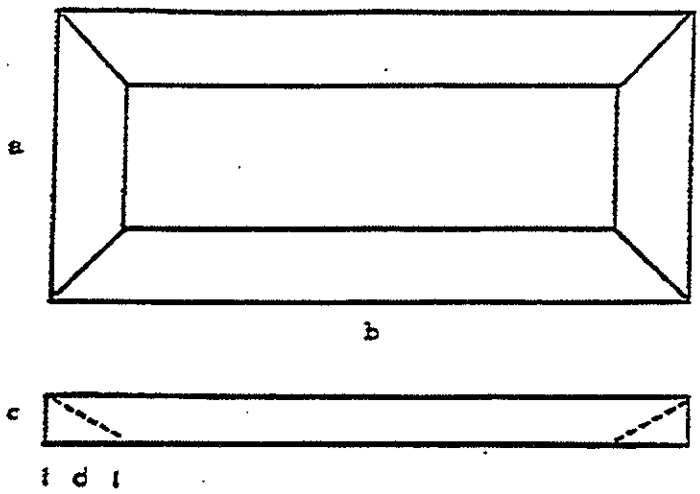
where, F = friction force
N = normal load



9.0 Product Information

NOTE: These specifications are offered as a guide for consideration to assist Engineers with their specifications. However; Gundle assumes no liability in connection with the use of this information.

CAPACITY CALCULATIONS FOR RECTANGULAR LANDFILL WITH SLOPED SIDES USING TEXTURED SHEET



Volume = c (ab-ad-bd+2d²) *

Where: 50 acres

a	= length of side a	= 440 yds.
b	= length of side b	= 550 yds.
c	= depth	= 12 yds.
d	= (side slope ratio) (depth)	

SMOOTH MEMBRANE	GUNDLINE HDT
Slope ratio = 3.5/1	Slope ratio = 2.5/1
d = 42 yds.	d = 30 yds.
Volume = 12[(440)(550)-(440)(42)-(550)(42)+2(42)^2]	Volume = 12[(440)(550)-(440)(30)-(550)(30)+2(30)^2]
= 12[242,000-18,480-23,100+3,528]	= 12[242,000-13,200-16,500+1,800]
= 2,447,376 yds.^{3}	= 2,569,200 Yds.^{3}

Volume Increase = 2,569,200 - 2,447,376 = 121,824 cubic yards

Revenue Increase = (Volume increase) (Compaction factor) (Dumping charge/cubic yard)

= (121,824)(2.7)($5.00) = $1,644,624

Net Savings = Revenue Increase - Cost of HDT + Savings from Replaced Smooth Sheet

* Koerner, R.M., "Designing with Geosynthetics", pg. 243, Prentice-Hall, Englewood Cliffs, N.J., 1986.

Gundle®

TENSILE BREAK PROPERTIES OF GUNDLINE HDT

Gundline HDT is made with a 3-layer coextrusion die, mingling the turbulent flow in the outside textured layers with the inside smooth layer. Since this mixing occurs in the molten phase, the textured surface is fully integrated with the inside layer, which acts as the barrier to waste migration equivalent to Gundline HD. The textured surface therefore resists abrasion and cannot be loosened by chemical absorption, nor physically scraped off as can happen with spray-on versions of textured surfaces.

The texturing of the outside layers sets up a wavy interfacial zone between outside and inside layers of the sheet and creates a jagged edge. This wavy interfacial zone at the edges of the inside layer is not smooth like the surface and edges of Gundline HD. Therefore, Gundline HDT does not behave the same as Gundline HD when stretched beyond the yield point in a one-dimensional narrow specimen tensile test. Beyond the yield point, the rough edge initiates tearing earlier than with smooth-surfaced Gundline HD in the stretch to break. Ultimate elongations to break in the one-dimensional tensile test are therefore reduced for Gundline HDT. And because copolymer HDPE has a stress/strain curve with a local maximum at the yield point, as illustrated in Figure 2, break strengths are also reduced in textured sheets due to the early tearing prompted by the rough edge.

Tensile break properties, however, in HDPE are not significant in designing for membrane applications. Standard practice is to design, with appropriate factors of safety, around the yield point. The sheet will not exceed yield stress, by design.

At the yield point, Gundline HD and Gundline HDT are functionally the same. Dr. Robert Koerner of the Geosynthetic Research Institute says, "The focus of design is on yield strength and yield elongation. The difference in break strength and elongation between textured sheet and smooth sheet is not as relevant using current design methods."

Furthermore, modern design practice considers multiaxial elongation testing (large scale burst testing) per methods such as GRI GM4 to better reflect field performance than narrow specimen one-dimensional tensile tests (considered index tests, not performance tests). As attached results indicate, there is no significant difference between smooth and textured sheet in multiaxial testing to break.

Reduced tensile break performance therefore, in addition to being irrelevant to design, is merely an artifact of the narrow specimen one-dimensional elongation where "edge effects" introduce material responses inappropriate for field applications.

FIGURE 2: STRESS/STRAIN DIAGRAM OF COPOLYMER HDPE

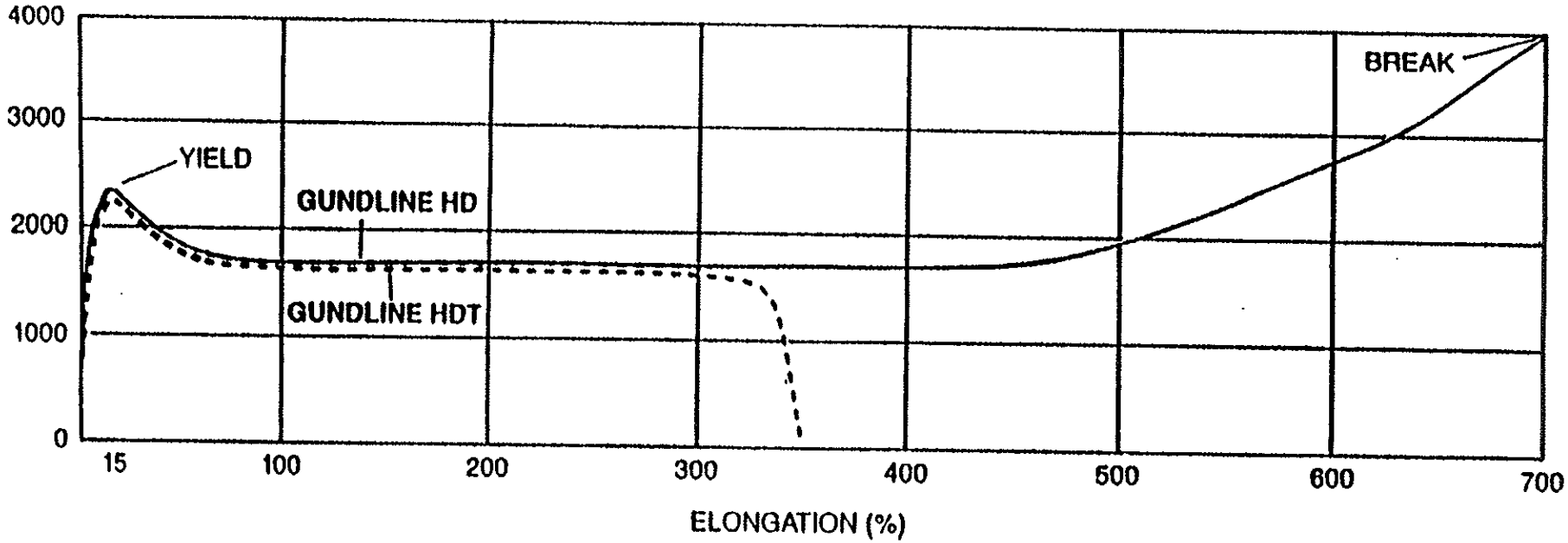


TABLE 4

Comparison of Multiaxial Stress Testing for HDPE and Textured HDPE (GRI GM 4)

Description	Strain (%)	Stress MPa	Stress (PSI)
HDPE			
Average	21	24	(3459)
Standard Deviation	5	1	(125)
Maximum Value	29	26	(3728)
Minimum Value	13	22	(3238)
Count (No. of Specimens)	10		
HDPE TEXTURED			
Average	19	24	(3421)
Standard Deviation	3	1	(180)
Maximum Value	23	27	(3859)
Minimum Value	14	22	(3186)
Count (No. of Specimens)	16		

Table 5 provides the same comparison for textured VLDPE versus smooth VLDPE, showing as well the excellent elongation of VLDPE in the multiaxial mode.

TABLE 5

Comparison of Multiaxial Stress Testing for VLDPE and Textured VLDPE (GRI GM 4)

Description	Strain (%)	Stress MPa	Stress (PSI)
VLDPE			
Average	102	58	(8358)
Standard Deviation	5	4	(541)
Maximum Value	113	62	(8978)
Minimum Value	94	49	(7109)
Count (No. of Specimens)	10		
VLDPE TEXTURED			
Average	107	75	(10812)
Standard Deviation	4	10	(1438)
Maximum Value	113	101	(14679)
Minimum Value	99	64	(9213)
Count (No. of Specimens)	10		

Smooth Geomembrane in Multiaxial Testing

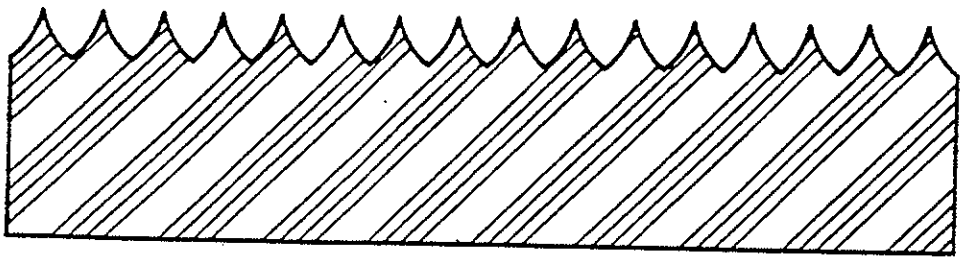
Textured Geomembrane in Multiaxial Testing

Product Information

TEXTURED SHEET CROSS SECTIONS (MAGNIFIED)

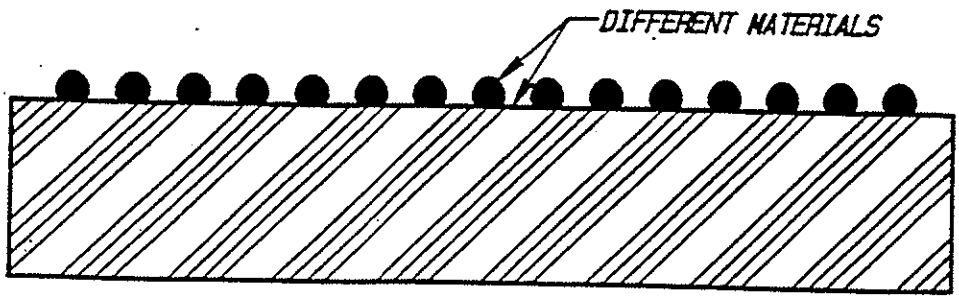
GUNDLE TEXTURED SURFACE (CO-EXTRUDED)

- THOROUGHLY INTEGRATED TEXTURED SHEET
- ABRASION RESISTANT
- NO DELAMINATION POSSIBLE
- HIGH FRICTION



OTHER TEXTURED SURFACE (SPRAY-ON)

- POTENTIAL DELAMINATION
- LOW ABRASION RESISTANCE
- LESS FRICTION



Gundline® HDW

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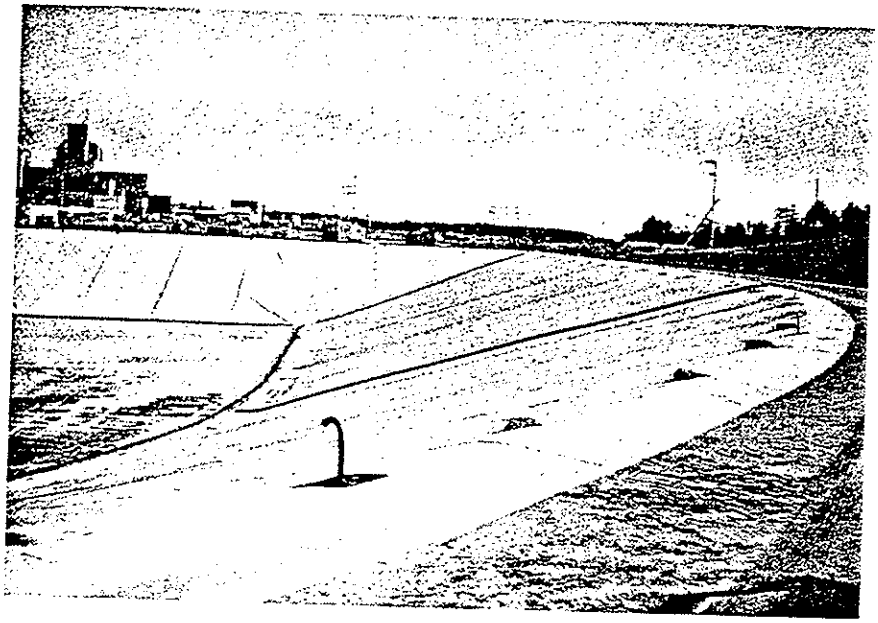
Product
Information



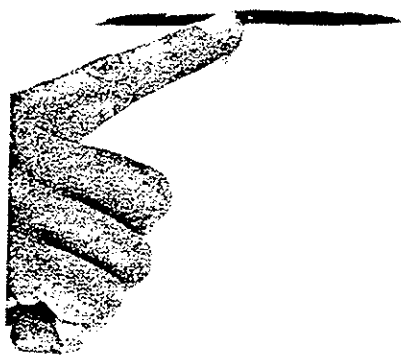
White Reflective Gundline® HDW Redefines The "State-Of-The-Art" For Synthetic Liners.

Much the way mini-vans have revolutionized the concept of the family car, white surfaced geomembranes are revolutionizing the concept of protective synthetic liners. Gundline HDW boasts all the qualities of HDPE liners while bringing significant new benefits to the geotechnical engineer. Gundline HDW is a co-extruded HDPE liner, with a typically 5 mil (0.125 mm) thick UV stabilized white layer, fully integrated in layered form with standard carbon black stabilized material in total thicknesses from 30-140 mils (0.75-3.5 mm). Gundline HDW adds extra value to an already valuable product because it makes installation damage easily detected and reduces liner temperature by reflecting solar energy. Reducing liner temperature means less expansion/contraction, less subgrade desiccation and more durability in long-term aging.

Improved Damage Detection Increases Performance.

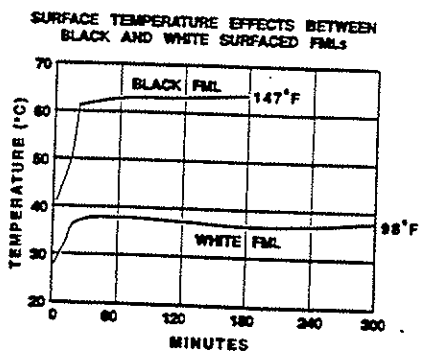
Gundline HDW provides the next level of insurance for conscientious engineers, regulators and site owners. The reason is simple: the carbon black stabilized HDPE underneath the white surface of Gundline HDW makes holes, slits, score marks, punctures and other installation-related damage much more visible than usual, and thus more easily detected and repaired. The result is improved quality control, insurance against accidental leaks and better environmental protection.

It's interesting to note that dust marks from footprints and other dirt collected on liners sometimes make it difficult to distinguish actual score marks in standard black sheets. But with the white surface of Gundline HDW, significant damage is clearly distinguished, even at great distances.



Decreased Liner Temperature Reduces Wrinkling And Tension.

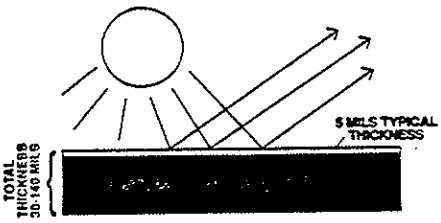
High Density Polyethylene (HDPE) has become the material of choice for containment lining systems today. Gundline HDW extends the benefits of HDPE still further by reducing the tendency to wrinkle up and bridge or become too taut when exposed to the weather. Gundline HDW reflects solar heat, substantially reducing the liner's temperature and subsequently its expansion/contraction. That means personnel can count on liners and cover soils that are easier to install.



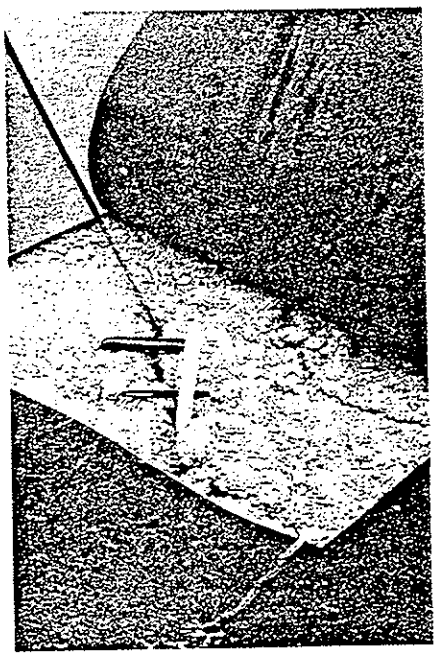
Because the liner will lay flatter, installers can gauge the fit of the liner into a facility better. That, in turn, significantly reduces the risk of the sheet being put in too tight, lessening the chance of tension-related cracking.

Control Subgrade Desiccation With Radiant Energy Reflection.

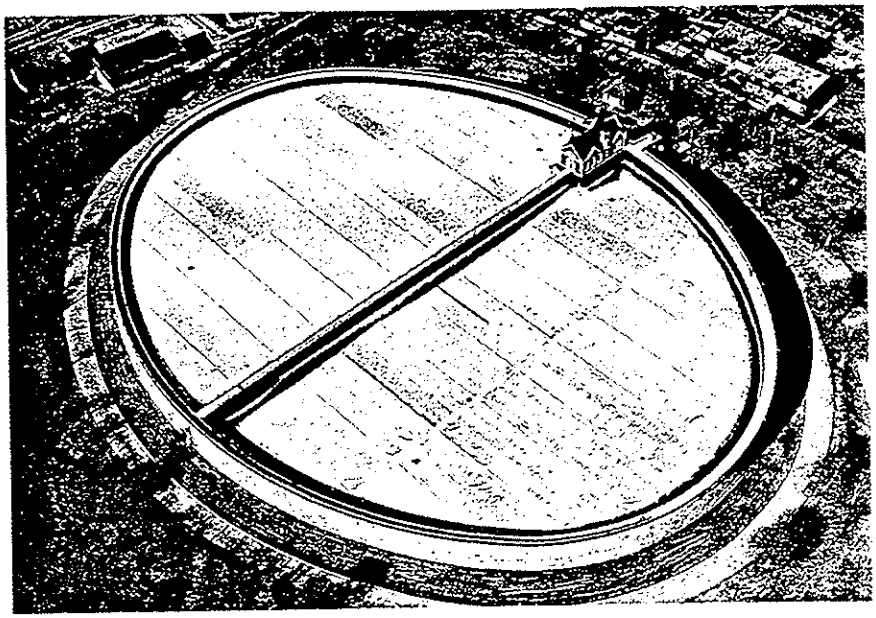
Temperature reduction of the sheet due to radiant energy reflection also helps control loss of soil moisture in underlying subgrades. Soil dessiccation leads to cracks and fissures in soil liners, lowering the leak prevention performance of



these important back-up lining systems. Various studies have concluded that the higher the surface temperature above the soil liner, the more moisture tends to migrate out of the soil. Maintaining the proper moisture content under synthetic liners is especially important on side slopes where escaped moisture under a synthetic liner can drain downhill.

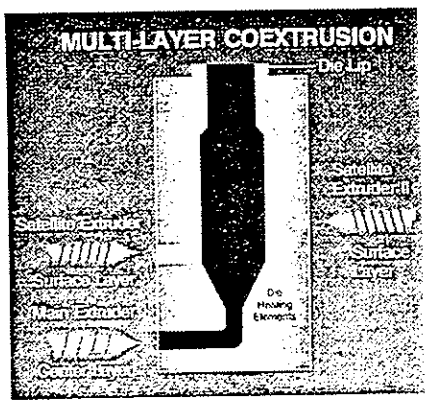


U.S. Patent No. 5,139,853



Co-Extrusion Combines The Tried And True With The Brand New.

Gundle's co-extrusion process fully integrates the white HDPE surface of Gundline® HDW with the standard black HDPE section of the sheet. That means every liner boasts maximum integrity. And while carbon black remains the most effective UV stabilizer for polyethylene today, hindered amine light stabilizers (HALS) have been developed as powerful UV inhibitors for Gundline HDW's white surface. Gundline HDW is therefore suitable for long-term exposure as well as for short-term and unexposed applications.



Gundle's co-extrusion capabilities mean Gundline HDW can be given a fully integrated textured surface providing increased slope stability. In addition, for increased flexibility and elongation, white surfaced VLDPE, textured or untextured, is also available as Gundline® VLW. So the future is here. You can improve your lining systems with white-surfaced geomembranes from Gundle.

Gundle Lining Systems Inc

Gundle®

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Product Information

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WHAT CONSTITUTES A SIGNIFICANT DEFECT OR SCORE MARK IN HDPE?

Modern fracture mechanics technology in polyethylene gas transmission pipe has produced an empirical method for estimating lifetimes in polyethylene for stresses sustained across a notch defect at various temperatures. M. F. Kanninen of the Southwest Research Institute, San Antonio, Texas has published "A Methodology for Forecasting the Lifetimes of Geomembranes That Failed by Slow Crack Growth" extending this technique to HDPE geomembranes.[1] The technique has certain uncertainties associated with it but it does provide an approximation of the significance of defect depth. Kanninen et al noted that the stresses in deployed geomembranes occur from differences between installation and service temperature, i.e., contraction stresses that result from service temperatures which are colder than installation temperatures. Their work reinforces the installation practice of including as much slack as is necessary to eliminate tensile stresses occurring from geomembrane contraction in reduced temperatures. If there is no stress by good design and installation technique, then there is no driving force for penetrating cracks developing from flaws or defects left in the liner.

According to the empirical model presented by Kanninen, the difference between a 0.08 mm (3 mil) notch depth and a 0.03 mm (12 mil) notch depth is 20% in lifetime for a "no slack" initial condition and a temperature drop of 2° C. The difference in lifetime between a 3 mil notch depth and a 12 mil notch depth becomes 50% for a "no slack" initial condition and a temperature drop of 15° C.

Two conclusions stand out:

1. It is important to add slack (compensation) and to reduce liner temperature swings so that contraction stresses are eliminated or minimized.

2. Notch depth (score or scratch depth) is significant. Therefore, effective notches should be kept less than 3-5 mils deep.

Both strategies of good liner installation are enhanced by using co-extruded white-surfaced geomembrane, Gundline HDW. This durable liner not only stabilizes liner temperatures by reflecting solar energy and thereby reducing contraction stresses, but also provides an automatic depth gauge for overgrinding during welding and other scoring damage. The 5 mil thick layer of white HDPE reveals notch-type damage as easily visible black marks against the white background, making detection and repair of potential problems much more certain.

[1] Kanninen, M. F., Peggs, I. D., and Popelar, C. H., "A Methodology for Forecasting the Lifetimes of Geomembranes that Fail by Slow Crack Growth", Proceedings of Geosynthetics '93, Vancouver, B. C., March 30 - April 1, 1993.

Gundline® HDC

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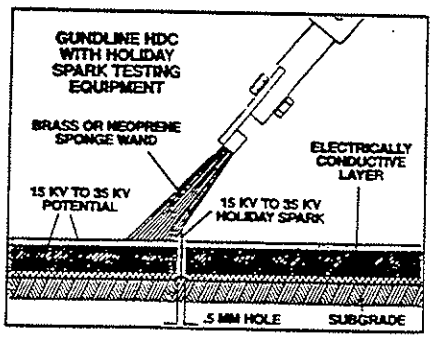
Product
Information

Gundline® HDC: A Revolution In Leak Detection.

No matter how carefully manufactured and quality controlled lining systems are, accidental damage during shipment and installation is possible. Such damage can result in leaks, reducing liner performance. But now, Gundle Lining Systems Inc. offers you a revolutionary new electrically conductive geomembrane, Gundline® HDC, which can be easily tested for leaks after installation with complete accuracy.



Co-Extruded Electrically Conductive Liner Is 100% Effective.

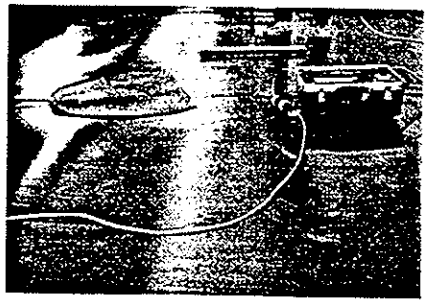
Gundline HDC incorporates an electrically conductive layer of high-purity carbon black, minimum 2 mils (0.05 mm) thick, co-extruded in the liner's bottom side. Spark testing, which was first developed to inspect coatings on steel pipes, is then possible over the entire liner surface. The co-extruded conductive undersurface can be manufactured in HDPE or VLDPE products, Gundline HDC or Gundline® VLC. The conductive layer does not affect the physical properties of either material.

To begin spark testing, the conductive layer is charged with 15,000 to 35,000 volts of electricity through electrical induction using a neoprene contact pad attached to a battery. Then, an operator applies a brass or neoprene wand to sweep the liner's non-conductive surface layer. Any penetration of the liner will automatically transmit a visible spark from the charged undersurface as the wand passes over, setting off an audible alarm.

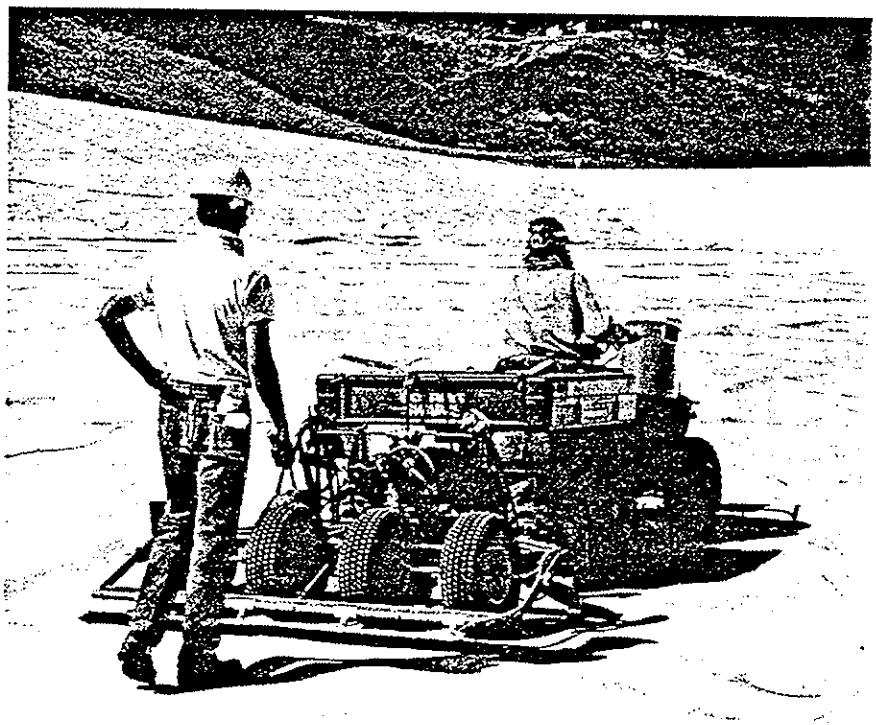
Surface moisture must be removed to avoid interference with spark testing. Dust and dirt will not affect the testing, nor will induced ground currents in areas near large power plants.

Safe, Fast And Comprehensive.

The spark testing voltage of Gundline HDC is high, enhancing test reliability. But current flow is minuscule, so it's totally safe. The testing procedure is easy and quick. Primary liners, secondary liners and complex configurations such as sumps and pipe boots can all be spark tested with Gundline HDC. Patches and repairs can also be immediately retested. Test operator skill requirements are minimal, helping to assure that if the wand has covered 100% of the Gundline HDC liner, it will be100% leak-free and meet maximum performance expectations.



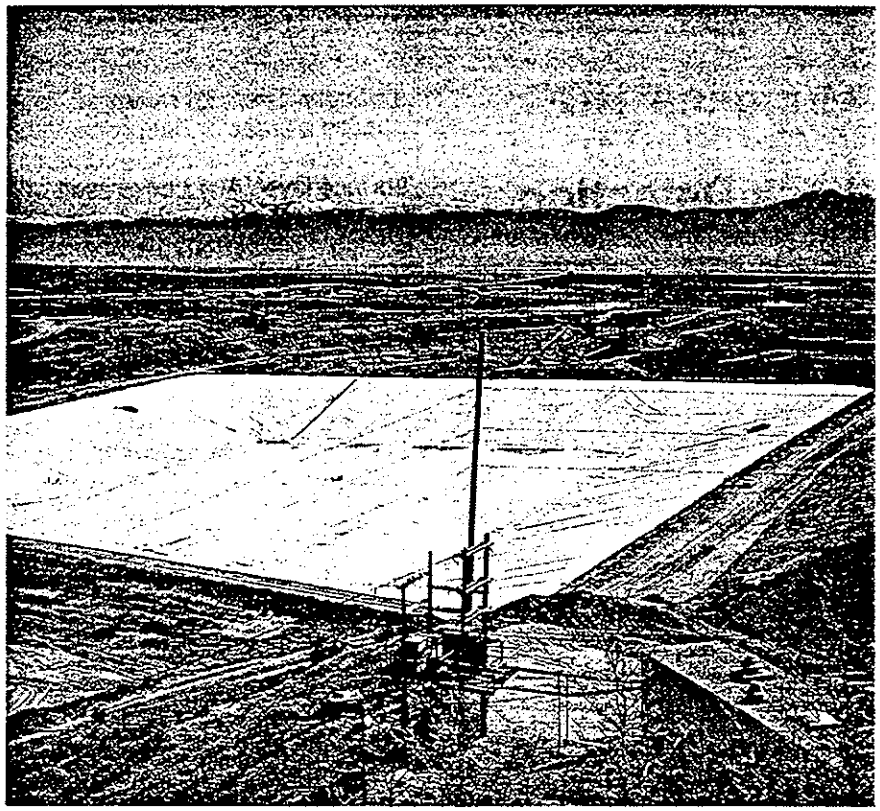
With Gundline HDC, an entire lined area can be tested for leaks after the liner is deployed and seamed, including critical liquid collection sumps and around penetrations or concrete attachments. Tedious vacuum box testing of extrusion welds can be replaced with the much quicker and more reliable spark testing. And convenient spark testing can be repeated year after year on exposed liners to check for damage and verify continued leak-free performance.



Gundline® HDC vs. Other Methods Of Complete Post-Installation Leak Testing.

Unlike traditional electric leak surveys, Gundline HDC spark testing does not require water flooding with its excess expense and time-consuming delays. Gundline HDC is 100% reliable, even for extremely small holes that heretofore would not have been detected with electric leak surveys. Furthermore, if a wrinkle lifts the liner off the subgrade during a flooded electric leak survey, the detection system can break down.

Equally problematic are smoke and detectable gas systems. With these tests, a lined area is isolated and then injected with detection media such as smoke or gas under a slight positive pressure. Both competing methods are costly, time-consuming, heavily dependent upon the skill and diligence of survey personnel, and of questionable effectiveness.



A Stellar Performance.

Gundline HDC's performance was demonstrated at a large mining operation which required lined containment of runoff to prevent water pollution. A reservoir was constructed requiring a double synthetic liner and leak detection drainage layer. A 60-mil (1.5 mm) secondary liner of Gundline HDC, Gundnet HDPE drainage net and an 80-mil (2.0 mm) primary liner of white-surfaced Gundline HDC comprised the system. The project totaled 1.7 million sq. ft. (164,000 m^2) of liner.

Not only was the primary liner spark-testable for leaks, due to its conductive underside, but the co-extruded white surface also reflected heat, lowered and stabilized temperatures and improved visual detection of scoring and other impact damage. The combination of a white surface on black liner with spark-testability resulted in maximum installation quality control, using a material with built-in comprehensive capability for damage detection.

For the spark testing operation, Gundle employed a 750-pound (340 kg), 6-tire All-Terrain Vehicle (ATV) which pulled a spark testing unit mounted on a trailer. The unit, operated by a single Gundle technician, consisted of a 30,000-volt battery charging a sliding neoprene contact pad and a 6-foot (1.8m) wide brass brush. It also contained voltage and sensitivity controls used to minimize any interference or noise created by moisture or humidity. As the ATV moved forward at 2 to 3 miles per hour, the brush swept over the liner surface, detecting the penetrating damage.

Mine personnel purposely made small holes in the liner, and a third party inspector recorded their locations without the knowledge of Gundle personnel. As expected, Gundle's innovative system detected every hole by displaying a spark and emitting an audible signal. Said the third party inspector, "I'm really impressed. I think it's an excellent product. They found all the perforations we introduced. It's working out really well."

When leaks were found, an extrusion weld bead or a patch was placed over the hole, depending on the extent of the damage. The end result was that, with the Gundline HDC System, all leaks were detected and repaired in a very cost-effective, reliable and safe manner. Today, the collected stormwater runoff in the containment is recycled back to leach pad operations for the successful extraction of copper.

Gundle Lining Systems Inc

Gundle®

"IF IT NEEDS LINING,
IT NEEDS GUNDLE."
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Gundline® HD/VL/HD

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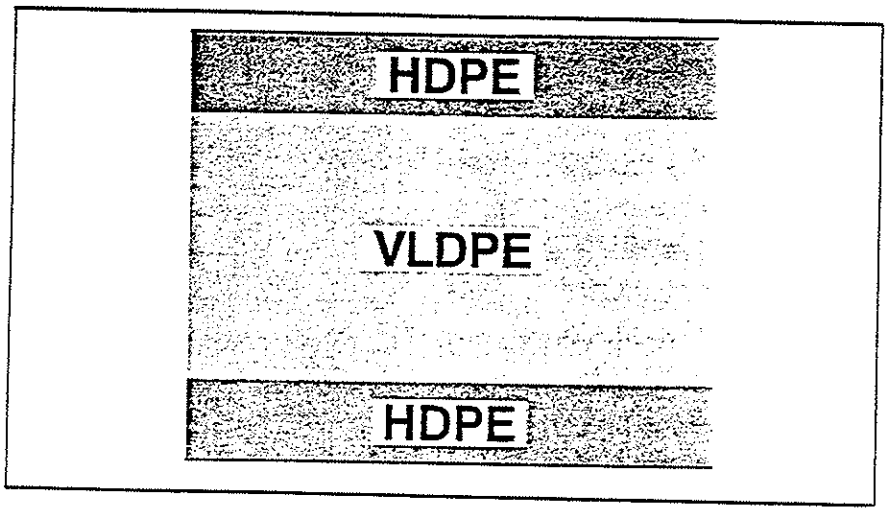
Product Information

GUNDLINE HD/VL/HD

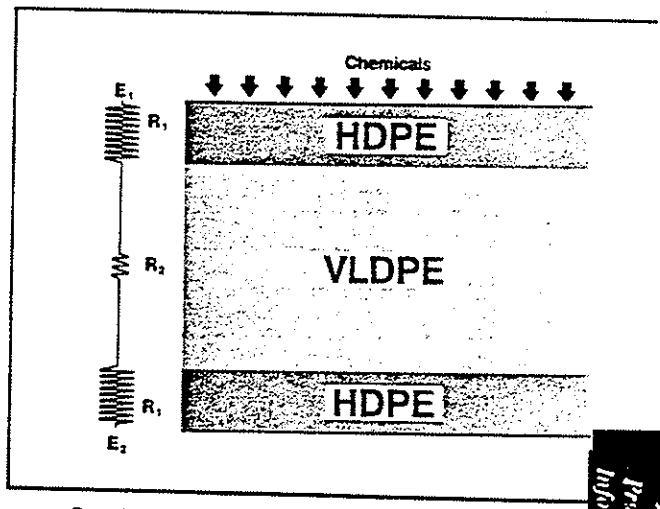
ndle introduces a new lining material combining the chemical resistance and impermeability of PE with the flexibility, elongation and stress crack resistance characteristics of VLDPE. undline HD/VL/HD is a co-extruded fully integrated composite liner with a VLDPE inner core dwiched between two outer surface layers of HDPE.



Drawing 1. Cross Section of Gundline HD/VL/HD

HEMICAL RESISTANCE

the HDPE outside layers, Gundline HD/VL/HD ossesses the barrier properties of an HDPE liner. ccordance with the science of Transport nomena, the layers function like electrical sistors in series. HDPE is the "controlling stance" to chemical penetration. The outer aces therefore become the "bottleneck" to emical movement through the liner.



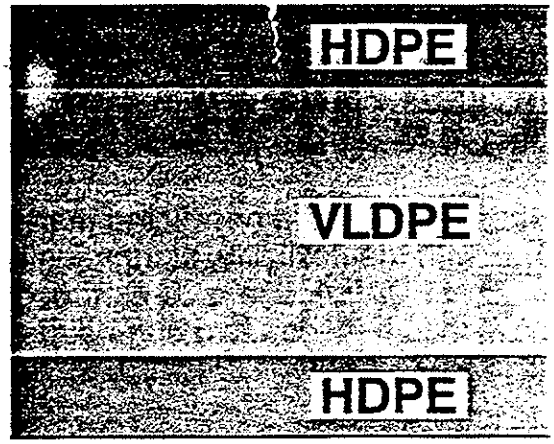
Drawing 2. Chemical Resistance of Gundline

Gundle Lining Systems Inc

Gundle®

STRESS CRACK RESISTANCE

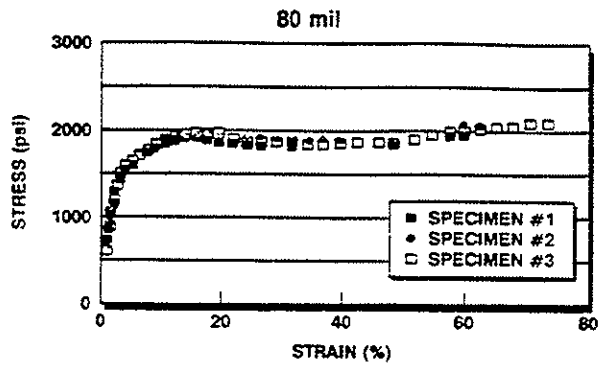
Long term stress crack testing has shown that induced stress cracks will not penetrate the VLDPE layer. This has been experimentally demonstrated by purposely notching one of the outside HDPE surfaces and noting the progress of crack propagation in constant load stress crack testing with stress-crack-accelerating solution. The ductile VLDPE inside layer stops crack propagation as soon as it encounters the HD/VLDPE interface.



Drawing 3. Gundline HD/VL/HDBlocking Stress Crack Growth

FLEXIBILITY AND ELONGATION

Gundline HD/VL/HD also offers the flexibility and elongation of VLDPE. This is because the bulk of the liner is the inner core. Gundline HD/VL/HD therefore behaves like VLDPE in standard performance testing. In particular, multi-axial elongation and truncated cone puncture performance are superb.



Drawing 4. Multi-axial Elongation Testing of Gundline HD//VL/HD

TYPICAL PROPERTIES

PROPERTY	METHOD	GUNDLINE HD/VL/HD 80 MIL
ELONGATION AT YIELD	ASTM D638	24%
ELONGATION AT BREAK	ASTM D638	900%
TENSILE BREAK	ASTM D638	340 lb/in (4250 psi)
TENSILE YIELD	ASTM D638	145 lb/in (1813 psi)
TEAR RESISTANCE	ASTM D1004	51 lbs
PUNCTURE RESISTANCE	FTMS 101, 2065	91 lbs
MULTI-AXIAL FAILURE STRESS	GRI GM4	2116 psi
MULTI-AXIAL FAILURE ELONGATION	GRI GM4	68%

Prefabricated Products

Whatever Your Lining Requirements, Gundle Plastics Fabrication Puts It All Together.

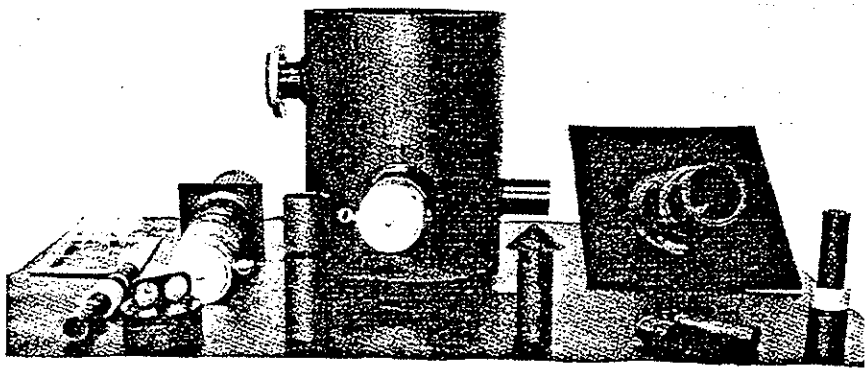
Prefabrication. Another innovative service from Gundle Lining Systems. Now, through Gundle Plastics Fabrication, we can offer you both HDPE and VLDPE liners in custom sizes and custom fitted sheets in all thicknesses from 30 to 140 mils. Custom panels up to 200' X 200' in size can be fabricated and delivered to your job site. Custom shapes range from boots, sumps, booms and baffle curtains to daily covers, decontamination pads, pond and pit liners, interim landfill covers, secondary containment and filtration systems.

Regardless of what your application may be, the ease of installation and time savings that Gundle Plastics Fabrication achieves can result in substantial cost reductions for each of your lining projects.

Whatever your prefabrication needs, Gundle assures total quality and customer satisfaction. We start with the highest quality raw materials for all prefabrication processes. We also conduct extensive in-house testing using ASTM standard test methods. And our skilled personnel all have at least five years of fabrication experience using the most up-to-date welding equipment and techniques to ensure the highest quality.

Gundguard is the flexible solution for temporary & reusable lining applications.

Gundguard is aesthetically pleasing as well as effective at leak prevention, as shown in this decorative pond.



Gundle Plastics can customize products to fit virtually any application.

Gundguard: The Affordable Short-Term Solution.

Only Gundle Plastics Fabrication offers the ultimate low cost, high performance alternative to ordinary scrim-reinforced and laminated liners. Introducing Gundguard, a new series of 12- and 20-mil polyethylene liners, uniquely co-extruded with 3 layers of LLDPE / VLDPE / LLDPE. Its unprecedented makeup gives Gundguard exceptional flexibility without sacrificing strength. The result: a highly versatile lining system, ideal for a wide range of permanent and temporary applications. In fact, Gundguard is so versatile, effective and easy to handle, customer-installed applications are the norm.

Gundguard has proven enormously successful in applications ranging from pond and pit lining, decontamination pads and secondary containment to simple daily covers and landscaping. And while normally available in $22\frac{1}{2}$-ft. seamless widths, Gundguard can also be prefabricated in customized sheet sizes up to our 200' X 200' maximum.

