REPSG
React Environmental
Professional Services Group, Inc.

May 19, 2017

Maryland Department of the Environment
Oil Control Program
1800 Washington Boulevard
Baltimore, Maryland 21230-1719
Attn: Ms. Jeannette DeBartolomeo

RE: Dual-Phase Extraction System Startup Summary
Calvert Citgo
2815 North East Road
North East, MD
MDE OCP Case No. 1992-2616CE
Facility No. 5678
REPSG Project Reference Number 5977.130.02

Regulatory Information

Regulatory Agency:	Maryland Department of the Environment
Agency Contact:	Jeannette DeBartolomeo
Case Number:	OCP Case No. 1992-2616CE
Facility ID:	5678
General Discharge Permit Number:	2017-OGR-25712
NPDES Permit Number:	MDG919013
Vacuum Extraction System Permit:	015-0173-9-0226
Current Case Status:	Quarterly groundwater sampling. On-Site and off-Site potable well monitoring. Vapor Extraction/Groundwater Extraction (DPE) system in operation.
Reporting Period:	April 24, 2017 to May 19, 2017

General Site Information

Calvert Country Store Contact:	Chandrakant Patel Pragnesh Patel
Consultant Contact:	Suzanne Shourds
Facility Status:	Operating Fuel Station
Area Property Use:	See Site Location Map and Site Map (Figures 1 and 2)

P.O. Box 5377
6901 Kingsessing Avenue, Suite 201
Philadelphia, PA 19142-0377

215 729.3220
215 729.1557 (Fax)
www.repsg.com

Monitoring Wells:	MP-001, MP-002, MW-001R, MW-002, MW-003, MW-005, MW-006 through MW-010, MW-008D through MW-010D
Vapor Monitoring Wells:	VMP-001 through VMP-004
Current DPE System Wells:	MW-005R
Future DPE System Wells:	MW-001 and MW-003R
Potable Wells:	DW-001 (on-Site), DW-004 (2794 North East Road), DW-005 (2802 North East Road)

Introduction

A Corrective Action Plan (CAP) and CAP Addendum detailing the feasibility of utilizing dual-phase extraction (DPE) for contaminant mass removal of petroleum-related regulated compounds in groundwater from the Calvert Citgo property located at 2815 North East Road, in Northeast, MD (the "Site") was initially approved by the Maryland Department of the Environment (MDE) in correspondence dated October 1, 2013. On October 6, 2014, following the completion of investigatory portions of the CAP, as well as additional on-Site and off-Site investigatory activities, the CAP was placed on hold by the MDE during a meeting between personnel from the MDE, React Environmental Professional Services Group, Inc. (REPSG), and Responsible Parties.

Subsequent to the October 2014 meeting, and following the completion of additional off-Site investigatory activities in 2014 and 2015, the MDE issued correspondence on February 26, 2016 reinitializing the CAP for the Site. On October 12, 2016, the MDE issued a Notice of Non-Compliance requiring immediate implementation of the DPE system as described in the approved CAP and CAP Addendum.

October 28, 2016, REPSG responded to the Notice of Non-Compliance detailing the responsible parties intent to comply with the requirements set forth in the letter. Within the Notice of Non-Compliance letter response, REPSG clarified the planned scope of implementation for the DEP System at the Site, which would include a large-scale system trenching and piping installation, which would be run in a step-wise manner, rather than a small-scale system as to avoid multiple mobilizations thereby reducing cost and to provide fewer disruptions to the operations of the service station. REPSG anticipated implementation of the DEP system at the Site would commence no later than December 31, 2016.

To comply with the requirements, REPSG began the process of securing the necessary permits for implementation of the CAP. These included: a Notice of Intent (NOI) for the Discharge of Treated Groundwater/National Pollutant Discharge System (NPDES) permit application, which was submitted on November 22, 2016, and approved on April 10, 2017; a Soil Vapor Extraction & Groundwater Air Stripping permit application, which was submitted on November 22, 2016 and approved on December 27, 2016; and all associated construction and electrical permits needed for installation and system start up.

Initial Site installation work activities began on December 12, 2016. Following the receipt of all permits, the completion of trenching & piping, system design and construction, and local utility

electrical installation and approval, the DPE system at the Site was initially started on April 24, 2017.

The system consists of a network of monitoring wells that have been converted to extraction wells piped to a central remediation system. This document is provided to illustrate the system location, dimensions, components, and functionality of the remediation system. This report will serve to summarize the month of operation, including both active-run days and system down-time.

Figure 1 in **Attachment 1** illustrates the Site vicinity. **Figure 2** illustrates the groundwater monitoring well network, on-Site and off-Site potable wells, and vapor monitoring points.

Monitoring Well Conversion and Vault Installation

As described in the May 2013 CAP, the DPE system was initially designed to include up to seven multiphase extraction wells. Four of the extraction wells were to be newly constructed, and three previously installed monitoring wells (MW-001, MW-003, and MW-005) were to be converted to extraction wells. These monitoring wells were chosen to be converted to extraction wells based on their proximity to the source area. Per the June 2013 CAP Addendum letter, the wells selected to become extraction wells were changed to MW-001R, MW-003R, and MW-005R.

As indicated on monitoring well construction logs, monitoring well MW-001R contains 15 feet of screen from 30 feet below grade (fbg) to 45 fbg, while both MW-003R and MW-005R contain 10 feet of screen from 15 fbg 25 fbg. All three wells are four-inches in diameter and are constructed with schedule 40 PVC piping with 0.2-inch slots as the screen material and unslotted schedule 80 PVC piping as the casing material. Upon review of the construction details of the three wells, REPSG determined that MW-001R was not appropriate for reuse as an extraction well, and opted to utilize MW-001 for the DPE system instead. Construction logs indicated MW-001 contains nine feet of screen from 19 fbg to 28 fbg and is constructed similar to MW-003R and MW-005R.

According to the June 2013 CAP Addendum, the four extraction wells proposed for installation as part of the proposed DPE system were also to be constructed of four-inch diameter PVC materials. The new extraction wells are to be installed to a total depth of 25 fbg, and screened from 10 fbg to the bottom of the well.

Remediation Equipment & Services (RES) began construction activities on December 12, 2016 for the installation of the DPE system. Monitoring wells MW-001, MW-003R, and MW-005R were successfully converted to extraction wells and were enclosed in traffic grade well vaults. In order to convert each of these wells over to extraction wells for use by the active DPE system, each well is fitted with a one-inch PVC riser that extends to approximately one foot below the static water level and is used for extraction. The well heads are housed within 18 inch by 18 inch traffic grade well vaults. Each vault contains a well head and a one-inch PVC connected to the riser within the well that connects to a two-inch PVC line which ties into the DPE system. The bottom of each well vault is finished with concrete.

In preparation for future extraction wells to be installed at the Site, an additional vault was installed on the eastern portion of the Site. No active extraction wells were installed in this vault, however, piping connecting the vault to the DPE system has been installed. Once the DPE system has demonstrated success, new extraction wells can be installed and/or converted as appropriate, and connected to the system. **Figure 3** details the design in each vault for the multiphase extraction wells. RES completed installation of the vaults on December 22, 2016.

Trenching and Piping Installation

Trenching work began at the Site on December 12, 2016. One dedicated subsurface PVC pipe runs from each vault into the DPE system. All piping connections were accomplished using primed and glued pressure couplings. The pipes were underlain by pea gravel and pea-gravel was used to fill trenches to four inches below grade. On December 28, 2016, trenches were then topped with compacted stone (mud stone). On January 3, 2016, concrete was poured over the trenches. On January 4, 2017, a paving contractor arrived on-Site and trenches were paved with a two-inch binder and topped with a two-inch top coat, to bring the trenches to grade. Due to inclement weather, additional on-Site asphalt paving repairs and clean up were completed in association with the trenching and piping installation through January 30, 2017. **Figure 4** depicts the trenching and piping runs.

In order to supply power to the DPE system, a dedicated electrical panel service box was installed by the local electrical utility, Delmarva Power, on the northern wall of the existing on-Site structure. Installation and approval for use of this dedicated electrical supply service box by the local electrical utility was completed the week of April 10, 2017. An electrical conduit running from the dedicated electrical service box connects to the DPE system trailer interior electrical panel.

In addition to the piping runs between the extraction wells and the DPE system, and the electrical conduit running from the exterior electrical supply service box to the DPE system trailer, a discharge line for recovered water leading from the DPE system to a temporary on-Site frac tank, located to the northwest of the DPE system, was installed.

The locations of the DPE system components and frac tank are provided in **Figure 4**.

Equipment Installation

At present, the on-Site DPE system trailer is a rental unit owned by RES. The unit was specifically calibrated to meet the needs of the Site and the requirements of the approved DEP system as described within the CAP and CAP Addendum. Calibration and adjustments to this system trailer were begun by RES at their facility in December 2016, and were completed in February 2017, with delivery of the trailer to the Site occurring the week ending February 28, 2017.

A system control panel and interior electrical panel are mounted on the inside of the DPE system trailer. The interior of the system houses a positive displacement vacuum blower for vapor removal, phase separation tank (moisture separator), a fluid transfer pump (for recovered groundwater), an inline filter for vapor, a secondary moisture separator, and a flow totalizer to

record the total volume of groundwater recovered. The equipment and wiring in the interior of the system are rated for explosive environments. Initially, vapor phase carbon (VPC) units were placed on the exterior of the system and were connected to treat the vapor effluent from the DPE system. A manual for the DPE trailer system is included as **Attachment 2**.

System Startup

On April 24, 2017, REPSG and RES personnel were on-Site to conduct DPE system startup activities. Test runs were performed on each of the individual wells and subsequently on all the wells simultaneously that are tied into the system to ensure that the system was operating correctly. To evaluate the effectiveness of the vacuum extraction, baseline pressure readings were collected prior to system startup from various vapor monitoring points (VMPs) and groundwater monitoring wells located near the converted well in which extraction was being performed. All baseline pressure readings were less than 1 "inches of water" of pressure. Once baseline pressures were established, extraction commenced and new pressure readings were collected. REPSG observed significant pressure differentials indicative of the vacuum extraction creating an effective radius of influence at each extraction well. Readings were collected using magnehelic pressure gauges to ensure that an area of influence was being established at each extraction point (see **Table 1**).

Table 1 – April 24, 2017 System Pressure Differential During Extraction (in inches of water)

MW-005	VMP-001	VMP-002	VMP-003	VMP-004
15	10	6	3.5	2

During extraction, REPSG measured concentrations of volatile organic compounds (VOCs) in the exhaust of the system to ensure acceptable levels were being emitted into the atmosphere. Measurements were made utilizing a photoionization detector (PID) at three discrete locations: pre-VPC filtration, mid-VPC filtration, and post-VPC filtration (see **Table 2**).

Table 2 – April 24, 2017 System PID Readings

Pre-VPC Filtration	Mid-VPC Filtration	Post-VPC Filtration
400 parts per million (ppm)	1 ppm	0.5 ppm

All PID readings were in-line with REPSG's expectations and demonstrated that the VPC units were effective. As indicated in REPSG's October 2016 response to the Notice of Non-Compliance, the system was set to extract from MW-005R only during initial startup activities. MW-005R has been selected as the initial well for treatment as it is the well with the highest levels of contamination at the Site. Treatment operations are planned on MW-005R for approximately three months to allow for a full evaluation of the success rate of the system, prior to the expansion of the DPE system to include additional wells.

On April 26, 2017, REPSG personnel returned to the Site to ensure the system was functioning properly. The system was still operating, however, PID readings collected at the VPC unit locations indicated breakthrough levels of VOCs which were indicative of the carbon within the VPC tanks having been expended (see **Table 3**). After approximately 48 hours of operation and the removal of approximately 800 gallons of groundwater, the system was shut down pending an evaluation of next steps.

Table 3 – April 26, 2017 System PID Readings

Pre-VPC Filtration	Mid-VPC Filtration	Post-VPC Filtration
550 ppm	250 ppm	250 ppm

After reviewing the available data, it was determined that the VPC tanks would be disconnected from the system and a catalytic oxidizer would be installed to address the high volume of contaminates being recovered. On May 4, 2017, following the completion of calibration and technical adjustments, the catalytic oxidizer was installed and the VPC units disconnected.

On May 10, 2017, the system was restarted utilizing the catalytic oxidizer. The Site's Case Manager for the MDE, Jeannette DeBartolomeo, was on-Site for the initiation of the system. To evaluate the effectiveness of the vacuum extraction, pressure readings were collected from various VMPs and groundwater monitoring wells located near the converted well in which extraction was being performed. REPSG observed significant pressure differentials indicative of the vacuum extraction creating an effective radius of influence at each extraction well. Readings were collected using magnehelic pressure gauges to ensure that an area of influence was being established at each extraction point (see **Table 4**).

Table 4 – May 10, 2017 System Pressure Differential During Extraction (in inches of water)

MW-005	VMP-001	VMP-002	VMP-003	VMP-004
10	8	6	3	1

During extraction, REPSG measured concentrations of volatile organic compounds (VOCs) in the exhaust of the system to ensure acceptable levels were being emitted into the atmosphere. Measurements were made utilizing a PID at two discrete locations: pre-catalytic oxidizer and post- catalytic oxidizer (**Table 5**).

Table 5 – May 10, 2017 System PID Readings

Pre-Catalytic Oxidizer	Post-Catalytic Oxidizer
280 ppm	0.4 ppm

All PID readings were in-line with REPSG's expectations and demonstrated that the VPC units were effective. As previously, the system was restarted and set to extract from only MW-005R.

REPSG personnel returned to the Site on May 12, 2017 to confirm that the system was functioning properly. PID readings showed VOC concentrations in the system exhaust to be at acceptable levels (see **Table 6**).

Table 6 – May 12, 2017 System PID Readings

Pre-Catalytic Oxidizer	Post-Catalytic Oxidizer
370 ppm	2 ppm

The system continues to run and is still only extracting from MW-005R at this time.

DPE System Start-Up Performance Summary

System Operation

Period:	April 24, 2017 to May 19, 2017
Operating Days:	13

Groundwater and Vapor Recovery

Cumulative Water Discharged into Frac Tank as of May 16, 2017:	1,627 gallons
Average Water Flow Rate:	125 gallons/day
Average Vapor Flow Rate:	39 cubic feet/minute

Pending Actions

Vapor influent (pre-catalytic oxidizer) and effluent (post-catalytic oxidizer) samples were collected on May 12, 2017. Effluent water samples were collected on April 26, 2017 (post-VPC filtration) and May 12, 2017 (post-catalytic oxidizer). Analytical results for these samples are pending, and will be provided in the system progress report to be submitted to the MDE for the Site by June 23, 2017.

In addition, a privacy-screened fence will be installed around the complete DPE system, including the catalytic oxidizer, frac tank, and electrical service panel, the week ending May 26, 2017. The system waste water collected within the frac tank will also be properly disposed of at that time. Details of these activities will be provided in the June 2017 system progress report.

Sincerely,

David Bishop
Environmental Scientist

Suzanne Shourds
Project Manager
React Environmental Professional Services Group, Inc

ATTACHMENT 1: FIGURES

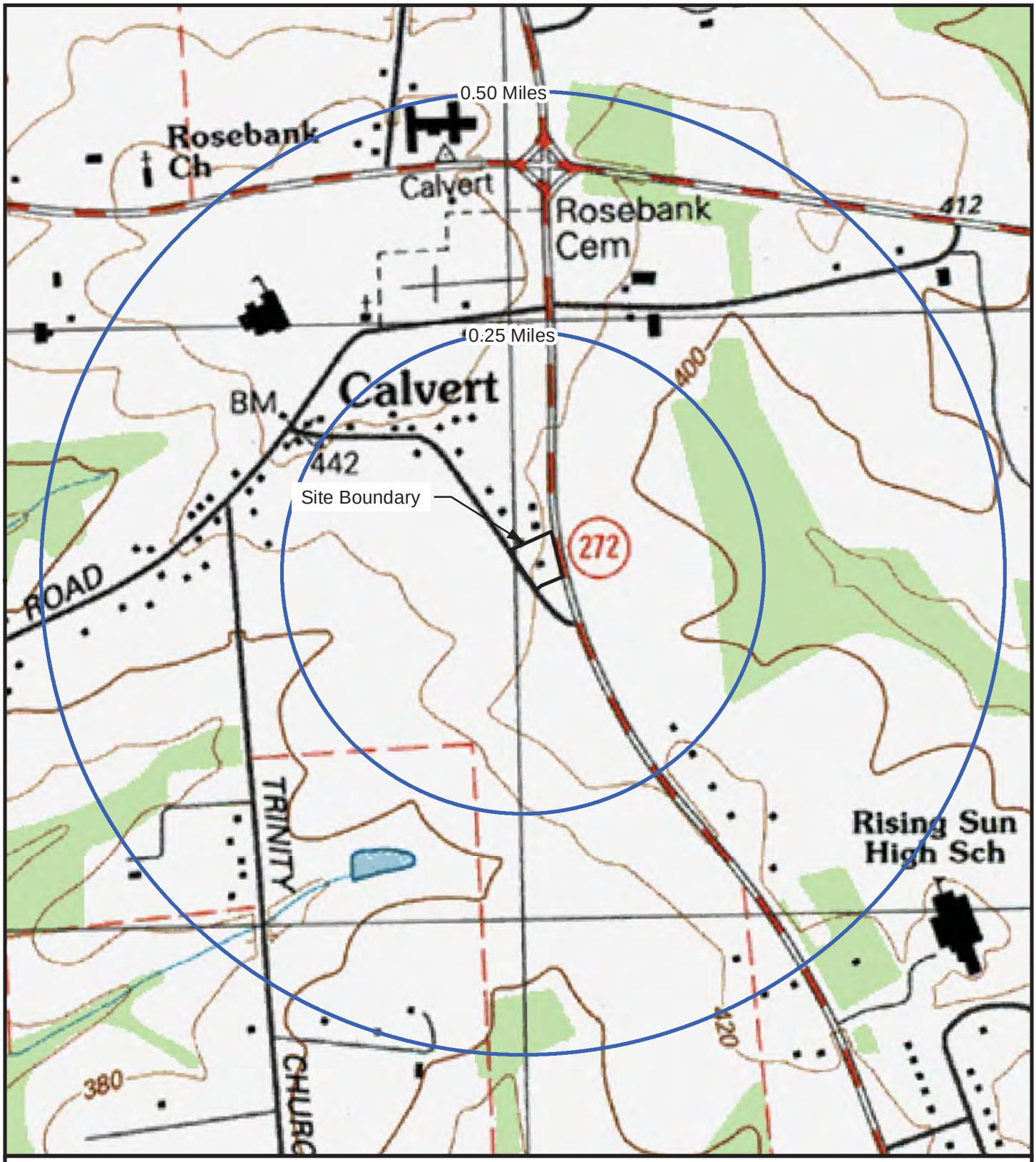

FIGURE 1: SITE LOCATION DIAGRAM

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MAP SCALE: *1 inch = 750 feet*