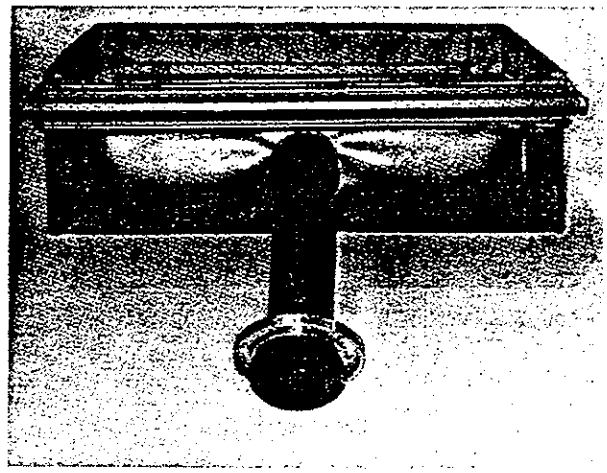
Self-installation is made easy for non-critical applications by using a durable acrylic adhesive tape.

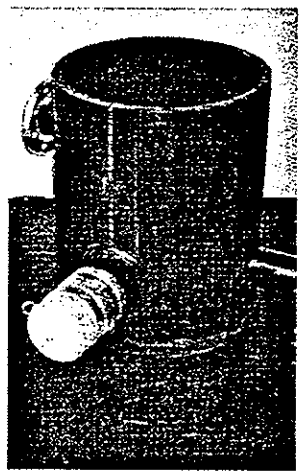
Primary And Secondary Containment Systems.

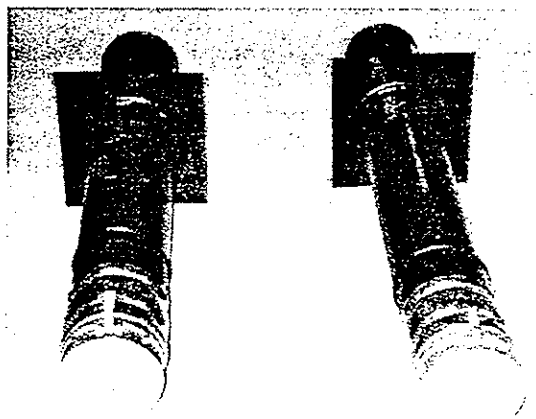
SUMPS- Sumps can be prefabricated from 40 to 140 mils thick using our standard lining materials. We also construct sumps using HDPE plating or piping 1/8" thick. Typically, these sumps would be installed at the lowest point of a sloped subgrade as a catch-basin for leachate or as part of a leak detection system. Also available is Gundline® HDC, electrically conductive liner which is 100% spark testable after installation.

BOOTLESS PIPES- These are prefabricated with 3/4" HDPE back-plate skirts with either single or double containment HDPE pipes that are sealed and pressure tested. Gundle's prefabricated bootless pipe can accommodate slope angles up to 2.5:1 Once sent to the field, all that is required is to weld the skirt of the bootless pipe to the existing liner. This system allows pre- and post-installation testing.

STANDARD BOOT- These boots are designed to slip over existing pipe penetrations in the field. Liner material used in the fabrication of boots are equal in thickness and material type to the deployed sheet. Gundle can prefabricate boot sizes from 1" to 24" diameter with a slope angle varying from vertical to 6:1.







Standard boots, bootless pipes and other custom shapes can be prefabricated and shipped directly to your job site.

Manholes

HDPE manholes are custom fabricated to customer specification and to specific design requirements, including dual containment applications. A wide range of outlets can be installed, including flange, butt fusion and electro fusion for a variety of installation applications.

Prefabricated Pipe

Custom fabrication of HDPE pipe sections, including elbows, tees, manifolds and flanges, is available. The pipe can be supplied and installed, including dual wall systems. Field installation is also available. Gundle Plastics Fabrication can also fabricate structures such as vessels and tanks to customer specification.

Sheet Panels

Roll widths are standard 22.5 or 34.5 with lengths varying according to your requirements. If you choose custom-size panels, we can produce sheets either narrower or wider than our standard size. We can even accommodate sizes up to one acre. For shipping purposes, the size of certain panels may vary due to mil thicknesses and material type. Partial rolls, which are available for all mil thicknesses and material types, are another option.

Booms And Baffle Curtains

Made from Gundle's VLDPE, booms for oil spills can be prefabricated in either 50 or 100 linear foot sections. Because each section is a complete unit, they can be attached to other units by interlocking and connectors. Our prefabricated flotation systems consist of cylindrical 6' foam sections varying from 6" to 12" in diameter, depending on the total height of the booms.

Gundle Plastics
Fabrication Division
A Gundle Lining Systems, Inc. Company

"IF IT NEEDS LINING,
IT NEEDS GUNDLE."
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Product Information

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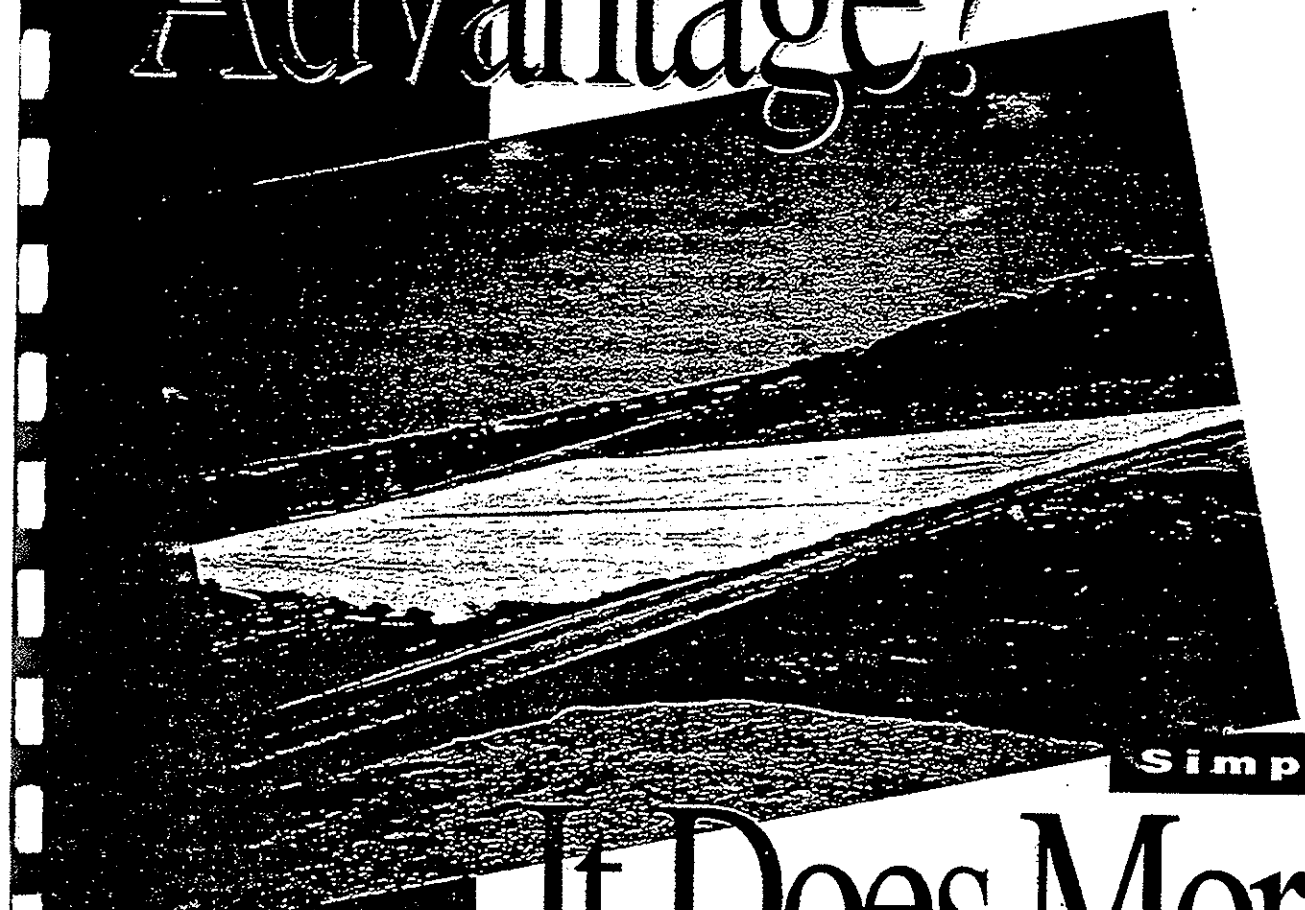
Gundguard

Gundguard's Advantage?



Simple...

It Does More.

GUNDLE'S NEW FLEXIBLE, PRE-FABRICATED LINER FOR SELF-INSTALLATION.

Gundle Plastics Fabrication presents Gundguard, the ultimate low cost, high performance alternative to ordinary scrim-reinforced and laminated liners. This new patented polyethylene liner is coextruded with LLDPE/VLDPE/LLDPE layers, thus providing unlimited advantages over other products. It's unparalleled manufacturing process, featuring a unique white surface, provides extraordinary flexibility without sacrificing strength and chemical resistance. Gundguard is available in 12, 20 and 30 mil thicknesses and can be fabricated into customized sheets up to 200' x 200'.

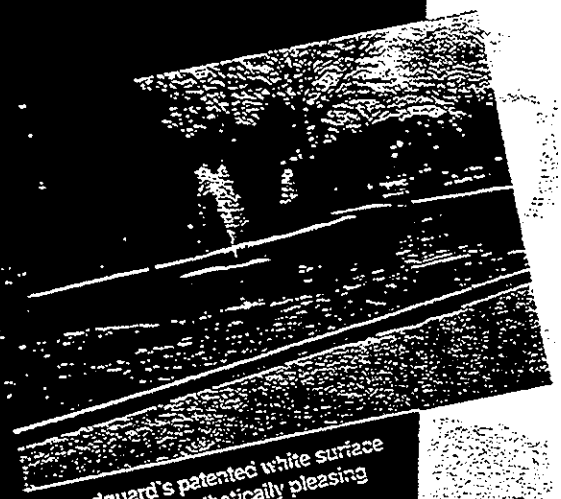
Due to Gundguard's numerous attributes, it can be used in a variety of applications ranging from pond liners and interim landfill covers to truck tarps and tank liners. In fact, Gundguard has proven so exceptionally durable and successful, there are few applications in which it could not be used.

So, it is easy to see that when you are looking for a high performance, flexible liner, Gundguard has an obvious advantage over the competition . . . it simply does more!

Gundle Plastics Fabrication

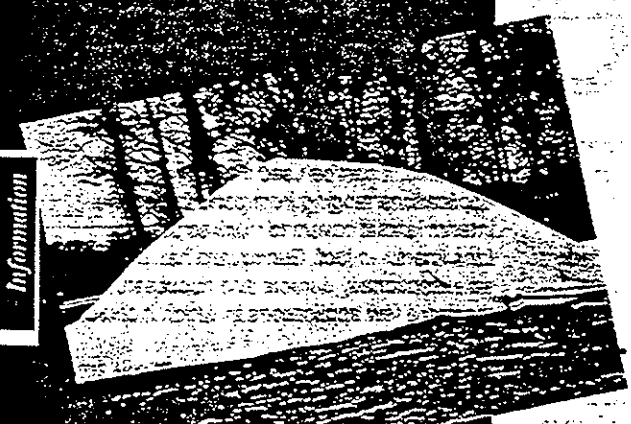
Gundle

Flexibility you can work with, Reliability you can count on.



Gundguard's patented white surface provides an aesthetically pleasing appeal for decorative ponds.

The flexibility and light weight of 20 mil Gundguard makes self-installation of 200' x 200' pre-fabricated panels simple.



Custom fabricated to your dimensions, Gundguard can be shipped directly to your site for immediate deployment.

Applications

- **Daily Covers** - Affordable alternative to costly soils. Material can be rolled up and reused for other projects.
- **Pond and Pit Liners** - White surface provides easy damage detection during installation. Flexibility and custom sizes make it possible for self-installation.
- **Decontamination Pads** - Custom fabricated to your dimensions in Gundle Plastic's controlled environment and shipped directly to your site.
- **Interim Landfill Covers** - Can be fabricated into panels up to 200' x 200' for self deployment, and is an effective methane barrier as well as an inexpensive preventive to rainwater until final closure.
- **Secondary Containment** - Outstanding chemical resistance for secondary containment of storage containers, drums, equipment wash racks and roll-off bins.
- **Irrigation (Canal) Systems** - Provides impermeable barrier to eliminate water loss through existing cracks in both base and sides of canal.
- **Vapor Barriers** - Low permeation rate and flexibility provides for excellent radon and/or methane protection.
- **Truck Tarps** - Gundguard keeps materials dry during shipment and allows truck bed to be used for storage.
- **Golf Course Pond Liners** - Low permeability solves problem of water loss and provides aesthetically pleasing surface.
- **Agricultural Covers** - Stops spoilage caused by moisture. Reduces storage costs by freeing up valuable warehouse space with outside storage capabilities.
- **Tank Liners** - Can be used as an internal liner for anti-corrosion or containment inside metal or concrete tanks.

Advantages

- **LLDPE/VLDPE/LLDPE** - Gives the ultimate in flexibility with added chemical resistance and low permeability. Material is highly durable with excellent tear and puncture resistance.
- **Patented White Surface** - Provides damage detection and reduced expansion/contraction.
- **Unique Coextrusion Process** - Produces a homogeneous liner that will not delaminate. Product is both non-toxic and non-leaching.
- **UV Resistant** - Material can be used in exposed applications.
- **Light Weight** - Easy to handle for self-installed applications.
- **Custom Sizes** - Available in customized sheet sizes up to 200' x 200'.
- **Reusable** - Material can be rolled up and/or folded, and stored for later use.

Product Information

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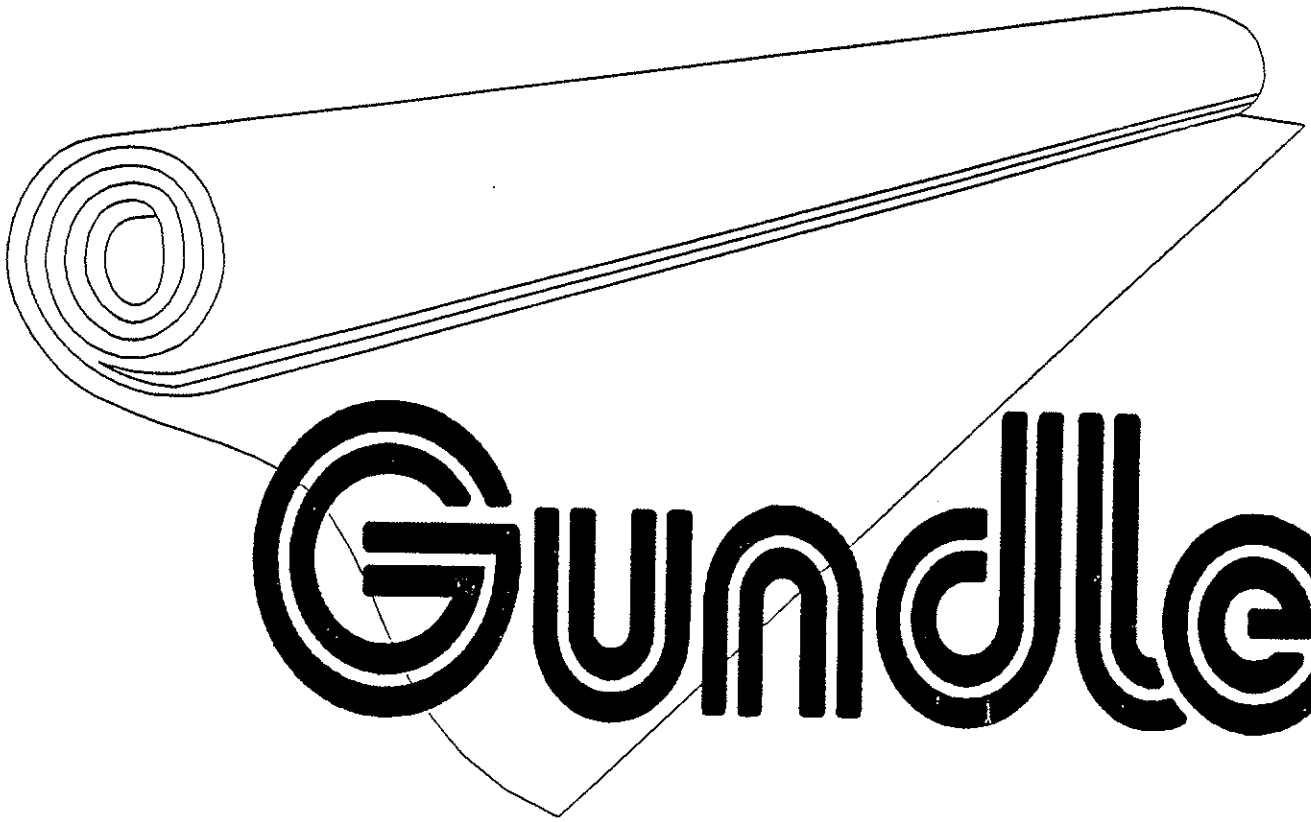
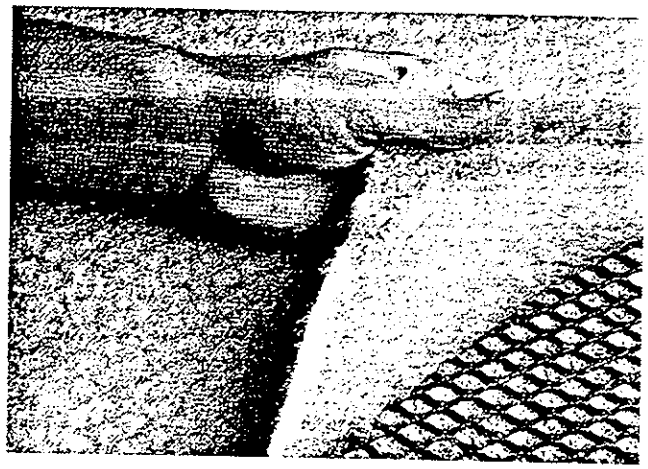


Gundle®

Standards Manual

Materials and Installation

Gundnet®
Fabri-Net®



Gundnet® Achieves Unsurpassed Efficiencies For Fluid Flow And Drainage Layer Installation.

In the past, one-foot thick layers of sand or gravel were specified by the RCRA as a drainage media for landfills & surface impoundments. But today, there is an alternative with more than a hundred times the (required) hydraulic transmissivity: Gundnet®. Gundnet is a net-like product of two overlapping polyethylene strands which transmits fluids in the plane of the net. Nominal transmissivities are greater than $1x10^{-3}m^2/sec$ (5 gallons per minute per foot width) for compressive loads under 20,000 psf (see Fig. 1).

One of the biggest advantages of Gundnet drainage net is its ease of installation. Gundle manufactures 6.5 and 14 foot wide rolls of this durable, high performance drainage media called Gundnet XL-14, made from the same raw material as Gundline® HD. Gundnet's outstanding performance qualities include high resistance to chemicals, rodents and microorganisms. In addition, tensile strength and resistance to strand layover is excellent. Gundnet XL-14 is another prime example of Gundle meeting the needs of today's marketplace.

Fabri-Net®: Geotextile-Gundnet Composite Provides One Material For A Complete Drainage System.

Fabri-Net® consists of a geotextile fabric heat bonded to Gundnet drainage net on one or both sides. With Gundles's heat bonding systems we can offer a wide variety of composite sections utilizing commonly specified geotextiles. This composite allows one-step installation of the drainage media for primary leachate collection, particularly when soil particles must be prevented from clogging the Gundnet flow channels. When combined with Gundline® HDT textured sheets, slope stability is greatly increased because the Fabri-Net grips the textured surface "like Velcro." An exceptionally high coefficient of friction is achieved and maintained, enhancing slope stability. Fabri-Net, available in 6.5 and 14 foot wide rolls, also maintains high standards of durability, longevity, and performance.

Gundnet and Fabri-Net are both simply unrolled to form a blanket for drainage in waste disposal facilities wherever drainage is desired. The ease and safety of installation of the synthetic drainage materials is important to consider since no heavy equipment is required to lay it down.

Installation of Gundnet and Fabri-Net can occur immediately after seaming of the liner. This is not usually the case for sand or gravel layers where the entire liner must be in place before grading of the sand begins. Installation of the synthetic drainage layer requires only a few days, whereas grading of sand or gravel can require a few weeks. Additionally, movement of heavy bulldozers over the liner is avoided if Gundnet or Fabri-Net is used in place of sand or gravel drains.

Gundnet and Fabri-Net are cost effective, saving owners valuable, air space in their landfill cells. Fabri-Net's ability to be placed on steep slopes also increases the capacity of a landfill.

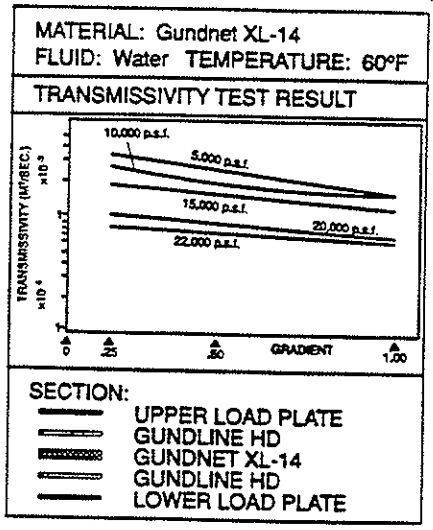


Figure 1

(Specifications on back)

SPECIFICATIONS FOR GUNDNET® XL-14

Gundnet is a high quality formulation of High Density Polyethylene containing approximately 97.5% polymer and 2.5% of carbon black, anti-oxidants and heat stabilizers. The product was designed specifically for exposed conditions. It contains no additives or fillers which can leach out and cause embrittlement over time.

TYPICAL PROPERTIES*	TEST METHOD	GUNDNET XL-14
Roll Length (typical)		100; 300 ft.
Roll Width (typical)		6.5; 14 ft.
Roll Weight (typical)		130 lbs.; 840 lbs.
Specific Gravity (g/cm³ minimum)	ASTM D1505	.94
Melt Flow Index (g/10 minutes) (maximum)	ASTM D1238 Condition E	0.3
Thickness (minimum)	ASTM D374 at Strand Intersection	5.0-6.5 mm 200 mil-265 mil .200-.265 in.
Percent Carbon Black (minimum)	ASTM D1603	2%
Transmissivity (minimum)	ASTM D4716 10,000 psf compressive load between two layers of Gundline HD; 0.25 Gradient	10 g/min./ft. or 2×10^{-3} m²/sec.

*Note: All values are typical test results, unless stated otherwise.

ROLL PROPERTIES FOR FABRI-NET®

TYPICAL PROPERTIES*	TEST METHOD	FABRI-NET
Roll Length (typical)		100 ft.; 200 ft.[2]
Roll Width (typical)		6.5 ft[1]. ; 14 ft.[1]
Roll Weight (typical)		194 lbs.[2] ; 835 lbs.[2]
Specific Gravity of Net (g/cm3) (minimum)	ASTM D1505	.94
Melt Flow Index of Net (9/10 minutes) (maximum)	ASTM D1238 Condition E	0.3
Thickness of Net (minimum)	ASTM D374 at Strand Intersection	5.0-6.5 mm 200 mil-265 mil .200 in.- .265 in.
Percent Carbon Black of Net (minimum)	ASTM D1603	2%

*Note: All values are typical test results,unless stated otherwise.
1) Width with geotextile overlap is 7ft. for 6.5 ft. width and 15 ft. for 14 ft. width.
2) This is the value for Fabri-Net double-sided with 6 ounce geotextile only. Bonding geotextile different weights will change the final roll weight and length.

Gundnet and Fabri-Net are rolled on 6" I.D. hollow cores. Each Gundnet roll is provided with a sling to aid handling on site. Fabri-Net is wrapped in a protective plastic bag. Dimensions and weights are approximate. Custom lengths available on request.

Gundle Lining Systems Inc

Gundle®

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*Gundle Lining Systems Inc. 1991 20MRPC1292-50767

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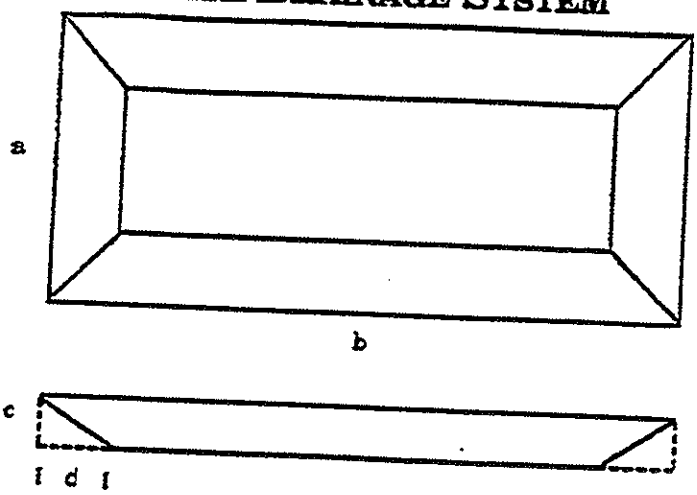
Capacity Calculations for Rectangular Landfill With Drainage System



Volume = $c(ab-ad-bd+2d^2)$ *

Where:

50 acres

a = length of side a = 440 yds.

b = length of side b = 550 yds.

c = depth

d = (side slope ratio) (depth)

SAND / GRAVEL

Slope ratio = 3.5/1

c = 12 yds.

d = 42 yds.

Volume = $12[(440)(550)-(440)(42)-(550)(42)+2(42)^2]$

$= 12[242,000-18,480-23,100+3,528]$

$= 2,447,376 \text{ yds.}^3$

GUNDNET / FABRINET

Slope ratio = 3.5/1

c = 12.3 yds.

d = 43 yds.

Volume = $12.3[(440)(550)-(440)(43)-(550)(43)+2(43)^2]$

$= 12.3[242,000-18,920-23,650+3,698]$

$= 2,498,474 \text{ yds.}^3$

Volume Increase = 2,498,474 - 2,447,376 = 51,098 cubic yards

Revenue Increase = (Volume Increase) (Compaction Factor) (Dumping Charge/Cubic Yard)

= 51,098(2.7)($15.00) = $2,069,000

Four Double Liner System - Multiply Revenue Increase Times 2 = $4,138,000

Net Savings = Revenue Increase - Cost of Net = + Savings from Replaced Sand/Gravel

*Koerner, R.M., "Designing with Geosynthetics," pg. 243, Prentice-Hall, Englewood Cliffs, N.J., 1986

Gundseal®

An Added Barrier Of Protection From Gundle: High Performance HDPE/Bentonite Composite Landfill Liner

As concern for our environment continues to grow worldwide, the demand for reliable synthetic landfill liners is escalating. More than ever, legislation mandates these lining systems, and often requires double lining solutions.

Responding to state-of-the-art engineering strategy of designing liner systems which combine synthetic and clay layers, Gundle offers GUNDSEAL. Gundseal is a bentonite clay/polyethylene composite liner for one step deployment (usually as an addition to a conventional single or double liner system). Gundseal is made by attaching the highest quality sodium bentonite to the highest quality synthetic liner using a patented nontoxic adhesive application system. This forms a single composite liner, which takes advantage of the complementary behavior of the synthetic liner together with the bentonite clay, and forms a complete barrier.

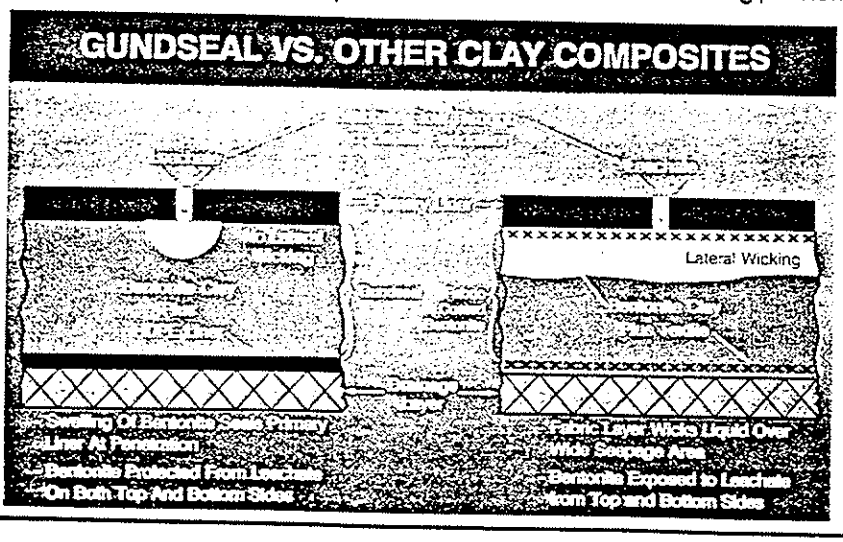
Swelling to several times its original volume when wet, the bentonite layer in Gundseal is able to seal potential leaks in a synthetic liner under confining pressures as low as 27 psf.

In a single composite liner application, the bentonite side is deployed face up. The primary liner is then installed on top and in direct contact with the bentonite. Any possible leakage becomes blocked by the bentonite layer with 1 x 10^{-9}cm/sec k-value followed by a polyethylene membrane with 2.7 x 10^{-13} cm/sec effective k-value. This means tremendous insurance is built into the liner system.

Using Gundseal, double composite liner systems can be constructed without having to compact soil on top of synthetic layers. The addition of a Gundseal blanket (bentonite face up) under a primary liner and above the drainage layer will add factors of safety in eliminating fluids in the leak detection zone. This is very attractive in light of EPA's new Response Action Plan (RAP) for leak detection systems.

Desiccation/weathering problems in standard clay caps can be solved by constructing a much less permeable, weathering- and settlement - resistant composite liner closure with Gundseal. In this case, the bentonite side of the Gundseal is also deployed facing upward and is used in conjunction with another geomembrane. In some cap designs, the Gundseal may be installed with the bentonite facing downward. However, different design parameters must be utilized depending on whether the bentonite is sandwiched between two geomembranes or if it is installed facing downward in contact with subgrade soils.

Compared with fabric coated bentonite blankets, Gundseal will not shrink after getting wet because, unlike fabric, the membrane cannot be flexed by bentonite. And there is no fabric to transmit fluids laterally over a wide area when a Gundseal bentonite blanket is used. With Gundseal, moisture is confined to a point, not distributed over a broad area. In contrast to many fabric-coated bentonite blankets, Gundseal packs very fine mesh bentonite particles in a dense layer. There are few agglomerates or areas of loose particles.



Gundseal®HDT

Textured Gundseal combines Gundline® HDT textured high density polyethylene sheet with the high quality fine mesh grade bentonite.

Textured Gundseal provides excellent slope stability due to the textured surface of Gundline HDT. Textured surface of Gundseal is therefore ideal for steeper slopes.

(Specifications on back)

GUNDSEAL® HDPE / BENTONITE COMPOSITE LINER

Standard Construction

Membrane Backing[1]	Gundline® HD Membrane	20 mil
Coating	Sodium Bentonite	1 lb./ft.² (min.) at 12% adjusted moisture content
Roll Width[2]		17 ft. 6 in. (5.3m)
Roll Length[3] (typical)		200 ft. (60m)
Roll Weight (typical)		4150 lbs.

[1] Other Gundle liner products (VLDPE) and mil thicknesses available.
[2] Eight foot width available for custom orders.
[3] Roll length will range from 200 ft. to 150 ft. for membrane backing thicknesses greater than 20 mils.

Typical Properties

Bentonite Coating	PG Technology QA / QC Procedures	1 lb./ft.² (min.) at 12% adjusted moisture content
Effective Hydraulic Conductivity (Gundseal)	GRI GLC-2	$< 4 \times 10^{-12}$ cm / sec
Coefficient of Permeability (Membrane)	ASTM E96	2.7×10^{-13} cm / sec
Hydraulic Conductivity (Bentonite)	ASTM D5084 @ 5 psi	$< 1 \times 10^{-9}$ cm / sec
Overlapped Seam Effectiveness	ASTM D5084 @ 5 psi	$< 1 \times 10^{-9}$ cm / sec
Composite Action	ASTM D5084 @ 5 psi	$< 1 \times 10^{-9}$ cm / sec
Wet / Dry Cycles[1]	ASTM D5084 @ 5 psi	No Effect on Permeability
Freeze / Thaw Cycles[2]	ASTM D5084 @ 5 psi	No Effect on Permeability
Free Swell	GRI GCL-1	0.4 in.
Moisture Content (Bentonite Coating)	ASTM D4643	20%

[1] 10 cycles [2] 4 cycles

TYPICAL PROPERTIES FOR 20 MIL HDPE USED IN THE PRODUCTION OF GUNDSEAL®[1]

PROPERTY	UNIT	TEST METHOD	VALUE
Thickness	mils	ASTM D751	18 min.
Density	g / cc	ASTM D1505	0.94 min.
Melt Flow Index	g / 10 min.	ASTM D1238	0.3 max
Tensile Strength @ Yield	lbs. / in.	ASTM D638 Type IV Dumbell @ 2 in. / min. 2" break gauge length	40
Tensile Strength @ Break	lbs. / in.		70
Tensile Elongation @ Yield	%		10
Tensile Elongation @ Break	%		500
Tear Resistance	lbs.	ASTM D1004 DIE C	12
Puncture Resistance	lbs.	FTMS 101 Method 2065	25

[1] Typical values provided by Gundle Lining Systems of Houston, Texas

GUNDSEAL is rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Rolls are stretch-wrapped to keep dry. Each roll has an overall sheet thickness of 0.125" (3 mm). Gundseal adhesive is non-toxic and non-polluting.

These specifications are to be used only as a general guideline by engineers in formulating preliminary specifications, and should not be relied upon absent site-specific product testing; Gundle assumes no responsibility for the improper reliance upon or misuse of such data. In addition, product design and specifications are subject to change without notice.

TYPICAL PROPERTIES FOR BENTONITE USED IN THE PRODUCTION OF GUNDSEAL®[2]

PROPERTY	UNIT	TEST METHOD	VALUE
Montmorillonite Content	%	X-ray Analysis	90 min.
Chemical Analysis	%	Determined by Inductively Coupled Argon Plasma Spectroscopy Utilizing Classical Wet Method	SiO_2 % 63.6% Al_2O_3 21.4% Fe_2O_3 3.8% CaO 0.7% MgO 2.0% Na_2O 2.7% K_2O 0.3% Bound Water 5.5%
Moisture Content	%	ASTM D2216	8.2 (10 max)
Fluid Loss	ml	API Spec 13A Sec 4	18
Dry Sieve Analysis	%	ASTM C136	+16 sieve 5 max -70 sieve 10 max -200 sieve 2 max
Free Swell	ml	USP-NF-XVII (dry)	28
Plate Water Absorption	%	ASTM E946 (dry)	850 min.
Bulk Density	pcf	ASTM B417	70

[2] Typical values provided by Bentonite Corporation of Denver, Colorado

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Product Information

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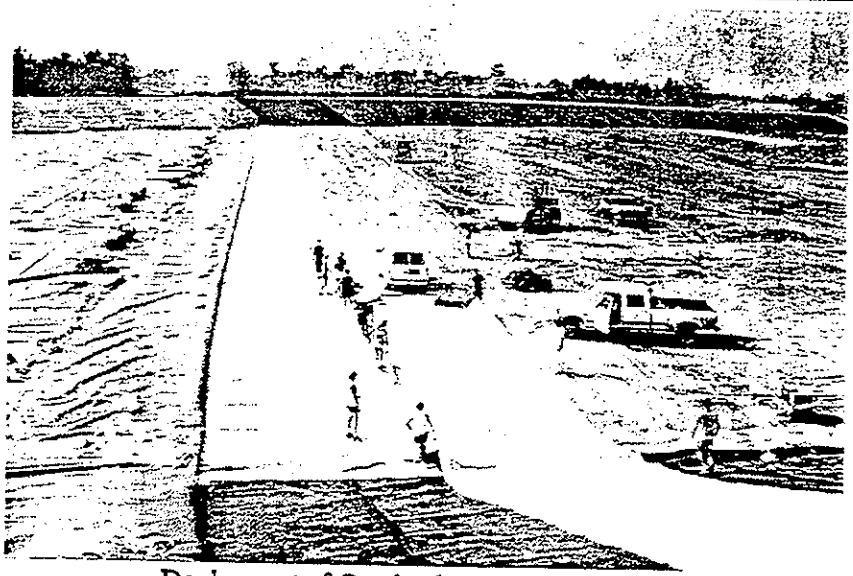
IMPROVED SOIL LINER CONSTRUCTION IS NOW POSSIBLE!



Deployment of Gundseal® at a New York Landfill

eosynthetic Clay Liners (GCL's) are uniform, factory produced blankets of bentonite clay which are deployed without heavy pment to replace or supplement traditional compacted clay liners. GCL's are not affected by many of the difficulties iated with compacting a clay liner. They are deployed dry and are, therefore, not ruined by desiccation. In service as soil ers, they have lower permeabilities than compacted clay, are not damaged by freeze/thaw or wet/dry cycles, and conform to f-rential settlement with flexibility and self healing.

dition to many performance advantages, geosynthetic clay liners provide owners, operators, and municipalities considerable onomic advantages through cost savings and revenue potential over compacted clay liners.

SAVINGS USING A GCL (Gundseal) FOR THE NY LANDFILL PICTURED ABOVE

res x 6 inch Lift*	=	479,000 ft^3 of Added Capacity
	=	24,000 Tons of Clay Not Needed
0 Tons x $50/Ton	=	$1,200,000
seal Installed Cost		500,000
ruction Cost Savings		$700,000

d Capacity of 479,000 ft^3 = $2,156,000 Landfill Revenue
se at $15/yd^3 dumping charge and compaction factor of 2.7

ngs would be even greater if more than one 6 inch lift of was replaced with the Gundseal. The State of Ohio allows GCL's eplace 2 ft of compacted clay.

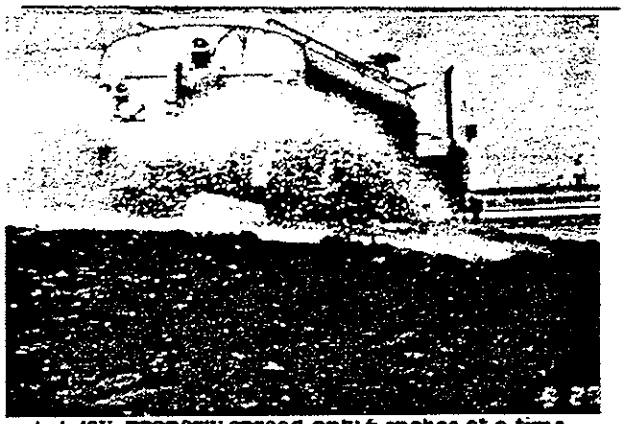
BENEFITS OF GUNDSEAL GEOSYNTHETIC CLAY LINER

- Bentonite Clay Layers Are Simply Unrolled No Heavy Equipment Needed
- Confined Bentonite Has Much Lower Permeability Than Compacted Clay
- Unlike Compacted Clay, Swelling Capability Provides True Intimate Contact For Composite Liner Systems
- Gundseal Is Less Affected By Freeze/Thaw Cycles Than Compacted Clay
- Gundseal Is Not Susceptible To Desiccation Since It Goes In Dry

Gundle Lining Systems Inc

Gundle®

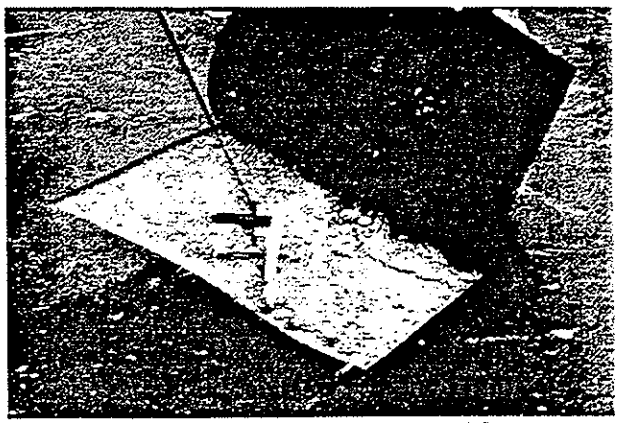
THE DIFFICULTIES AND UNCERTAINTIES OF BUILDING COMPACTED CLAY LINERS



1. Clay, properly spread only 6 inches at a time, must often be pulverized to remove clods, and must be dried out if too wet or wetted if too dry, to slightly wet of optimum moisture content for proper function as a soil liner.

2. Then the clay must be compacted to the correct field tested density, using the proper heavy equipment.

3. Assuming construction is performed correctly (a difficult task for large scale projects), compacted clay liners will still weather, dry out, and crack, even before being covered with geomembrane or cover soils.



4. Desiccation leading to cracks and fissures can also occur in compacted clay liners after they have been covered with geomembrane or soils.

COMPARATIVE LIQUID FLOW THROUGH A SINGLE COMPACTED CLAY LINER (CCL) VS SINGLE GEOSYNTHETIC CLAY LINERS (GCL's)

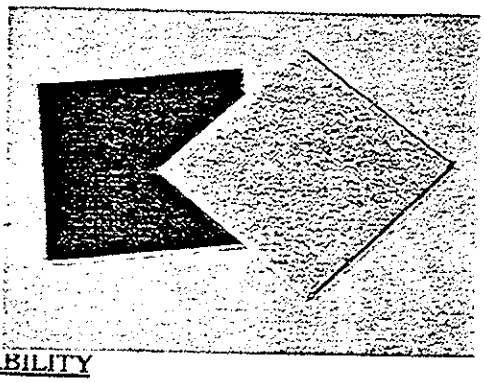
Flow Equation (Darcy's Law): $Q = KA(H + t)/t$

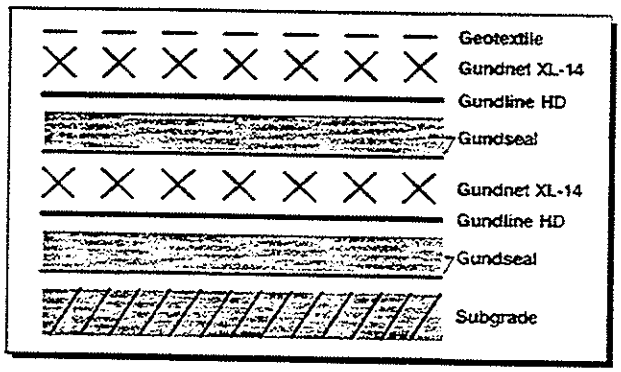
where K = hydraulic conductivity of liner, A = area of containment,
H = avg. height of liquid above liner, t = thickness of liner (including hydration swell under 2,500 psf),
Q = expected flow through the liner

CCL	Typical Fabric Encased GCL	Gundseal
H = 2 ft	H = 2 ft	H = 2 ft
t = 12 in	t = .2 in	t = .2 in
$K = 1 \times 10^{-7}$ cm/sec	$K = 5 \times 10^{-10}$ cm/sec	$K = 4 \times 10^{-12}$ cm/sec
A = 500,000 ft^2	A = 500,000 ft^2	A = 500,000 ft^2
Q = 0.0049 ft^3/sec = 3167 gal/day	Q = 0.00099 ft^3/sec = 640 gal/day	Q = 0.0000079ft^3/sec = 5 gal/day

GUNDSEAL - THE PREMIER GEOSYNTHETIC CLAY LINER

ndseal® is the only Geosynthetic Clay Liner (GCL) that provides the high swelling and sealing potential of bentonite clay and the ..w permeability of a geomembrane. Gundseal consists of one pound per square foot of high quality sodium bentonite adhered to either an HDPE or VLDPE geomembrane. This composite design lets the contractor conveniently roll out a blanket of clay, npetitively replacing or supplementing compacted clay that is required for liners and cap systems. The standard geomembrane .cking for Gundseal is 20 mil HDPE. However, the backing can be up to 80 mils in thickness and also may be textured for improved slope stability. The rolls are 17.5 feet wide and vary from 200 feet long for the 20, 30, and 40 mil backing to 150 feet long f the 80 mil backing. All Gundseal rolls weigh approximately 4,000 pounds.