0 162.5 325 650 975 1,300 Feet

PROJECT NAME: ***CALVERT CITGO***

PROJECT ADDRESS: ***2815 NORTH EAST ROAD, NORTH EAST, MD***

PROJECT NUMBER: ***005977***

DATE: ***MAY 2017***

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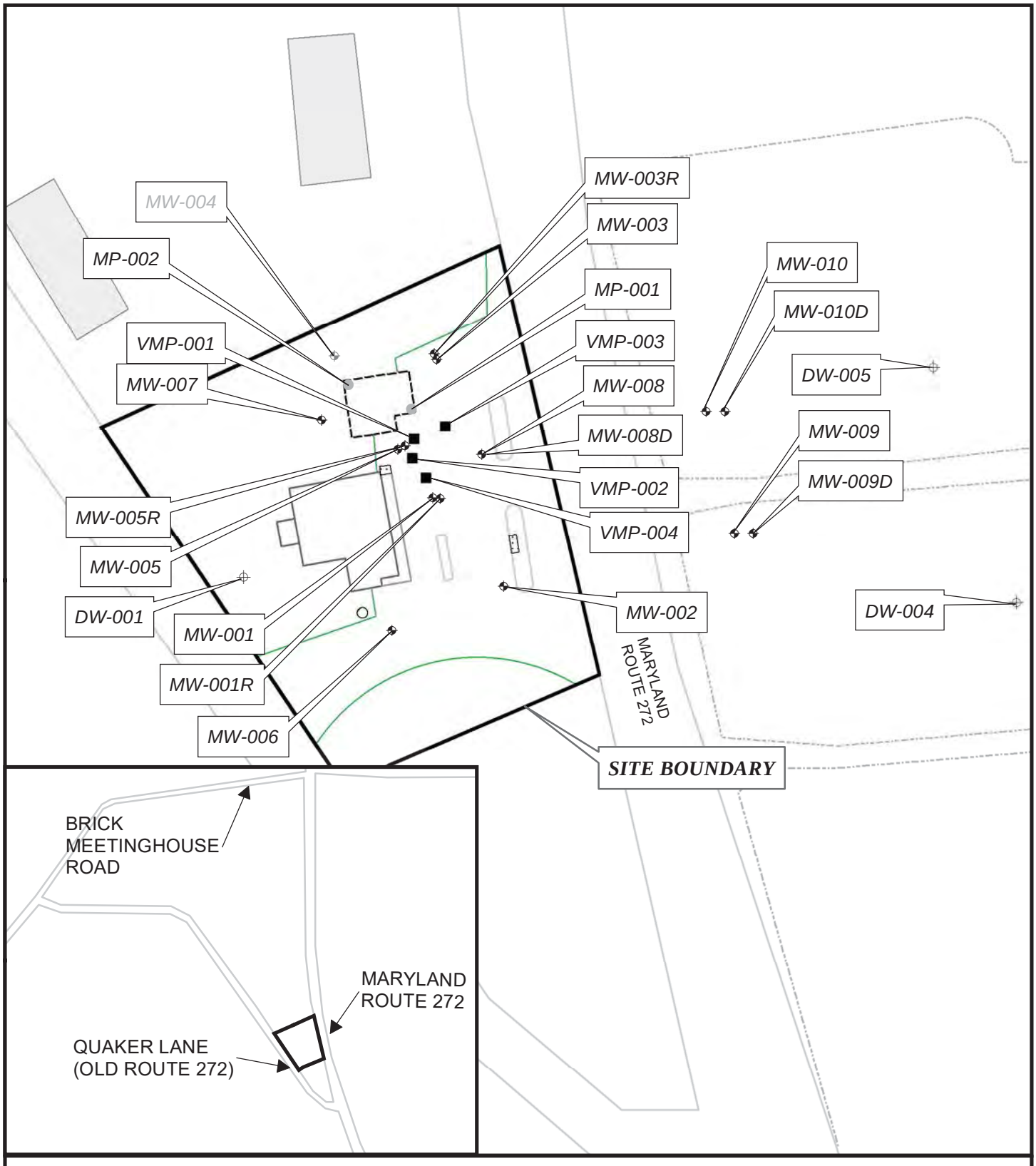

FIGURE 2: SITE PLAN

- Monitoring Well
- Lost/Abandoned Monitoring Well
- On-Site Potable Well
- Leak Detection Well
- Vapor Monitoring Points
- Diesel Pump
- Kerosene Pump
- Off-Site Bulding
- Septic Tank

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MAP SCALE: 1 inch = 75 feet
0 15 30 60 90 120 Feet

PROJECT NAME: ***CALVERT CITGO***
PROJECT ADDRESS: ***2815 NORTH EAST ROAD, NORTH EAST, MD***
PROJECT NUMBER: ***005977***
DATE: ***MAY 2017***

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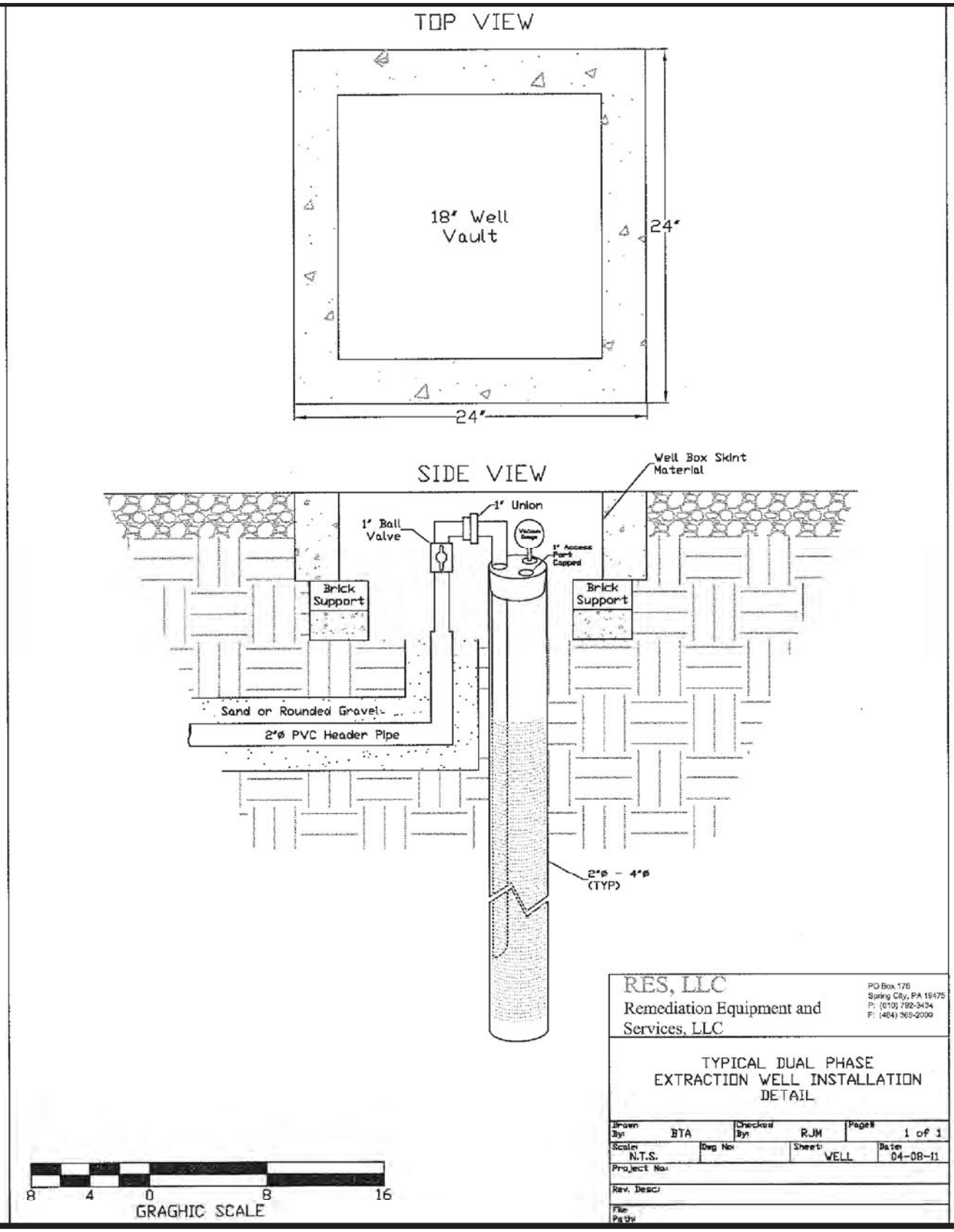

FIGURE 3: DESIGN OF MULTIPHASE EXTRACTION WELLS

REPSG
React Environmental Professional Services Group, Inc.