ERMEABILITY

ndseal is typically deployed in a liner system with its protective geomembrane backing facing downward against the subgrade or rainage layer and another geomembrane seamed over the top of the bentonite. This forms a composite liner system which asses any liner system developed with either compacted clay or a fabric encased GCL. The permeability of Gundseal has been rmined by researchers to be less than 4×10^{-12} cm/sec. The extremely low permeability allows regulators and engineers to eplace entirely or partially supplement compacted clay requirements for landfill liner and cap systems.

MPOSITE ACTION

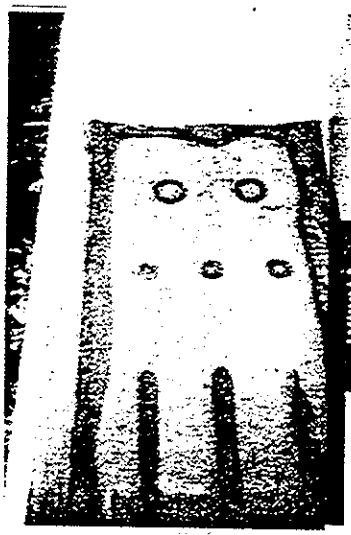
he fact that there is no geotextile covering the bentonite to prevent intimate contact with the overlying geomembrane allows the onite and upper geomembrane to have the kind of intimate contact unavailable with either compacted clays or fabric encased ynthetic clay liners, enabling construction of ideal composite liner systems.

Composite action of Gundseal illustrated by long-term tank tests at University of Texas showing intimate contact under worst case damage in overlying geomembrane (holes and razor blade slits). Results--absolutely no flow through the composite system and very limited wetting of the soil component.

Badly damaged geomembrane on top of Gundseal.

Gundle Lining Systems Inc

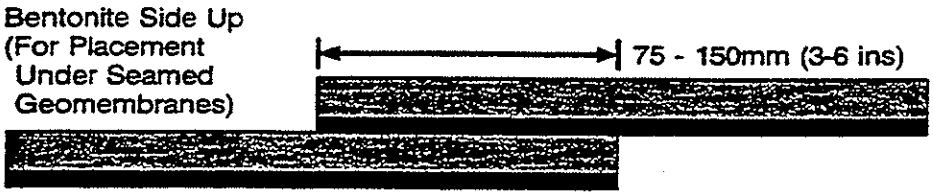
Gundle®

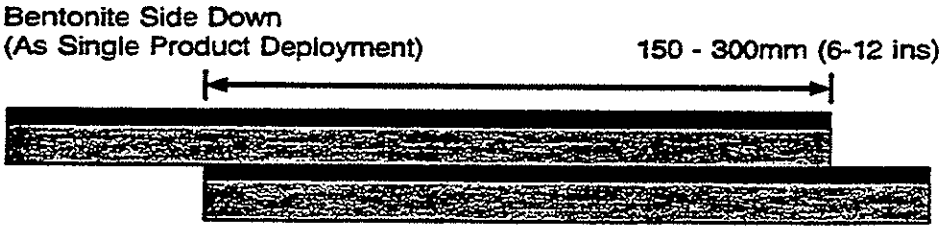


Gundseal after removal of damaged geomembrane showing very limited wetting.

9.0 Product

Gundseal Overlap





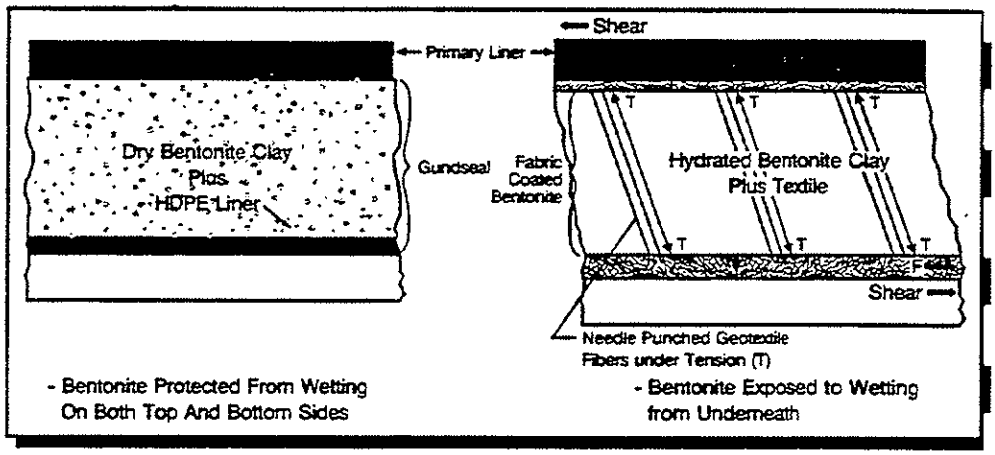
SEAM INTEGRITY

The intimate contact of Gundseal allows the seams to be simply overlapped with confidence that integrity of permeability will be maintained. Gundseal can also be placed bentonite side down, either overlapp as shown or extrusion welded, making it the most versatile GCL on the market. For bentonite side down applications, a thin fabr coating can be adhered to the bentonite face during manufacturing if desired.

SHEAR STRENGTH

When Gundseal is installed with the geomembrane facing downward and an overlying geomembrane covering the bentonite, the dry shear strength of the bentonite (22°) may be used in slope stability analyses. Test results have indicated that the excellent composite action developed between the overlying geomembrane and the bentonite prohibits the bentonite from becoming saturated in any way. In addition, the geomembrane backing prevents the bentonite from "sucking up" moisture from the subgrade soils as occurs with fabric encased GCL's. Therefore, the dry shear strength of the bentonite in Gundseal can be utilized for design purposes.

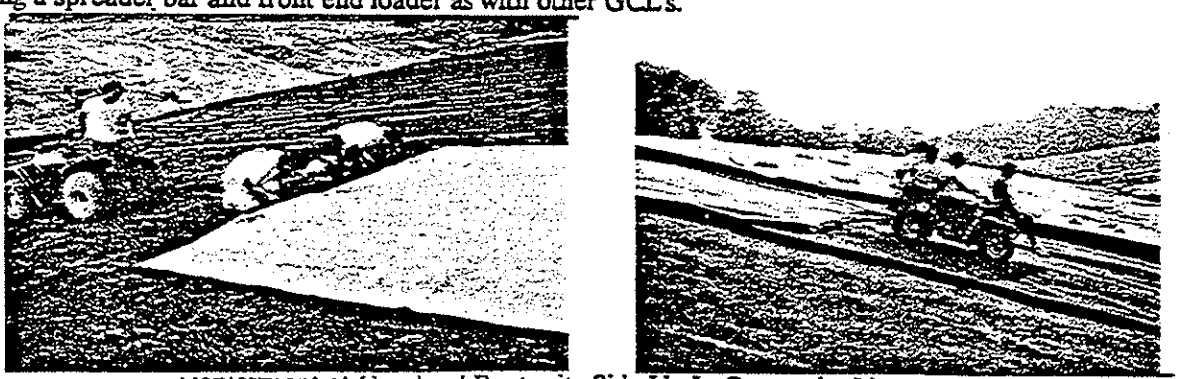
GUNDSEAL VS. OTHER GCL'S UNDER SHEAR STRESS



Gundseal maintains shear strength while others must depend on fabric fibers—an uncertainty over long-term.

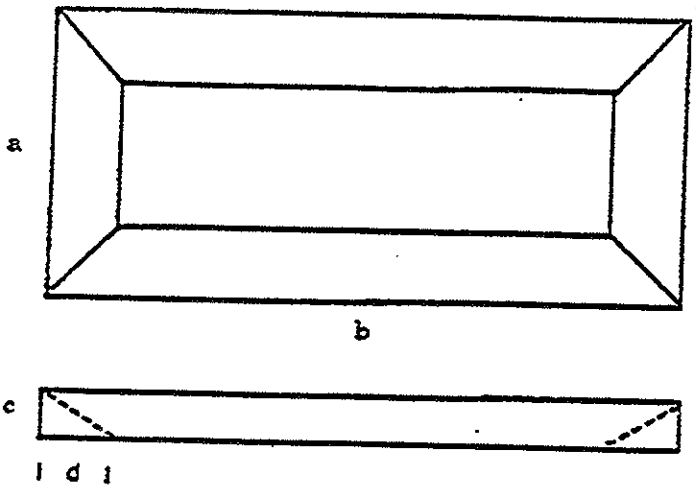
EASE OF INSTALLATION

On top of its outstanding engineering characteristics, another primary advantage of the Gundseal geosynthetic clay liner is that with its geomembrane backing, it is much easier to install than any other GCL available. Gundseal can be dragged or pulled into position without any fear that the dragging will dislodge the bentonite. This type of dragging cannot be achieved with other GCL's becau the geotextile component will snag on subgrades. For deployment of Gundseal bentonite side down, the material is unrolled in position using a spreader bar and front end loader as with other GCL's.



Deployment of Gundseal Bentonite Side Up In Composite Liner Construction

Capacity Calculations for Rectangular Landfill or Closure With Gundseal In Place Of Clay



Volume = $c(ab-ad-bd+2d^2)$ *

Where:

50 acres

a	= length of side a	=	440 yds.
b	= length of side b	=	550 yds.
c	= depth		
d	= (side slope ratio) (depth)		

CLAY	GUNDSEAL
Slope ratio = 3.5/1	Slope ratio = 3.5/1
c = 12 yds.	c = 12.6 yds.
d = 42 yds.	d = 44.1 yds.
Volume = $12[(440)(550)-(440)(42)-(550)(42)+2(42)^2]$	Volume = $12.6[(440)(550)-(440)(44.1)-(550)(44.1)+2(44.1)^2]$
$= 12[242,000-18,480-23,100+3,528]$	$= 12.6[242,000-19,404-24,255+3,889.6]$
$= 2,447,376$ yds.^{3}	$= 2,548,106$ yds.^{3}

Volume Increase = 2,548,106 - 2,447,376 = 100,730 cubic yards

Revenue Increase = (Volume Increase) (Compaction Factor) (Dumping Charge/Cubic Yard)

= (100,730)(2.7)($15.00) = $4,080,000

Net Savings = Revenue Increase - Cost of Gundseal + Savings from Replaced Clay

9.0 Product Information

* Koerner, R.M., "Designing with Geosynthetics", pg. 243, Prentice-Hall, Englewood Cliffs, N.J., 1986.

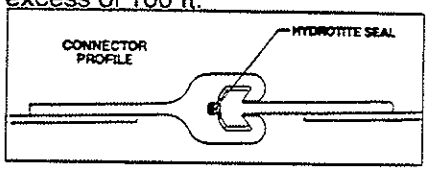
Gundwall®

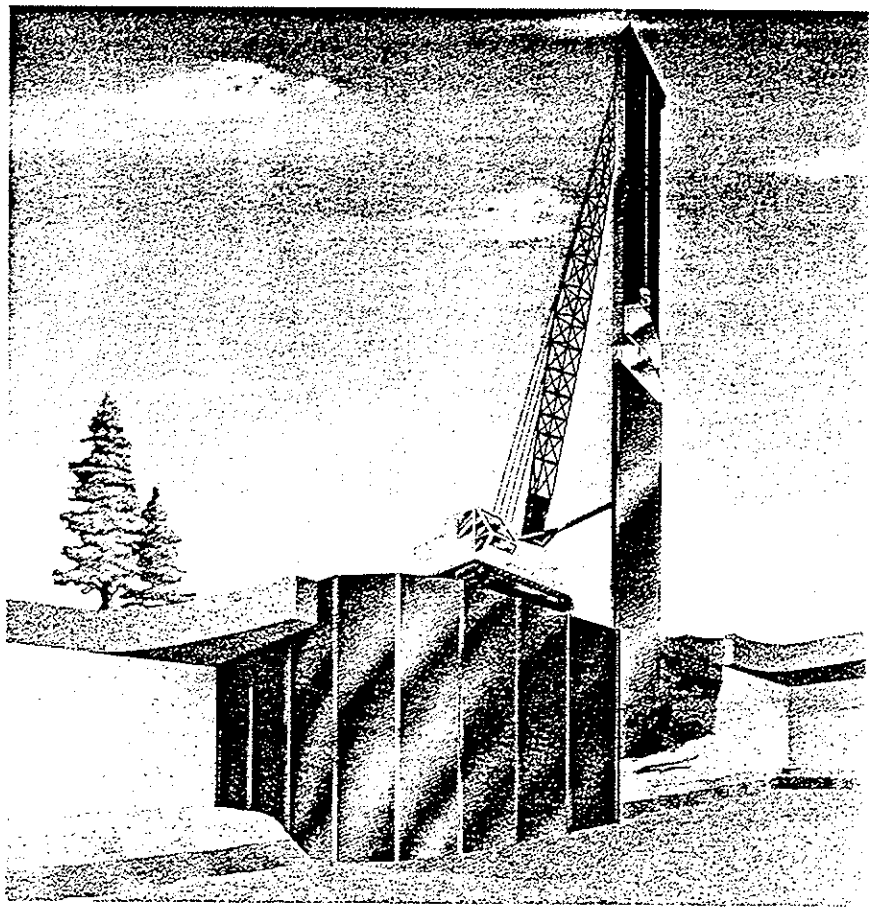
Gundwall Subsurface Polyethylene Vertical Barrier

The Problem: Hazardous chemicals migrating through soils contaminated by industrial activities or leaking storage tanks.

The Solution: Vertical barrier wall construction with flexible, chemical resistant, impermeable HDPE membrane.

The vertical barrier system, Gundwall, consists of Gundline® HD sheets welded to a patented locking profile. The panels are installed with a vibratory hammer and insertion plate, interlocked and sealed with each preceding panel. Ranging in thickness from 80 to 120 mils, Gundwall can be constructed to reach depths in excess of 100 ft.



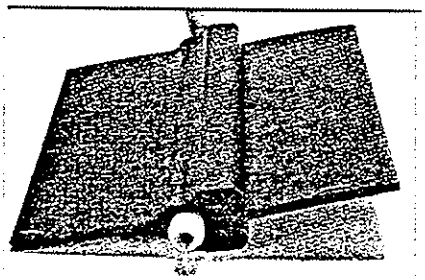


The flexible nature of Gundwall is such that even substantial soil deformation will not compromise the vertical barrier. Unlike soil barriers, Gundwall retains its integrity. This ability, along with Gundwall's inherent chemical resistance and impermeability, makes it the barrier of choice for underground applications. Gundwall can be used in place of or in conjunction with traditional slurry walls.

Hydrotite Seals Gundwall Locking Sections

To be effective, geomembrane barriers must have seams that are impervious to fluid movement. These seams must not only seal out fluids at the initial installation, but must retain their sealing ability through the life of the barrier. Enhancing Gundwall's impermeability at the interlock is Hydrotite, Gundle's hydrophilic joint seal.

Hydrotite is made of chloroprene rubber which is combined with a hydrophilic polymer. This exceptionally durable material is able to swell up to five times its volume when exposed to water. This quality enables hydrotite to continue to seal the Gundwall lock section even after substantial soil deformation and settlement.

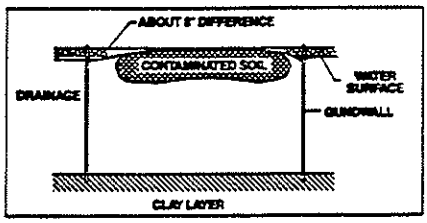


Only Gundwall Features The Superior Properties Of Gundline HD

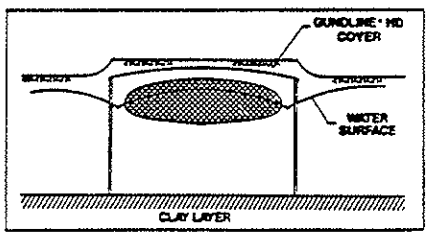
Gundline HD is made from the most field-proven, highest grade polyethylene available, and contains carbon black and anti-oxidants for extra long-term durability. When Gundline HD is used for contaminated soil containment, you're assured of maximum durability, impermeability and chemical resistance. Gundline HD is resistant to decay, rodents, microorganisms and chemicals. It is also resistant to punctures, tearing, low temperature brittleness and environmental stress cracking.

Environmental Applications

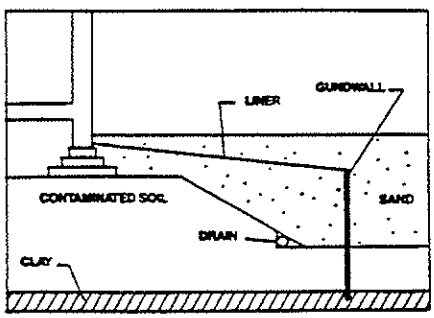
By installing Gundwall to the depth of a relatively impermeable clay layer, the lateral migration of toxic waste is prevented.



Constructing a Gundwall vertical barrier system limits the size of the contaminated area and substantially reduces the amount of groundwater requiring treatment in pump-and-treat, on-site cleanup operations. This results in considerable cleanup cost savings.

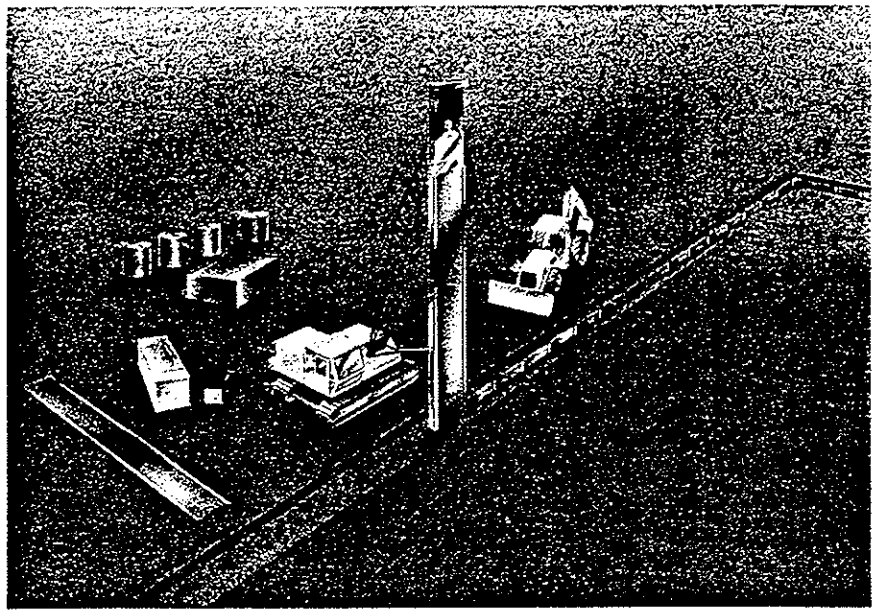


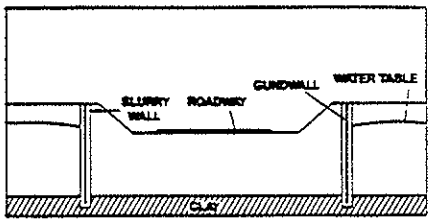
Complete protection and site rehabilitation is achieved by installing a Gundline HD cap to prevent the infiltration of rainwater into the containment area.



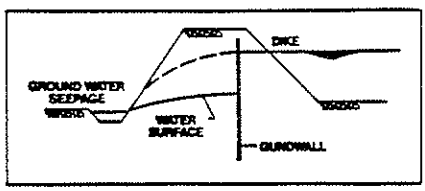
Civil And Hydraulic Engineering Applications

Applications for Gundwall are not limited to pollution containment and cleanup. By surrounding an excavation site with a Gundwall barrier, dewatering of the soil is facilitated and the threat of unacceptable settlement of surrounding structures is eliminated. An example of a civil engineering application for Gundwall is the E-25 motorway outside Best, Holland, built to a grade below the existing watertable. Gundwall, installed as a groundwater barrier, keeps the motorway dry.





Gundwall has also been used to reinforce earthen dams and dikes. The insertion of a Gundwall barrier eliminates seepage and prevents structural collapse.



Proper Installation Maximizes Performance And Efficiency

Methods of installing Gundwall vary with soil conditions and required installation depth. The preferred method is to vibrate the panels into place with an insertion plate. Installations by this method are possible to a depth of approximately 40 feet. The advantage of this method is that there are no trenching spoils to remove.

Additional options with the insertion method include: 1) the addition of a drainage element to facilitate the movement of liquids across the barrier face, and 2) the injection of a bentonite grout to improve the seal at the base or to form a composite barrier. Both the drainage element and the grout seal are constructed simultaneously with the Gundwall installation.

For deeper installations, or for installations through soils that are unsuitable for using the vibration technique, Gundwall can be installed using standard slurry wall construction methods. The result is the most effective composite barrier system available.

Gundle Lining Systems Inc

Gundle®

If It Needs Lining, It Needs Gundle.

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9.0 Product Information

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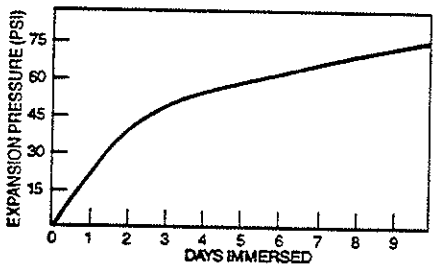
Hydrotite

Hydrotite: Rubber Joint Sealing Material For Maximum Leak Protection

Hydrotite is a hydrophilic rubber joint seal, now available from Gundle Lining Systems. What makes this material so special is its unmatched durability and water sealing capacity. Hydrotite expands up to *FIVE TIMES* its volume when exposed to water. This remarkable hydrophilic property enables Hydrotite to reliably expand and seal leaks long after conventional seals would have failed.

A sample of the wide variety of Hydrotite products.

Exceptional Qualities Ensure Maximum Performance



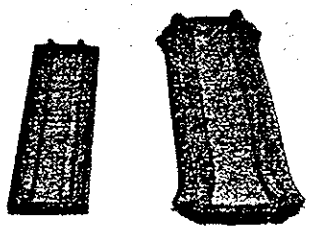
Gundle's Hydrotite is available in composite and non-composite form. In composite form, the material is co-extruded with high quality non-hydrophilic rubber. Thus, greater directional control of the swelling is achieved, which results in increased contact pressure. The non-hydrophilic rubber also supplements Hydrotite's already impressive strength in the swollen state.

Hydrotite is a chloroprene-based rubber developed for maximum long-term sealing capability. It consistently exhibits excellent microbial resistance, rubber elasticity and stress-relaxation properties. And whatever your requirements are, Hydrotite is available in a variety of profiles and expansion capacities to meet your specific need. It's this kind of product selection and flexibility that has made Gundle the world leader in lining products.

Hydrotite DST: Ideal In Shield Segment Tunnel Lining Systems

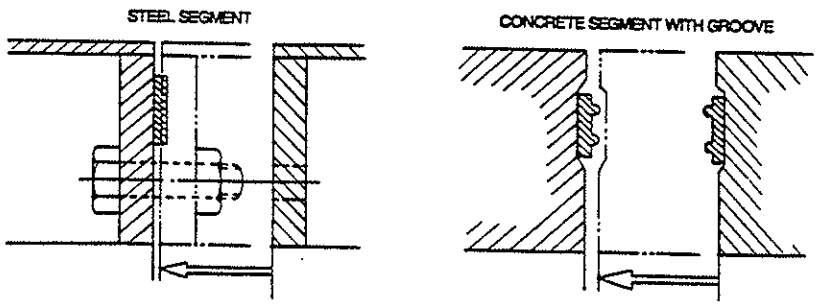
The outstanding hydrophilic performance of Gundle's Hydrotite DST enables it to follow the expansion and contraction of joint gaps, creating an effective seal even under high water pressure. In contrast, conventional compression seals tend to lose their elasticity and restoring force over time and, therefore, their water-sealing effectiveness. Furthermore, conventional seals must be thicker compared to Hydrotite DST to have the same gap-sealing ability.

This difference greatly facilitates segment installation since smaller joint gaps are required. The thicker conventional seals are also more prone to being knocked out of alignment during installation, and require higher bolting forces to seal them properly.



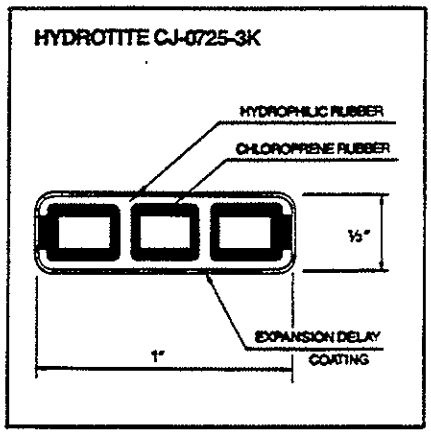
DST: before and after expansion.

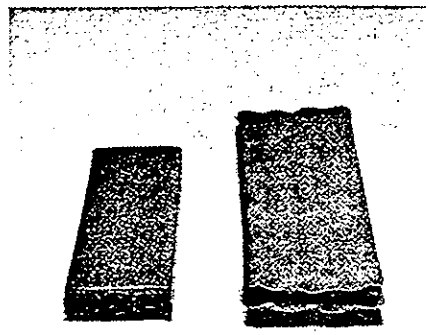
TUNNEL SHIELDING JOINTS



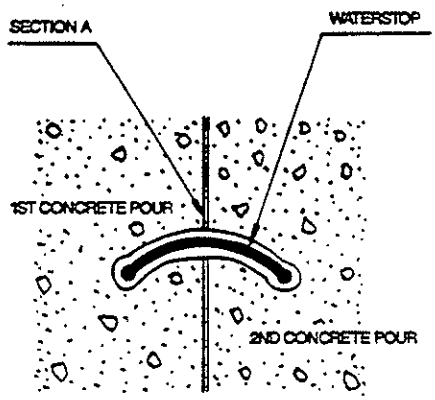
Hydrotite CJ: A Superior Waterstop For Concrete Joint Gaps

As this innovative product absorbs water and expands, it conforms to gap variations along the joint. This action ensures complete sealing even under extraordinary hydrostatic pressures. And due to its slim profile, it won't project like conventional waterstops and trap air or become displaced by the second pour. The result is optimum concrete placement. In fact, Hydrotite CJ is treated with a special expansion-delay coating to prevent it from reacting to the fresh, moist concrete and expanding before curing takes place. Every step of the way, Gundle's Hydrotite products provide maximum performance for all your sealing requirements.

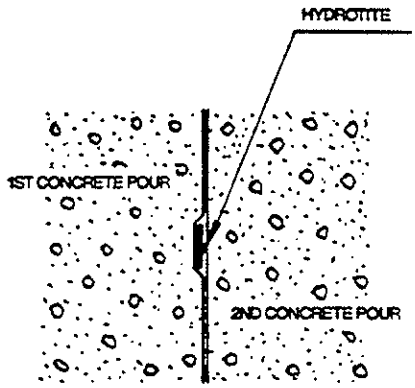




CJ: before and after expansion.



STANDARD WATERSTOP



HYDROTITE WATERSTOP

Note: Installing Hydrotite in a groove as shown above is the preferred method of installation, but is not required.

HYDROTITE SPECIFICATIONS

TYPICAL PROPERTIES* ITEM	HYDROPHILIC SECTION	NON-HYDROPHILIC SECTION
Tensile Strength (PSI)	683	1877
Elongation (%)	720	450
Hardness	12	14

*Note: All values, except when specified as minimum or maximum, are typical test results.

Packaging Per Carton:
CJ Type contains 4 reels, 32 feet long. DST Type contains 5 reels, 65 feet long. Thicker profiles will differ in packaging units.

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Gundle®

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These specifications are to be used only as a general guideline by engineers in formulating preliminary specifications, and should not be relied upon without site-specific product testing; Gundle assumes no responsibility for the improper reliance upon or misuse of such data. In addition, product design and specifications are subject to change without notice.

*Gundle Lining Systems Inc 1991 20MO392RPH

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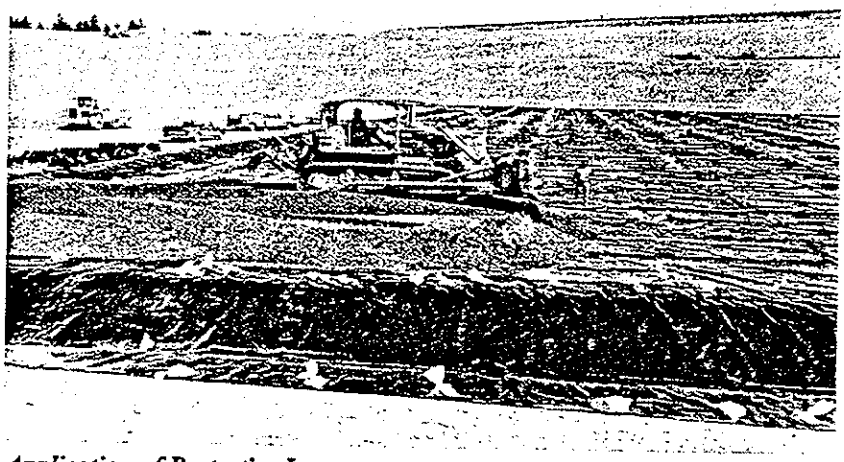
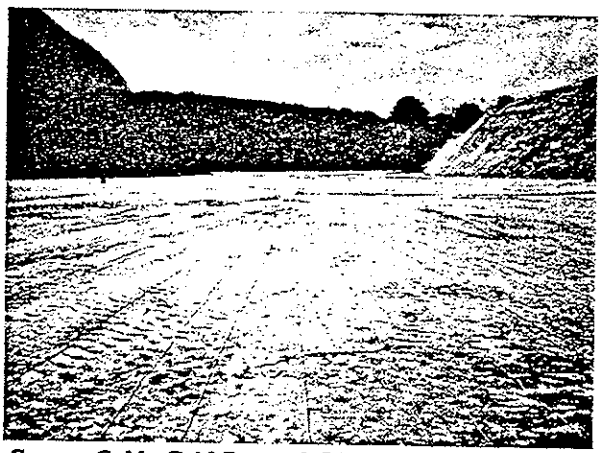
Sensor™

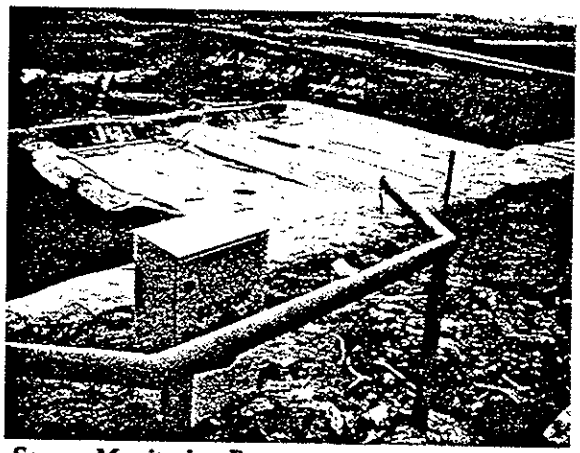
SENSOR



Application of Protective Layer



Sensor Cable Grid Beneath Liner



Sensor Monitoring Box

THE SENSOR DAMAGE DETECTION SYSTEM

Geomembrane lining systems based on Gundline HD have been used extensively in many countries for over 10 years for solid and liquid waste containment. There is an increasing requirement for additional methods of quality control which will enable any accidental damage to the liner during the placing of the protective layer to be detected and repaired before the placing of the waste. Gundle is now able to offer the Sensor Damage Detection System (DDS) as part of its service to the waste disposal industry to provide secure lining systems. The Sensor system can also be used to monitor the liners' performance in the long term - systems are available to permit monitoring for over 30 years. Shorter term (for example 2 year) systems are also available.

Spreading protective soil cover can damage the liner system.

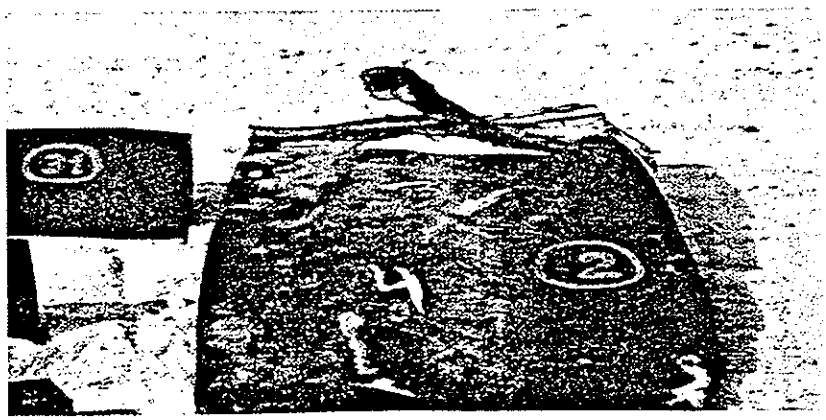
Damage Potential

In solid and liquid containment projects, engineers are very careful to correctly specify the use of lining materials which are manufactured under conditions of strict quality control and which are also installed using site quality control methods to insure the best possible installation for the customer.

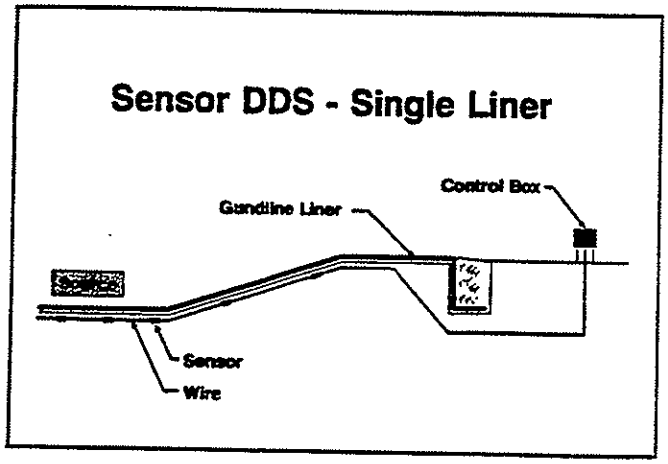
As a professional liner manufacturer and installation company, Gundle takes all necessary precautions to insure that there is no damage to the liner during the unrolling and welding operations. To provide added security, Gundle has developed the Gundline HDC conductive liner system which has a coextruded undersurface conductive layer that enables the liner to be 100% spark tested using special spark test equipment.

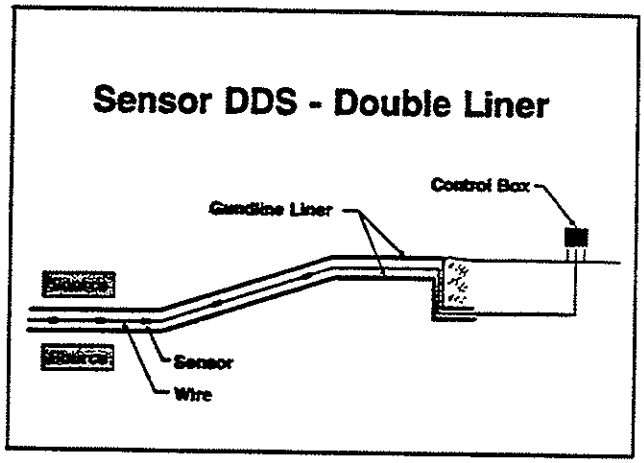
However, there still remains the potential for accidental damage of the liner system during the placing of the sand or soil protective layer. A Sensor system is now available through Gundle which can accurately detect and locate such damage, permitting repair of the liner system after removal of the cover material in the actual location of the damage, thus avoiding the cost of removal of cover material from large areas of liner.

Gundle is able to provide a totally monitored and controlled lining system to the customer who requires long term containment security.



Examples of damaged liners which occured during soil cover placement.





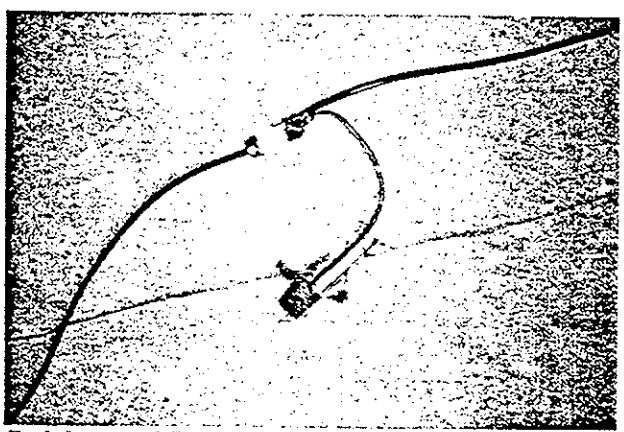
The Principle

Specially designed sensors are placed at predetermined locations in the subgrade prior to lining. They are connected by insulated wires to a central control box next to the landfill or waste disposal area. After lining with Gundline HD, using all standard Quality Control procedures, and application of the protective soil/sand layer, an electrical source sensor is placed above the liner and a current applied. The sensors below the liner measure current density and any damage in the liner system gives rise to abnormality in the current. Interpretive software analyzes the data from the control box producing a three dimensional diagram. Any abnormalities show up as peaks on a contour like display. The positions of the abnormalities can be precisely related back to the site and located with an accuracy of +/- 150 mm. Digging away the protective layer in this location will reveal damaged areas or holes made during the application of the protective layer. The damage is easily repaired with the Gundle extrusion welding machine.

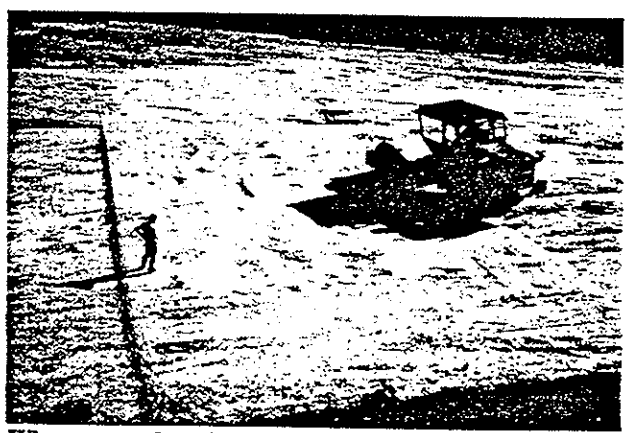
The Sensor system can be used to confirm the integrity of single and double liner systems. If the sensors are placed between two liners, the integrity of both the primary and secondary liner can be confirmed.

After completion of the Sensor surveys, a Clear Field Report of Integrity (CFRI) is issued to the customer. Subsequent surveys can be conducted on a regular basis as required and agreed with the customer.

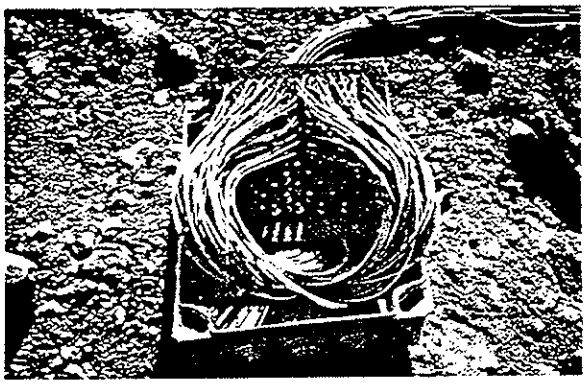
A mobile Sensor system is also available for use on projects where the liner has already been installed. A mobile sensor is moved by the Sensor operator across the upper surface of the protective soil cover at predetermined grid points. After positioning an active source, the current density is measured and interpreted enabling the position of damage to be determined and repairs to be made.



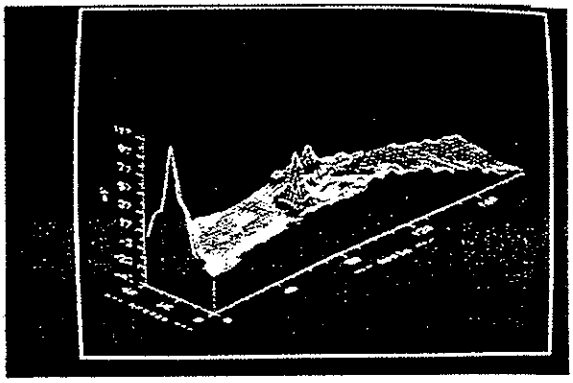
Stainless steel Sensors connected to wires.



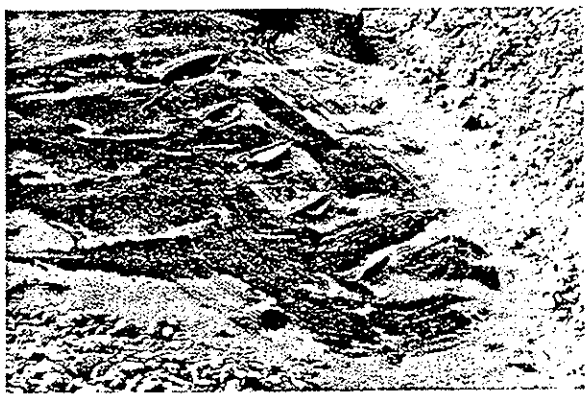
Wires are gathered and brought to one point.



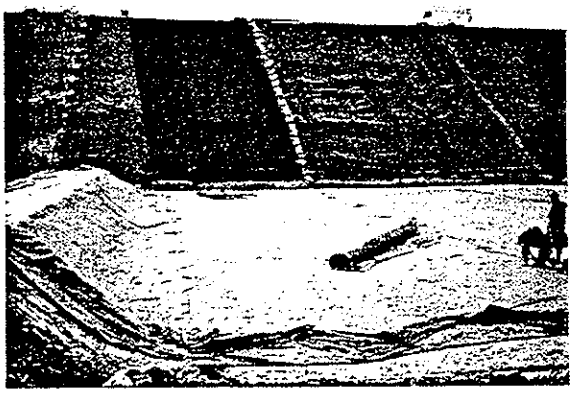
Sensor wires are connected to the central control box.



The 3D Diagram interpretation of current density anomalies.



The Sensor System detects several holes made during the placing of the gravel drain material.



The Sensor System can be used to detect damage to both primary and secondary liner.

The Sensor Damage Detection System

* Sensors are placed at predetermined locations in the subgrade.
* Sensors are connected by wires to a central control box.
* After installation of Gundline HD and protective soil cover an electric source is placed above the liner.
* Current density is measured and abnormalities arising from damage in the liner will be monitored and interpreted using special computer software.
* Damaged areas can be located on site within +/- 150 mm and after removal of the soil cover in the immediate vicinity, repairs to the liner can be made.
* A final Clear Field Report of Integrity (CFRI) is issued to the customer. Subsequent monitoring surveys can be conducted on a regular basis as required.
* A mobile Sensor system may be available for damage detection when the liner has already been installed and covered.

Gundle®

19103 Gundle Road
Houston, TX 77073 U.S.A.
Phone: (713) 443-8564
Fax: (713) 875-6010

SENSOR™

Z.I. - Rue Pierre et Marie Curie
51530 OIRY, France
Phone: (33) 26 54 85 57
Fax: (33) 26 54 52 36

Geogrid

TENSAR®

Proven Application Technology

The use of Tensar geogrids as a support for critical waste containment systems is based on proven geostructural technology pioneered by The Tensar Corporation in response to similar massive foundation problems encountered nationwide. Leading engineers, owners, and regulators who are defining the state-of-practice in waste containment trust the proven application technology incorporated in Tensar structural support systems to reduce the risk of containment failure with its devastating environmental implications.

Tensile stresses of a magnitude severe enough to cause rupture of the containment system may be induced by foundation movements associated with a variety of geomechanical phenomena. Although the strains induced in the system may appear quite low, the long-term effects on non-structural elements can be significant. For example, axisymmetric, three-dimensional *membrane tensile stresses of approximately 50 percent of the short-term tensile strength of the critical component materials may be induced at as little as two percent strain.* The long-term polymeric response of these low strength materials, including their ability to sustain such relatively high stress levels, is questionable.

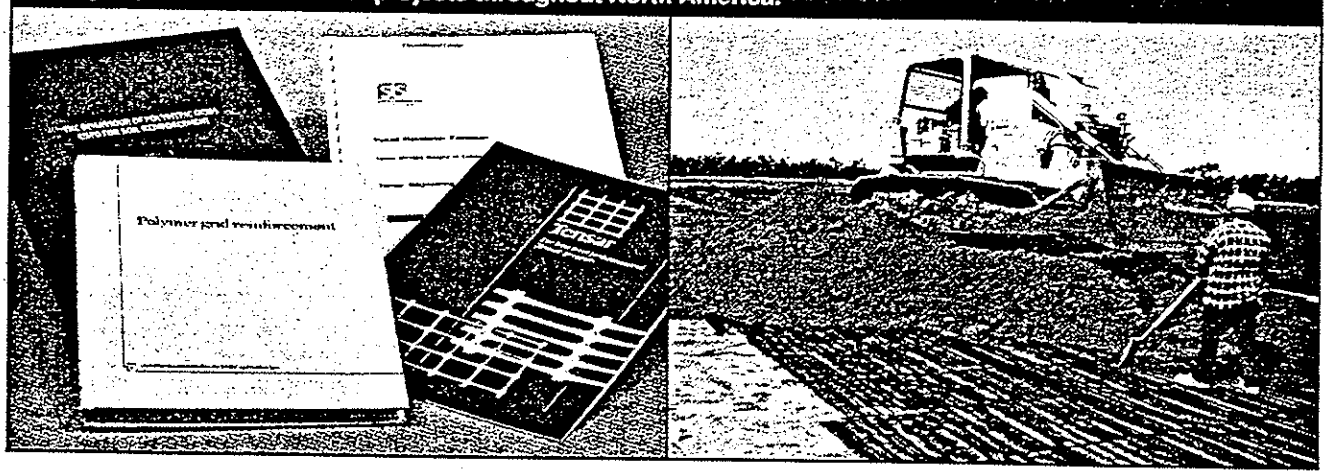
Our experience in the evaluation, analysis, and design of synthetic structural grid systems has allowed us to develop a geostructural technology which successfully interprets, coordinates, and extrapolates soil arching, soil interaction, and structural tensioned membrane theories. This technology has been proven at numerous locations nationwide. In addition, our knowledge of the mechanisms and behavior of synthetic materials has proven invaluable to engineers who must assess the long-term polymeric response of critical synthetic components in such applications.

When a depression forms beneath a layer of structural synthetic grids, the high tensile modulus immediately limits the deflection of the containment system and thereby minimizes the axisymmetric tensile stresses in the synthetic components. Yet, this limited deflection of the grid has two effects: bending of the soil and/or waste materials above and tensioning of the structural geogrid.

Bending of the soil and/or waste materials will generate arching within these materials which transfers a portion of the overburden pressure away from the depression. As a result, the applied vertical stress above the depression may be significantly reduced from the overall overburden pressure which existed at the foundation level prior to movement. The integrity of the structural support is dependent on the ability to accurately predict the stress variance due to arching.

Tensioning mobilizes the structural performance characteristics of the grid. The high modulus minimizes the strain in the system while the high tensile strength maintains the integrity of the critical components at a high margin of safety. The ability of the structural support system to provide long-term structural stress relief can only be assured if the polymeric response of both the structural grid and component materials have been accurately assessed and scientifically extrapolated.

The application technology of Tensar products has been proven, both by independent research and analysis, and in hundreds of projects throughout North America.



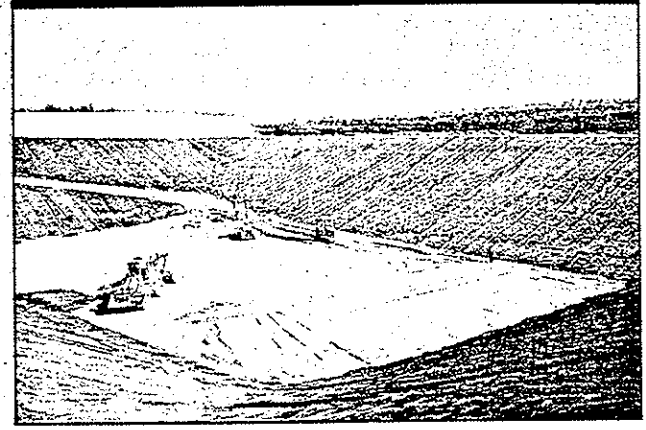
The Survivability of a Waste Containment System

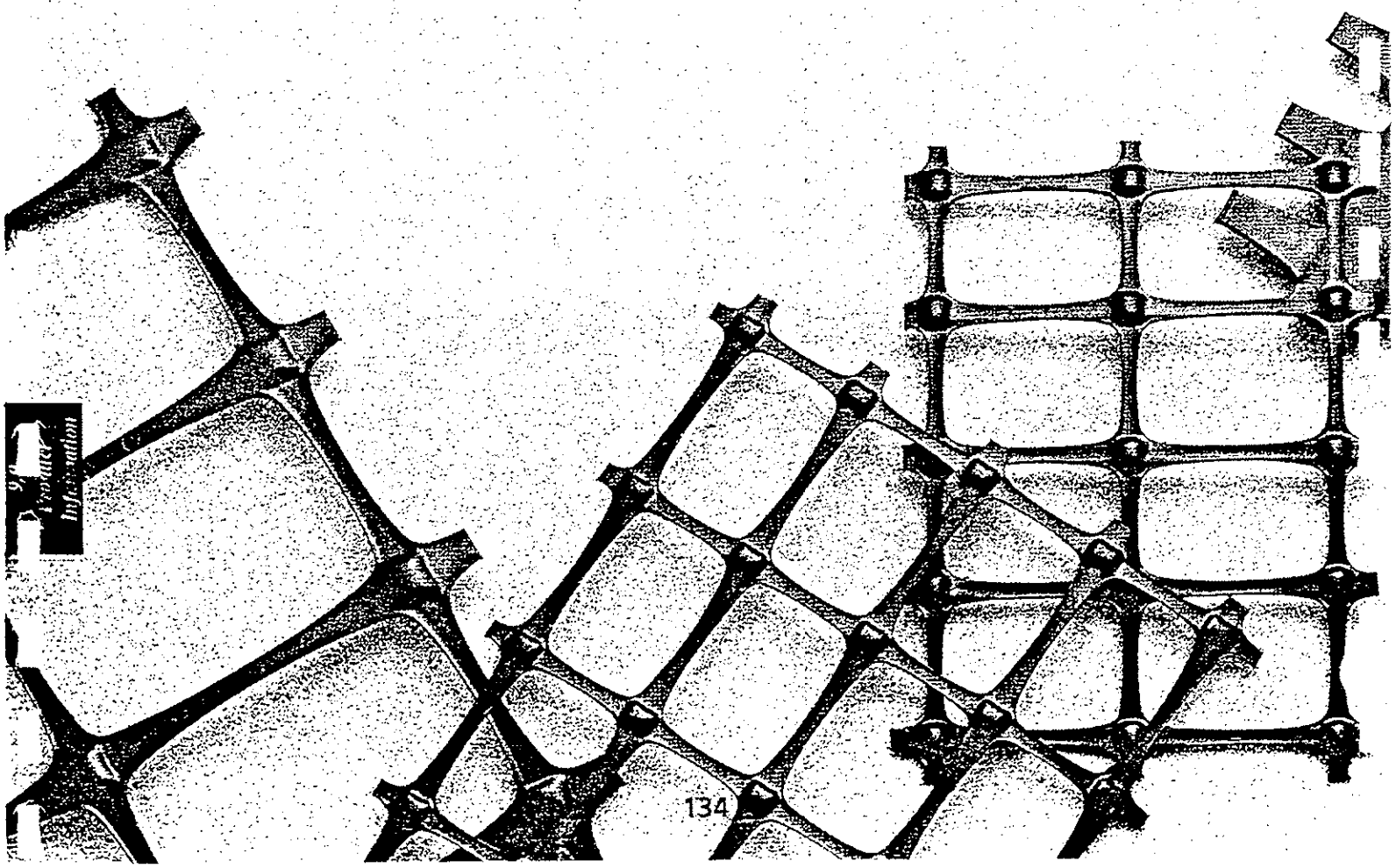
Today's state-of-the-art waste facilities often require the regulated use of specially designed containment systems to assure the long-term collection, detection, and containment of leachate. The components of the system include synthetic or clay liners together with synthetic drainage media. The performance of these components is critical. A rupture or leak could result in contamination of the surrounding groundwater.

Although the barrier and leachate transmissivity properties of these component materials are excellent, they have no significant tensile strength. This lack of tensile resistance creates significant problems which may jeopardize the integrity and survivability of the system when used in areas or applications which may induce tensile stresses of even moderate magnitude into the component materials.

Unfortunately, availability, site constraints, and permitting considerations are increasingly restricting the location of waste management facilities to areas with compressible foundations; void-prone, collapsible, or deleterious subsoils; or even atop previously placed waste with questionable support characteristics. The differential settlements or movements inherent in such areas are difficult to predict and are virtually impossible to control without prohibitively expensive foundation remediation measures. As a result, the placement of a containment system on such sites without a well-engineered support system greatly increases the risk of failure of the system as the critical components approach their limited strain capabilities in response to differential foundation movements.

Lining systems must provide reliable long-term environmental protection.





Tensar Structural Security™

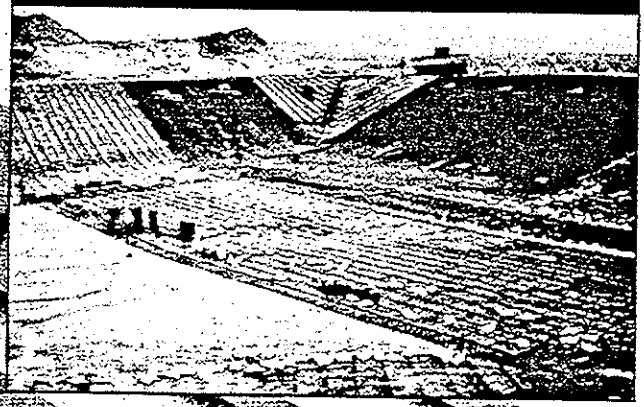
The long-term performance of critical containment system components when placed over marginally stable or highly deformable foundations is recognized as a significant problem by leading owners, regulators, and engineers in waste management nationwide. Their solution—the *Structural Security*™ offered by Tensar structural grids. Tensar structural grids provide positive structural support of critical component materials by acting as a synthetic "bridge" which spans voids, depressions, and decaying organics. The extraordinary tensile strength, tensile modulus, durability, and soil interaction characteristics of Tensar structural grids minimize the distortions and deformations within the system and reduce the induced tensile stresses to within acceptable limits. The high-performance structural characteristics of Tensar grids have been validated and documented by extensive laboratory research and development and verified in numerous critical waste containment facilities across the U.S.

At these and other facilities currently under construction, Tensar structural grids have been selected because they:

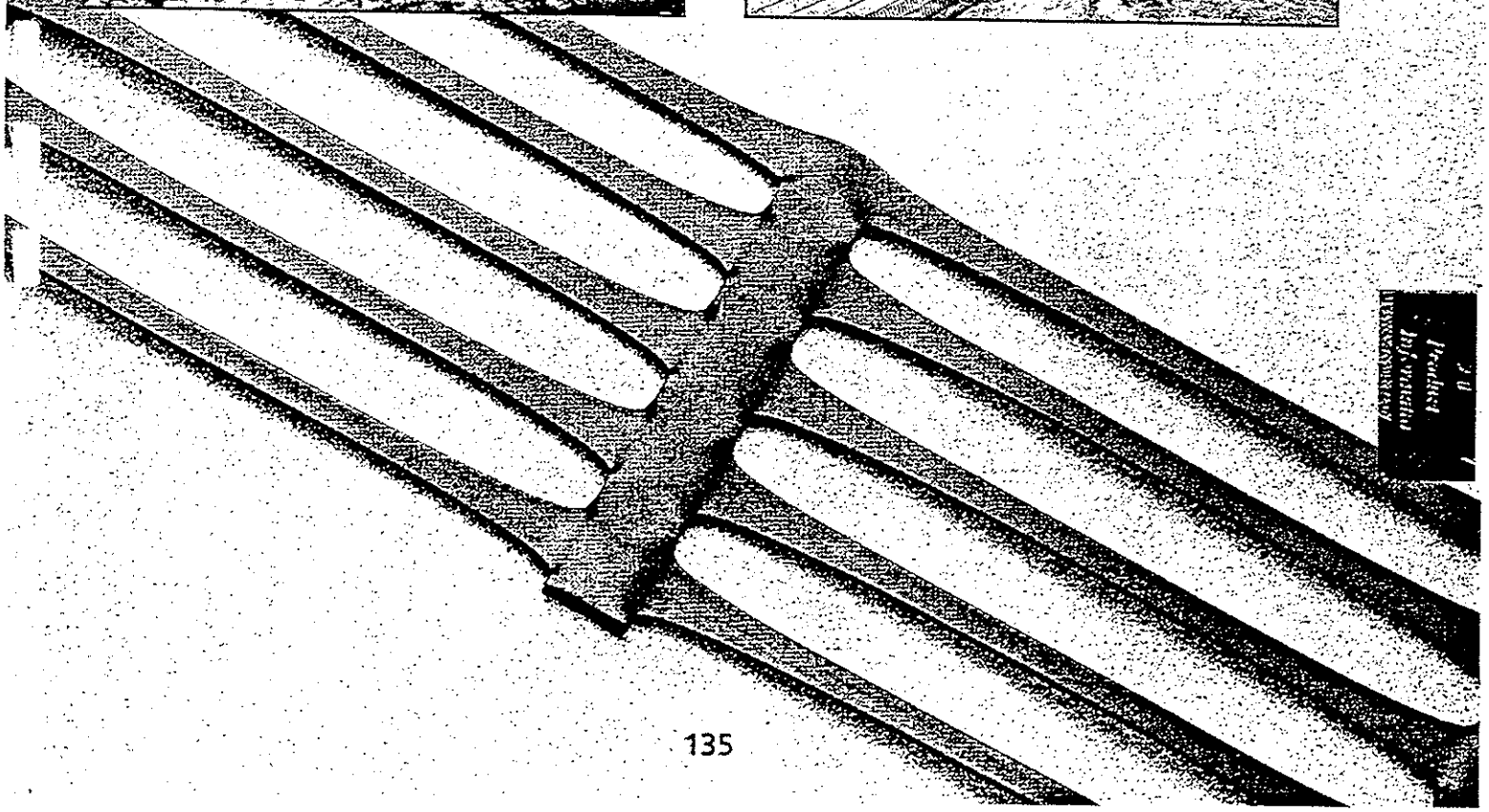
- substantially reduce the risk of long-term rupture of the critical containment system;
- provide the structural reinforcing capabilities upon which such innovative, alternative engineered concepts as lateral and vertical expansion can be confidently based.

Engineers who define waste management practice rely on Tensar products and services to solve difficult waste containment problems nationwide. Their trust is based on the *Structural Security*™ offered by Tensar—reliable products with documented structural performance, proven application technology pioneered and developed by The Tensar Corporation together with our highly-regarded engineering design services.

Long Island, NY—support of incinerator ash cell



State of Washington—vertical expansion of municipal solid waste facility

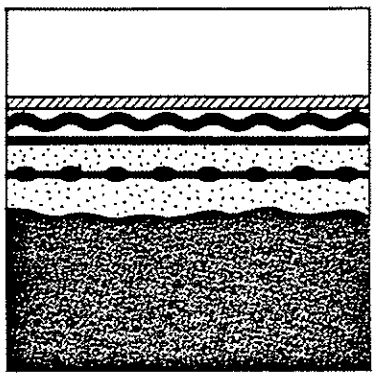


Applications

For New Facilities

By structurally securing critical components, long-term performance can be assured on sites considered too risky by conventional analysis—sites which include soft, compressible foundations, pockets of mud and decaying organics, or collapsible subsoils. In these areas, Tensar grids form a synthetic "bridge" which fully supports both the containment system and the impounded waste without destructive deformations to critical non-structural components.

In numerous cases nationwide, Tensar grids have been used as the ultimate foundation support system—allowing engineers, owners, and regulators to cope with potentially destructive foundation conditions without operating restrictions, reductions in waste storage volume or inefficient staged placement of waste materials.



Structural grid supports waste containment systems of new facilities when installed on top of soft, compressible, or void-prone foundations.

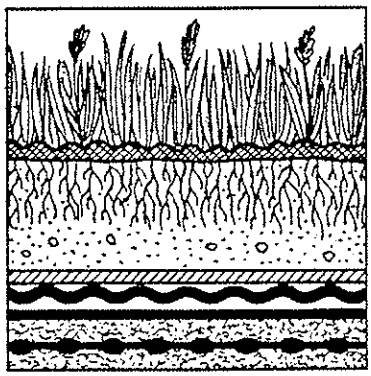
For Expansion of Closed Facilities

Siting and permitting of new facilities often takes years of effort—without any assurance of success. Expansion and reuse of previously permitted but closed facilities offers several advantages, but only if it can be accomplished without rupture of the closure cap system. It is often the only means to deal with skyrocketing regional waste storage requirements in areas of rapidly diminishing capacity.

Tensar structural grids allow construction above previously placed waste by stress-relieving both the closure cap system and the new containment system. Problems associated with the unpredictable decay, collapse, and differential settlement characteristics of waste can be confidently solved using the Tensar structural synthetic support proven at numerous sites nationwide.

For Secured Closure Systems

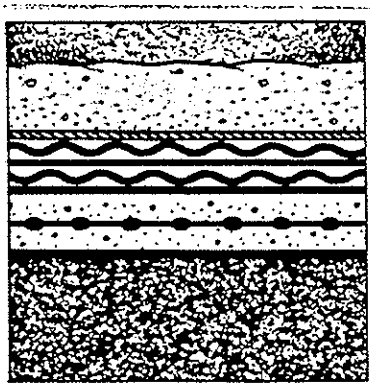
When a landfill facility is finally closed, it is often regraded or landscaped for other use, often as public parkland. Due to the non-homogeneous composition of previously placed waste, uneven and unpredictable settlement can occur which will severely stress the capping system unless it is reinforced in a manner that minimizes this problem. When Tensar grids are used to support these closure systems, they act as a structural support which provides a higher measure of structural integrity over the post closure life mandated by the Environmental Protection Agency (EPA).



The long-term integrity of final closure systems is assured using durable structural geogrid.

For Expansion of Operating Facilities

Stiff new environmental regulations are being enacted across the country which mandate sealed closure of existing cells of operating sites which do not meet the new stringent containment standards. Continued use of such sites requires installation of a state-of-the-art containment system for all new cells which is generally placed adjacent to and often above the closed and capped cells in an attempt to prevent further contamination of the surrounding groundwater. Tensar structural grids span voids, collapses, and differential settlement associated with the often unpredictable nature of the previously placed waste providing positive long-term support of the critical containment system components.



Structural synthetic grids allow secure expansion of both closed and operating facilities.

TABLE OF EXHIBITS

10.0	**EXHIBITS**
10.1	Geomembrane QC Certificate
10.2	Geonet/Fabri-Net QC Certificate
10.3	Resin Certification from Supplier
10.4	Gundle Resin Testing Report
10.5	Destructive Weld Test Report
10.6	Pre-start Site Inspection Form
10.7	Subgrade Surface Acceptance Form
10.8	Daily Progress Report
10.9	Weld Sample Label
10.10	Sample Material & Workmanship Warranties
10.11	Organizational Charts

Gundle®

Quality Assurance Certificate

RAILCAR : PSPX6128
MATERIAL : HDT 060 MIL
BATCH # : 040594
ROLL # : 07014351

MANF. DATE : 04/05/1994
PROJECT NAME : GHENT GENERATING ST
MR NUMBER : 9106-05 PROJECT # : D194
LOCATION : COLUMBUS OH 001

TEST PARAMETER		TESTING FREQUENCY	REQUIRED SPECIFICATIONS	TEST RESULTS	ASTM METHOD
Average Thickness (mils)		EVERY ROLL	60.0 min	61.0	D 751
Carbon Black	(%)	1/SHIFT	2.0 to 3.0	2.4	D 1603
Melt Index	(g/10 min)	1/SHIFT	0.30 max	0.10	D 1238 E
Density	(g/cm3)	1/SHIFT	0.940 min	0.947	D 1505 A
Tensile Properties:					
T.S. Yield	(ppi)	2ND ROLL	126 min	170	D 638
Elong. Yield	%	2ND ROLL	12 min	17	2 ipm
Puncture Resistance (lbs)		2ND ROLL	70 min	112	FTMS 101 , Meth 2065
Tear Resistance	(lbs)	2ND ROLL	39 min	56	D 1004,Die C
Low Temp.Brittleness degF		CERTIFIED	-60 max		D 746, B
Environ.Stress Crack hrs		CERTIFIED	1500 min		D 1693
Dimensional Stability (%)		CERTIFIED	-2 to 2		D 1204

CERTIFIED BY:

Thomas P. Moran

Thomas P. Moran
Lab Manager

10.0 Exhibits

EXHIBIT 10.1

Gundle®

Quality Assurance Certificate

MATERIAL : FA2060060C
BATCH # : 100293
ROLL # : 10032642

MANF. DATE : 10/02/1993
PROJECT NAME : GHENT GENERATING ST
NR NUMBER : 9106-02 PROJECT # : D194
LOCATION : COLUMBUS OH 001

TEST PARAMETER	TESTING FREQUENCY	TYPICAL SPECIFICATIONS	TEST RESULTS	ASTM METHOD
Mass/Unit Area (net)lb/sf	2/DAY	0.170 min	Pending	D 3776
Average Thickness (mils)	5TH ROLL	200.0 to 270.0	200.0	D 1777
Carbon Black (%)	1/SHIFT	2.0 min	2.4	D 1603
Melt Index (g/10 min)	1/SHIFT	1.00 max	0.11	D 1238 E
Density (g/cm3)	1/SHIFT	0.940 min	0.946	D 1505 A
Tensile Properties:				
T.S. @ Break (MD) ppi	5TH ROLL	44	51	D751 2IPM/2"X5"SPEC.
Peel Strength (g/in):				
Min MD Top (g/in)	5TH ROLL	100 min	596	F904
Min MD Bottom (g/in)	5TH ROLL	100 min	1305	F904
Avg. MD Top (g/in)	5TH ROLL	150 min	838	F904
Avg. MD Bottom (g/in)	5TH ROLL	150 min	1593	F904

* The above test results assure the quality of the following roll #:
10032639 10032640 10032641

CERTIFIED BY:

Thomas P. Moran

Thomas P. Moran
Lab Manager

Exhibits

EXHIBIT 10.2

PHILLIPS 66 COMPANY
A DIVISION OF PHILLIPS PETROLEUM COMPANY

PASADENA, TEXAS 77501-0792
BOX 792 PHONE: 713-475-3656

PHILLIPS PLASTICS RESINS
Houston Chemical Complex

March 25, 1994

JHV# 4014-94

FAX: 713-443-4627

Gundle Lining Systems Inc.
1340 East Richey Road
Houston, TX 77073

ATTN: Rick Schaefer

This letter will certify that the Marlex* resin shown below, as supplied by Phillips 66 Company, conforms to our manufacturing specification.

Type:	HHM TR-400GF
Lot Number:	7340083
P.O. Number:	S030350
Date Shipped:	03/24/94
Package:	PSPX 6128
Quantity:	153700 LBS.
HLMI:	17.1 G/10 MIN
Density:	.937 G/CC

J. H. Vaden
Quality Assurance Manager
PHILLIPS 66 COMPANY

JHV:PSN:sr

* Reg. U.S. Pat. Off.

cc: QA-File-RC

EXHIBIT 10.3

Gundle®

GUNDLE LABORATORY
MELT INDEX / DENSITY

DATE: MARCH 30 1993
RAILCAR#: PSPX6128
PRODUCT CODE: HHM-TR400GF
MANUFACTURER: PHILLIPS

	MELT INDEX ASTM D1238,E (G/10MIN.) TEST RESULTS	DENSITY ASTM D1505 (G/CC) TEST RESULTS
1.	0.13	0.936
2.	0.13	0.935
3.	0.13	0.936
4.	0.12	0.936
5.	0.12	0.936
6.	0.14	0.935
7.	0.13	0.936
8.	0.12	0.936
AVG.	0.13	0.936
STD.	0.01	

RATIO (N/E): _____ HLMI: 12.93

EXHIBIT 10.4

Exhibits

Gundle®

Destructive Sample Report DS-11692

MATERIAL : HDT060N000
DATE: 06/01/94

Name: GHENT GENERATING ST
MR Number: D194
Location: COLUMBUS OH 001

TEST METHOD:

[ASTM D4437 One inch speciment were used for peel and shear testing of the welds.]

Specifications:		Weld Method	#Coupons	Average Min	#Fails allowed	Specimen Min
Peel	stress, ppi	FUS	2	78	0	78
Peel	stress, ppi	EXT	2	78	0	78
Shear	stress,ppi	EXT	2	120	0	120
Shear	stress,ppi	FUS	2	120	0	120

Seam	Sample	Weld Type	Result Type	Peel Stress	Shear Stress
RP 50-51	DS79	EXT	FTB	91	195

CONCLUSION:

All welds passed.

CERTIFIED BY:

Thomas P. Moran
Lab Manager

EXHIBIT 10.5

10.0 Exhibits

Gundle®

PROJECT: _____

LOCATION: _____

DATE _____ P.F.# _____

PRE-START SITE INSPECTION

1. INSPECTED BY:

NAME	REPRESENTING	POSITION

2. DESCRIPTION OF INSPECTED AREA

_____

_____

_____

PHOTOS ENCLOSED ☐ TO FOLLOW ☐

3. REMEDIAL WORK REQUIRED:

_____

_____

_____

4. DATE & CONDITIONS OF GUNDLE START–UP:

_____

_____

_____

5. FURTHER INSPECTION REQUIRED: YES ☐ NO ☐ DATE: _____

6. BILLING FOR ADDITIONAL INSPECTION/WORK (Must be accompanied by Change Order)

_____

_____

GUNDLE REPRESENTATIVE	OWNER/CONTRACTOR	INSPECTOR
(WHITE)	(YELLOW)	(PINK)

EXHIBIT 10.6

Form No. 05128
Southwest Data Corp. 713-680-3306

GUNDLE REPRESENTATIVE

CALL HOUSTON OFFICE DAILY REPORTING ITEMS MARKED IN RED — 1-800-435-2008
EXT. 760 / CONSTRUCTION EXT. 830 / SPECIAL APPLICATION

DAILY PROGRESS REPORT MASTER

PROJECT _____ LOCATION _____ JOB # _____ DATE _____

GUNDLE REP _____ OWNER / CON _____ INSPECTOR _____

DESTRUCTIVE SAMPLES

SAMPLE NO.	MAIN NO.	DATE WELDED	WELD NO.	WELDED BY	DATE TESTED	TEST NO.	CLOCK LOCATION

	NUMBER	TOTAL HOURS
SUPERVISOR		
TECHNICIAN		
TOTAL	TOTAL	
LABOR		
OPER		
OTHER		
TOTAL	TOTAL	

DAILY PRODUCTION

TYPE & SIZE MATERIAL	SF. DEPLOYED	SF. WELD	SF. QC

CUMULATIVE

TYPE & SIZE MATERIAL	SF. DEPLOYED	SF. WELD	SF. QC

PRE-WELD QUALIFICATION

MACHINE	OPERATOR	TEMP F	TEMP C	TYPE	RESULTS

PROGRESS - DELAYS - COMMENTS - ACCIDENTS ON SITE

Number of Weld Samples Shipped	Fed X #
Precip. (Rain/Snow)	Wind Velocity
Temp AM °F	Temp Noon °F Temp PM °F

FORM NO 03183 PRODUCED BY [illegible]

DEPLOYMENT

TYPE	PANEL #	ROLL #	LENGTH

WELDING

CLOCK	TECH	SEAM #	LENGTH

NON DESTRUCTIVE TESTING

TEST TYPE	BEARD	LENGTH	CLOCK	TECH	REPAIR LOCATION	DATE REPAIRED	DATE TESTED	TECH

Exhibit 10.8

request exhibits 10.0

Gundle Lining Construction Corp **WELD SAMPLE**

Gundle

Project Number _____

Mil _____ FUSION EXTRUSION
CIRCLE ONE

Seam # _____ Sample # _____

Supervisor # _____

Date _____ Tech # _____

Machine # _____ Priority _____

EXHIBIT 10.9

Gundle Lining Systems Inc

Gundle®

19103 Gundle Road
Houston, Texas 77073-3598
U.S.A.

Phone: (713) 443-8564
Toll Free: (800) 435-2008
Telex: 166657 GUNDLE HOU
FAX: (713) 875-6010

WARRANTY NO.: **SAMPLE**

EFFECTIVE DATE: **TO BE DETERMINED**

MATERIAL WARRANTY

GUNDLE LINING SYSTEMS, INC. warrants to (and only to) **OWNER** ("Company") the material GUNDLINE HD to conform at the time of sale to the specifications of GUNDLE LINING SYSTEMS, INC., to be free from defects in materials and to be able to withstand normal weathering and use from the date of installation or sale for a period of 2 years for # mil HDPE under normal uses and services for which it is designed and manufactured, in any customary weather which may be encountered and which is not customarily considered to be in the nature of an Act of God, casualty or catastrophe, such as but not limited to earthquake, flood, piercing hail or tornado. Normal use and service excludes, among other things but without limitation, the exposure of the liner to chemicals known to be harmful to the liner, mechanical abuse by machinery, equipment or people or excessive pressure or stress from any source.

Should defects or premature loss of use within the scope of the above Material Warranty occur, GUNDLE LINING SYSTEMS, INC. will, at its option, supply repair or replacement material on a pro-rata basis at the then current price in such manner as to charge Company only for that portion of the warranted 2 year life which has elapsed since the purchase of the material. To enable GUNDLE LINING SYSTEMS, INC.'S technical staff properly to determine the cause of any alleged defect and to take appropriate steps to supply repair or replacement material for timely corrective measures, any claim for alleged breach of warranty must be made by Company in writing, by certified mail, to GUNDLE LINING SYSTEMS, INC. within 30 days after the alleged defect was first noticed and within the warranty period or the defect and all warranties will be deemed to have been waived by Company. If repairs or replacements are to be effected, the lined area must be tendered to GUNDLE LINING SYSTEMS, INC. in a clean, dry, unencumbered condition. This includes but is not limited to removal of all water, dirt, sludge, residuals or liquid of any kind from the lined area.

GUNDLE LINING SYSTEMS, INC.'S liability under this Material Warranty shall in no event exceed the amount of the sale price of the material sold to the Company for the particular installation in which any defect or premature loss of use is alleged to have occurred, and under no circumstances shall GUNDLE LINING SYSTEMS, INC. have any liability for consequential damages arising from loss of production or product owing to the failure of the material or installation, and no allowance will be made for repairs, replacements or alterations made by Company unless with GUNDLE LINING SYSTEMS, INC.'S written consent. GUNDLE LINING SYSTEMS, INC. neither assumes nor authorizes any person (other than an officer of GUNDLE LINING SYSTEMS, INC.) to assume for it any other or additional liability in connection with the GUNDLINE HD liner. Any repairs, replacements or alterations made without GUNDLE LINING SYSTEMS INC.'S written consent or any attempted assumption of any such liability will void this Material Warranty.

This Material Warranty is limited to the installation and sale for commercial, industrial or municipal uses at the location described below and does not apply to consumer uses as defined by the Magnuson-Moss Warranty Act, any similar successor federal statute or any similar state consumer warranty statute. This Material Warranty extends to no person, entity or municipality other than Company.

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This Material Warranty shall not be effective unless payment in full has been made to GUNDLE LINING SYSTEMS, INC. for all material provided.

The Material Warranty is extended to Company and is non-transferable and non-assignable. No rights against GUNDLE LINING SYSTEMS, INC. shall be created by any attempted transfer or assignment, nor shall any rights against GUNDLE LINING SYSTEMS, INC. survive any attempted transfer or assignment. This Warranty does not extend to any materials furnished or installed by others in connection with the intended use of the Material.

THE LAWS OF THE STATE OF TEXAS SHALL GOVERN THE RIGHTS AND DUTIES OF THE PARTIES UNDER THIS WARRANTY. VENUE FOR ALL LEGAL PROCEEDINGS INVOLVING THIS MATERIAL WARRANTY OR ANY MATTER CONTAINED WITHIN SHALL BE IN HARRIS COUNTY, TEXAS.

THE FOREGOING MATERIAL WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES (EXCEPT OF TITLE), EXPRESS, IMPLIED, OR STATUTORY. IN NO EVENT SHALL GUNDLE LINING SYSTEMS, INC. BE LIABLE FOR LOSS OF PROFITS OR ANY OTHER INCIDENTAL OR CONSEQUENTIAL LOSSES RESULTING FROM ANY DEFECTS IN ITS MATERIAL.

PURCHASER/(COMPANY): OWNER

LOCATION OF INSTALLATION: CITY, STATE

DESCRIPTION OF INTENDED USE: PROJECT TYPE

GUNDLE LINING SYSTEMS, INC.
19103 GUNDLE ROAD
HOUSTON, TX 77073

SAMPLE

Carolyn G. Hite
Senior Contract Specialist

Date

revised 05/25/94 llc

Gundle Lining Construction Corp

Gundle®

19103 Gundle Road
Houston, Texas 77073-3598
U.S.A.

Phone: (713) 443-8564
Toll Free: (800) 435-2008
Telex: 166657 GUNDLE HOU
FAX: (713) 875-6010

WARRANTY NO.: **SAMPLE**

EFFECTIVE DATE: **TO BE DETERMINED**

WORKMANSHIP WARRANTY

GUNDLE LINING CONSTRUCTION CORP. hereby warrants to (and only to) **OWNER** ("Company") that the GUNDLINE HD linings installed by GUNDLE LINING CONSTRUCTION CORP. at the location and for the intended use described below (the "Linings") shall be installed free from defects in GUNDLE LINING CONSTRUCTION CORP.'S workmanship. The warranty set forth in the preceding sentence (the "Workmanship Warranty") shall commence on the date that GUNDLE LINING CONSTRUCTION CORP. completes the installation of the Linings, shall apply until the last day of a period of 2 years from said date, and shall be subject to the following conditions:

1. The Workmanship Warranty shall extend only to proper installation of the Linings. The Workmanship Warranty shall not apply to any alleged defect in installation that is occasioned by fire, Acts of God or acts of any person or entity other than GUNDLE LINING CONSTRUCTION CORP. or its agent, including without limitation abuse, negligence, misuse, improper treatment, vandalism or any alleged defects caused, directly or indirectly, by falling objects, abnormal environmental conditions, improper site preparation, subgrade settlement or by any event beyond the reasonable control of GUNDLE LINING CONSTRUCTION CORP.

2. The Workmanship Warranty shall not be effective unless GUNDLE LINING CONSTRUCTION CORP. receives Company's written claim therefor within 30 days after the date of discovery of such defect and within the warranty period. GUNDLE LINING CONSTRUCTION CORP. shall have the right to verify by its own representative the nature and extent of the defects complained of.

3. The extent of GUNDLE LINING CONSTRUCTION CORP.'S liability for breach of the Workmanship Warranty shall be limited to timely repairing or replacing the defective installation workmanship, utilizing such workmanship as should result in providing the pro-rated performance remaining under the original period of the Workmanship Warranty. If it is necessary for GUNDLE LINING CONSTRUCTION CORP. to repair or replace any defective workmanship with respect to the Linings, Company shall afford GUNDLE LINING CONSTRUCTION CORP. clear and unrestricted access to the Linings, which shall not be encumbered by any overlying material or liquid, and Company shall cooperate in all respects with GUNDLE LINING CONSTRUCTION CORP. to accomplish said repair. In no event will GUNDLE LINING CONSTRUCTION CORP. be liable for the cost of labor expended by any person or entity other than GUNDLE LINING CONSTRUCTION CORP. or its agent on any defective workmanship with respect to the installation of the Linings. Under no circumstances shall GUNDLE LINING CONSTRUCTION CORP. have any liability for consequential damages arising from loss of production or product owing to the failure of the material or installation, and no allowance will be made for repairs, replacement or alterations made by Company unless with GUNDLE LINING CONSTRUCTION CORP.'S written consent. GUNDLE LINING CONSTRUCTION CORP. neither assumes nor authorizes any person (other than an officer of GUNDLE LINING CONSTRUCTION CORP.) to assume for it any other or additional liability in connection with the GUNDLINE HD liner. Any repairs, replacements or alterations made without GUNDLE LINING CONSTRUCTION CORP.'S written consent or any attempted assumption of any such liability will void this Workmanship Warranty.

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4. The Workmanship Warranty is extended to Company only and is non-transferable and non-assignable. No rights against GUNDLE LINING CONSTRUCTION CORP. shall be created by any attempted transfer or assignment, nor shall any rights against GUNDLE LINING CONSTRUCTION CORP. survive any attempted transfer or assignment. This Warranty does not extend to any materials furnished or installed by others in connection with the intended use of the Linings.

5. No terms or conditions other than those stated herein and no agreement or understanding, oral or written, and no course of conduct or performance in any way purporting to modify the Workmanship Warranty or to waive GUNDLE LINING CONSTRUCTION CORP.'S rights hereunder shall be binding on GUNDLE LINING CONSTRUCTION CORP. unless the same shall be clearly described in written memorandum that expressly refers to the Workmanship Warranty and is separately signed by a duly-authorized officer of GUNDLE LINING CONSTRUCTION CORP. Moreover, additional liabilities of or limitations upon the rights and remedies of GUNDLE LINING CONSTRUCTION CORP. contained in such documents as purchase orders, order acknowledgments or change orders which may subsequently be exchanged between the parties shall have no force or effect upon the Workmanship Warranty. All proposals, negotiations and representations, if any, made prior to the date hereof or with reference hereto are merged herein.

6. This Workmanship Warranty shall not be effective unless payment in full has been made to GUNDLE LINING CONSTRUCTION CORP. for all labor, installation and other services provided.

7. THE LAWS OF THE STATE OF TEXAS SHALL GOVERN THE RIGHTS AND DUTIES OF THE PARTIES UNDER THIS WARRANTY. VENUE FOR ALL LEGAL PROCEEDINGS INVOLVING THIS WORKMANSHIP WARRANTY OR ANY MATTER CONTAINED WITHIN SHALL BE IN HARRIS COUNTY, TEXAS.

THE FOREGOING WORKMANSHIP WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES (EXCEPT OF TITLE), EXPRESS, IMPLIED, OR STATUTORY. IN NO EVENT SHALL GUNDLE LINING CONSTRUCTION CORP. BE LIABLE FOR LOSS OF PROFITS OR ANY OTHER INCIDENTAL OR CONSEQUENTIAL LOSSES RESULTING FROM ANY DEFECTS IN ITS WORKMANSHIP, INCLUDING WITHOUT LIMITATION IMPROPER INSTALLATION OF THE LININGS.

PURCHASER/(COMPANY): **OWNER**

LOCATION OF INSTALLATION: **CITY, STATE**

DESCRIPTION OF INTENDED USE: **PROJECT TYPE**

SAMPLE

GUNDLE LINING CONSTRUCTION CORP.
19103 GUNDLE ROAD
HOUSTON, TX 77073

Carolyn G. Hite
Senior Contract Specialist

Date

Exhibit

revised 05/25/94 llc

GUNDLE ENVIRONMENTAL SYSTEMS, INC.

April 20, 1994

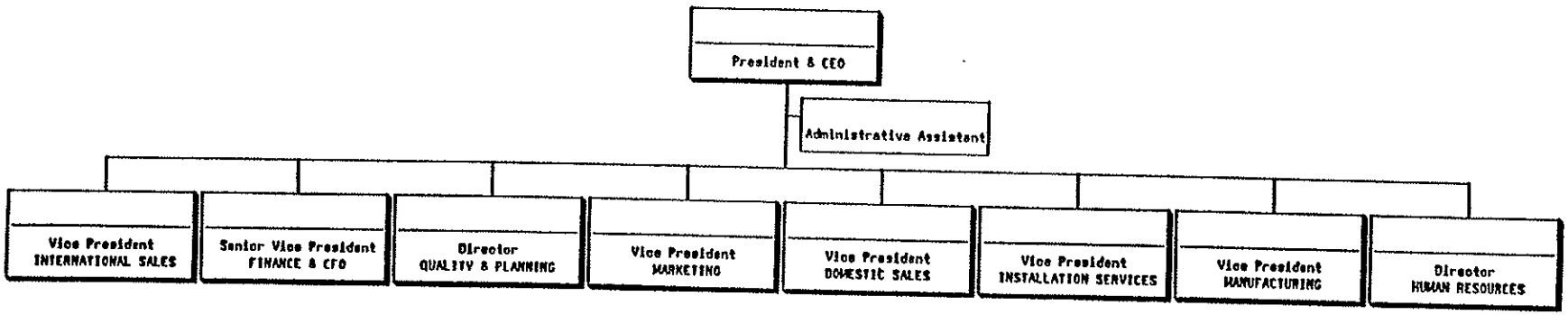
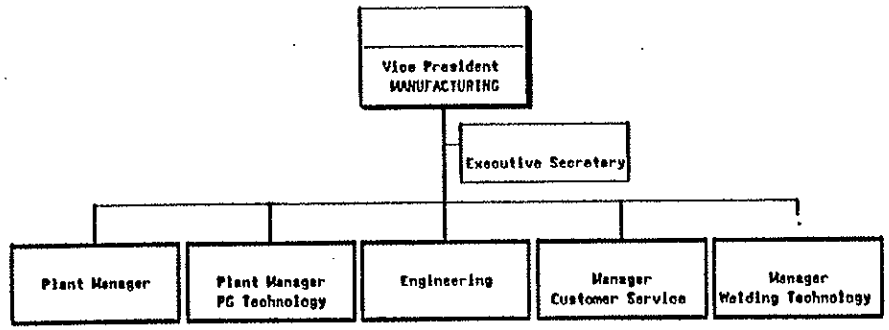


Exhibit 10.0

GUNDLE ENVIRONMENTAL SYSTEMS, INC.

April 20, 1994



GUNDLE ENVIRONMENTAL SYSTEMS, INC.