MAP SCALE:
NOT TO SCALE

PROJECT NAME: ***CALVERT CITGO***
PROJECT ADDRESS: ***2815 NORTH EAST ROAD, NORTH EAST, MD***
PROJECT NUMBER: ***005977***
DATE: ***MAY 2017***

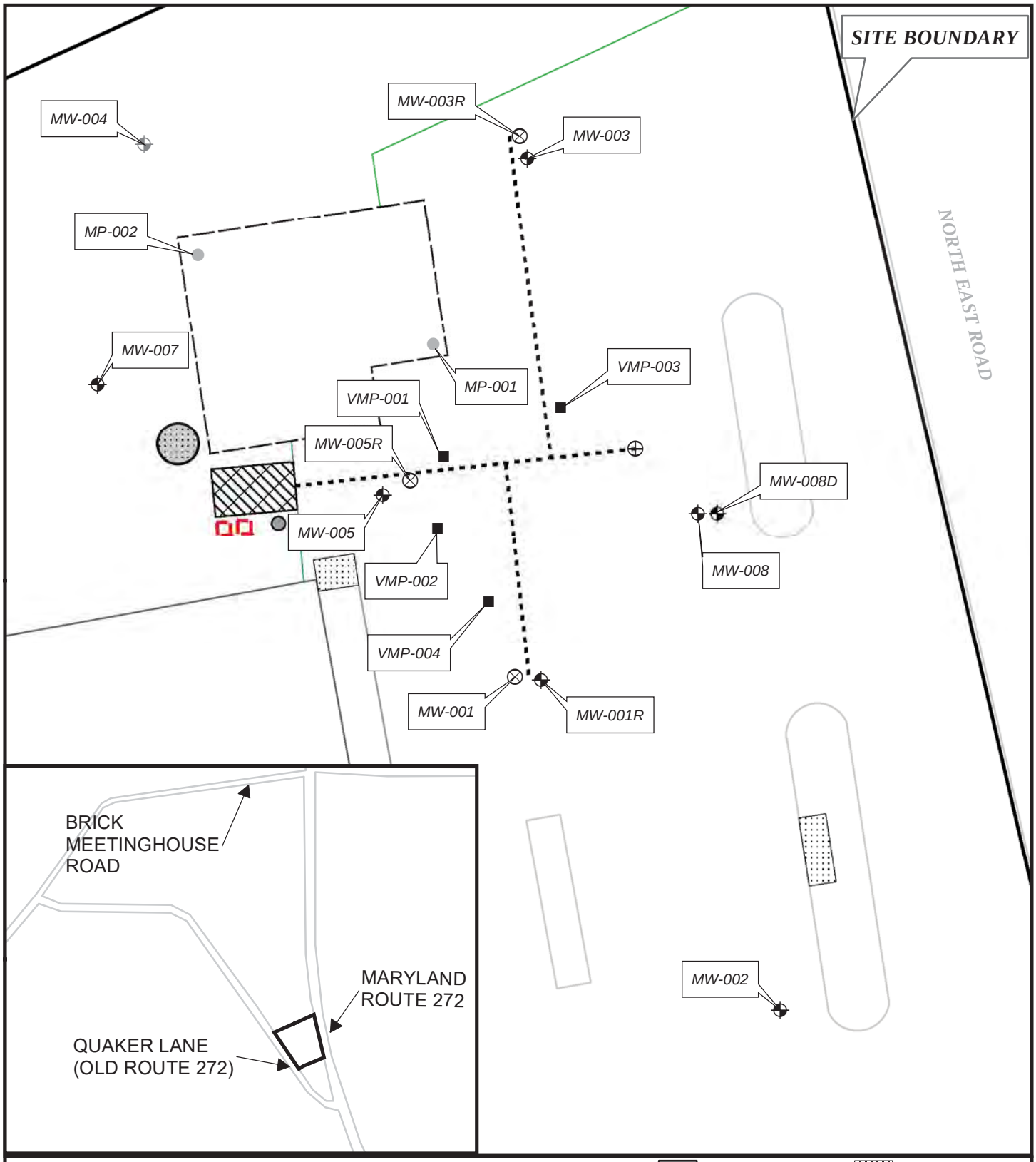

FIGURE 4: REMEDIATION SYSTEM

- Monitoring Well
- Lost/Abandoned Monitoring Well
- Leak Detection Well
- Vapor Monitoring Points
- Extraction Well
- Future Extraction Well
- GAC Unit -Disconnected
- Catalytic Oxidizer
- Remediation Trailer
- Frac Tank
- Tank Field
- Diesel Pump
- Kerosene Pump
- Septic Tank
- Extraction Piping

REPSG
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MAP SCALE: 1 inch = 20 feet

0 4 8 16 24 32 Feet

PROJECT NAME: ***CALVERT CITGO***
PROJECT ADDRESS: ***2815 NORTH EAST ROAD, NORTH EAST, MD***
PROJECT NUMBER: ***005977***
DATE: ***APRIL 2017***

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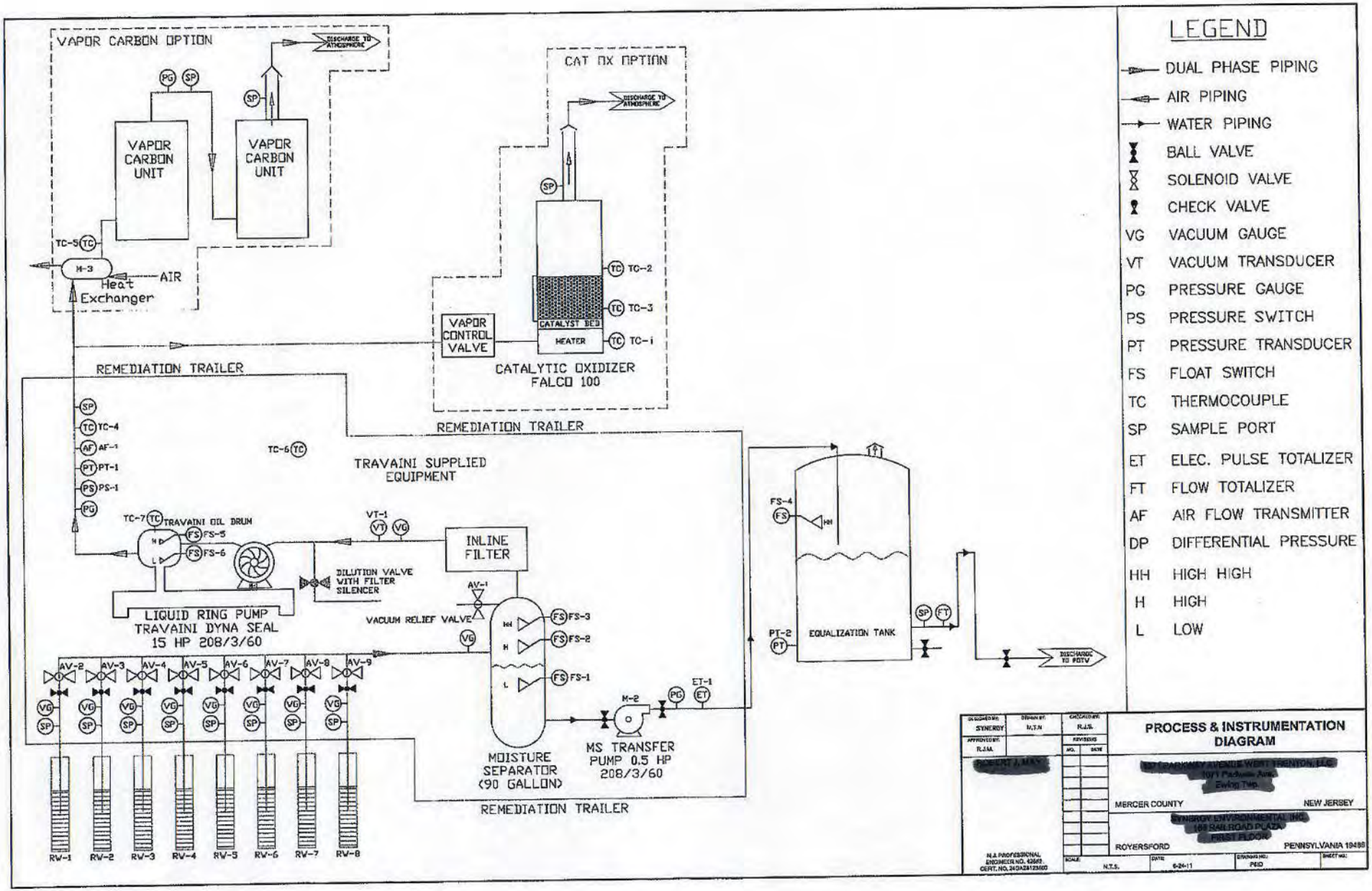
ATTACHMENT 2: DPE SYSTEM MANUAL

Section 2 Figures

- Detailed Site Plan (Need)
- SVE Well Network and Locations (Need)
- Remediation System Area Layout
- P&ID – LRP Extraction System


VAPOR CARBON OPTION
DISCHARGE TO ATMOSPHERE
VAPOR CARBON UNIT
VAPOR CARBON UNIT
CAT OX OPTION
DISCHARGE TO ATMOSPHERE
TC-5
M-3
AIR
Heat Exchanger
VAPOR CONTROL VALVE
CATALYST BED
HEATER
TC-2
TC-3
TC-1
CATALYTIC OXIDIZER FALCO 100
REMEDIATION TRAILER
REMEDIATION TRAILER
TC-4
AF-1
PT-1
PS-1
TC-6
TRAVAINI SUPPLIED EQUIPMENT
TC-7
TRAVAINI OIL DRUM
FS-5
FS-6
VT-1
INLINE FILTER
DILUTION VALVE WITH FILTER SILENCER
AV-1
VACUUM RELIEF VALVE
LIQUID RING PUMP TRAVAINI DYNA SEAL 15 HP 208/3/60
AV-2
AV-3
AV-4
AV-5
AV-6
AV-7
AV-8
AV-9
FS-3
FS-2
FS-1
MOISTURE SEPARATOR (90 GALLON)
M-2
ET-1
MS TRANSFER PUMP 0.5 HP 208/3/60
REMEDIATION TRAILER
RW-1
RW-2
RW-3
RW-4
RW-5
RW-6
RW-7
RW-8
FS-4
EQUALIZATION TANK
PT-2
DISCHARGE TO POTW
LEGEND
DUAL PHASE PIPING
AIR PIPING
WATER PIPING
BALL VALVE
SOLENOID VALVE
CHECK VALVE
VG VACUUM GAUGE
VT VACUUM TRANSDUCER
PG PRESSURE GAUGE
PS PRESSURE SWITCH
PT PRESSURE TRANSDUCER
FS FLOAT SWITCH
TC THERMOCOUPLE
SP SAMPLE PORT
ET ELEC. PULSE TOTALIZER
FT FLOW TOTALIZER
AF AIR FLOW TRANSMITTER
DP DIFFERENTIAL PRESSURE
HH HIGH HIGH
H HIGH
L LOW
PROCESS & INSTRUMENTATION DIAGRAM
MERCER COUNTY
NEW JERSEY
ROYERSFORD
PENNSYLVANIA 19468
N.T.S.
6-24-11
P&ID

Section 3 Operation Procedures

- Liquid Ring Pump system operation procedures

General Description

The remediation system at this location utilizes a dual phase extraction system via a liquid ring pump (LRP) and a Falco Catalytic Oxidizer.

The following text describes the operation and maintenance for a dual phase extraction system as manufactured by Gasho and installed at the site by Synergy Environmental Inc. The soil vapor extraction system is installed within a 14' (L) x 7' (W) x 6.5' (H) tandem axial trailer. The Master Control Panel is mounted in the interior of the trailer. All electric installation is done by AI Control Systems.

Primary System Components

- Enclosed 14 foot long by 7 foot wide trailer,
- Travaini Pumps USA LRP with knockout separator,
- 1,500 gallon holding tank,
- Falco Catalytic Oxidizer (100 cfm) with a 20-foot stack,
- AI Control Systems electrical control box
- AI Control Systems PLC with HMI using C-More system.

Process Description

Refer to the following procedures for the start-up process. After operational parameter are met, a vacuum is applied through drop tubes set approximately 12' in the extraction wells via the Liquid Ring Pump (LRP) system. Air will enter the moisture separator. If there is any entrained liquid in the influent air, it will be dropped from the air stream accumulating in the bottom of the vessel. Air is drawn through the top of the moisture separator then through a particulate filter and through the LRP system. The LRP then exhausts the vapors from its discharge port, through the trailer wall, and then through the catalytic oxidizer before discharging into the atmosphere.

Any liquid that has dropped out of the air stream will accumulate in the bottom of the moisture separator. When enough liquid has accumulated in the moisture separator, it is pumped into a 1,500 gallon holding tank. From the holding tank, the liquid is discharged to the local sanitary sewer per the local POTW permit.

Section 4 Soil Vapor Extraction System

- Travaini Pumps USA DPE with knockout separator O&M Manual
- Moyno Pumps Service Manual
- Baldor Motor Installation & Operation Manual
- Gasho Moisture Separator Specification Sheets
- Solberg Inline Filter Specification Sheet
- Falco Catalytic Oxidizer

Operating & Maintenance Manual *for* Liquid Ring Vacuum Pumps, Compressors & Systems

TRH-TRS-TRM-TRV-SA

Water Sealed & Oil Sealed (DynaSeal™) Systems

TRAVAINI PUMPS USA
Liquid Ring & Rotary Vane Vacuum Pumps and Systems

TRAVAINI PUMPS USA
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Web Site: www.travaini.com

PRINTED IN USA
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DATE 4/02

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

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

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

MANUFACTURER:

TRAVAINI PUMPS USA
200 Newsome Drive
Yorktown, VA 23692
Telephone: (757) 988-3930
Fax: (757) 988-3975
Website: www.travaini.com

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

PROPRIETY DOCUMENT:

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

TRAVAINI PUMPS USA
Liquid Ring & Rotary Vane Vacuum Pumps and Systems

OUR PRODUCTS

LIQUID RING VACUUM PUMPS

LIQUID RING COMPRESSORS

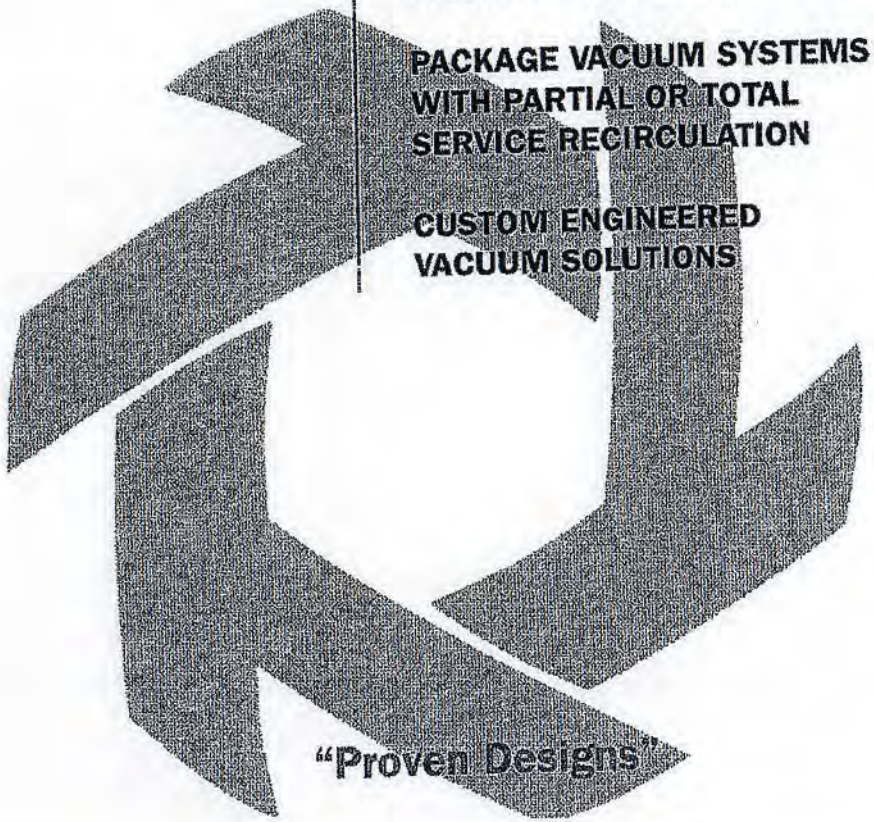
ROTARY VANE VACUUM PUMPS

ROTARY VANE VACUUM SYSTEMS

MEDICAL SYSTEMS (NFPA99)

PACKAGE VACUUM SYSTEMS WITH PARTIAL OR TOTAL SERVICE RECIRCULATION

CUSTOM ENGINEERED VACUUM SOLUTIONS



1 - GENERAL INSTRUCTIONS

This manual is intended to provide reference to:

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

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

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

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

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

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

2 - SAFETY INSTRUCTIONS

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

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

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

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

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

TABLE 1

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

3 - IN CASE OF EMERGENCY

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

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

3.1 - BASIC FIRST AID

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

4 - PUMP OUTLINES

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

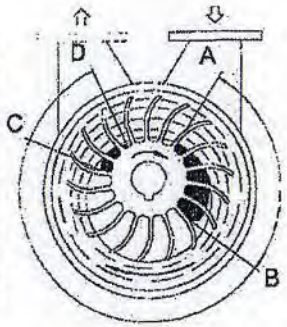
NOTE: Capacities, vacuum and pressures are nominal and are the maximum attainable values under standard operating conditions. Please contact TRAVAINI PUMPS USA for data on liquid ring compressors series TR...