April 20, 1994

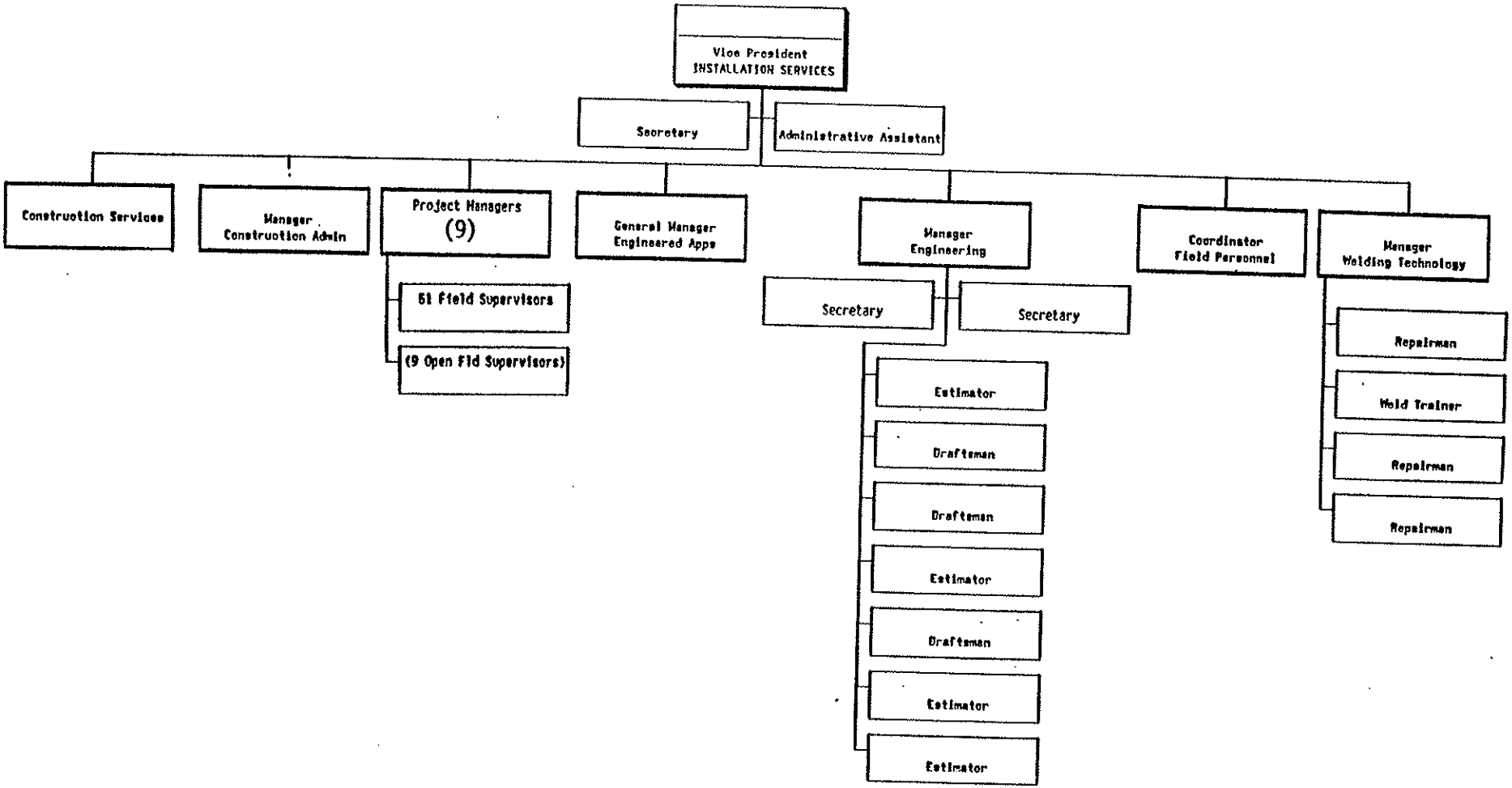


Exhibit 10.0

GEOSYNTHETICS TERMINOLOGY

ASTM	American Society for Testing & Materials
Angle of Friction	(Angle of friction between solid bodies.) (Degree) Angle whose tangent is the ratio between the maximum value of shear stress that resists slippage between two solid bodies at rest with respect to each other, and the normal stress across the contact surfaces.
Bonded Seam Strength	Strength of a seam of liner material measured either in shear or peel modes. Strength of the seams is reported either in absolute units: e.g., pounds per inch of width; or as a percent of the strength of the sheeting.
Breaking Strength	Tensile force to break measured in pounds (Newtons) on a supported or unsupported membrane.
Carbon Black	Additive for elastomeric and plastic sheeting or film for ultraviolet absorption and pigmentation. Typically 1% to 2% of the base product in the case of thermoplastics and crystalline thermoplastics, and 10% to 45% in the case of elastomers and thermoplastic elastomers; imparts a black color to the compound which retards aging by ultraviolet light from the sun and increases the stiffness of elastomeric compounds.
Crystallization, Polymer	Arrangement of previously disordered polymer segments of repeating patterns into geometric symmetry.
Density	The mass per unit volume, $(ML^{-3})kg/m^3$; g/cc.
Dimensional Change	A generic term for changes in length or width of a geosynthetic specimen subjected to a specified condition.
Direct Shear Test	A shear test in which soil or rock under an applied normal load is stressed to failure by moving one section of the sample or sample container (shear box) relative to the other section.
Dispersion	1.) A distribution of finely divided particles in a medium; for example a colloidal suspension of a substance. 2.) A qualitative estimation of the separation and uniform distribution of fibers, typically in a water suspension for wet forming.
Elongation at Break	The extension of a uniform section of a specimen at rupture expressed as percent of the original length.
Elongation, Percent	For geosynthetics, the increase in a length of a specimen expressed as a percentage of the original gage length, i.e., engineering strain.
Elongation at Yield	The extension of a uniform section of specimen at yield expressed as percent of the original length.

Environmental Stress Crack	The development of cracks in a material that is subjected to stress or strain in the presence of specific chemicals.
Extrusion Welded Seams	A bond between the two flexible membrane sheets achieved by extruding the hot parent material between or over the overlapped materials (followed by applied pressure if between the sheets).
Film Tear Bond (FTB)	Failure of one of the parts of a peel or ply adhesion test specimen by tearing, instead of separating from the other part of the specimen at the manufactured or formed interface.
FTMS	Federal Test Method Standard
Geosynthetic Clay Liners (GCLs)	Uniform factory produced blankets of bentonite clay used to replace or supplement traditional compacted clay liners.
High Density Polyethylene (HDPE)	A polymer prepared by low-pressure polymerization of ethylene as the principal monomer.
ISO	International Standards Organization
ISO-9000	An international standard emphasizing conformance to well defined and documented quality management systems.
Melting Point	The temperature at which the solid and liquid states of a substance are in equilibrium; generally, the temperature at which a substance changes from a solid to a liquid.
Modulus of Elasticity	The ratio of stress to strain for a material under given loading conditions; numerically equal to the slope of the tangent or the secant of a stress-strain curve. The use of the term Modulus of Elasticity is recommended for materials that deform in accordance with Hooke's law; the term Modulus of Deformation for materials that deform otherwise.
Moisture Content	The percentage by weight of water contained in the pore space of a rock or soil with respect to the weight of the solid material.
Nets	Polymer strands, typically 1 to 5 mm (3/64 to 3/16 in.) in diameter, obtained by extrusion, are used to make nets. They consist of two sets of coarse parallel extruded strands intersecting with a constant angle (generally between 60° to 90°).
NSF	National Sanitation Foundation.
Puncture Resistance	Extent to which a material is able to withstand the action of a sharp object without perforation. Examples of tests for the property are Federal Test Method Standard No. 101, Methods 2031 or 2065.

Seam Peel Strength	A representative specimen is taken across the seam and placed in a tensile testing machine (tensiometer). For the peel test, one end and the closest end of the adjacent piece are gripped, placing the seamed portion between them in a tensile mode. The resistance to peel is measured.
Seam Shear Strength	A representative specimen is taken across the seam and placed in a tensile testing machine. For the shear test, the two separate pieces of geomembrane are pulled apart, placing the joined or seamed portion in shear. The resistance to shear is measured.
Tear Strength	The maximum force required to tear a specified specimen, acting substantially parallel to the major axis of the test specimen. Values are reported in stress, e.g., pounds, or stress per unit of thickness, e.g., pounds per inch.
Tensile Strength	The maximum tensile stress per unit of original cross sectional area applied during stretching of a specimen to break; units: SI kilopascal, newton per square meter, pound per square inch.
Thermal Stability	The ability of materials to resist degradation at extreme temperatures.
Thickness	The normal distance between two surfaces of a geosynthetic. Note: Thickness is usually determined as the distance between an anvil, or base, and a presser foot used to apply a specified compressive stress.
Transmissivity	For geonets and geotextiles, the volumetric flow rate per unit thickness under laminar flow conditions, in the planar direction of the fabric.
Water Absorption	The increase in weight of a test specimen after immersion in water under specified conditions of time and temperature, expressed as a percentage of its dry weight.
Water Vapor Transmission	Water vapor flow normal to two parallel surfaces of a material, through a unit area, under the conditions of a specified test such as ASTM E 96.

11200-
1-11

OPERATION AND MAINTENANCE MANUAL

PELHAM BAY LANDFILL

FLYGT SUBMERSIBLE EXPLOSION PROOF PUMPS

CONTRACTOR
BARBELLA ENVIRONMENTAL TECH.
P.O. BOX 273
SALEM INDUSTRIAL PARK BUILDING #8
WHITEHOUSE, N.J. 08888

VENDOR
G.A. FLEET ASSOCIATES, INC.
55 CALVERT STREET
BOX 616
HARRISON, N.Y. 10528

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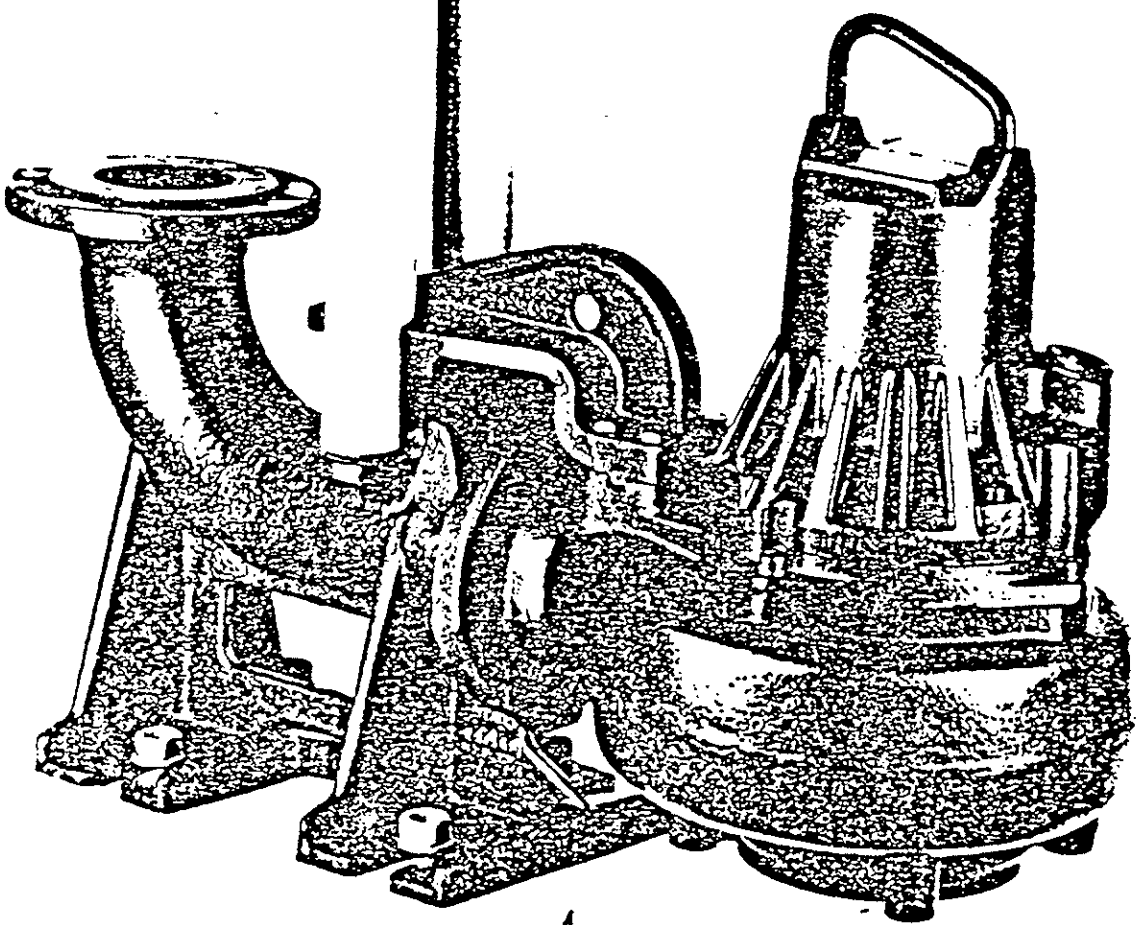
3085.091

FLYGT

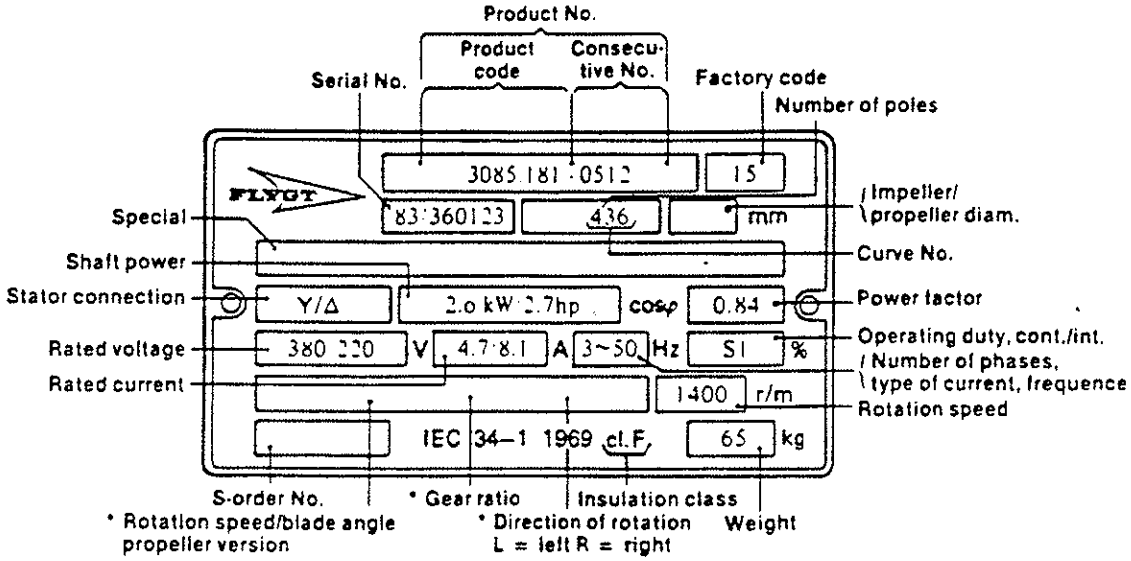
INSTALLATION, CARE AND MAINTENANCE

EXPLOSION PROOF PUMP

EEx d IIB T4
FM Class I Div I Grp. C and D
Class II Div I Grp. E, F and G



DATA PLATES INTERPRETATION



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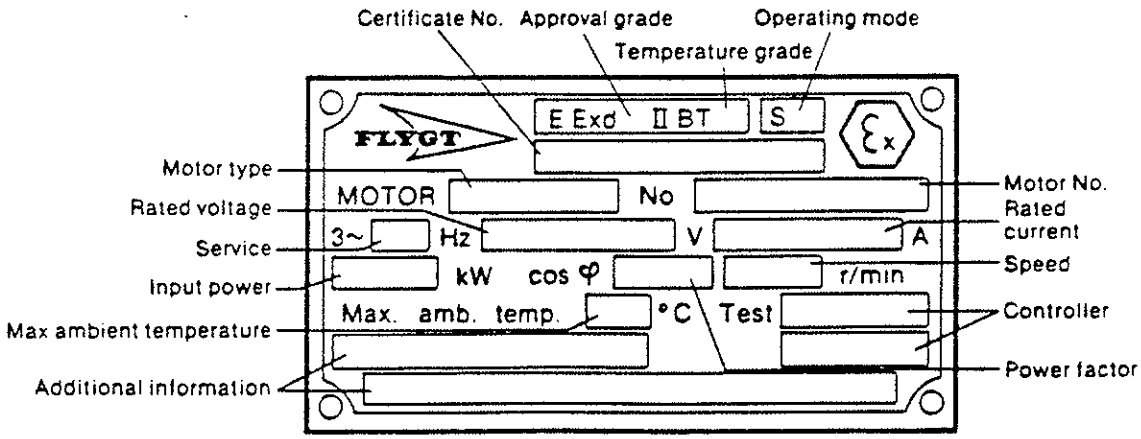


Flygt undertakes to remedy faults in products sold by Flygt provided:

— that the fault is due to defects in design, materials or workmanship;

— that the fault is reported to Flygt or Flygt's representative during the guarantee period;

— that the product is used only under conditions described in the care and maintenance instructions and in applications for which it is intended;

— that the monitoring equipment incorporated in the product is correctly connected:

— that all service and repair work is done by a workshop authorized by Flygt;

— that genuine Flygt parts are used.

Hence, the guarantee does not cover faults caused by deficient maintenance, improper installation, incorrectly executed repair work or normal wear and tear.

Flygt assumes no liability for either bodily injuries, material damages or economic losses beyond what is stated above.

Official approval applies only providing:

— that the product is used under conditions described in the care and maintenance instructions and in applications for which it is intended;

— that the monitoring equipment incorporated in the product is correctly connected;

— that all service and repair work is done by a workshop authorized by Flygt;

— that genuine Flygt parts are used.

Flygt guarantees that a spare parts stock will be kept for 15 years after the manufacture of this product has been discontinued.

The manufacturer reserves the right to alter performance, specification or design without notice.

PRODUCT DESCRIPTION

These care and maintenance instructions apply to an explosion, submersible Flygt pump.

Applications

3085.091 is intended to be used for:

pumping of waste water

pumping of sludge

pumping of ground water

pumping of light liquid manure and urine

The pump is designed for use in explosive environments in accordance with the following approval:

EN European Norm

FM Factory Mutual

The pump is available in the following versions:

Pump type	Impeller types available		
CP	LT	MT	HT
CS	LT	MT	HT
DP	—	MT	HT
FP	LT	—	—
FS	LT	—	—
GF	—	MT	—
LL	LT	—	—
CF	—	MT	—
DF	—	MT	—

CP = for permanent installation in a sump. The pump slides down along guide bars and connects automatically to a discharge connection.

CS = portable, with hose connection, base stand and strainer.

CF = pedestal version for free standing installation in a pump sump.

DP has the same mode of installation as CP, but is equipped with a vortex impeller.

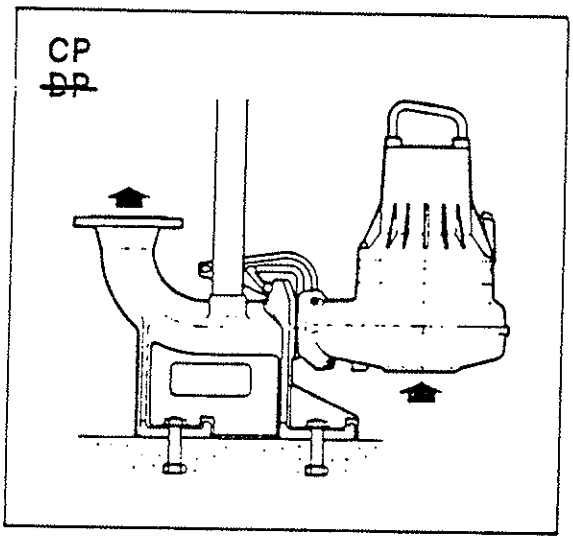
DF has the same mode of installation as CF, but is equipped with a vortex impeller.

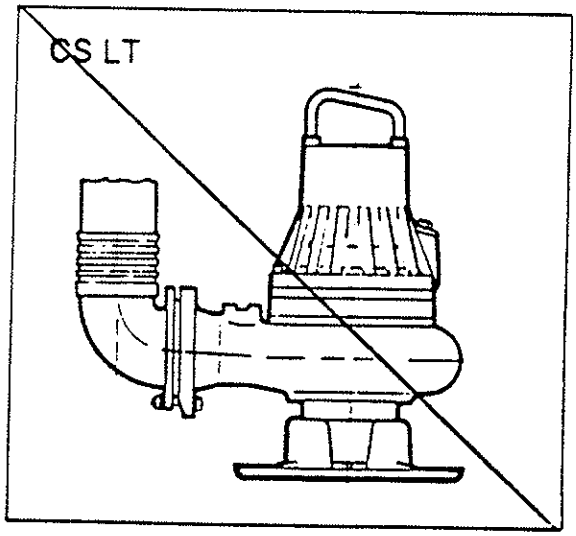
F = one of the Flygt series of submersible manure pumps. The pump housing and impeller are specially designed for pumping liquid manure and urine of low litter content.

GF is intended for pure ground water pumping from e.g. basements, garages and laundry rooms. The pump is installed free-standing in a sump.

LL = one of the Flygt series of submersible lift pumps intended for land drainage systems. The pump system can be used for draining temporarily waterlogged land, or land which is low-lying in relation to the surrounding area.

LT = Low-head version
MT = Medium-head version
HT = High-head version





Liquid temperature: max. 40°C (103°F)

Liquid density: max. 1100 kg/m³ (9.2 lb per US gal.)

The pumped liquid may contain particles up to a size which corresponds to the throughlet of the pump.

The pH of the pumped liquid: 6—11.

Lowest liquid level: The pump can work continuously under full load conditions provided that the liquid level covers the middle of the stator housing.

Depth of immersion: max. 20 m (66 ft).

Pumps with a vortex impeller may not be operated at a too low discharge head, since this causes overloading of the motor.

For other applications, contact your nearest Flygt representative for information.

Design

3085.091 is a submersible, electric motor-driven pump.

Impellers

The pump is available with the following types of impellers:

single-vane impeller of cast iron.

two-vane impeller of cast iron.

vortex impeller of cast iron.

impeller of cast iron with cutting edges, e.g. for liquid manure.

Shaft seals

The pump has two mechanical seals.

Materials:
Inner seal: ceramic — carbon.

Outer seal: tungsten carbide — tungsten carbide or

ceramic — ceramic.

Shaft

The shaft is delivered with the rotor as an integral part.

The shaft is completely sealed and will not come into contact with the pumped liquid.

Shaft material: stainless steel.

Bearings

The pump bearings are designed for at least 10 000 hours of operation.

The lower bearing consists of a double-row angular contact ball bearing.

The upper bearing consists of a single-row deep-groove ball bearing.

Oil casing

The oil lubricates and cools the seals and acts as a buffer between the pump casing and the electric motor.

Pressure build-up within the oil casing is reduced by means of a built-in air volume.

Motor

Squirrel-cage 1-phase or 3-phase induction motor for 50 Hz or 60 Hz.

The motor is started by means of

direct on-line start.

The motor can be run:

continuously or intermittently with a maximum of 15 evenly spaced starts per hour.

The stator is insulated in accordance with class F (155°C, 310°F). The motor is designed to supply its rated output at ±5 % variation of the rated voltage. Without overheating the motor, ±10 % variation of the rated voltage can be accepted provided that the motor does not run continuously at full load. The motor is designed to operate with a voltage imbalance of up to 2 % between the phases.

Monitoring equipment

The stator incorporates two thermal switches connected in series.

The thermal switches:
open at 125°C (260°F).

See also "Electrical connections" and separate instructions for starter equipment.

Cooling

The pump is cooled by the surrounding liquid.

Technical data

The table shows available pump-motor combinations.

50 Hz, 3-phase

Stator	Rated output kW	Speed rev/min	Current (A)		
			220 V	380 V	550 V
408 40 xx	2.0	1400	8.1	4.7	3.2
408 41 xx	1.3	1400	5.9	3.4	2.4
408 42 xx	2.4	2850	8.5	4.9	3.4
427 11 xx	0.9	935	5.4	3.1	2.1

60 Hz, 3-phase

Stator	Rated output kW (hp)	Speed rev/min	Current (A)		
			230 V	440 V	575 V
408 40 xx	2.4 (3.2)	1700	9.0	4.7	3.6
408 41 xx	1.6 (2.2)	1700	6.4	3.4	2.6
408 42 xx	3.0 (4.0)	3450	10.0	5.2	4.0
434 84 xx	0.9 (1.2)	3400	3.6	1.9	1.4

60 Hz, 1-phase

Stator	Rated output kW (hp)	Speed rev/min	Current (A)		
			230 V	440 V	575 V
408 40 12	1.8 (2.4)	1700	10.0	—	—
408 41 12	1.2 (1.6)	1700	7.1	—	—
408 42 12	2.2 (2.9)	3440	12.0	—	—

Stator 408 40 xx 408 41 xx 408 42 xx 427 11 xx 434 84 xx	Configuration	Voltage (V)	
		50 Hz	60 Hz
xxx xx 12	Y_{ser}	—	440—460
	Y_{par}	—	220—230
27	Y	190—200	200—220
29	Y	—	380
		—	220—230
30		—	380
32	Y	346—350	400
		200—208	230—240
34	Y	380	440—460
		220	260
37	Y	—	440—460
		—	220—230
38	Y	660	—
		380	440—460
40		400	400
43	Y	400—440	480
51	Y	500—550	575

For further information, see "Parts list".

Dimensions and weights

All dimensions are in mm (in).

Weight in kg (lb) without motor cable and discharge connection:

	CP/~~DP~~	CS/CF DF
LT	73 (161)	78 (172)
MT (1.3 kW 50 Hz, 1.6 kW 60 Hz)	62 (136)	68 (150)
MT (2.0 kW 50 Hz, 2.4 kW 60 Hz)	65 (143)	71 (156)
HT	62 (136)	68 (150)

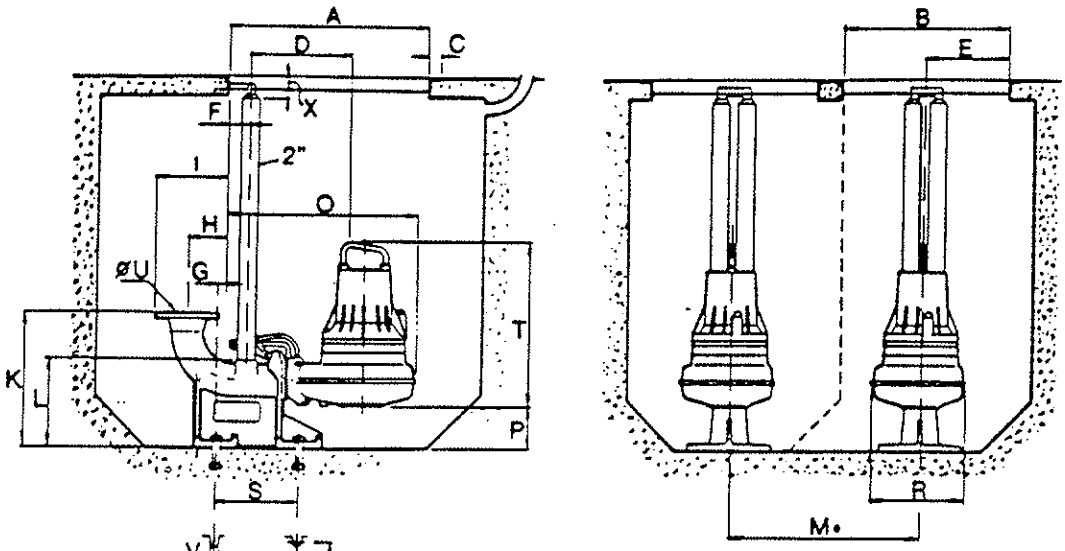
The following abbreviations are used:

LT = low-head version
MT = medium-head version
HT = high-head version
D = vortex impeller

For other abbreviations see "Installation alternatives".

For assistance in sizing sumps, pumping stations and acess frames with covers, consult your nearest Flygt representative.

CP, ~~DP, FP~~

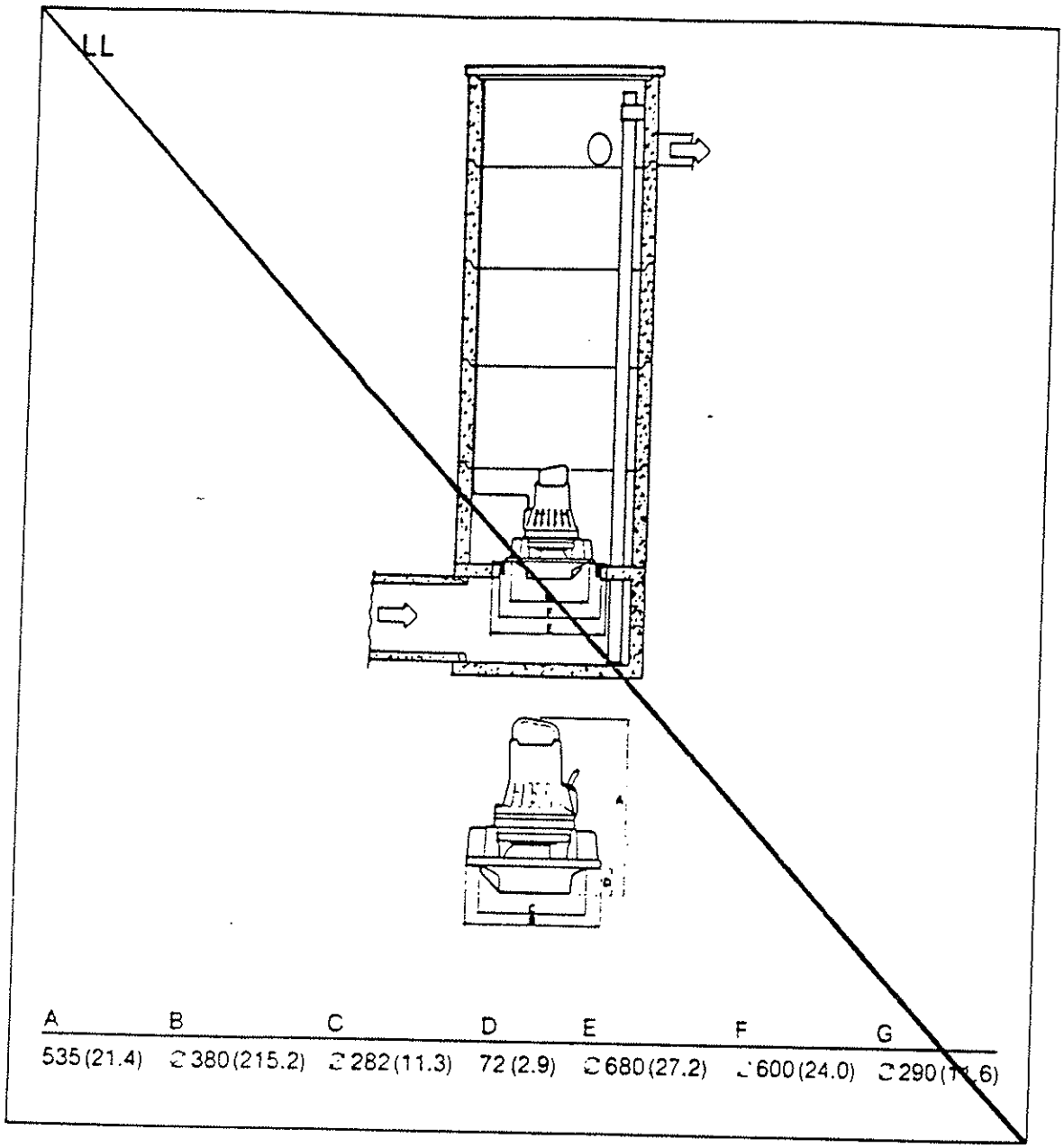


Type	A	B	C	D	E	F	G
LT Curve No. 412, 414	780 (30.7)	570 (22.4)	50 (2.0)	368 (14.5)	262 (10.3)	85 (3.3)	69 (2.7)
LT Curve No. 420, 422	780 (30.7)	570 (22.4)	50 (2.0)	373 (14.7)	262 (10.3)	85 (3.3)	69 (2.7)
CP/DP, MT	780 (30.7)	570 (22.4)	50 (2.0)	317 (12.5)	262 (10.3)	85 (3.3)	59 (2.3)
CP, HT	780 (30.7)	570 (22.4)	50 (2.0)	317 (12.5)	262 (10.3)	85 (3.3)	59 (2.3)
DP, HT	780 (30.7)	570 (22.4)	50 (2.0)	317 (12.5)	262 (10.3)	85 (3.3)	59 (2.3)

Type	H	I	K	L	M*	N	O
LT Curve No. 412, 414	164 (6.5)	274 (10.8)	400 (15.7)	258 (10.2)	670 (26.4)	200 (7.9)	646 (25.4)
LT Curve No. 420, 422	164 (6.5)	274 (10.8)	400 (15.7)	258 (10.2)	670 (26.4)	200 (7.9)	675 (26.6)
CP/DP, MT	154 (6.1)	254 (10.0)	400 (15.7)	258 (10.2)	670 (26.4)	200 (7.9)	593 (23.3)
CP, HT	154 (6.1)	254 (10.0)	400 (15.7)	258 (10.2)	670 (26.4)	200 (7.9)	576 (22.7)
DP, HT	154 (6.1)	254 (10.0)	400 (15.7)	258 (10.2)	670 (26.4)	200 (7.9)	576 (22.7)

Type	P	R	S	T	U	V	X
LT Curve No. 412, 414	68 (2.7)	317 (12.5)	250 (9.8)	533 (21.0)	DN 100 (4.0)	23 (0.9)	70 (2.8)
LT Curve No. 420, 422	95 (3.7)	365 (14.4)	250 (9.8)	520 (20.5)	DN 100 (4.0)	23 (0.9)	70 (2.8)
CP/DP, MT	119 (4.7)	316 (12.4)	250 (9.8)	504 (19.8)	DN 80 (3.2)	23 (0.9)	70 (2.8)
CP, HT	140 (5.5)	282 (11.1)	250 (9.8)	464 (18.3)	DN 80 (3.2)	23 (0.9)	70 (2.8)
DP, HT	135 (5.3)	282 (11.1)	250 (9.8)	486 (19.1)	DN 80 (3.2)	23 (0.9)	70 (2.8)

* Minimum



TRANSPORTATION AND STORAGE

The pump may be transported and stored in a vertical or horizontal position. Make sure that it cannot roll or fall over.

Always lift the pump by its carrying handle, never by the motor cable or the hose.

The pump is frostproof as long as it is operating or is immersed in the liquid. If the pump is taken up when the temperature is below freezing, the impeller may freeze. The pump shall be operated for a short period after being taken up in order to expel all remaining water.

A frozen impeller can be thawed by allowing the pump to stand immersed in the liquid for a short period before it is started. Never use an open flame to thaw the pump.

For longer periods of storage, the pump must be protected against moisture and heat. The impeller should be rotated by hand occasionally (for example every other month) to prevent the seals from sticking together. If the pump is stored for more than 6 months, this rotation is mandatory.

After a long period of storage, the pump should be inspected before it is put into operation. Pay special attention to the seals and the cable entry.

Follow the instructions under the heading "Before starting".

INSTALLATION

Safety precautions

In order to minimize the risk of accidents in connection with the service and installation work, the following rules should be followed:

1. Never work alone. Use a lifting harness (part No. 84 33 02), safety line (part No. 84 33 03) and a respirator (part No. 84 33 01), as required. Do not ignore the risk of drowning!
2. Make sure that there is sufficient oxygen and that there are no poisonous gases present.
3. Check the explosion risk before welding or using electric hand tools.
4. Do not ignore health hazards. Observe strict cleanliness.
5. Bear in mind the risk of electrical accidents.
6. Make sure that the lifting equipment is in good condition.
7. Provide a suitable barrier around the work area, for example a guard rail.
8. Make sure you have a clear path of retreat!
9. Use safety helmet, safety goggles and protective shoes.
10. All personnel who work with sewage systems shall be vaccinated against diseases that can occur.
11. A first-aid kit must be handy.

Follow all other health and safety rules and local codes and ordinances.

Handling equipment

Lifting equipment is required for handling the pump.

The lifting equipment shall be able to hoist the pump straight up and down in the sump, preferably without necessitating resetting the lifting hook.

The minimum height between the lifting hook and the access frame/cover/floor shall be:

0.6 m (2.0 ft) in order to lift the pump out of the sump.

Oversize lifting equipment could cause damage if pump gets stuck when being lifted.

Make sure that the lifting equipment is securely anchored.

WARNING! Keep out from under suspended loads.

Installation alternatives

CP version

In the CP version, the pump is installed on a stationary discharge connection and operates completely or partially submerged in the pumped liquid.

In addition to the pump, the following items are required:

Guide bars or guide wire

Guide bracket for attaching the guide equipment to the access frame or to the upper part of the sump.

Level sensors or other control equipment for start, stop and alarm.

Cable holder for holding the cable and regulating the height of the level sensors.

Access frame (with covers) to which the upper guide bar bracket and cable holder can be attached.

Discharge connection for connecting the pump to the discharge line. The discharge connection has a flange which fits the flange of the pump casing, and a bracket for attaching the guide equipment.

Bushings for vibration damping between the guide bars and the discharge connection.

CP installation

All dimensions are in mm (in).

Provide a barrier around the pump pit, for example a guard rail.

Arrange for a cable between the sump and the electric control box. Make sure that the cables are not sharply bent or pinched.

NOTE! The end of the cable must not be submerged. Leads have to be above flood level, as water may penetrate through the cable into the junction box or the motor.

Place the access frame in position.

Align the frame so that it is horizontal and then grout it in place.

Grout the anchor bolts in place. Be careful when aligning and positioning the discharge connection in relation to the access frame.

See dimensional drawing.

Place the discharge connection in position and tighten it.

Secure the guide equipment in the brackets.

Check that the guide equipment is placed vertically by using a level or a plumb line.

Connect the discharge pipe to the discharge connection.

Bolt the cable holder to the access frame. Thread the level regulator cables through the holes in the cable holder and adjust the height of the sensors.

It is recommended that the level regulators be used with low voltage. The data sheet delivered with the regulators gives the permissible voltage. Local rules may specify otherwise.

Protect bolts and nuts with corrosion-preventive compound.

Lower the pump along the guide rail or wire.

On reaching its bottom position, the pump will automatically connect to the discharge connection.

Fasten the lifting chain on the access frame and the cables on the cable holder. Make sure that the cables cannot be sucked into the inlet of the pump. Support straps are required for deep installations.

Run the cables up to the electric control box.

Clean out debris from the sump before starting up the station.

The pump can be hoisted up along the guide equipment for inspection without any connections having to be undone.

CS version

In the CS version, the pump is transportable and intended to operate completely or partially submerged in the pumped liquid.

The pump is equipped with a connection for hose or pipe, see "Parts list".

The MT- and HT-pump stands on a strainer with a support plate.

The LT-pump stands on a base stand.

CS installation

Run the cables so that they have no sharp bends, are not pinched and cannot be sucked into the pump inlet. Connect the discharge line and the motor cable. See "Electrical connections".

Lower the pump into the sump.

Place the pump on a base which prevents it from sinking into a soft sump bottom.

Alternatively, the pump can be suspended from above by its handle just above the bottom of the sump.

LL version

In the LL version, the pump is installed in a stationary discharge arrangement.

The pump operates completely under water and requires no extra connections.

In addition to the pump, the following items are required:

Discharge pipe with bottom plate in which the pump is installed.

Cable holder for holding the cable and regulating the height of the level sensors.

Cleaning screen at intake.

Level sensors or other control equipment for start, stop or alarm.

LL installation

The pump is lowered into position in the finished station.

No additional anchoring of the pump is required.

Fasten the motor cables on the cable holder and run them to the electric control box.

NOTE! The end of the cable must not be submerged. Leads have to be above flood level, as water may penetrate through the cable into the junction box or the motor.

The pump can easily be hoisted for inspection without any connections having to be undone.

CF version

In the CF version, the pump stands on the bottom of the sump and is held in place by the discharge pipe. It operates completely or partially submerged in the liquid.

CF installation

Run the cables so that they do not have any sharp bends and are not pinched.

NOTE! The end of the cable must not be submerged. Leads have to be above flood level, as water may penetrate through the cable into the junction box or the motor.

Clean out debris from the sump.

Protect bolts and nuts with corrosion-preventive compound.

Connect the discharge line and motor cable. See "Electrical connections".

Lower the pump into the sump.

With regard to cable entries, installation of access frame and adjustment of level sensors, see "CP installation".

GF version

The GF version is intended for pumping ground water.

GF installation

Clean out the sump.

Connect the discharge pipe and motor cable. See "Electrical connections".

NOTE! The end of the cable must not be submerged. Leads have to be above flood level, as water may penetrate through the cable into the junction box or the motor.

Lower the pump into the sump.

The pump is transportable and can be moved between different work sites. It is intended for operation completely or partially submerged in the pumped liquid.

The pump has a connection for a hose or pipe. See "Accessories and tools".

The pump stands on a strainer.

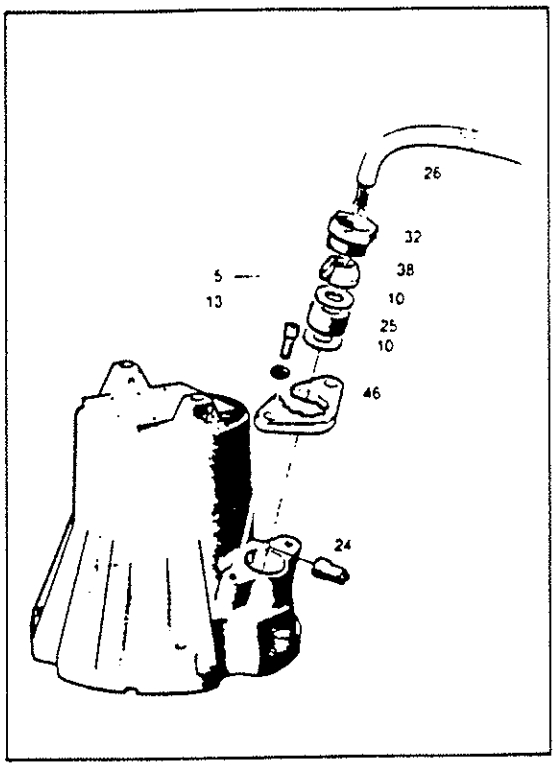
3085.091 in F installation

The same installation with discharge connection as described under CP installation can be used for the liquid manure version.

Poisonous or explosive gases may pose a risk in connection with the installation of pumps in liquid manure wells or tanks which have been in use for some time. Extra caution must therefore be exercised and the following rules should be followed.

1. **Never work alone.** There should always be one person on the surface to provide assistance and, if necessary, lift up the person working down in the tank.
2. The person working down in the tank shall always wear a **lifting harness** (84 33 02) and a **safety line** (84 33 03). The safety line should be arranged so that the person down in the tank can be lifted out quickly in an emergency.
3. **Air out the well or tank before starting work.** If there is a risk or a possibility that poisonous gases may form use an **air-fed mask** (84 33 01). The most common poisonous gas is **hydrogen sulphide (H_2S)**, which has a threshold limit value of 10 ppm. Concentrations of more than 100 ppm cause loss of consciousness and respirator paralysis.
4. Before the installation work is begun, the tank shall be emptied and rinsed out in order to minimize the amount of liquid manure which can emit poisonous gases. Adding lime tot the remaining manure (5—10 % lime will prevent further generation of hydrogen sulphide and kill any salmonella bacteria. The lime-mixed manure and any lime water used to clean pumps and boots can be mixed in with the rest of the manure, but this will reduce the nitrogen content of the manure somewhat.
5. **Methane gas (CH_4)** may be present in sufficient quantity in manure handling facilities to create the **risk of explosion.** The lower explosion limit is 5 % by volume methane in an air-methane mixture. Check the explosion risk before welding or using electric hand tools.
6. **When the manure in the tank is mixed,** large quantities of hydrogen sulphide are released, so **it is advisable to keep away from the downwind side of the tank.**

7. Pumps which are moved from one farm to another shall be hosed down and bathed in lime water. Let the pump soak for several hours in the lime water solution before lifting it out and hosing it out. Use 4—5 kg (0.25—0.3 lb/ft³) crushed burnt lime per m³ water. The water can dissolve 2 kg lime per m³ (0.13 lb/ft³). The excess lime keeps the pH value up even if some of the lime is bound to other substances.