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

4.1 - PRINCIPLE OF OPERATION

(See figure at side)

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



4.2 - SERVICE LIQUID PROPERTIES

For good operation, the liquid ring pumps must be supplied with a service liquid, which is clean, non-abrasive and free of any solids. The service liquid temperature should not exceed 80 °C and the gas handled should be maximum 100 °C; the liquid density should be between 0.8 and 1.2 g/cm3 and the viscosity should be less than 40 °C (the pump performance will change if the service liquid has properties different than those of water at 15°C (60°F). All engineering data is based on the use of 15°C (60°F) as service liquid, see section 17 for additional information. Contact TRAVAINI PUMPS USA before using liquids with properties outside the ranges listed above.

4.3 - PUMP MODELS AND TABLES FOR MATERIAL OF CONSTRUCTION

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

Example of pump model number:

T R H C 80 - 750 / C - M / GH

T	– Manufacturer POMPETRAVAINI	**750**	– Nominal capacity in m³/h
R	– Liquid ring pump	**C**	– C = Shaft sealing by mechanical seal B = Shaft sealing by stuffing box
H	– M and V = Single stage pump with high vacuum S = Single stage pump with medium vacuum H = Two stage pump with high vacuum	**M**	– Monoblock design with motor flange (upon request)
		GH	– Material of construction GH - F - RZ - RA - A3 (see following table)
C	– Revision of hydraulic design		
80	– Ø Flange size (mm)		

STANDARD materials of construction

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

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

5 - UNCRATING, LIFTING AND MOVING INSTRUCTIONS

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

When uncrating, follow the instructions listed below:

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

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

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

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

⚡	For safe lifting to prevent material damages and/or personal injuries is recommended to use ropes, or belts properly positioned on the pump and/or lifting eyebolts and make correct movements. NOTE: Lifting eyebolts fitted on single components of the assembly (pump or motor) should not be used to lift the total assembly.

Avoid lifts whereby the ropes or straps, form a triangle with the top angle over 90° (see fig. 3). The fig. 4 shows several additional examples of lifting to be avoided. Prior to moving the unit from an installation, always drain any pumped fluid from the pump, piping and accessories, rinse and plug all openings to prevent spillage. For instructions to remove the unit from installation see section 15.

Fig. 1

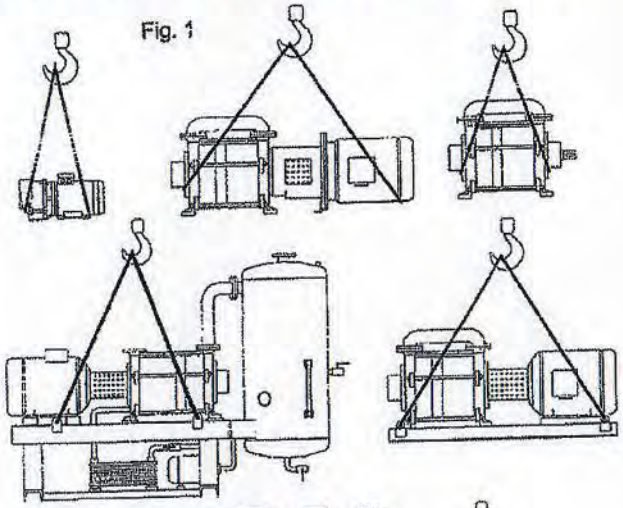


Fig. 2

OK

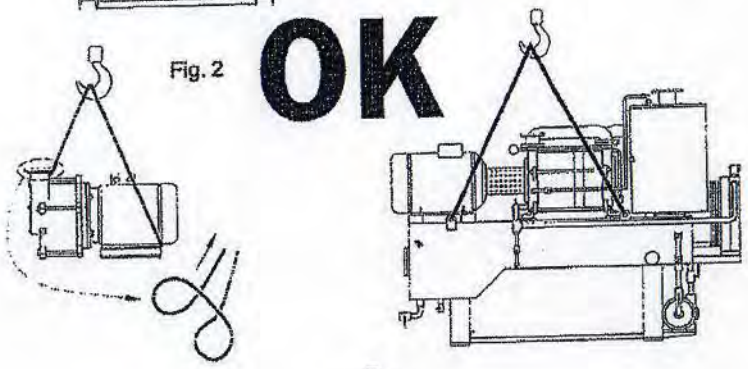
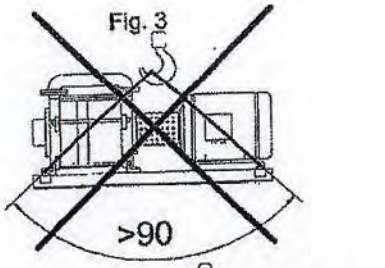


Fig. 3

NO



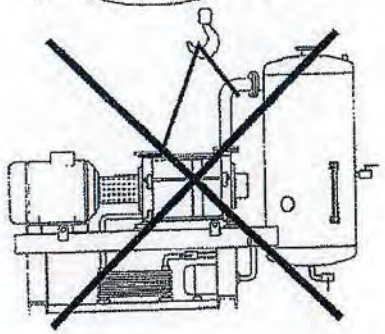
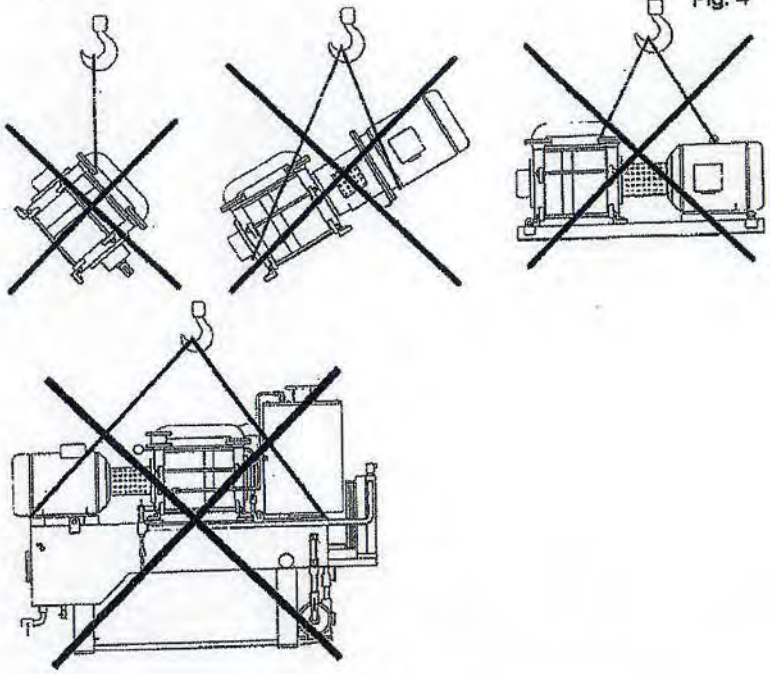


Fig. 4



6 - STORAGE INSTRUCTIONS

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

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

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

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

7 - MOUNTING AND ALIGNMENT INSTRUCTIONS

7.1 - ASSEMBLY OF BASE MOUNTED PUMP UNIT

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

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

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

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

When selecting Flexible couplings the following must be considered:

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

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

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

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

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

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

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

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

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

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

7.3 - ALIGNMENT INSTRUCTIONS

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

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

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

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

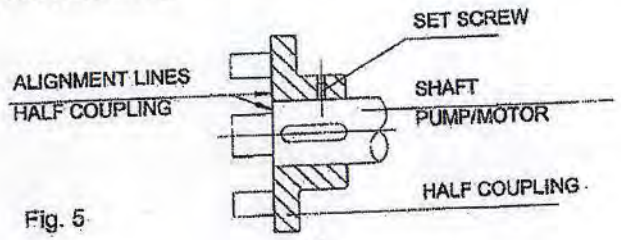


Fig. 5

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

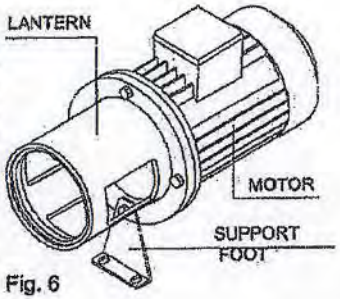


Fig. 6

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

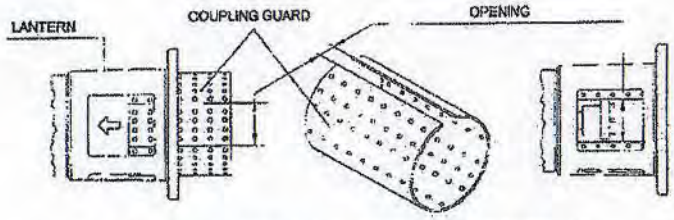


Fig. 7 - PREPARING TO ASSEMBLE THE MONOBLOCK DESIGN

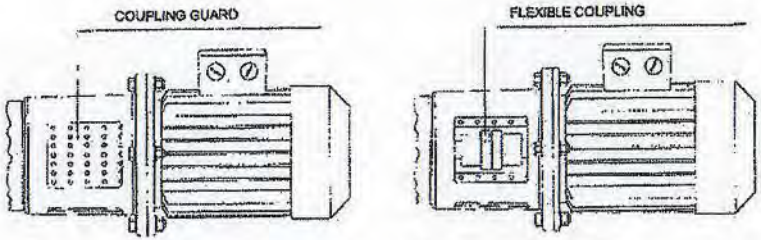


Fig. 8 - CHECKING THE ALIGNMENT ON MONOBLOCK DESIGN

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

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

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

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

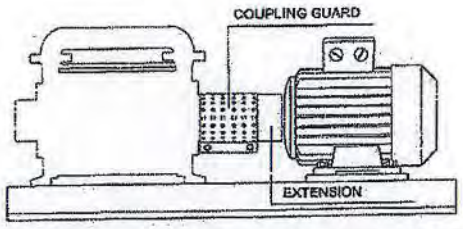


Fig 9 - CHECKING ALIGNMENT ON BASE MOUNTED PUMP DESIGN

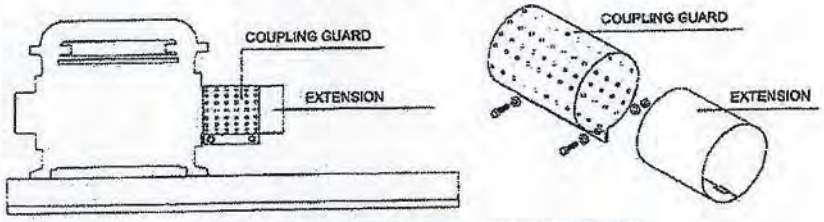


Fig. 10 - ASSEMBLING THE UNIT ON THE BASEPLATE

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

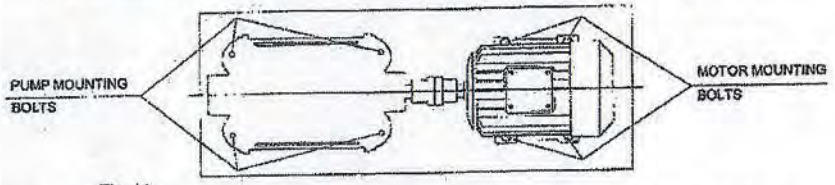


Fig. 11

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

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

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

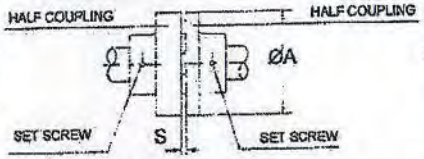


Fig. 12 (Center - Under view)

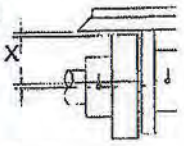


Fig. 13

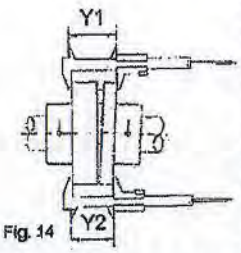


Fig. 14

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

Table 2

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

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

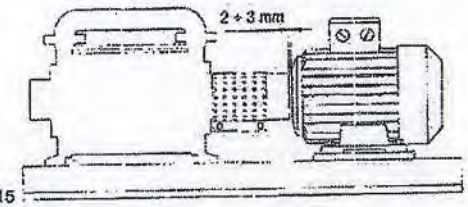


Fig. 15

8 - ELECTRICAL CONNECTIONS

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

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

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

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

9 - INSTALLATION INSTRUCTIONS

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

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

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

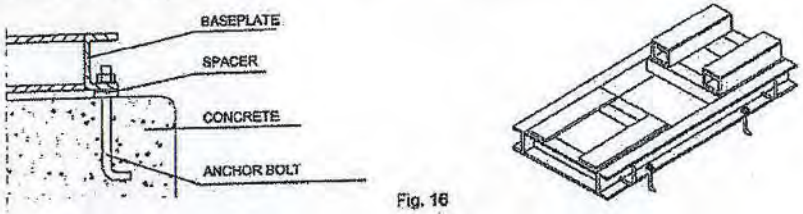


Fig. 16

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

9.1 - PIPING CONNECTIONS

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

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

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

9.2 - ACCESSORIES

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

Non return valve, (check valve)

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

Vacuum relief valve

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

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

Automatic draining valve

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

Vacuum gauge

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

Discharge reservoir separator

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

Heat exchanger

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

Filter

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

9.3 - INSTALLATION SCHEMATICS FOR LIQUID RING VACUUM PUMPS

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

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

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

9.3.2 - Service liquid: Partial recovery system

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

9.3.3 - Service liquid: Total recovery system

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

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

9.4 - INSTALLATION SCHEMATICS FOR LIQUID RING COMPRESSORS

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

9.5 - INSTALLATION OF "WATER SEALED" SYSTEMS

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

9.6 - INSTALLATION OF "OIL SEALED (DynaSeal™)" SYSTEMS

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

ATTENTION:
HOT SURFACES, DO NOT TOUCH TO AVOID POSSIBLE BURNS!

During operation, the temperature of pump, frame, separator and piping can reach values over 60 °C. Therefore, take all precautions necessary to comply with the safety regulations.

9.7 - SERVICE LIQUID (H_2O at 60 °F) FLOW (in GPM) FOR VACUUM PUMPS

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

Table 3

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

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

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

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

9.8 - SERVICE LIQUID FLOW (H_2O at 60°F) AND PRESSURE FOR COMPRESSORS SERIES "SA"

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

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

9.9 - TYPICAL INSTALLATION SCHEMATICS FOR VACUUM PUMPS

Fig. 17

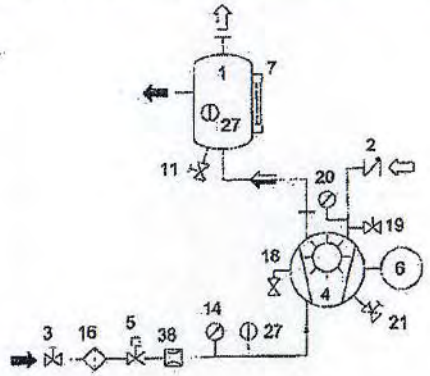


Fig. 18

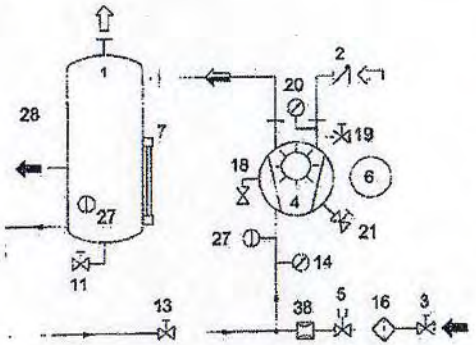
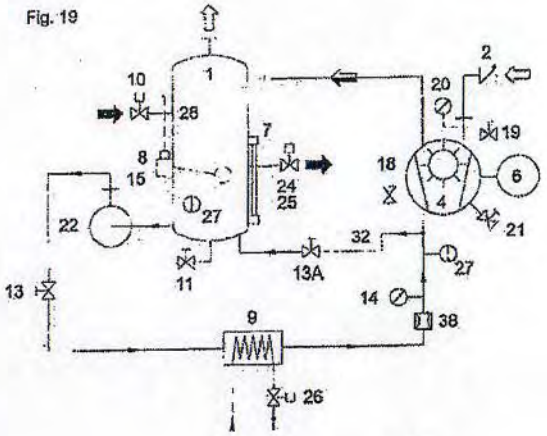