Electrical connections

All electrical work shall be carried out under the supervision of an authorized electrician.

Local codes and regulations shall be complied with.

> **NOTE for Ex version**
>
> **All work on the explosion-proof motor section must be performed by authorized Flygt personnel or personnel authorized by Flygt.**

Check that the mains voltage and frequence agree with the specifications on the pump data plate.

The motor can be connected for different voltages as shown on the data plate.

If intermittent operation is prescribed (see data plate), the pump shall be provided with a control equipment that provides such operation.

Under no circumstances may the starter equipment be installed in the pump pit.

Install the motor cable as illustrated in the figure.

To avoid leakage into the pump, check:

- that the cable entry seal sleeve and washers conform to the outside diameter of the cable. See the parts list.
- that the outer jacket on the cable is not damaged. When refitting a cable which has been used before, **always** cut off a short piece of the cable so that the cable entry seal sleeve does not close around the cable at the same point again.

NOTE! For safety reasons, the earth lead should be approx. 50 mm (2.0") longer than the phase leads. If the motor cable is jerked loose by mistake, the earth lead should be the last lead to come loose from its terminal. This applies to both ends of the cable.

Check on the data plate which connection, Y or △, is valid for the voltage supply. Then, depending on voltage, arrange the connections in accordance with Y or △.

Two thermal switches are incorporated in the stator. The thermal switches are normally closed. The thermal switches can be connected to max. 250 V, breaking current max. 6 A at power factor 0.6. Flygt recommends the thermal switches to be connected to 24 V over separate fuses to protect the other automatic equipment.

Make sure that the pump is correctly earthed (grounded).

Tighten the gland nut (32) so that the cable entry unit bottoms out.

Check the direction of rotation, see "Before starting".

If the direction of rotation is wrong, transpose two of the phase leads.

For 1-phase pumps going in wrong direction, please contact your nearest Flygt representative.

Remember that the starting surge with direct-on line start can be up to six times higher than the rated current. Make sure that the fuses or circuit breakers are of the proper amperage.

Fuse amperage and cable shall be selected in accordance with local rules and regulations. Note that with long cables, the voltage drop in the cable must be taken into consideration.

The overload protection (motor protection breaker) shall be set to the motor's rated current, as given on the data plate.

Wall stuffing box

A gastight cable entry unit in the form of a wall stuffing box shall be cast into the shaft wall or shaft roof when:

- the motor and control cables are run directly from the pump pit (without ground contact) to a space outside of the explosion risk area.
- non-gastight cast-in ground cables are run through a protective pipe underground to an electric control box.

Cable splices

If the motor and control cables are to be lengthened, they shall be spliced with the type of cast resin or shrinking sleeves permitted for explosive areas and with explosive-proof connecting boxes. (Follow the manufacturer's instructions for this equipment.)

Stator

The stator leads are colour-marked as follows:

U1 (S1)	— red
V1 (S2)	— brown
W1 (S3)	— yellow
U2 (S4)	— green
V2 (S5)	— blue
W2 (S6)	— black
U5 (S7)	— red
V5 (S8)	— brown
W5 (S9)	— yellow
U6 (S10)	— green
V6 (S11)	— blue
W6 (S12)	— black

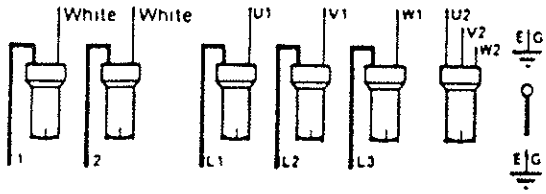
Thermal switch
= White

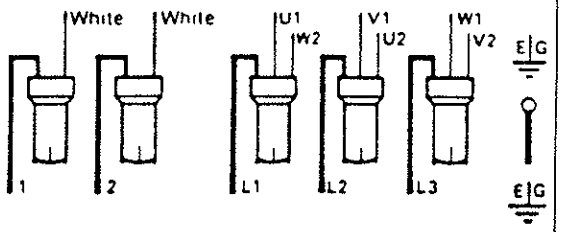
Motor cable

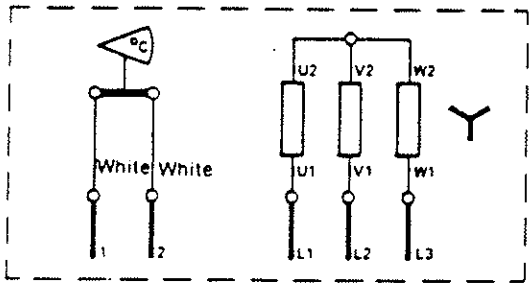
	(USA)
Brown = L1	(red)
Black = L2	(black)
Blue = L3	(white)
Yellow/ = Green	(green

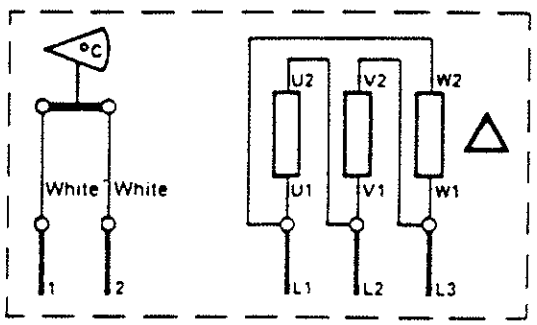
The stator leads are connected to the motor cable as follows:

6 stator leads



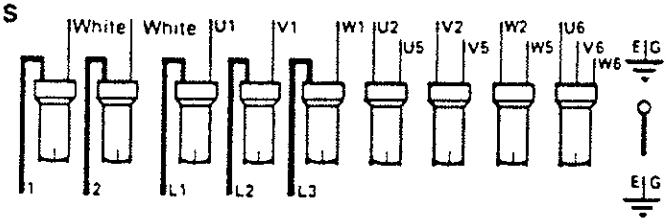


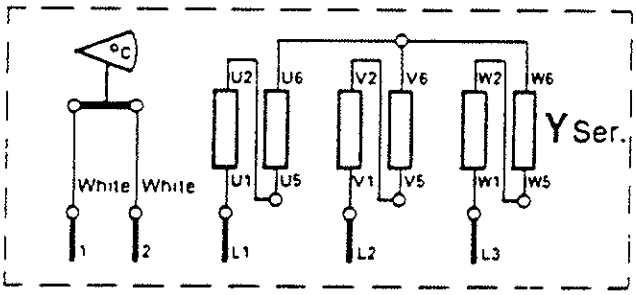




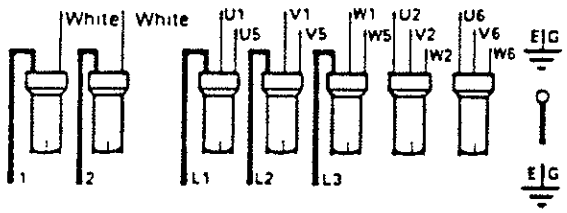
12 stator leads

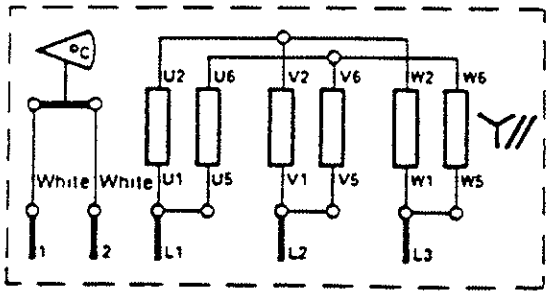
Y Ser.
50 Hz 400 V
60 Hz 460 V



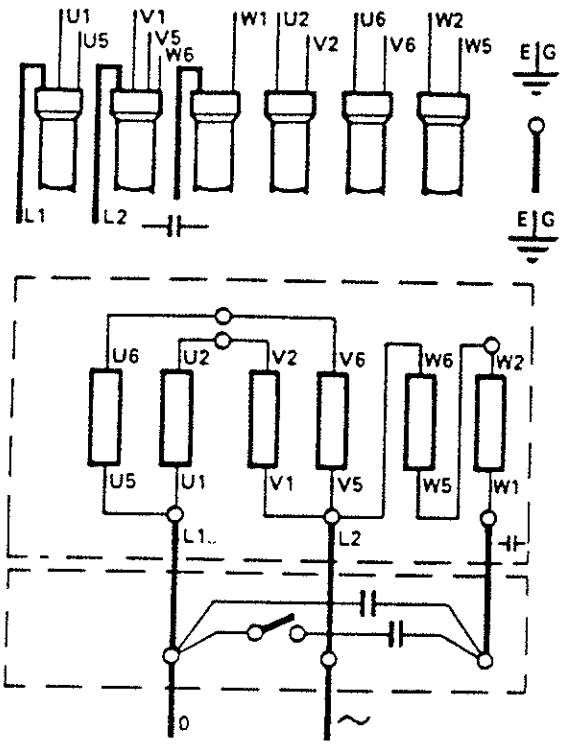


Y //
50 Hz 200 V
60 Hz 230 V

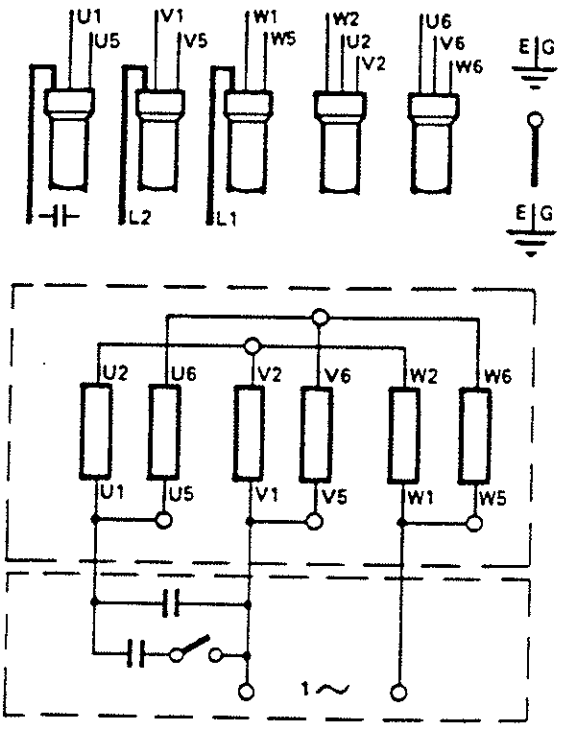




Single-phase



Single-phase, USA only



Leads not in use must be isolated.

Before starting

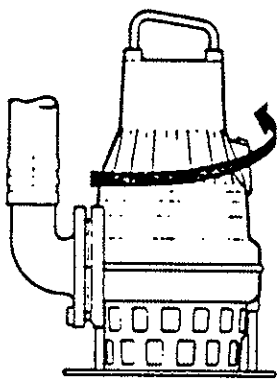
Check the oil level in the oil casing.

Remove the fuses or open the circuit breaker and check that the impeller can be rotated by hand.

Check that the monitoring equipment (if any) works.

Check the direction of rotation. See the figure. The impeller shall rotate clockwise, as viewed from above. When started, the pump will jerk in the opposite direction to the direction in which the impeller rotates.

Starting jerk



CARE AND MAINTENANCE

The figures in parentheses are item numbers and refer to the cutaway figure.

Safety precautions

Before starting work on the pump, make sure that the pump is isolated from the power supply and cannot be energized.

NOTE! This applies to the control circuit as well.

The following points are important in connection with work on the pump:

- make sure that the pump has been thoroughly cleaned.
- observe good personal hygiene.
- beware the risk of infection.
- follow local safety regulations.

The pump is designed for use in liquids which can be hazardous to health. In order to prevent injury to the eyes and skin, observe the following points when working on the pump:

- Always wear goggles and rubber gloves.
- Rinse the pump thoroughly with clean water before starting work.
- Rinse the components in water after disassembly.
- Hold a rag over the oil casing screw (20) when removing it. Otherwise, pressure that may have built up in the pump due to leakage of liquid into the pump may cause splatter into the eyes or onto skin.

Proceed as follows if you get hazardous chemicals

in your eyes:

- rinse immediately in running water for 15 minutes. Hold your eyelids apart with your fingers.
- contact an eye doctor.

on your skin:

- remove contaminated clothes.
- wash skin with soap and water.
- seek medical attention if required.

NOTE for Ex version

All work on the explosion-proof motor section must be performed by authorized Flygt personnel or personnel authorized by Flygt.

Flygt renounces all responsibility for work done by untrained, unauthorized personnel.

Inspection

Regular inspection and preventive maintenance ensure more reliable operation.

The pump should be inspected after 2000 hours of operation or at least once a year, more frequently under severe operating conditions.

Under normal operating conditions, the pump should have a major overhaul in a service shop after 6000 hours of operation or at least every third year for CP, every year for CS.

This requires special tools and should be done by an authorized service shop.

When the pump is new or when the seals have been replaced, inspection is recommended after one week of operation.

Service contract

Flygt or its agent offers service agreements in accordance with a preventive maintenance plan. For further information, please contact your Flygt representative.

Recommended inspections

Inspection of	Action
Visible parts on pump and installation	Replace or fix worn and damaged parts.
	Make sure that all screws, bolts and nuts are tight.
	Check the condition of carrying handle/lifting eyes, chains and wire ropes.
	Check that the guide bars are vertical.
Pump casing and impeller	Replace worn parts if they impair function.
	If the clearance between the impeller skirt and the pump casing exceeds 2 mm (0.08 in), see "Replacing the wear ring".
	Wear on the outlet flange on the pump casing usually causes corresponding wear on the discharge connection.
	Wear on the impeller and the parts around it necessitates fine adjustment of the impeller or replacement of worn parts. See "Replacing the impeller".
Oil quantity	**WARNING.** If the seals leak, the oil casing may be under pressure. Hold a rag over the oil casing screw in order to prevent splatter. See "Safety precautions" for additional information.
	Check that the oil reaches up to the oil hole when the pump is tilted about 18°.
	Add oil as needed. See "Changing the oil".
Condition of the oil	A check of the condition of the oil can show whether there has been an increased leakage. **Note!** Air/oil mixture can be confused with water/oil mixture.
	Insert a tube (or hose) into the oil hole. Cover the top end of the tube and take up a little oil from the bottom.
	Change the oil if it contains too much water, i.e., is heavily emulsified (cream-like), or if the oil casing contains separated water. See "Changing the oil". Check again one week after changing the oil.

Inspection of	Action
	If the oil contains too much water again, the fault may be: — that an oil screw (30) is not sufficiently tight. — that the O-ring (15) of an oil screw or its sealing surface is damaged. — that the lower mechanical seal (35) is damaged. Contact a Flygt service shop.
Liquid in the stator casing	**WARNING.** If there has been leakage, the stator casing may be under pressure. See "Safety precautions" for additional information. Lay the pump on its side. Unscrew the screws (6). Tilt the pump so that any liquid in the stator casing can run out. If there is water in the stator casing, the cause may be: — that an O-ring (20) is damaged. — that the cable entry is leaking. If there is oil in the stator casing, the cause may be: — that the inner mechanical seal (35) is damaged. Contact a Flygt service shop.
Cable entry	If the cable entry leaks: — check that the entry is firmly tightened into its bottom-most position. — cut a piece of the cable off so that the seal sleeve (25) closes around a new position on the cable. — replace the seal sleeve (25). — check that the seal sleeve (25) and the washers (10) conform to the outside diameter of the cables.
Cables	Replace the cable if the outer jacket is damaged. Make sure that the cables do not have any sharp bends and are not pinched.
Level sensors or other level equipment	Check function. Clean, adjust, replace or repair damaged level sensing equipment. Follow the instructions for the level sensing equipment in question. **NOTE!** The level sensor contains a mercury switch. Damaged sensors should therefore be disposed of in a proper manner.
Starter equipment	If faulty, contact an electrician.

Inspection of	Action
Monitoring equipment (should be checked often)	Follow the instructions for monitoring equipment. Check: — signals and tripping function. — that relays, lamps, fuses and connections are intact. Replace defective equipment.
Rotation direction of pump (requires voltage)	Transpose two phase leads if the impeller does not rotate clockwise as viewed from above. Rotation in the wrong direction reduces the capacity of the pump and the motor may be overloaded. Check the direction of rotation, during **non-load** every time the pump is reconnected.
Pipes, valves and other peripheral equipment	Repair faults and notify supervisor of any faults or defects.
Insulation resistance in the stator	Use insulation tester. With a 1000 V-DC megger the insulation between the phases and between any phase and earth (ground) should be > 1 MΩ.

Changing the oil

WARNING. If the seals leak, the oil casing may be under pressure. Hold a rag over the oil plug to prevent splatter.

Lay the pump on its side on a bench or over two supports.

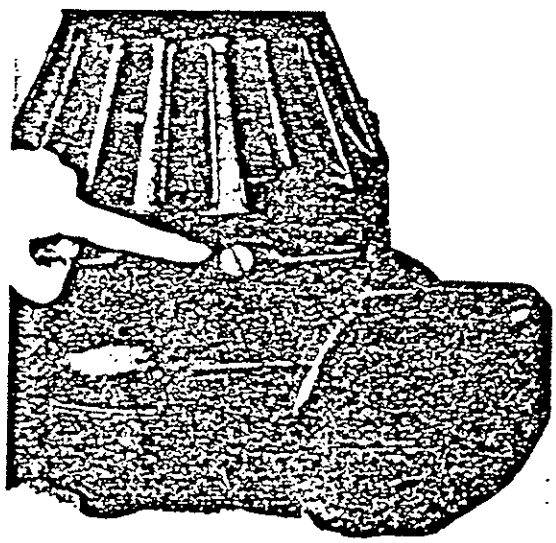
Unscrew the oil casing screw (30).

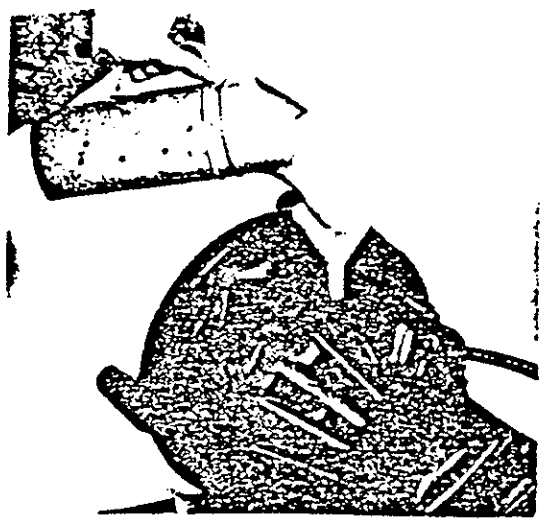
Turn the pump so that the oil hole faces downwards.

It is easier to drain the oil if the other oil hole screw is also removed.

In order to get out all the oil, the pump must be raised upright for a short while during drainage.

Replace the O-rings under the oil casing screws with the new ones. Install the "Oil out" screw and fill with oil through the other hole. It is important





that the oil be added through the hole marked "Oil in" since the oil casing must contain some air for pressure equalization. The pump should be slightly tilted and put down again horizontally in order to get the full amount of oil in. To check that the pump contains the right amount of oil, raise the pump again to an angle of roughly 18° to the horizontal and oil will begin to seep out through the hole, marked "Oil in".

Fill up with 1.0 litres (1.1 US quarts) of new oil. Use an ordinary SAE 10W-30 motor oil. Always replace the O-rings of the oil hole screws. Put the screws back and tighten them. Tightening torque 10 Nm (7.4 ft lb).

Replacing the wear ring

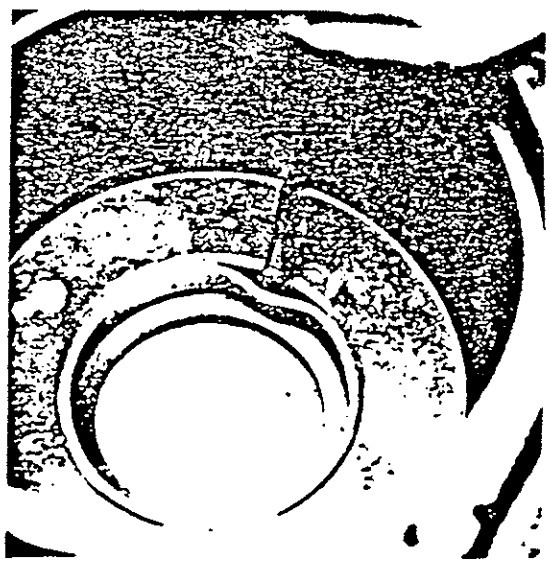
When the clearance between the impeller skirt and the pump casing exceeds 2.0 mm (0.08 in), the following replacement must be made.

Replacing the wear ring in the pump casing.

Disconnect and lift off the motor section from the pump casing.

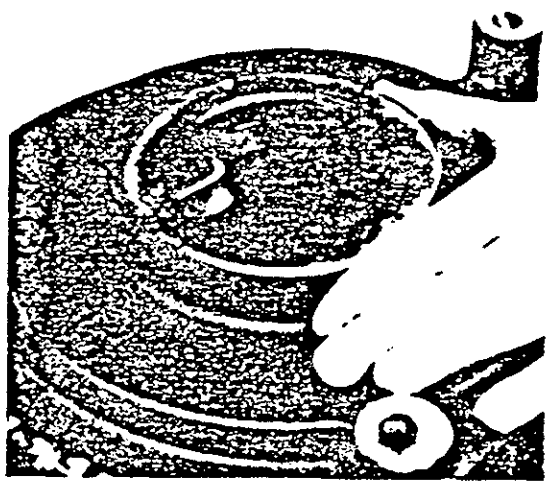
Remove the wear ring.

Knock out the wear ring using a hammer and a chisel.



Drive in the new wear ring. Use a rubber mallet or wooden block to prevent deformation.

The work will proceed more easily if the pump casing is first heated and/or the wear ring cooled.



Replacing the impeller

Removing the impeller

WARNING! Worn impellers often have very sharp edges.

Remove bolts (7) and lift the motor section off of the pump casing.

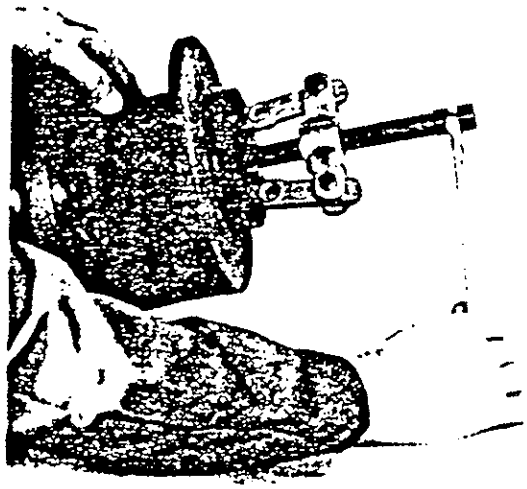
Lay the motor section on its side.

Remove impeller screw (5).

Pull off the impeller.

Use impeller puller according to the table, page 27.

Do **not** pry off the impeller, since it can easily be damaged.

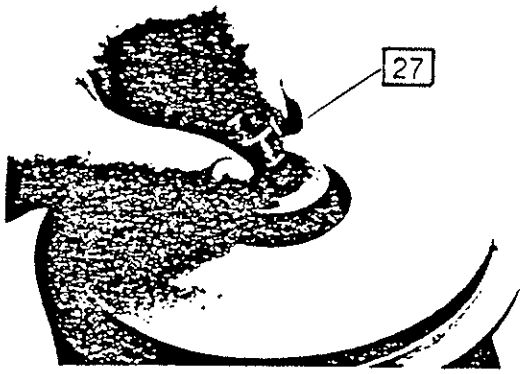


Installing the impeller

Make sure that the end of the shaft is clean and free of burrs. Polish off any flaws with fine emery cloth.

Check:

— that the conical sleeve (27) is seated in the impeller hub.

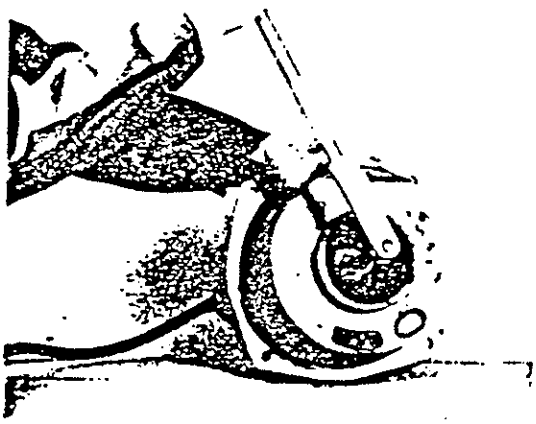


Press the impeller onto the shaft with the impeller screw.

Note the following points when replacing the impeller:

The **F, LL** and **LT**-impeller have a separate washer under the impeller screw. The **MT** and **HT**-impellers have a press-fit washer which is integral with the impeller.

Make sure that the separate washer fits properly into the recess of the impeller. If the washer (for LT and LL, 303 45 03 for F 403 94 00 is not properly positioned, the impeller can scrub against the oil casing bottom.



Tighten the impeller screw.

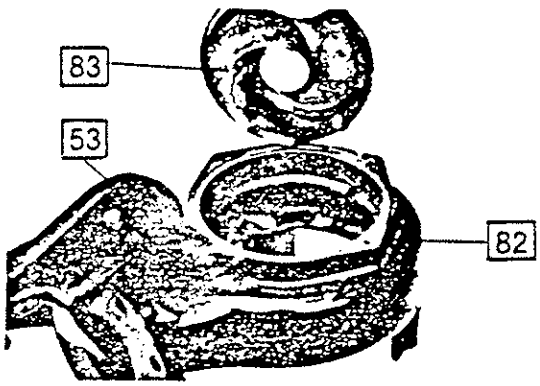
Tightening torque 34 Nm (25 ft lb).

Check that the impeller can be rotated by hand.

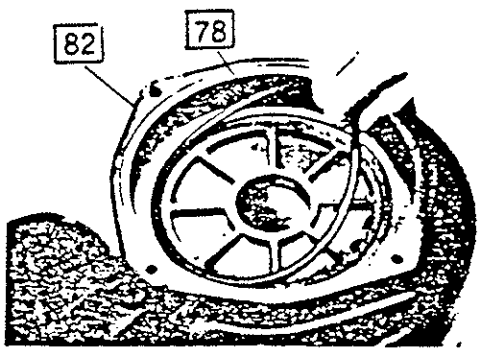
Fit the motor section to the pump casing. Make sure that the pump casing has the right orientation. Tightening torque of screws 44 Nm (32.5 ft lb).

The F-impellers require an adjustment to get correct cutting ability.

Start with placing the cover (83) in the pump casing. Look after that the guide boss fits into the corresponding recess of the pump casing.

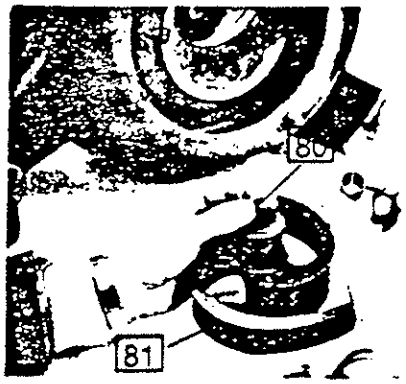


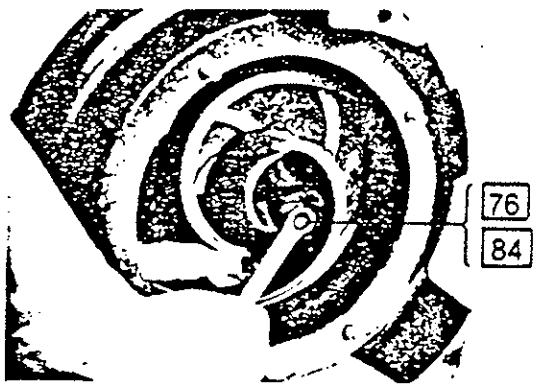
Then put O-ring (78) between the washer and the pump motor which then should be bolted to the pump casing.



Then mount the impeller.

The play is to be adjusted by means of the adjusting washers 250 23 00, 1 mm (0.04") and 250 23 02, 0.25 mm (0.01").

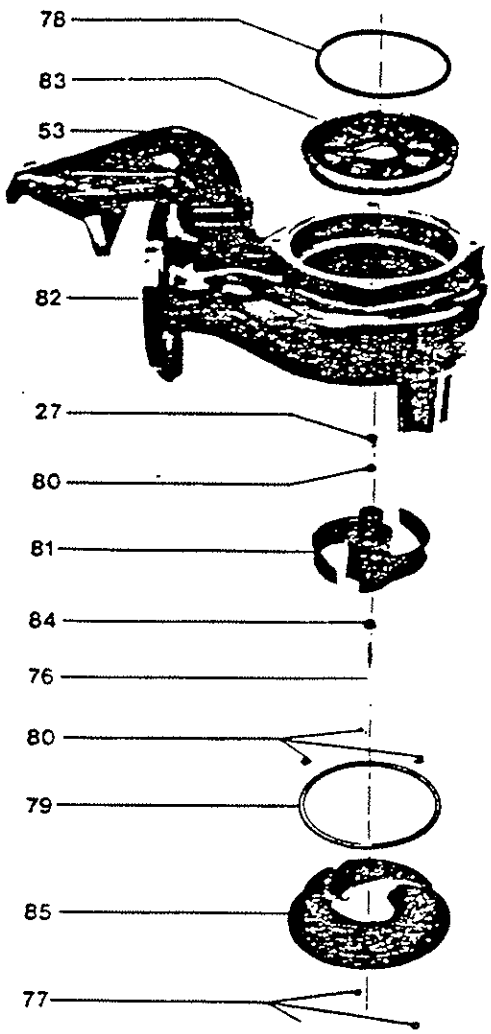




The play between the tightened impeller's upper edge and the cover (83) shall be 0.5—1.5 mm (0.02—0.06").

Use the same adjusting washers for adjusting the pump housing bottom as are used in the impeller hub.

Then fit and adjust the pump housing bottom (85) so that there is a clearance of 0.5—1 mm (0.02—0.04") between the impeller and the pump housing bottom.



More extensive repairs require special tools and should be carried out by an authorized service technician. See "Flygt Workshop Manual".

ACCESSORIES AND TOOLS

Zinc anode set

In order to reduce corrosion on the pump, it can be fitted with zinc anodes.

Order No.	
443 26 00	Hydraulic end LT
443 26 01	Hydraulic end HT
443 26 02	Hydraulic end GF
443 26 03	Hydraulic end D
443 26 04	Hydraulic end MT
443 26 05	Motor unit

Level sensor

Flygt supplies level sensors suited for different liquid densities and with different cable lengths. See separate brochure.

Start and control equipment

Flygt has suitable start and control equipment for the pump. Contact Flygt for further information.

Besides ordinary standard tools, the following tools are required in order to perform the necessary care and maintenance of the pump:

Order No.		Description
249 92 00	or 395 70 00	LL, LT Impeller puller
303 60 00		MT Impeller puller
251 35 01		HT Impeller puller
389 25 01		F Impeller puller
251 35 00		GF Impeller puller
84 13 60		D Impeller puller
82 04 90		Socket head screw for Neva Clog impeller
84 13 62		Puller for Neva Clog impeller
84 15 66		Torque wrench 0—137 Nm
84 13 04		Hexagon bit adaptor 6 mm
85 15 55		Extension bar length = 125 mm
84 17 08		Allen key

For further information on tools, see Flygt's Tool Catalogue.

FAULT TRACING (TROUBLESHOOTING)

A universal instrument (VOM), a test lamp (continuity tester) and a wiring diagram are required in order to carry out fault tracing on the electrical equipment.

Fault tracing shall be done with the power supply disconnected and locked off, except for those checks which cannot be performed without voltage.

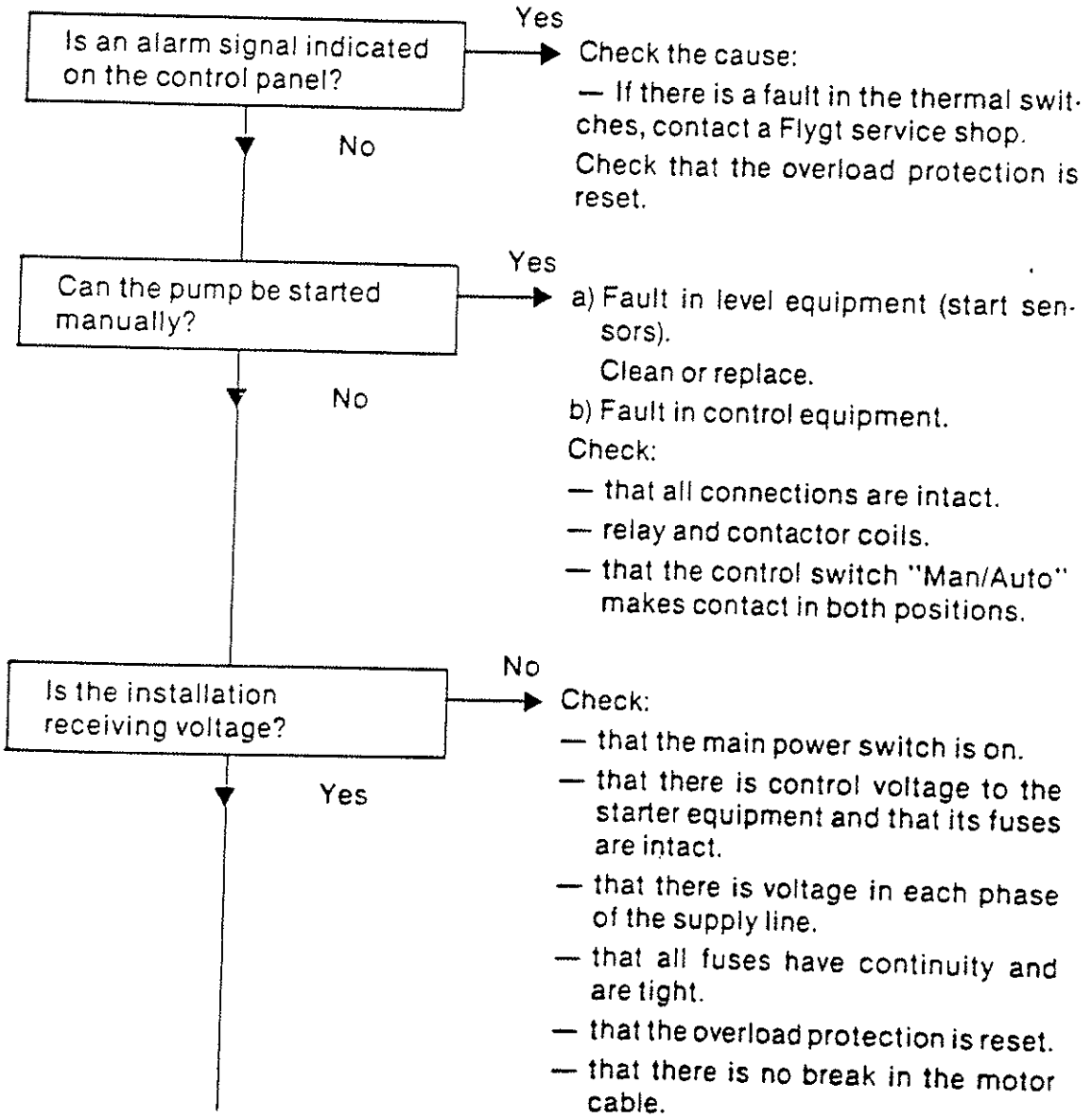
Always make sure that there is no one near the pump when the power supply is turned on.

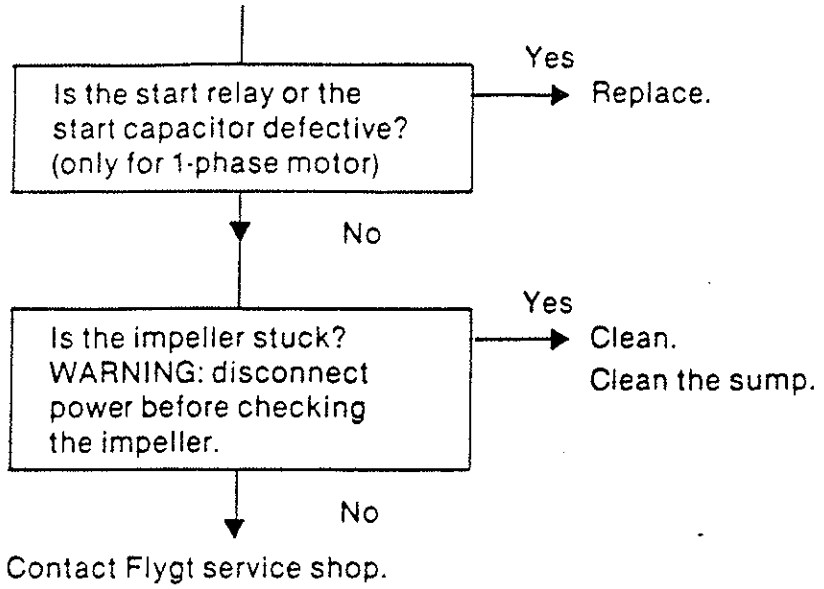
Use the following checklist as an aid to fault tracing. It is assumed that the pump and installation have formerly functioned satisfactorily.

Electrical work shall be performed by an authorized electrician.

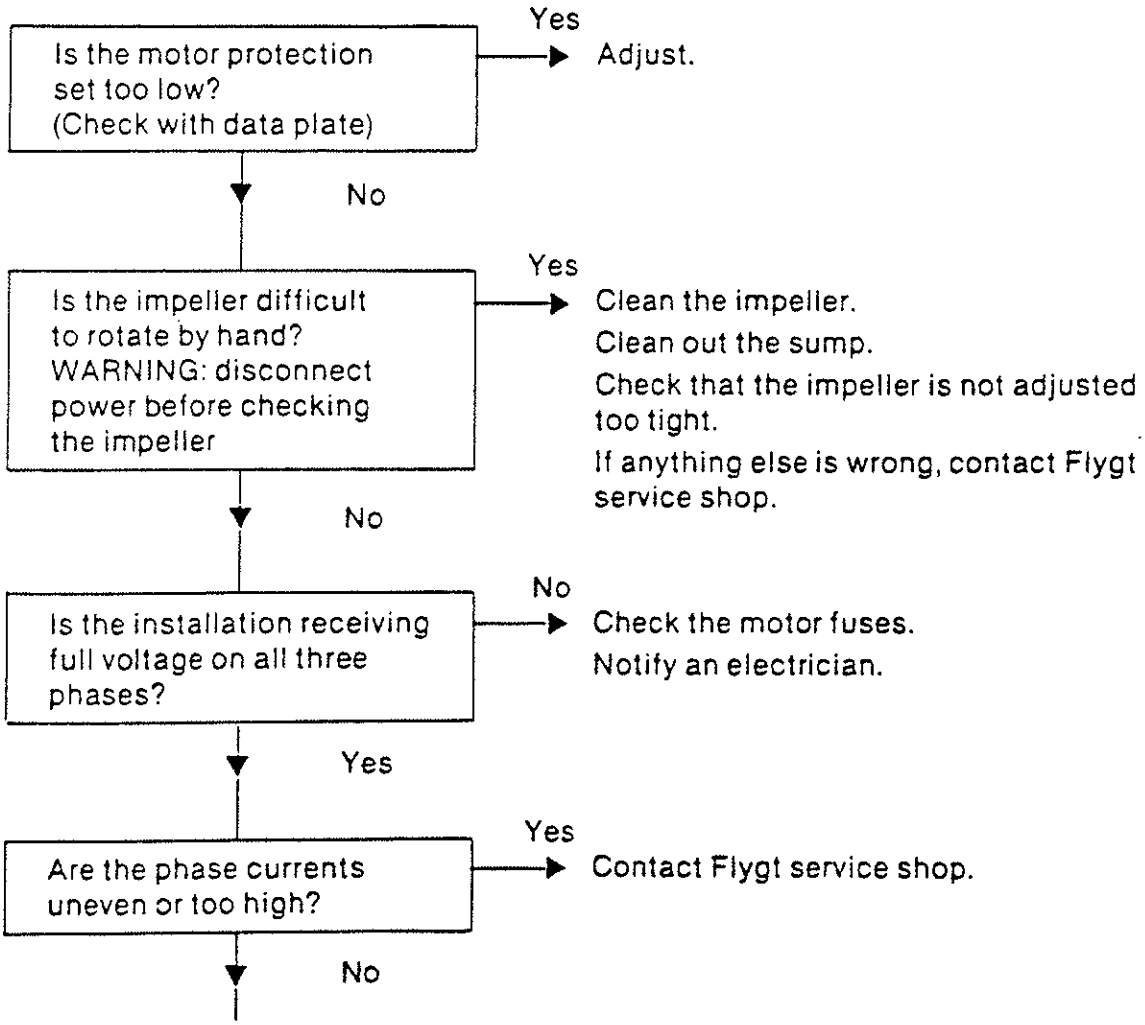
Follow local safety regulations and observe recommended safety precautions.

1. Pump fails to start





2. Pump starts but motor protection trips



Is the insulation between the phases and earth (ground) in the stator defective? (Use insulation tester. With a 1000 V-DC megger, the insulation between the phases and between any phase and earth (ground) should be > 1 MΩ)

Yes → Contact Flygt service shop.

No ↓

Is the density of the pumped liquid too high? (Max density 1100 kg/m³, 9.2 lb per US gal)

Yes → Dilute the liquid.
Change to a more suitable pump.
Contact Flygt.

No ↓

Fault on overload protection?

Yes → Replace the overload protection.

No ↓

Contact Flygt service shop.

3. The pump does not stop

Is the pump able to empty the station to the stop level?

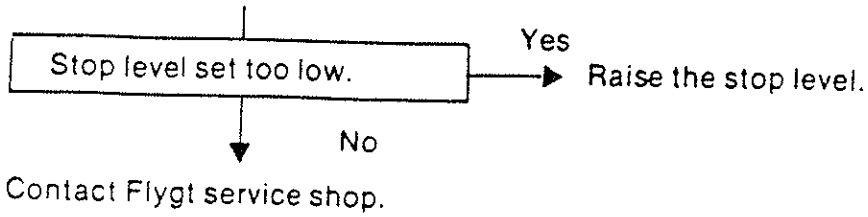
No → Check:
- — for leakage in pipe and/or discharge connection.
- — that the impeller is not clogged. WARNING: disconnect power before checking the impeller.
- — the non-return valve(s).
- — that the pump has adequate capacity. Contact Flygt.

Yes ↓

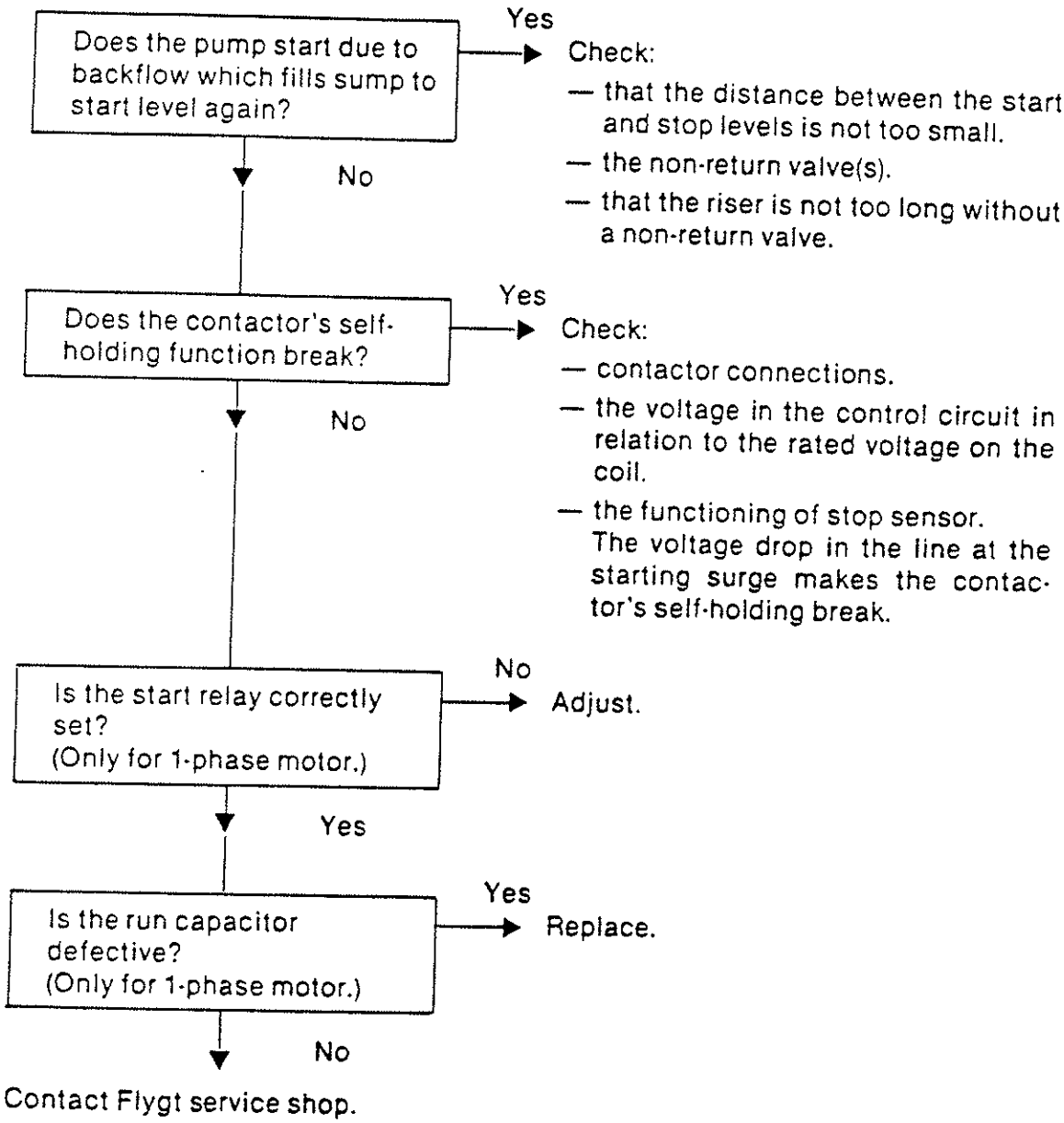
Fault in level sensing equipment?

Yes → Clean the level sensors.
Check the functioning of level sensors.
Check the contactor and holding circuit.
Replace defective items.

No ↓



4. The pump starts-stops-starts in rapid sequence



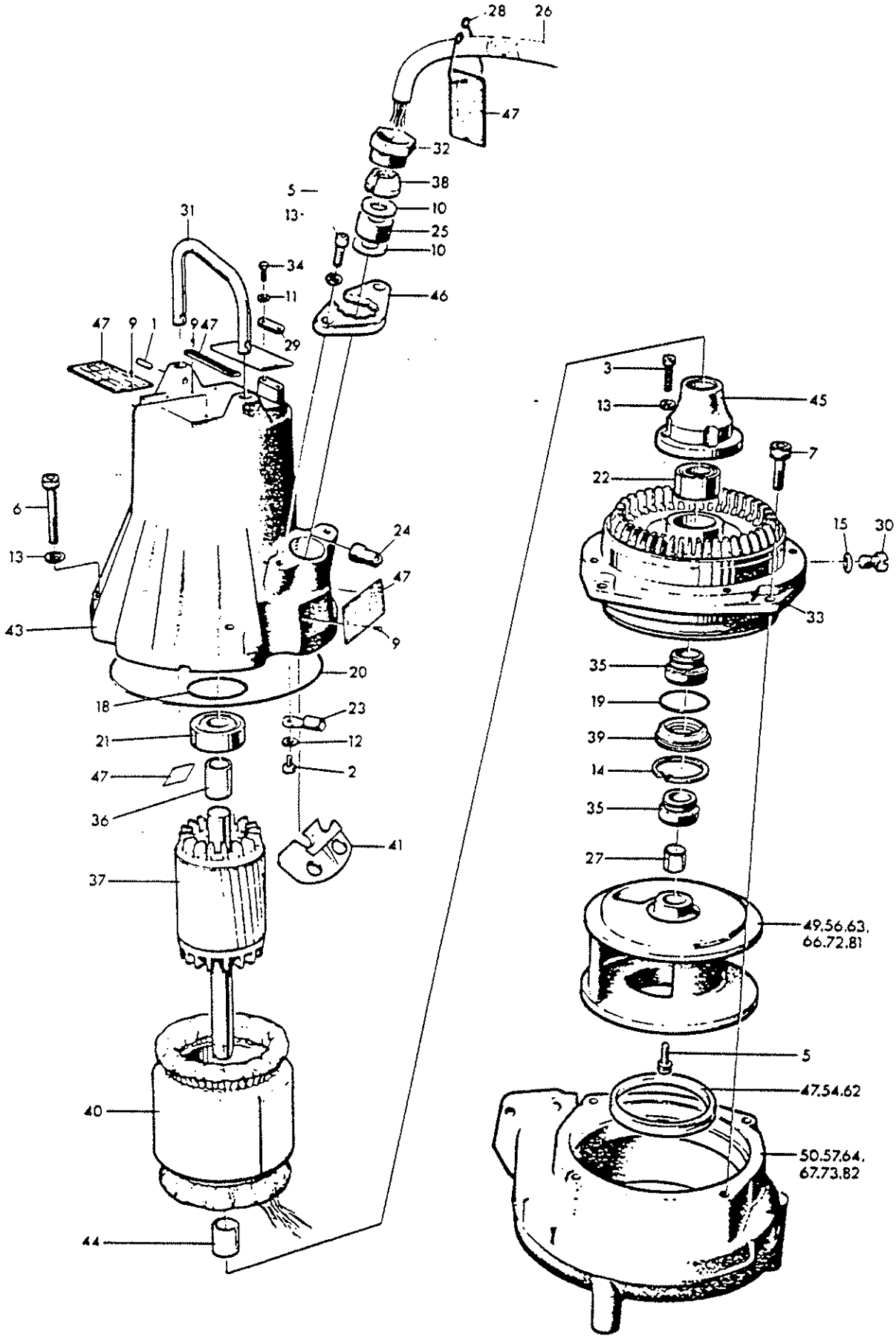
5. Pump runs but delivers too little or no water

Check:

— direction of rotation of pump, see "Before starting".
— that valves are open and intact.
— that pipes, impeller and strainer are not clogged.
— that the impeller rotates easily.
— that the suction lift has not been altered.
— for leakage in the pump installation.
— for wear on wear ring, impeller, pump casing.

See also under "Inspection".

Do not override the motor protection repeatedly if it has tripped.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66.72.81
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47.54.62
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50.57.64.
67.73.82
44

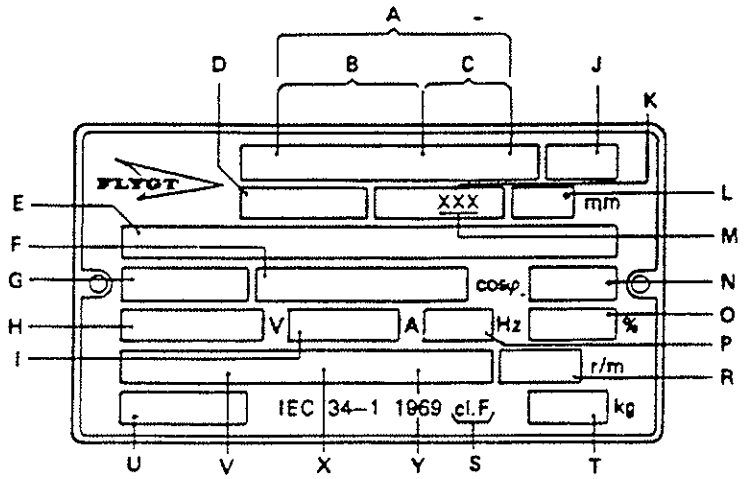
PARTS LIST

FLYGT

FM: Class I Div.1 Grp. C and D
Class II Div.1 Grp. E, F and G

3085.091

How to read the data plate.



Dataskylt inskription:

A Produktnummer
B Produktkod
C Löpnummer
D Tillverkningsnummer
E Special
F Axeleffekt, motor
G Statorkoppling
H Märkspänning
I Märkström
J Fabrikskod
K Poltal
L Pumphjul/Propeller diam.
M Kurvnummer
N Effektfaktor
O Driftart, kont./int. drift
P Fastal, strömart, frekvens
R Varvtal
S Isolationsklass
T Vikt
U S-order nummer
V *Propellervarvtal/bladvinkel propellertyp
X *Utväxlingsförhållande
Y *Rotationsriktning L = vänster R = höger

*För omrörare

Data plate interpretation:

A Product No
B Product code
C Consecutive No
D Serial No.
E Special
F Shaft power
G Stator connection
H Rated voltage
I Rated current
J Factory code
K Number of poles
L Impeller/propeller diam.
M Curve No.
N Power factor
O Operating duty, cont./int.
P Number of phases, type of current, frequence
R Rotation speed
S Insulation class
T Weight
U S-order No.
V *Rotation speed/blade angle propeller version
X *Gear ratio
Y *Direction of rotation L = left R = right

*For mixers

Datenschild, Beschriftung:

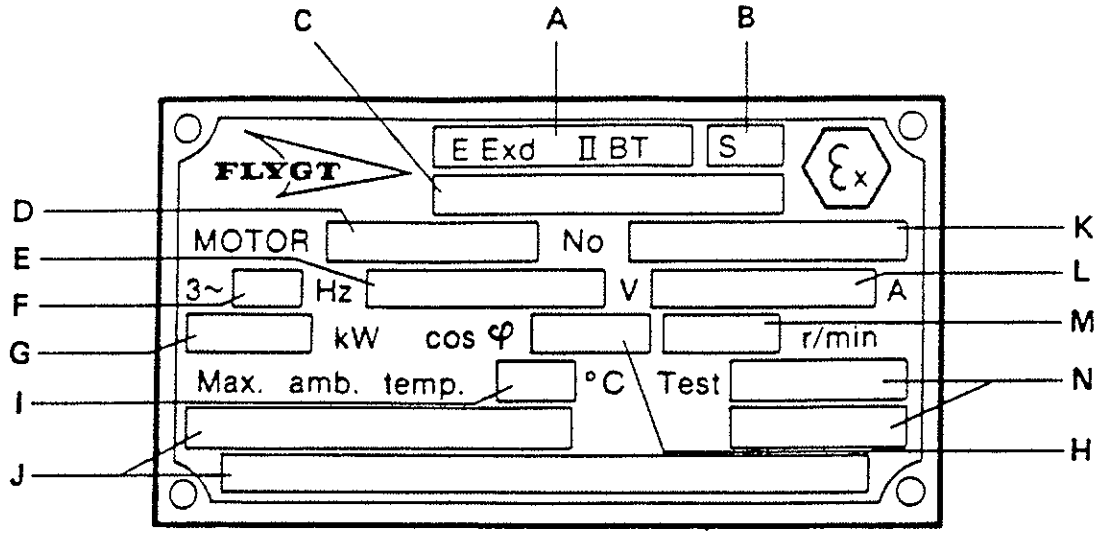
A Produkt Nr.
B Produktkode
C Lfd. Nr.
D Fabrikations-Nr.
E Sonderbezeichnung
F Leistungsabgabe
G Statorschaltung
H Nennspannung
I Nennstrom
J Fabrikskode
K Polzahl
L Laufrad/Propeller Durchmesser
M Kurve Nr.
N Leistungsfaktor
O Betriebsart, kont./int.
P Phasenzahl, Stromart, Frequenz
R Drehzahl
S Isolationsklasse
T Gewicht
U S-Auftragsnummer
V *Propellerdrehzahl/Winkel des Propeller flügels Propellerausführung
X *Übersetzungsverhältnis
Y *Drehrichtung L = links R = rechts

*Für Rührwerke

Légende de la plaque signalétique:

A N° de produit
B Code de produit
C N° d'ordre
D N° de série
E Indications spéciales
F Puissance sur l'arbre, moteur
G Couplage du stator
H Tension nominale
I Intensité nominale
J Code d'usine
K Nombre de pôles
L Roue/Hélice diamètre
M N° de courbe
N Facteur de puissance
O Type de fonctionnement, continu/intermittent
P Nombre de phases, type de courant, fréquence
R Régime
S Classe d'isolation
T Poids
U Numéro d'ordre S
V *Vitesse de rotation d'hélice/angle des pâles d'hélice version à hélice
X *Rapport de réduction
Y *Sens de rotation L = gauche R = droite

*Pour les agitateurs



A	Godkännande	A	Approval
B	Driftart	B	Operating duty, cont./int.
C	Godkännande Nr.	C	Approval No.
D	Motor Nr.	D	Motor No.
E	Märkspänning	E	Rated voltage
F	Fastal, strömart, frekvens	F	Service
G	Axeleffekt, Motor	G	Rated output
H	Effektfaktor	H	Power factor
I	Max omgivningstemp.	I	Max. ambient temp.
J	Kompletterande uppgifter	J	Additional information
K	Tillverknings Nr.	K	Serial No.
L	Märkström	L	Rated current
M	Varvtal	M	Speed
N	Kontrollant	N	Controller

A	Genehmigung	A	Approbation
B	Betriebsart, kont./int.	B	Type de fonctionnement, continu/intermittent
C	Genehmigung Nr	C	Approbation N°
D	Motor Nr.	D	Moteur N°
E	Nennspannung	E	Tension nominale
F	Phasenzahl, Stromart, Frequenz	F	Nombre de phases, type de courant, fréquence
G	Leistungsabgabe	G	Puissance sur l'arbre, moteur
H	Leistungsfaktor	H	Facteur de puissance
I	Max. Umgebungstemp.	I	Temperature ambiante max.
J	Komplettierende angaben	J	Informations complementaires
K	Fabrikations-Nr.	K	N° de serie
L	Nennstrom	L	Intensité nominale
M	Drehzahl	M	Régime
N	Kontrolleur	N	Controleur

Uppge pumpens produktnummer och tillverkningsnummer vid reservdelsbeställning.
Använd inte pos.nr utan detaljnr vid reservdelsbeställning och lagerhållning.

Tillverkarens garantibestämmelser gäller endast under förutsättning att Flygts originaldelar används samt att reparations- och servicearbetet utförs av en av Flygt auktoriserad verkstad.

Rätt till ändringar i utförande och specifikationer förbehålles.

Garantivillkoren förutsätter att pumpen används enligt instruktionen och i applikationer för vilka den är avsedd.

State product No. and serial No. of pump when ordering parts.
Do not use item Nos. when ordering spare parts or for stock records.

The provision of the manufacturer's guarantee applies only under the condition that genuine Flygt spare parts are used and that the repair and service work is carried out by a workshop authorized by Flygt.

The manufacturer reserves the right to alter specification and design.

The terms of the guarantee apply only providing the pump is used in accordance with the instructions and in applications for which it is intended.

Bei Bestellung bitte die Produkt Nr. und die Fabrikations Nr. der Pumpe angeben.
Die Pos.-Nummern sind nicht für die Lagerorganisation vorgesehen.

Die Garantiebestimmungen des Herstellers gelten nur unter der Voraussetzung, daß Original Flygt-Ersatzteile verwendet werden, und daß Reparatur- und Wartungsarbeiten von einer von Flygt autorisierten Werkstatt durchgeführt werden.

Änderungen in bezug auf Ausführung und Specifikationen vorbehalten.

Die Garantiebedingungen voraussetzen daß die Pumpe laut der Instruktion und in Applikationen, zu welchen sie bestimmt ist, verwendet wird.

Pour toute commande de pièces de rechange, prière d'indiquer le N° de produit et le N° de série de la pompe à laquelle ces pièces sont destinées.
Ne pas utiliser les numéros de repérage lors de la commande de pièces de rechange, ou sur les fiches de stocks. Utiliser les numéros de pièces.

La garantie du constructeur n'est valable que dans la mesure où sont exclusivement utilisées des pièces de rechange Flygt d'origine et où les réparations et interventions sont assurées par un atelier agréé par Flygt.

Nous nous réservons le droit de modifier l'exécution et les spécifications de nos produits.

La garantie n'est valable que dans la mesure où la pompe est utilisée conformément aux directives du constructeur et uniquement affectée aux usages auxquels elle est destinée.

För att pumpen skall uppfylla bestämmelserna och myndigheters godkännande ska alltid Flygts originaldelar användas vid reparation.
Ingrepp på special-godkända pumpar får endast göras av Flygt eller av Flygt-auktoriserad verkstad/personal.

Reservdelar markerade med rött är underkastade måttkontroll.

In order for the mixer to fulfil requirements and obtain official approval, genuine Flygt parts must always be used for repairs.
Only Flygt or Flygt-authorized service personnel may undertake repair work on specially approved mixers.

Spare parts marked with red are subjected to dimensional accuracy inspection.

Das Rührwerk entspricht den Vorschriften und den behördlichen Genehmigungen nur unter Voraussetzung, daß bei Reparaturen ausschließlich Original-Flygt-Ersatzteile eingebaut werden.
Arbeiten an Rührwerken mit Spezial-Zulassung dürfen nur von Flygt-Personal oder von durch Flygt autorisiertem Personal durchgeführt werden.

Mit rot gekennzeichnete Ersatzteile werden besonderen maßhaltigkeitskontrollen unterzogen.

Pour que l'agitateur demeure conforme à la réglementation ainsi qu'à l'homologation accordée par les autorités compétentes, il est indispensable que seules des pièces Flygt d'origine soient utilisées lors des réparations.
Les interventions au niveau des agitateurs spécialement approuvés doivent être confiées uniquement à un personnel Flygt ou à un atelier agréé par Flygt.

Les pièces indiquées en rouge sont soumises à un contrôle de cotes.

Säljkoder
Verkaufskodes

Sales codes
Codes de vente

LT =	Lågtrycksutförande Niederdruckausführung	Low-head version (Curve No. 412—414, 612—614, 620—622) Modèle basse pression
MT =	Medeltrycksutförande Mitteldruckausführung	Medium-head version (Curve No. 432—440, 632—636) Modèle moyenne pression
HT =	Högtrycksutförande Hochdruckausführung	High-head version (Curve No. 250—252) Modèle haute pression
D =	Virvelhjulsutförande Wirbelradausführung	Vortex impeller version (Curve No. 276—284, 471—477, 671—675) Version roue vortex
GF =	Grundvattenpump Grundwasserpumpe	Groundwater pump (Curve No. 244) Pour eau de souterraine
F =	För flytgödselpumpning Für Gülleförderung	For pumping liquid manure (Curve No. 490—493) Pour pompage de lisier
LL =	Invalliningsutförande Hebepumpausführung	Liftpump version (Curve No. 412, 414, 612, 614) Modèle pompe de levage

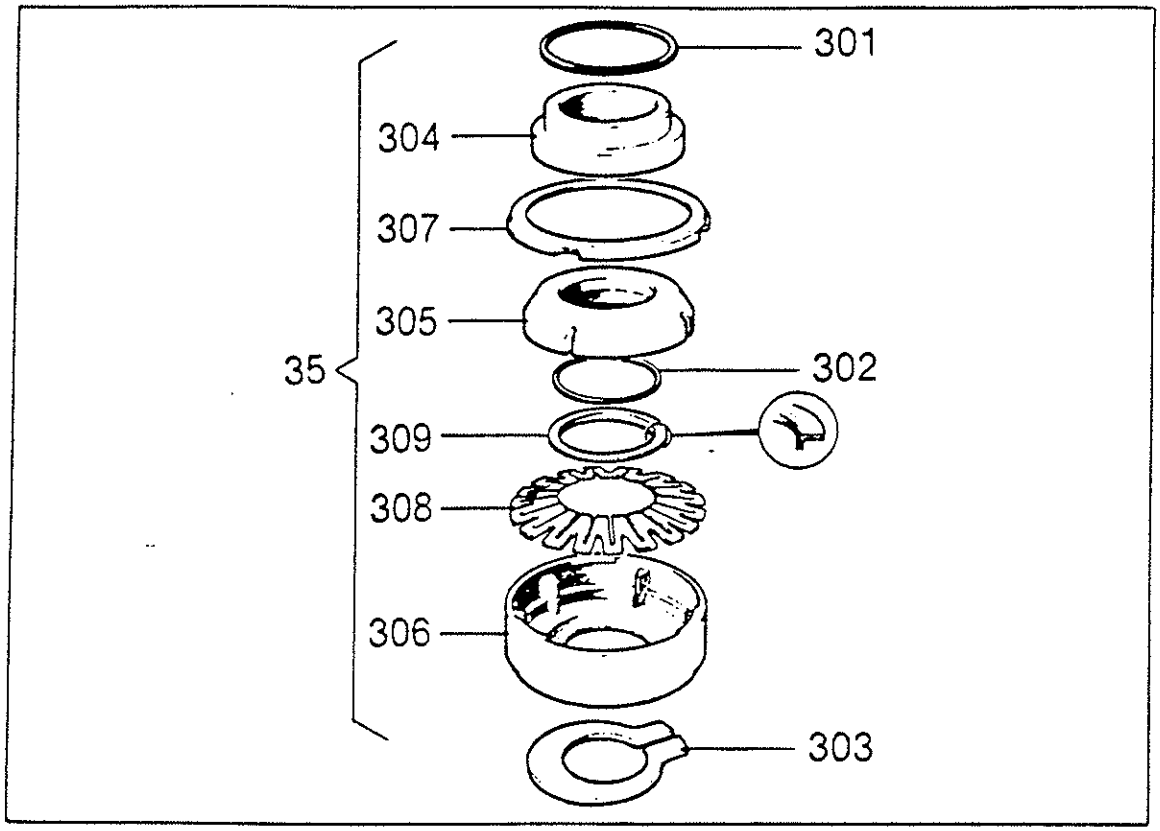
Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
1	80 58 89	Fjädrande rörpinne Federstift	Tension pin Goupille	2
2	81 40 80	6-kantskruv (M 6 x 12) Schraube	Hexagon screw Vis	1
		INSEXSKRUV SCHRAUBE	SOCKET HEAD SCREW VIS ALLEN	
3	82 00 13	M 6 x 16		3
5	82 00 34	M 8 x 25		3
6	82 00 39	M 8 x 50		4
7	82 00 68	M 12 x 25		4
8	82 20 04	Skruv (R x S B6 x 8) Schraube	Screw Vis	4
9	82 20 88	Drivskruv (4 x 5) Treibschraube	Drive screw Vis autotaraudeuse	8
10		BRICKA SCHEIBE	WASHER RONDELLE	
	82 40 57	(16)—18 mm (0.63"—0.71")	"FM"	
	82 40 59	(18)—20 mm (0.71"—0.79")	"EN"	
		FJÄDERBRICKA SCHEIBE	SPRING WASHER RONDELLE	
11	82 48 57	FBB 5.1		2
12	82 48 58	FBB 6.1		4
13	82 48 61	FBB 8.2		6
14	82 63 68	Spårring (SgH 65) Nutring	Retaining ring Circlip	1
		O-RING O-RING	O-RING ANNEAU TORIQUE	
15	82 73 85	13.3 x 2.4		6
16	82 77 95	52.5 x 3.0		1
17	82 77 97	53.0 x 4.0		1
18	82 78 37	200.0 x 3.0		1

Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
		KULLAGER KUGELLAGER	BALL BEARING ROULEMENT A BILLES	
19	83 34 40	6304 RS		1
20	83 36 24	3204/C-3		1
21	438 54 00	Låsbricka Sicherungsscheibe	Lock washer Rondelle de blocage	1
22		KLÄMMA KLAMME	CLAMP COLLIER	1
	398 98 03	(16)—18 mm "FM"		
	398 98 05	(18)—20 mm "EN"		
23	83 43 44	Kabelsko Kabelschuh	Cable lug Cosse	1
24	83 44 24	Ändhylsa Hülse	End sleeve Douille	9-12
25		TÄTNINGSHYLSA DICHTUNGSHÜLSE	SEAL SLEEVE MANCHON	1
	84 35 33	(16)—18 mm (0.63"—0.71") "FM"		
	84 35 34	(18)—20 mm (0.71"—0.79") "EN"		
26		MOTORSLADD MOTORLEITUNG	POWER CABLE CABLE	1
	94 11 50	NSSHÖU-J 6 x 2.5 mm², "EN"		
	94 18 90	SPC 14 AWG/3-2-1, "FM'		
	94 20 54	SUBCAB 7G 2.5 mm² "EN"		
	14 51 20 27**			
27	397 88 00	Hylsa Hülse	Sleeve Douille	1
28	262 05 00	Fästögla Hebeöse	Fixing eye Ecrou a oeil	1
29	279 29 00	Jordningsbleck Erdungsblech	Earthing plate Plaque de terre	1
30	303 44 03	Inspektionsskruv Inspektionsschraube	Inspection screw Vis d'inspection	1
31	397 80 00	Bärbygel Tragbügel	Carrying handle Poignée	1
32	397 81 00	Hylsskruv Verschraubung	Gland screw Ecrou de serrage	1

** Endast för USA — USA only
Nur für die USA — Seulement pour les USA

Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
33	397 85 07	OLJEHUSENHET ÖLGEHÄUSEEINHEIT	OIL CASING UNIT BAC À HUILE COMPL.	1
	435 48 00	Lagerhållare Lagerhalter	Bearing holder Boîtier de roulement	(1)
	*	Oljehus Ölgehäuse	Oil casing Bac à huile	(1)
	*	Hylsa Hülse	Sleeve Douille	(1)
34	298 88 04	Jordningsskruv Erdungsschraube	Earthing screw Vis de terre	2
35		PLANTÄTNINGSENHET GLEITRINGDICHTUNG	SEAL UNIT JOINT MECANIQUE	2
	397 90 00	Tätningsringar i keramik Nedre, Övre, "EN" Dichtungsringe aus Keramik Unter, Obere, "EN"	Seal ring of ceramics Lower, Upper, "EN" Anneaux en céramique Inf., Sup., "EN"	
	397 90 01	Tätningsringar i hårdmetall Nedre, "FM", "EN" Dichtungsringe aus Hartmetall Unter, "FM", "EN"	Seal rings of tungsten carbide Lower, "FM", "EN" Anneaux en carbure Inf., "FM", "EN"	
	397 90 02	Tätningsringar i kol-keramik Övre, "FM", "EN" Dichtungsringe aus Keramik-Graphit Obere, "FM", "EN"	Seal rings of ceramic-carbon Upper, "FM", "EN" Anneaux en céramique-carbone Sup., "EM", "EN"	
301	82 79 23	O-ring (28 x 4 mm) O-Ring	O-ring Anneau torique	(2)
302	82 72 95	O-ring (19.2 x 3 mm) O-Ring	O-ring Anneau torique	(2)
303	397 94 01	Låsring Federring	Locking ring Circlip	(2)
304	*	Tätningsring, stat. Dichtungsring, stat.	Seal ring, stat. Joint, fixe	(2)
305	*	Tätningsring, rot. dichtungsring, rot.	Seal ring, rot. Joint, tournant	(2)

* Levereras ej separat
Nicht separat geliefert
Not delivered separately
N'est pas livré séparément



Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de piece	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
306	*	Fjärderhus Federgehäuse	Spring housing Boîtier de ressort	(2)
307	*	Ring Ring	Ring Anneau	(2)
308	*	Fjäder Feder	Spring Ressort	(2)
309		Stödring Stützring	Supporting ring Anneau de support	(2)
36	398 97 06	Distanshylsa Distanzhülse	Spacing sleeve Manchon d'écartement	1

* Levereras ej separat
Nicht separat geliefert

Not separately delivered
N'est pas livré séparément

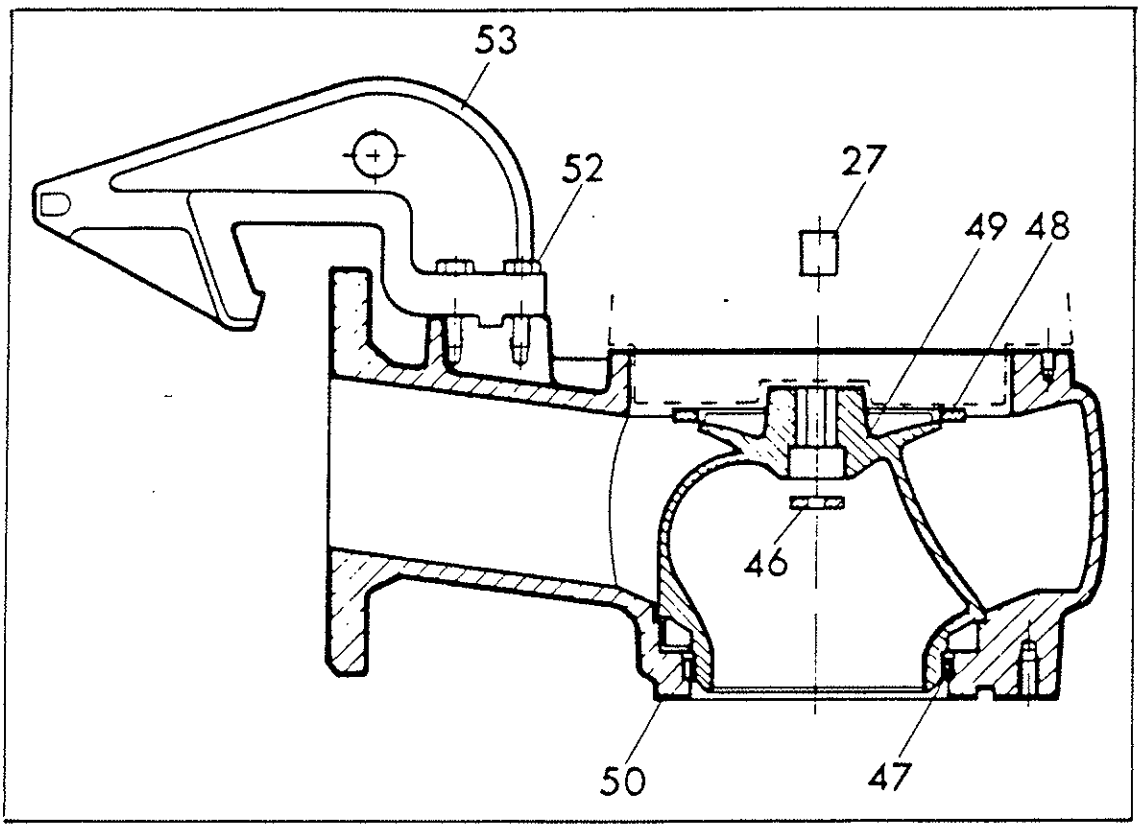
Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
37		AXEL-ROTORENHET ROTOREINHEIT	SHAFT-ROTOR UNIT ARBRE-ROTOR COMPL.	1
	397 79 03	För stator 408 40 xx, 427 11 xx		
	397 79 04	For stator 408 41 xx		
	399 07 02	Für Stator 408 42 xx		
	399 07 03	Pour stator 434 84 xx		
39	426 32 00	Släpringshållare Dichtungsringhalter	Seal ring holder Boîtier de joint	1
40		STATOR STATOR	STATOR STATOR	1
		50 Hz	60 Hz, 0.9 kW (1.2 hp) 3400 r/min	
	434 84 27**	—	200—220 VY	
	434 84 29**	—	380 VY/220—230 V△	
	434 84 32**	—	400 VY/230—240 V△	
	434 84 34**	—	440—460 VY/260 V△	
	434 84 37**	—	440—460 VY ser./220—230 VY par	
	434 84 38**	—	440—460 V△	
	434 84 40**	—	400 V△	
	434 84 43**	—	480 VY	
	434 84 51**	—	575 VY	
		50 Hz, 2.4 kW, 2850 r/min	60 Hz, 3.0 kW (4.0 hp), 3450 r/min	
	408 42 12	—	440—460 VYser./220—230 VYpar	
	408 42 27	200—220 VY	200—220 VY	
	408 42 32	350 VY/200—208 V	400 VY/230—240 V△	
	408 42 34	380 VY/ 220 V△	440 VY/260 V△	
	408 42 38	660 VY/380 V△	440—460 V△	
	408 42 43	400—440 VY	—	
	408 42 51	500—550 VY	575 VY	
		50 Hz, 1.3 kW	60 Hz, 1.6 kW (2.2 hp), 1700 r/min	
	408 41 12	—	440—460 VYser./220—230 VYpar	
	408 41 27	190—200 VY	200—220 VY	
	408 41 30	—	380 V△	
	408 41 32	350 VY/200—208 V	400 VY/230—240 V△	
	408 41 34	380 VY/220 V△	440 VY/260 V△	
	408 41 38	660 VY/ 380 V△	440—460 VY	
	408 41 40	400 V△	400 V△	
	408 41 43	400—440 VY	—	
	408 41 51	500—550 VY	575 VY	

** Endast för GF utförande
Nur für GF-Ausführung
Only for GF-version
Pour Modèle GF

Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
		50 Hz, 2.0 kW	60 Hz, 2.4 kW (3.2 hp), 1700 r/min	
	408 40 12	—	440—460 VYser./220—230 VYpar	
	408 40 27	190—200 VY	200—220 VY	
	408 40 30	—	380 V⎓	
	408 40 32	350 VY/200—208 V	400 VY/230—240 V	
	408 40 34	380 VY/220 V⎓	440 VY/260 V⎓	
	408 40 38	660 VY/380 V⎓	440—460 VY	
	408 40 40	400 V⎓	400 V⎓	
	408 40 43	400—440 VY	—	
	408 40 51	500—550 VY	575 VY	
		50 Hz, 0.9 kW	60 Hz,1.1 kW (1.5 hp) 940 r/min	
	427 11 27	190—200 VY	—	
	427 11 30	—	380 V⎓	
	427 11 32	350 VY/200—208 V⎓	—	
	427 11 34	380 VY/220 V⎓	—	
	427 11 38	660 VY/380 V⎓	—	
	427 11 40	400 V⎓	—	
	427 11 43	400—440 VY	—	
	427 11 51	500—550 VY	—	
		1-Fas 1-Phase 50 Hz	1-Phase 1-Phase 60 Hz	
	408 42 12	—	2.2 kW, 3440 r/min, 230—240 V	
	408 41 12	—	1.6 kW, 1700 r/min, 230—240 V	
	408 40 12	—	1.8 kW, 1700 r/min, 230—240 V	
41	433 72 01	Skyddsskiva Schutzscheibe	Protection disc Disque de protection	1
42		SKYLT SCHILD	PLATE PLAQUE	
	274 52 00	"Made is Sweden"		1
	426 67 00	Tape, "60 Hz connections", U1—W5		1
	426 69 00	Tape, "60 Hz connections", U1—W6		1
	426 71 00	Tape, "Y-connection", U1—W2		1
	426 74 00	Tape, T1—°C—T2		1
	438 37 00	Dataskylt Datenschild	Data plate Plaque signalétique	2
	441 29 00	Certifikatskylt, "FM" Prüfschild	Approval plate Plaque d'agrement	1
	441 56 00	Certifikatskylt, "EN" Prüfschild	Approval plate Plaque d'agrement	2

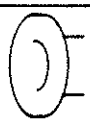
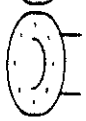
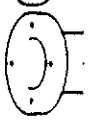
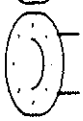
Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
43	435 47 02	Statorhus Statorhgehäuse	Stator casing Logement de stator	1
44		DISTANSHYLSA DISTANZHÜLSE	SPACING SLEEVE MANCHON D'ECARTEMENT	1
	435 52 00	För rotor 397 79 03 L = 31.4 mm		
	435 52 01	For rotor 399 07 02 L = 42.4 mm		
	435 52 02	Für Rotor 397 79 04 L = 62.4 mm		
	435 52 04	Pour rotor 399 07 03 L = 91.4 mm		
45	435 53 00	Lagerlock Lagerdeckel	Bearing cover Cache roulement	1

Pumpdetaljer, LT-utförande
Pumpenteile, LT-Ausführung
Pump parts, LT-version
Pièces de la pompe, Modèle LT



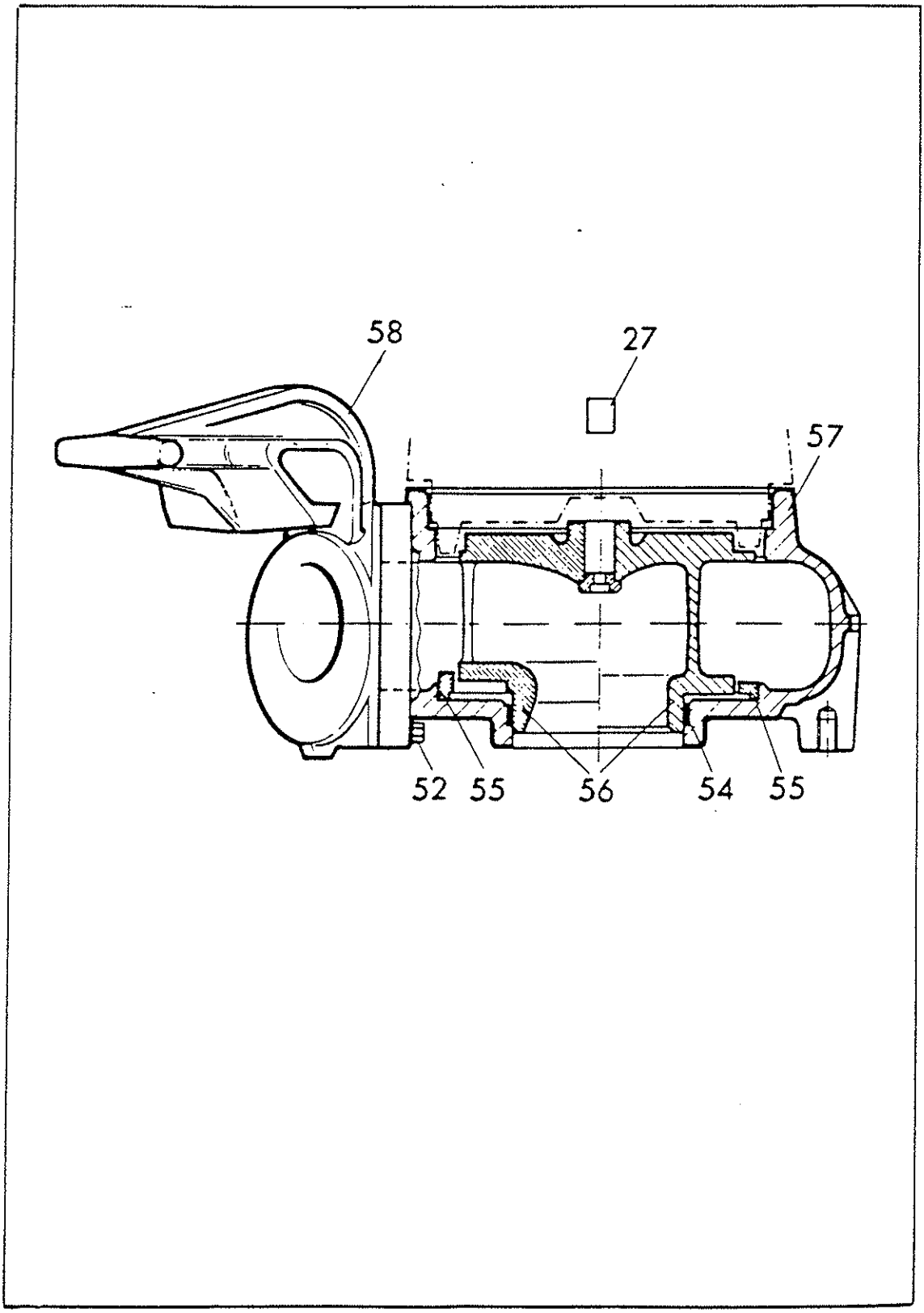
Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
46	303 45 03	Bricka Scheibe	Washer Rondelle	1
47	314 88 01	Slitring Verschleißring	Wear ring Anneau d'usure	1
48	379 79 00	Bricka för 379 75 XX Scheibe für 379 75 XX	Washer for 379 75 XX Rondelle pour 379 75 XX	1
49		PUMPHJUL, Kurva nr... LAUFRAD, Kurve Nr...	IMPELLER, Curve No... ROUE, Courbe N°...	1

397 76 00	412, 612, 50 Hz	Genomlopp	diam. 100 mm (4.0")
379 33 00	414, 50—60 Hz 614, 50 Hz	Throughlet	diam. 80 mm (3.2")
373 12 01	620, 50 Hz	Durchgang	diam. 100 mm (4.0")
373 10 01	622, 50 Hz	Section de passage	diam. 100 mm (4.0")
431 69 01	621, 50 Hz		diam. 100 mm (4.0")

Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
50		PUMPHUS PUMPENGENGEHÄUSE	PUMP CASING VOLUTE	1
		Kurva nr 412, 414, 612, 614 Kurve Nr...	Curve No... Courbe N°...	
	379 75 00	DN 100 4"		
	379 75 02	DN 100 4"	1882 Standard	
		Kurva nr 620—622 Kurve Nr...	Curve No... Courbe N°...	
	383 99 00	DN 100 4"		
	383 99 01	DN 100 4"	 SMS 342 DIN 2533 BS 4622:1970 Table 11	
	383 99 02	DN 100 4"	 1882 Standard	
	383 99 05	DN 100 4"	 ANSI B 16.1:1967 Table 5	
52	81 41 58	Skruv (M12 x 45) Schraube	Screw Vis	4
53		GLIDSKO GLEITKLAUE	SLIDING BRACKET GLISSIÈRE	1
	380 91 00	För rör Für Rohr	For pipes Pour tube	

Pumpdetaljer, MT-utförande
Pumpenteile, MT-Ausführung

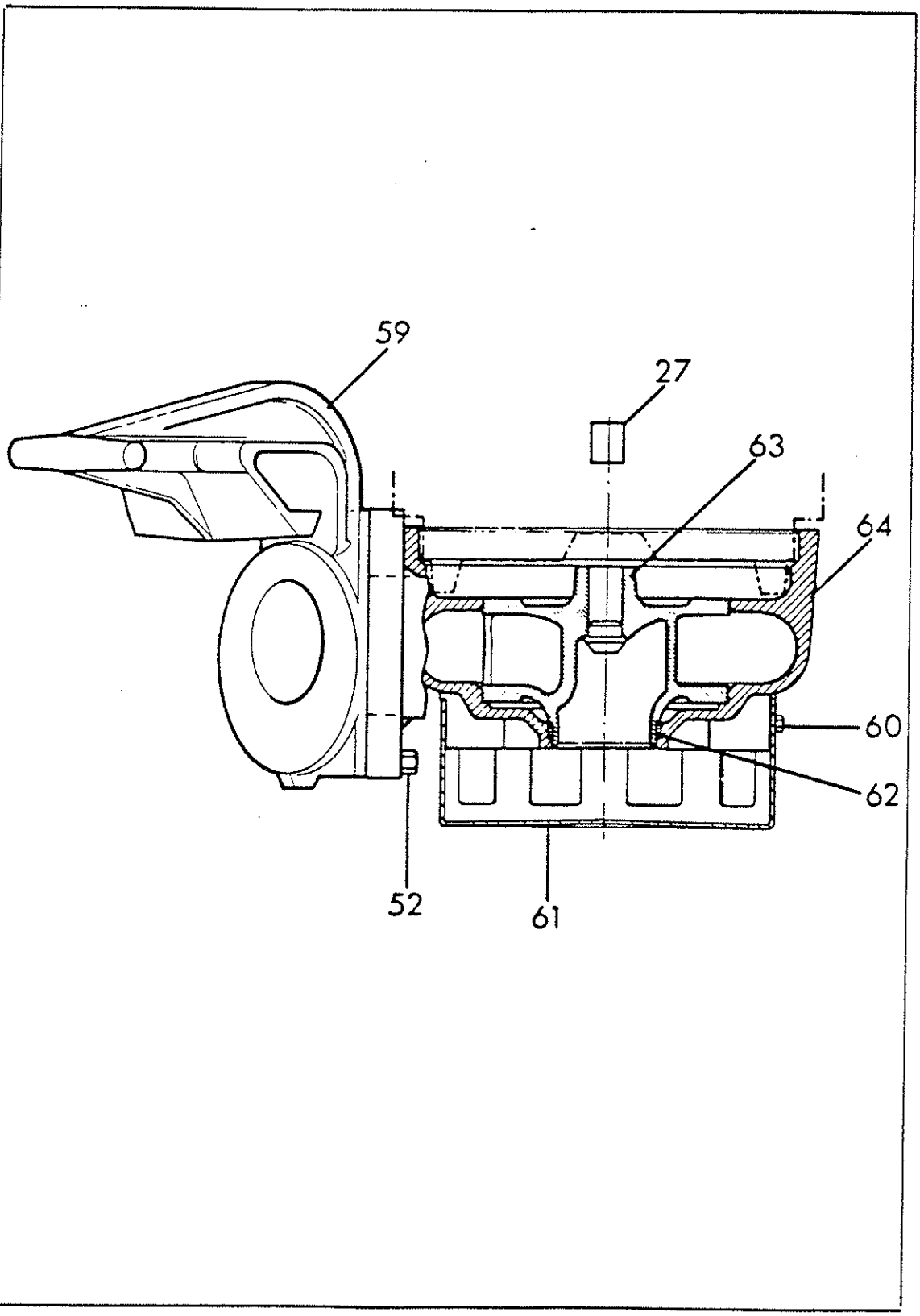
Pump parts, MT-version
Pièces de la pompe, Modèle MT



Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
52	81 41 58	Skruv (M12 x 45) Schraube	Screw Vis	2
54	398 92 00	Slitring Verschleißring	Wear ring Anneau d'usure	1
55	399 11 00	Distansring för pumphjul 430 07 00, 430 07 01	Distance ring for impeller 430 07 00, 430 07 01	1
		Distanzring Für Laufrad 430 07 00, 430 07 01	Anneau d'ecartement pour roue 430 07 00, 430 07 01	
56		PUMPHJUL LAUFRAD	IMPELLER ROUE	1
	430 07 00	50 Hz/60 Hz	Kurva nr 438 Curve No.	Genomlopp Throughlet	diam. 64 mm (2.5")
	430 07 01	50 Hz/60 Hz	Kurve Nr 440 Courbe N°	Durchgang Section de passage	diam. 64 mm (2.5")
	461 78 00	50 Hz	432, 632		diam. 76 mm (3.0")
	461 80 00	50 Hz/60 Hz	434, 634		diam. 76 mm (3.0")
	461 82 00	50 Hz/60 Hz	436, 636		diam. 76 mm (3.0")
57		PUMPHUS PUMPENGEHÄUSE	PUMP CASING VOLUTE	1
	398 90 01	DN 80 3.2"		
58		GLIDSKO GLEITKLAUE	SLIDING BRACKET GLISSIÈRE	1
	398 93 00	För rör Für Rohr	For pipes Pour tube	

Pumpdetaljer, HT-utförande
Pumpenteile, HT-Ausführung

Pump parts, HT-version
Pièces de la pompe, Modèle HT

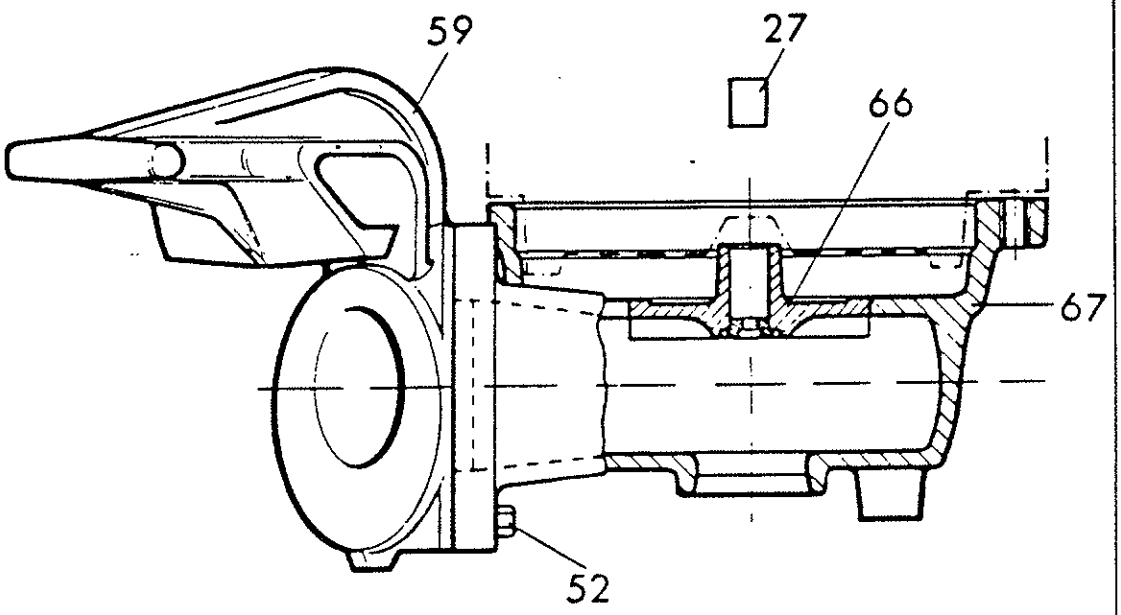


Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
52	81 41 58	Skruv (M 12 x 45) Schraube	Screw Vis	2
59		GLIDSKO GLEITKLAUE	SLIDING BRACKET GLISSIÈRE	1
	398 93 00	För rör Für Rohr	For pipes Pour tube	
60	81 41 29	Skruv (M 10 x 20) Schraube	Screw Vis	3
61	384 07 00	Sil (hålstorlek 32 x 35 mm) Sieb (Lochgrösse 32 x 35 mm)	Strainer (size of hole 32 x 35 mm) Crépine (grandeur de trou 32 x 35 mm)	1
62	398 92 01	Slitring Verschleißring	Wear ring Anneau d'usure	1
63		PUMPHJUL LAUFRAD	IMPELLER ROUE	1
	492 44 00	50 Hz Kurva nr 250 Curve No.	Genomlopp diam. 40 mm Throughlet (1.4")	
	492 44 01	50 Hz/60 Hz Kurve Nr 252 Courbe N°	Durchgang diam. 40 mm Section de passage (1.4")	
64		PUMPHUS PUMPENGEHÄUSE	PUMP CASING VOLUTE	1
	408 44 00	DN 80 3.2"		

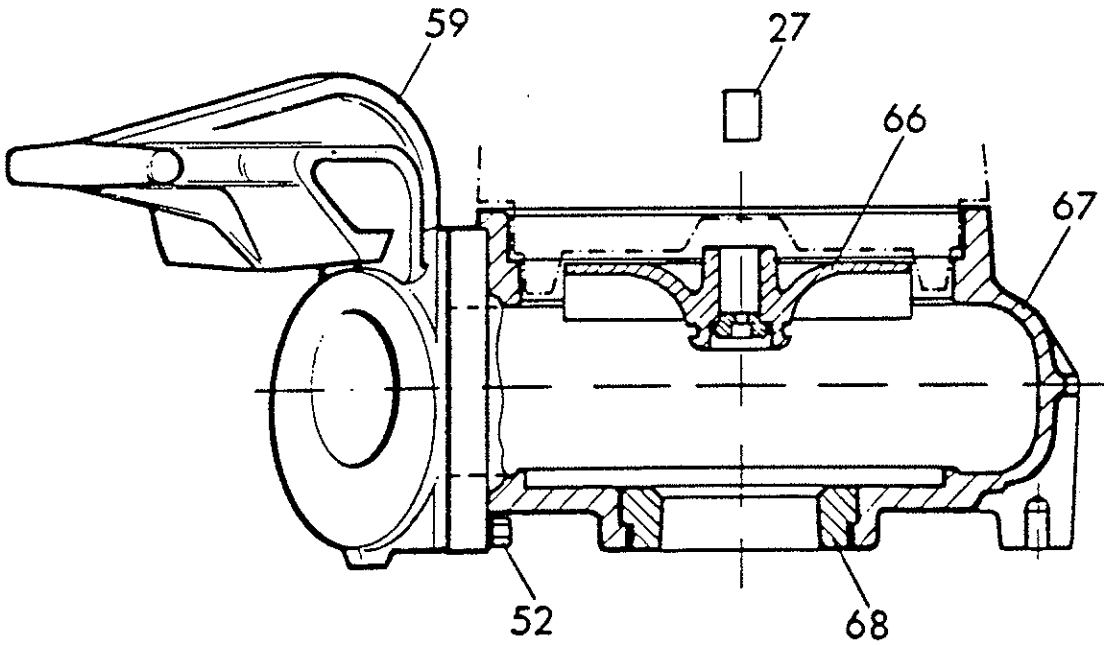
Pumpdetaljer, D-utförande
Pumpenteile, D-Ausführung

Pump parts, D-version
Pièces de la pompe, Modèle D

2 pol, HT



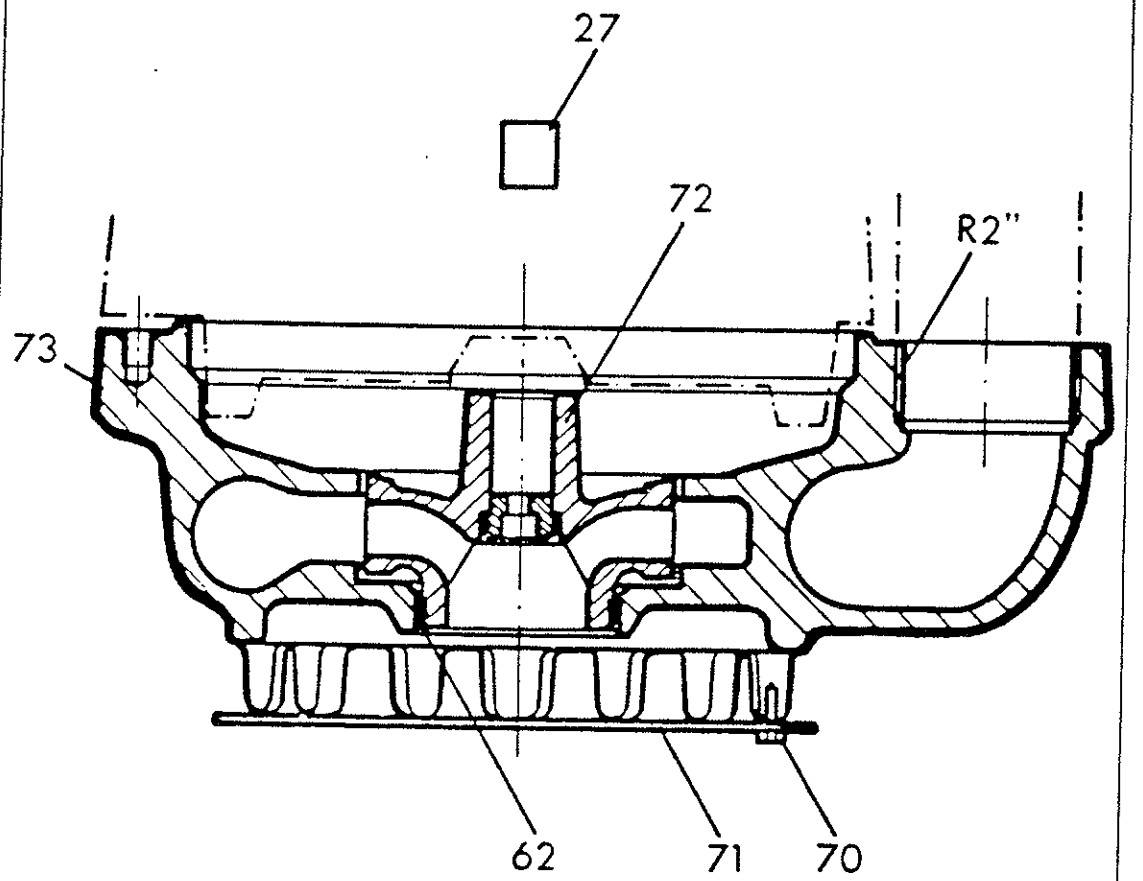
4 pol, MT



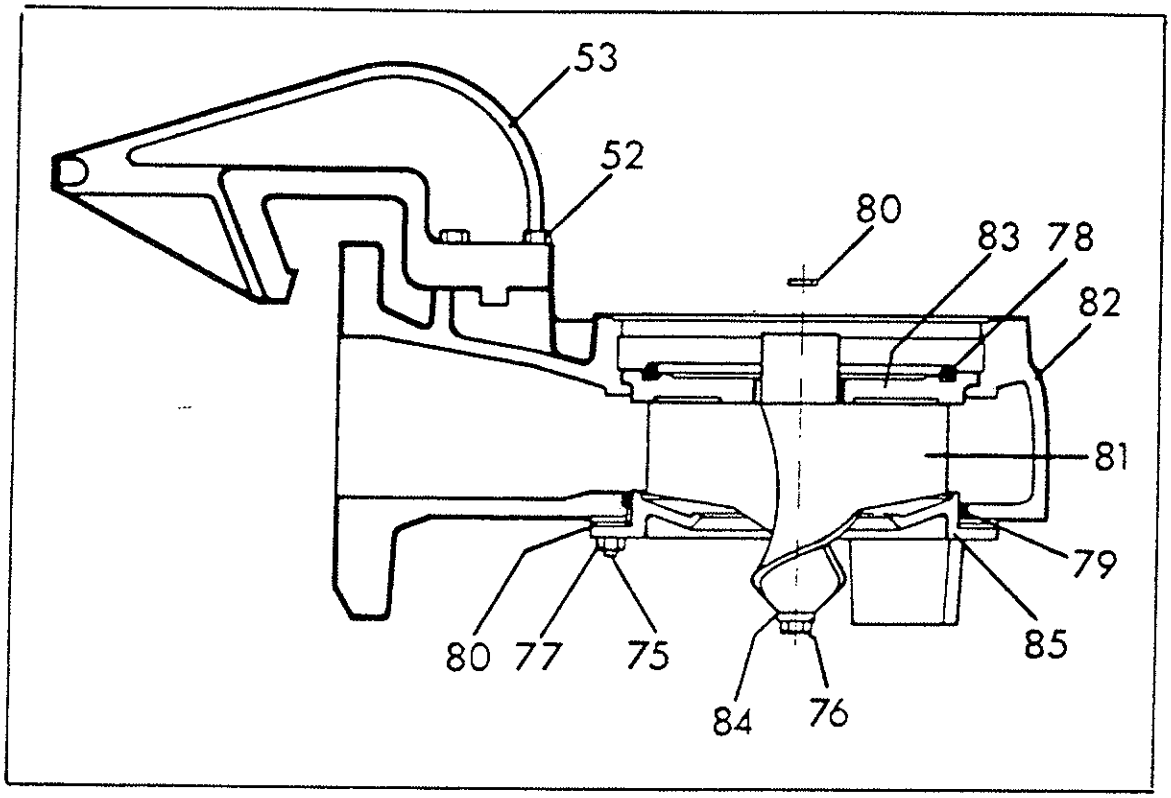
Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre	
				2-pol	4-pol
52	81 41 58	Skruv (M 12 x 45) Schraube	Screw Vis	2	2
59		GLIDSKO GLEITKLAUE	SLIDING BRACKET GLISSIÈRE	1	1
	380 91 00	För rör Für Rohr	For pipes Pour tube		
	444 67 00	För wire Für Stahlseil	For wire Pour câble		
66		PUMPHJUL LAUFRAD	IMPELLER ROUE		
	339 69 10	Kurva nr 471, 671 Curve No. Kurve Nr. Courbe n°	Pumphjulsdiam. 171 mm Impeller diam. Laufraddiam. Roue diam.	—	1
	339 69 12	473, 673	150 mm	—	1
	339 69 14	475, 675	135 mm	—	1
	339 69 16	477	120 mm	—	1
	403 86 00	276	120 mm	1	—
	403 86 01	280	114 mm	1	—
	403 86 02	278	104 mm	1	—
	403 86 03	282	101 mm	1	—
	403 86 24	284	88 mm	1	—
67		PUMPHUS PUMPENGEHÄUSE	PUMP CASING VOLUTE		
	398 90 00	DN 80		—	1
	403 87 00	3.2"		1	—
		Genomlopp Durchgang	Throughlet Section de passage	diam.52 mm (2.1")	diam.76 mm (3.0")
68	403 85 00	Ring Ring	Ring Anneau	—	1

Pumpdetaljer, GF-utförande
Pumpenteile, GF-Ausführung

Pump parts, GF-version
Pièces de la pompe, Modèle GF

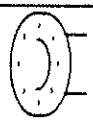


Pumpdetaljer, F-utförande
Pumpenteile, F-Ausführung
Pump parts, F-version
Pièces de la pompe, Modèle F

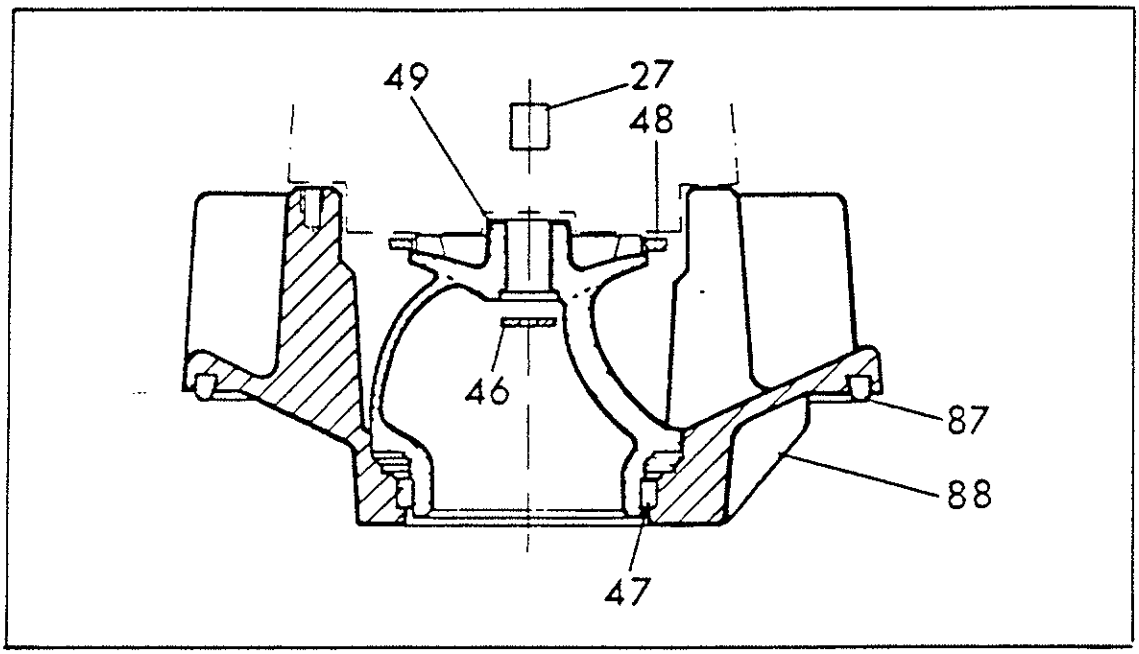


Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
52	81 41 58	Skruv (M 12 x 45) Schraube	Screw Vis	4
53		GLIDSKO GLEITKLAUE	SLIDING BRACKET GLISSIÈRE	1
	380 91 00	För rör Für Rohr	For pipes Pour tube	
	444 67 00	För wire Für Stahlseil	For wire Pour câble	
75	80 94 87	Pinnskruv (M 8 x 40) Stiftschraube	Stud Goujon	1-3
76	82 03 12	Insexskruv (M 8 x 120) Schraube	Socket head screw Vis Allen	1
77	82 27 27	Mutter (M 8) Mutter	Nut Ecrou	3

Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
62	398 92 01	Slitring Verschleißring	Wear ring Anneau d'usure	1
70	81 40 80	Skruv (M 6 x 15) Schraube	Screw Vis	3
71	253 66 01	Silbotten Siebboden	Strainer bottom Fond de crépine	1
72		PUMPHJUL LAUFRAD	IMPELLER ROUE	1
	399 18 01	50 Hz/60 Hz Kurva nr 244 Curve No. Kurve Nr Courbe N°	Genomlopp diam.19 mm (0.76") Throughlet Durchgang Section de passage	
73		PUMPHUS, DN 50 PUMPENGEHÄUSE, DN 50	PUMP CASING, DN 50 VOLUTE, DN 50	1
	403 83 00	Med anslutning R2" With connection R2" Mit Anschluß R2" Ance connexion R2"	SMS 36 ISO/ 228-1961	
		Genomlopp Durchgang	Throughlet diam.17 mm (0.68") Section de passage	

Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
		O-RING O-RING	O-RING ANNEAU TORIQUE	
78	82 74 28	174,1 x 8,4		1
79	82 74 94	209,3 x 5,7		1
80		JUSTERBRICKA JUSTIERSCHEIBE	ADJUSTING WASHER RONDELLE DE REGLAGE	
	82 35 17	18 x 10 x 2		15
	250 23 02	18 x 10 x 0,25		12
81		PUMPHJUL, Kurva... LAUFRAD, Kurve Nr...	IMPELLER, Curve No... ROUE, Courbe N°...	1
	410 33 00	490, 3 ~ 50 Hz		
	410 33 01	492, 3 ~ 50 Hz		
	410 33 02	491, 3 ~ 50 Hz/60 Hz		
	410 33 03	493, 1 ~ 60 Hz		
82		PUMPHUS PUMPENGEHÄUSE	PUMP CASING VOLUTE	1
	435 34 01	DN 100 4"	 SMS 342 DS 4622:1970 table 11 DIN 2533	
	435 34 05	DN 100 4"	ANSI B 16.1:1967 table 5	
83		PUMPHUSLOCK PUMPENGEHÄUSE-DECKEL	PUMP CASING COVER COUVERCLE DE VOLUTE	1
	394 39 00	50 Hz		
	410 15 00	60 Hz		
84	403 94 00	Bricka, spec. Scheibe	Washer Rondelle	1
85	435 36 00	Suglock Pumpengehäuseboden	Pump casing bottom Fond de volute	1

Pumpdetaljer, LL-utförande
Pumpenteile, LL-Ausführung
Pump parts, LL-version
Pièces de la pompe, Modèle LL



Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
46	303 45 03	Bricka Scheibe	Washer Rondelle	1
47	314 88 01	Slitring Verschleißring	Wear ring Anneau d'usure	1
48	379 79 00	Bricka Scheibe	Washer Rondelle	1
49		PUMPHJUL, Kurva nr... LAUFRAD, Kurve Nr...	IMPELLER, Curve No... ROUE, Courbe N°...	1
	379 76 00 379 33 00	412, 612 50 Hz 414, 614 50—60 Hz	Genomlopp / Durchgang / Throughlet / Section de passage: diam. 100 mm (4.0") diam. 80 mm (3.2")	
87	82 83 40	G-ring G-Ring	G-ring Anneau G	1
88	396 72 00	Ledskenedel Diffusor	Diffuser Anneau diffuseur	1

Uförande med läckage-givare FLS

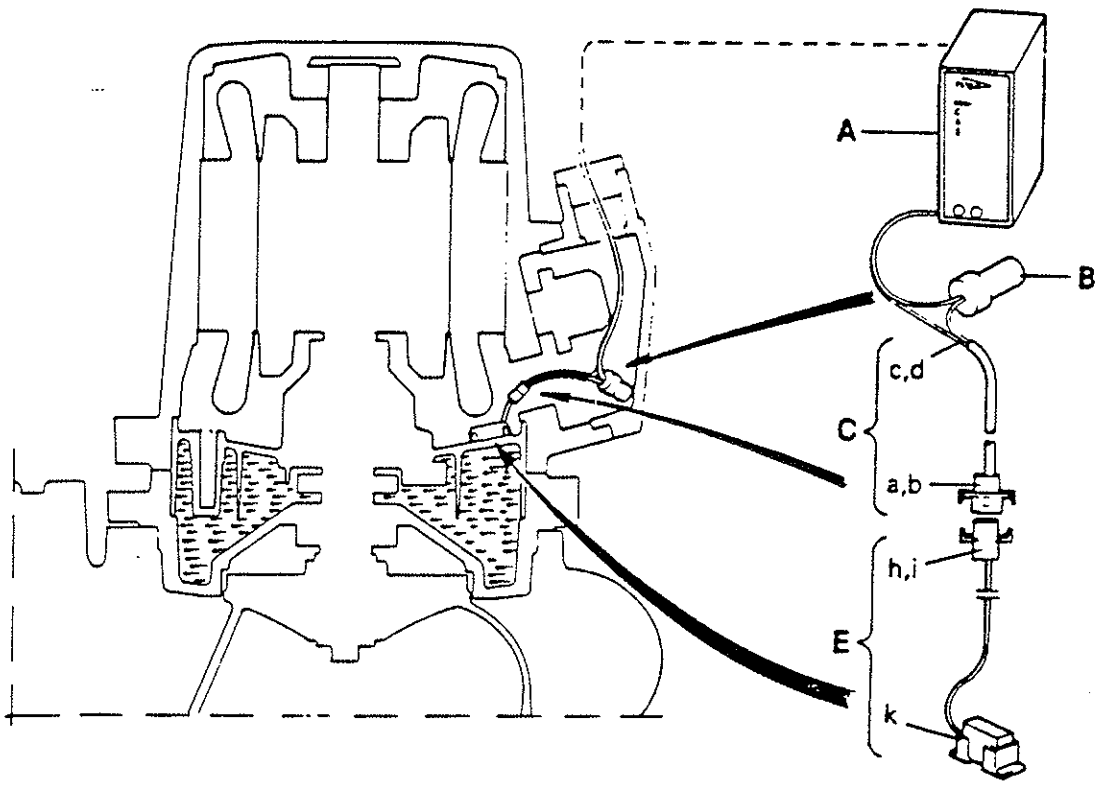
Ausführung mit leckage-detektor FLS

Version with leakage sensor FLS, floating type

Modèle avec détecteur de fuites FLS

Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
A	83 58 48	Larmreläenhet Alarmeinheit	Alarm relay unit Unité l'alarme	1
B	83 44 24	Ändhylsa Aderendhülse	End sleeve Douille de boul	2
C	504 78 07	KABELENHET KABELEINHEIT	CABLE UNIT UNIT DE CÂBLE	1
a	*	Kontakthylsa Kontakthülse	Receptacle Manchon d'accouplement	(2)
b	*	Kopplingsdon Kontakt vorrichtung	Terminale device Pince de raccordement	(1)
c	*	Ledning Kabel	Cable Câble	(1)
d	*	Ledning Kabel	Cable Câble	(1)
E	518 89 01	LÄCKAGE SENSOR ENHET, FLS LECKAGE DETEKTOR EINHEIT, FLS	LEAKAGE SENSOR UNIT, FLS UNITE DE DÉTECTEUR DE FUITES, FLS	1
k	*	Nivåvaktenhet Pegelgeber-Einheit	Level switch unit Unité de regulaterus de niveu	(1)
h	*	Kopplingsdon Kontakt vorrichtung	Terminal device Pince de raccordement	(1)
i	*	Kontaktstift Anschlussteck	Terminal Contact à fiches	(2)

* Levereras ej separat
Nicht separat geliefert
Not delivered separately
N'est pas livré séparément



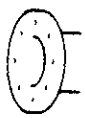
30022

Pumpgropsdetaljer CP och FP 3085
FP endast i LT-utförande
CP i samtliga utföranden

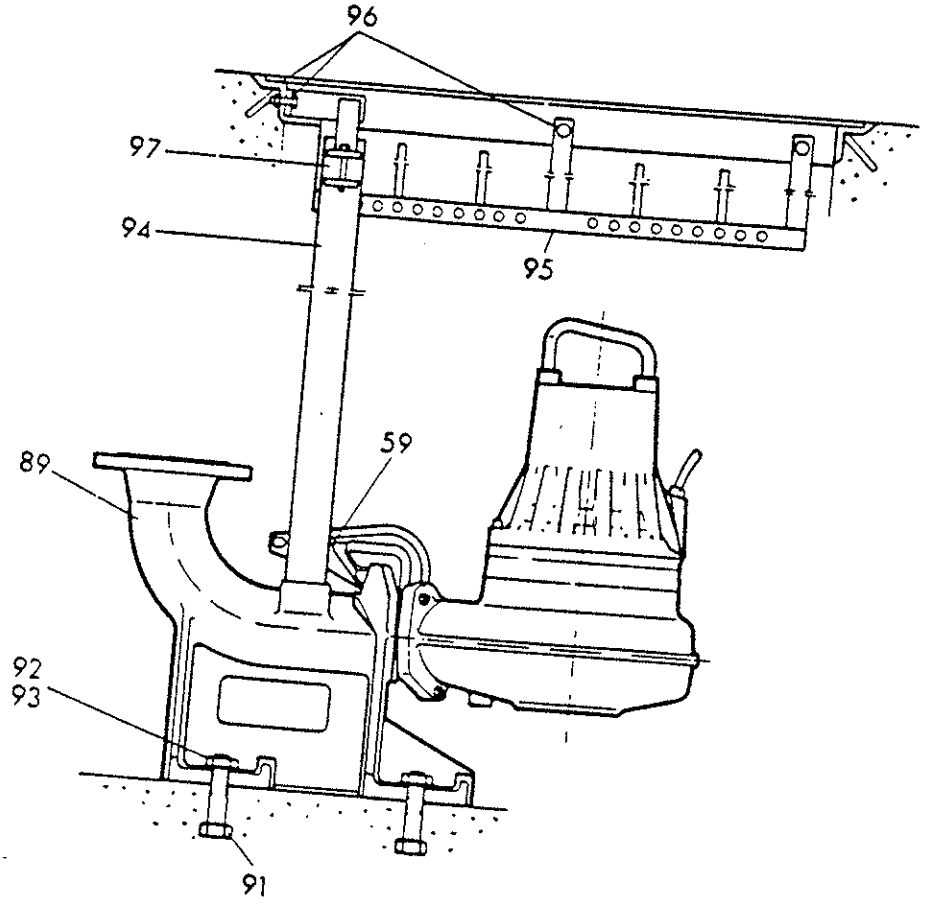
Schachteinbauteile CP und FP 3085
FP nur in LT-Ausführung
CP in alle Ausführungen

Sump Components CP and FP 3085
FP only in LT-version
CP in all versions

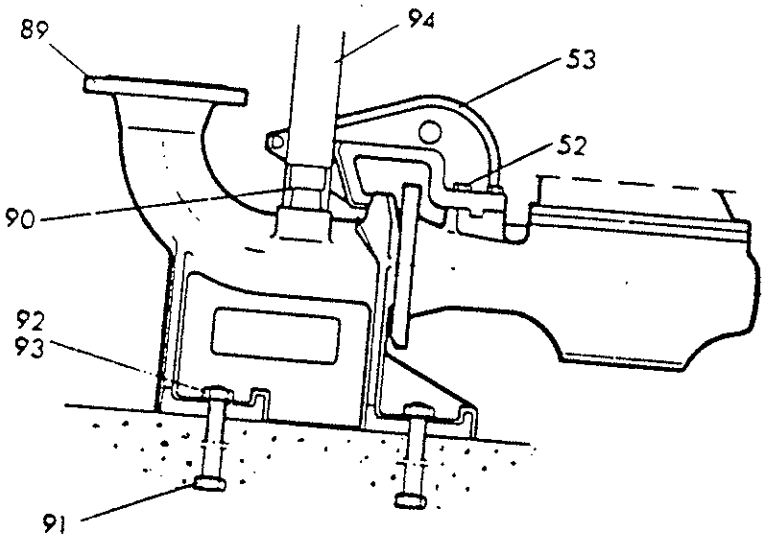
Equipement du puisard CP et FP 3085
FP seulement en modèle LT
Tous les modèles CP

Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Anzahl Quantity Nombre LT FP	MT	DP	HT
89		KOPPLINGSFOT KUPPLUNGSFUß	DISCHARGE CONNECTION ASSY. PIED D'ASSISE				
	444 68 00	DN 80 (3.2")		—	1	1	1
	444 69 00	DN 100 (4.0")		1	1	1	—
							
	444 69 01	DN 100 (4.0")	SMS 342, DIN 2533 BS 4622:1970 Table 11	1	1	1	—
	444 69 05	DN 100 (4.0")	ANSI B 16.1:1967 Table 5	1	1	1	—
	444 68 01	DN 80 (3.2")	SMS 342. DIN 2533, 1882 Standard	—	1	1	1
	444 68 05	DN 80 (3.2")	ANSI B 16.1:1967 Table 5	—	1	1	1
	444 68 07	DN 80 (3.2")	BS 4622:1970 Table 11	—	1	1	1

CP, ~~DP~~ (MT, HT)



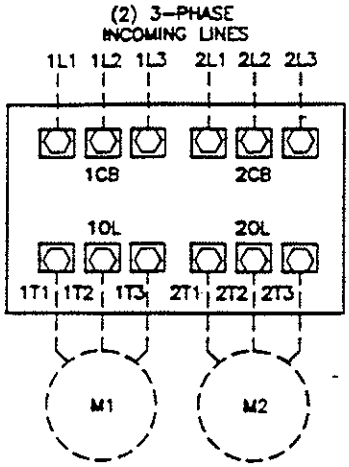
CP (LT), ~~FP~~



Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
90	255 47 00	Mellanlägg Gummihülse	Rubber sleeve Manchon	2
91	81 39 82	Skruv (M 20 x 120) Schraube	Screw Vis	4
92	82 35 26	Bricka (21 x 36) Scheibe	Washer Rondelle	4
93	82 23 62	Mutter (M 20) Mutter	Nut Ecrou	4
94		Varförzinkat rör 2" SMS 326 Feuerverzinktes Rohr 2" DIN 2440	Tube hot dip galv. 2" ISO 65 Tube galvanisé à chaud	2
95	251 36 00	Sladdhållare Kabelhalter	Cable holder Fixe-câbles	1
96		INMURNINGSRAMENHET EINSTIEGRAHMEN	ACCESS FRAME CADRE DE TRAPPE D'ACCES	1
	304 18 00	Enkel station Svartmålad Einpumpenstation Schwartzgemalt	Single station Black painted Station simplex Peinte en noir	
	304 18 01	Enkel station Varmgalvaniserad Einpumpenstation Feuerverzinkte Station	Single station Hot dip galv. Station simplex Galvanisée à chaud	
97		ÖVRE GEJDFÄSTE OBERER FÜHRUNGS- ROHRHALTER	UPPER GUIDE HOLDER ATTACHE SUPERIEURE POUR BARRES DE GUIDAGE	1
	304 28 00	Svartmålad Schwartzgemalt	Black painted Peinte en noir	
	304 28 01	Varmförzinkad Feuerverzinkt	Hot dip galv. Galvanisée à chaud	

Tillbehör Accessories
Zubehör Accessoires

Pos nr Item No. Pos.-Nr. N° de repérage	Detalj nr Part No. Bestell-Nr. N° de pièce	Benämning Bezeichnung	Denomination Désignation	Antal Quantity Anzahl Nombre
		SLANGKLÄMMA SCHLAUCHSCHELLE	HOSE CLAMP COLLIER DE SERRAGE POUR TUYAU	
	82 31 33	3"		
	82 31 36	4"		
		SLANG SCHLAUCH	HOSE TUYAU	1
		Flygt Standard	2 kordlager / 2 Gexebeeinlagen / 2-ply / double armature	
	94 06 28	3" 10, 20, 40 m (33, 66, 132 ft)		
	94 06 29	4" 5, 10, 20, 40 m (16.5, 33, 66, 132 ft)		
		Flygt High Head	2 kordlager / 2 Gexebeeinlagen / 2-ply / double armature	
	94 06 58	3" 10, 20, 40 m (33, 66, 132 ft)		
	94 06 59	4" 5, 10, 20, 40 m (16.5, 33, 66, 132 ft)		
		Flygt RVC Standard	1 kordlager / 1 Gewebeeinlagen / 1-ply / mono-armature	
	94 06 65	3" 10, 20, 40 m (33, 66, 132 ft)		
	94 06 66	4" 5, 10, 20, 40 m (16,5, 33, 66, 132 ft)		
		Flygt PVC Superior	2 kordlager / 2 Gewebeeinlagen / 2-ply / double armature	
	94 06 70	3" 10, 20, 40 m (33, 66, 132 ft)		
	94 06 71	4" 5, 10, 20, 40 m (16.5, 33, 66, 132 ft)		



WIRE SIZE CU/AL – LINE TERMINALS (1)(2)

MAXIMUM HORSEPOWER (EACH)	VOLTAGE
	440–480V
3	#12 AWG–#3/0 AWG

WIRE SIZE CU/AL – MOTOR TERMINALS (1)(2)

MAXIMUM HORSEPOWER (EACH)	VOLTAGE
	440–480V
3	#14 AWG–#8 AWG

(1) PER PHASE

(2) FOR CORRECT WIRE SIZING, REFER TO THE NATIONAL ELECTRICAL CODE, NFPA70.

#1	2	3	4	23	24	25	28	29	30	1W1	1W2	2W1	2W2	100	101	102	103	104	105	106	107

1W1, 1W2: TO PUMP #1 MOTOR SENSOR

2W1, 2W2: TO PUMP #2 MOTOR SENSOR

100, 101, 102, 103: N.O., N.C. — PUMP #1 RUNNING REMOTE ALARM CONTACTS

104, 105, 106, 107: N.O., N.C. — PUMP #2 RUNNING REMOTE ALARM CONTACTS

108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	200	201

108, 109, 110, 111: N.O., N.C. — HIGH HIGH WATER LEVEL REMOTE ALARM CONTACTS

112, 113, 114: N.O., N.C. — PUMP MOTOR #1 SEAL LEAK REMOTE ALARM CONTACTS

115, 116, 117: N.O., N.C. — PUMP MOTOR #2 SEAL LEAK REMOTE ALARM CONTACTS

118, 119, 120: N.O., N.C. — PUMP MOTOR #1 OVERTEMP REMOTE ALARM CONTACTS

121, 122, 123: N.O., N.C. — PUMP MOTOR #2 OVERTEMP REMOTE ALARM CONTACTS

200, 201: SEPARATE 110–120 VAC SINGLE PHASE INCOMING LINES

TERMINAL TIGHTENING TORQUE		
TERMINAL TYPE	WIRE SIZE	TIGHTENING TORQUE
CONTROL AND ALARM TERMINALS	#14–10 AWG	9 lb-in

INTRINSICALLY SAFE TERMINAL BLOCKS

8	9	10	11	12

8: TO STOP PUMP LEVEL PROBE

9: TO START LEAD PUMP LEVEL PROBE

10: TO START LAG PUMP LEVEL PROBE

11: TO HIGH HIGH WATER LEVEL PROBE

12: TO REF. PROBE OR TANK GND.

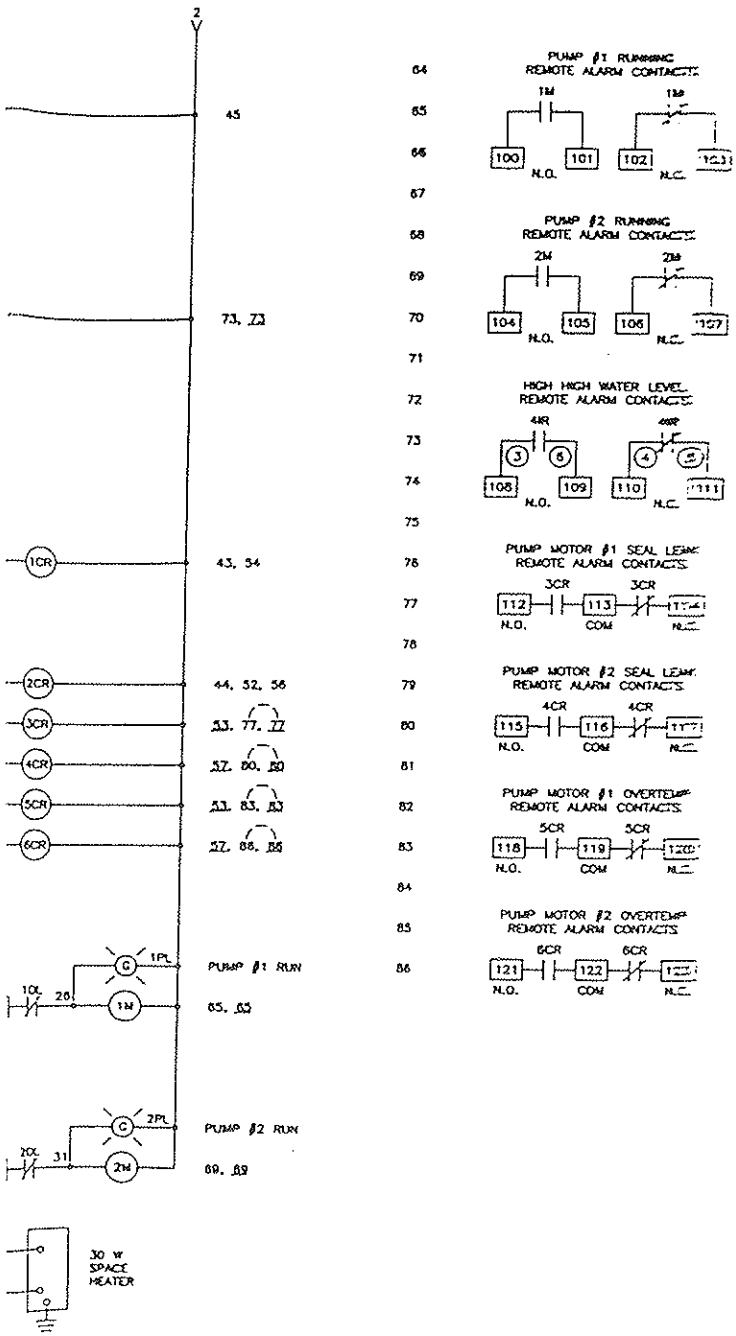
CONTACTS RATED FOR PILOT DUTY ONLY. 120 VAC, 10 AMPS MAXIMUM LOAD.

PELHAM BAY LANDFILL
P.O.# E18811

G.A. Fleet Associates, Inc.
P.O. BOX 616
HARRISON, NY 10528

DWG. NO.	
FC58550-01	
DATE 10/3/94	REV. A

LOC: A-JOB FILE



PELHAM BAY LANDFILL
P.O.# E18811

			FTA620: DUPLEX PUMP CONTROLLER					
								LOC: C-JOB FILE
D	10/3/94		CUST.			P.O.	MARK	
D	8/27/94	CFD	DRTM.	CFD	ENG.	CFD	DWG. NO.	WS58550-01
	DATE	APVD.	DATE	4/29/94	SCALE			

68.4

Service Log

Most recent service date	Pump No.	Hours of operation	Remarks	Signature