Fig. 19



1 Separator/ reservoir

2 Non-return valve

3 Shut-off valve (check valve)

4 Liquid ring vacuum pump

5 Solenoid valve

6 Electric motor

7 Level gauge glass

8 Float valve

9 Heat exchanger

10 Make-up solenoid valve

11 Drain valve

13 Flow control valve

13A By-pass valve

14 Pressure gauge

15 Level switch

16 Filter (y-strainer)

18 Automatic drain valve (check valve)

9.10 - TYPICAL INSTALLATION SCHEMATICS FOR COMPRESSORS

Fig. 20

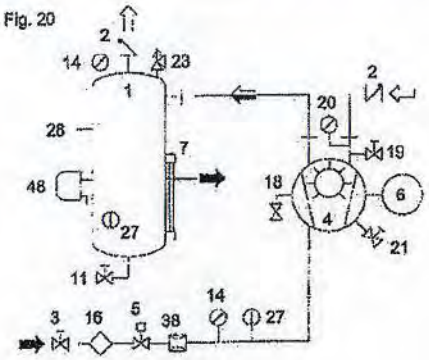


Fig. 21

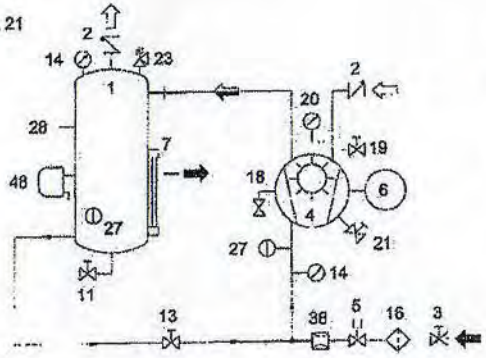
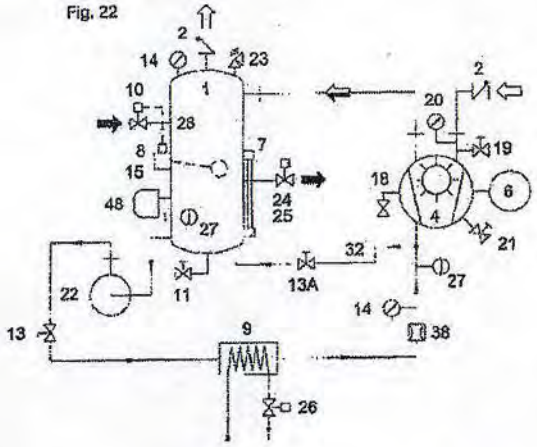


Fig. 22



19 Valve for spare vacuum connection

20 Vacuum gauge

21 Anti-cavitation valve

22 Circulating pump

23 Pressure relief valve

24 Overflow valve

25 Draining solenoid valve

26 Solenoid valve for heat exchanger cooling liquid

27 Temperature gauge

28 Fill connection

32 By-pass piping

38 Orifice flow

48 Automatic drain valve or water trap

⇧ Air or Gas

⇧ Liquid-Gas mixture

⇧ Liquid

9.11 - CONNECTIONS LOCATION

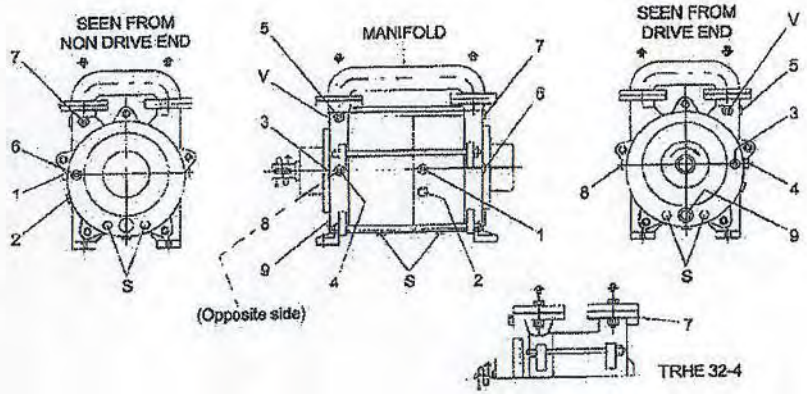


Fig. 23 - Pump series TRH (for details, see table 4)

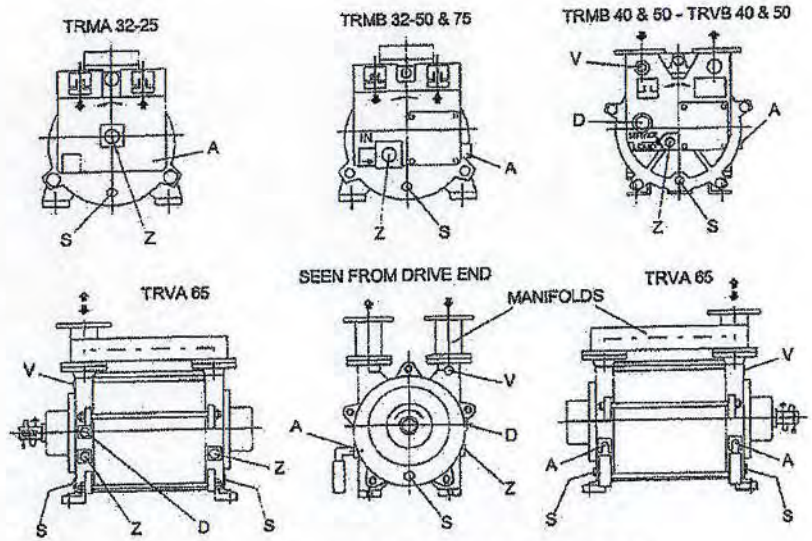


Fig. 24 - Pump series TRM - TRV (for details see table 5)

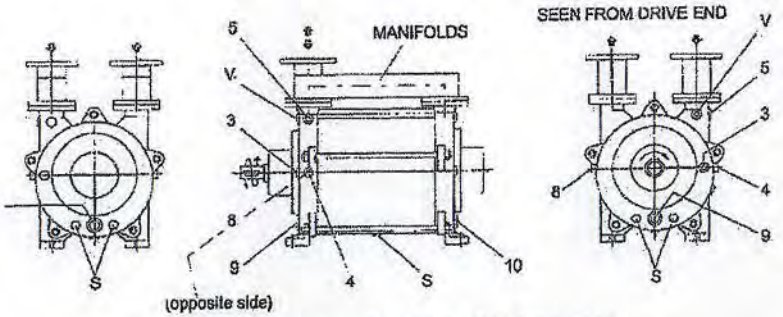


Fig. 25 - Pump series TRS (for details, see table 6)

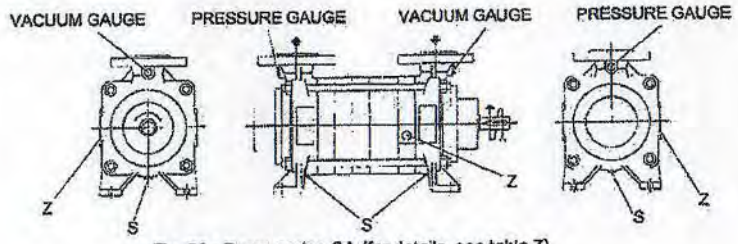


Fig. 26 - Pump series SA (for details, see table 7)

Table 4 – Pump series TRH

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

Table 5 - Pump series TRM – TRV

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

Table 6 - Pump series TRS

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

Table 7 - Pump series SA

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

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

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

9.12 - PUMP ENGINEERING DATA

Table 8

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

Table 8 (continued)

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

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

PUMP MODEL	Noise Level	Weight assembly Monoblock 50 Hz motor	Weight assembly Monoblock 60 Hz motor	Operating Speed RPM		Installed Motor Size kW	
	dB(A)	lbs.	lbs.	50 Hz	60 Hz	50 Hz	60 Hz
SA0E3U	67	123	242	2900	3500	11 15	15 20
SA0G2D	69	183	297	2900	3500	11 15	18,5 25
SA0G2G	69	191	139 157	2900	3500	15 22	20 30

NOTES:

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

10 - CHECK LIST PRIOR TO START-UP

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

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

11 - STARTING, OPERATING AND STOPPING PROCEDURES

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

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

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

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

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

11.1 - START-UP of WATER SEALED Systems

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

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

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

11.2 - OPERATION

After starting the vacuum pump check the following:

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

NEVER OPERATE THE PUMP DRY!

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

11.3 - SHUT DOWN of "WATER SEALED" SYSTEMS

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

11.4 – START-UP OF "OIL SEALED (DynaSeal™)" SYSTEMS

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

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

11.5 - OPERATION OF "OIL SEALED (DynaSeal™)" SYSTEMS

After starting the vacuum pump check the following:

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

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

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

11.6 - SHUT DOWN OF "OIL SEALED (DynaSeal™)" SYSTEMS

Close, if applicable, the cooling water to the water/oil heat exchanger ITEM 9, then turn off the power to the circulating pump ITEM 22. Where possible, gradually decrease the vacuum level to 300-625 Torr in about 10 seconds max. The discharged service liquid from pump ITEM 4 helps producing a slow deceleration rather than sudden stop.
Turn off motor ITEM 6, radiator ITEM 9 and any accessories and flushing circuitry. Make sure the non-return valves ITEM 2, or similar, at suction and discharge lines are leak tight. Should the system be idle for an extended period of time it is recommended to disconnect the electricity to the motor panel, drain all liquids from pump, separator and piping. Refer to chapter 6 for storage procedures.

12 - OPERATING MAINTENANCE

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

NEVER ALLOW THE PUMP TO OPERATE IN THE CAVITATION AREA!

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

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

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

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

12.1 - "OIL SEALED (DynaSeal™)" SYSTEMS

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

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

Every 100 - 200 working hours it is suggested to check the oil level in the oil reservoir, make-up oil if necessary and change the oil every 10,000 working hours (depending upon the use and the application).
Those installations where the handled gases are contaminated with dust or suspended solids that can alter the oil characteristics will require more frequent oil check and changes.

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

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

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

TYPICAL BILL OF MATERIALS

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

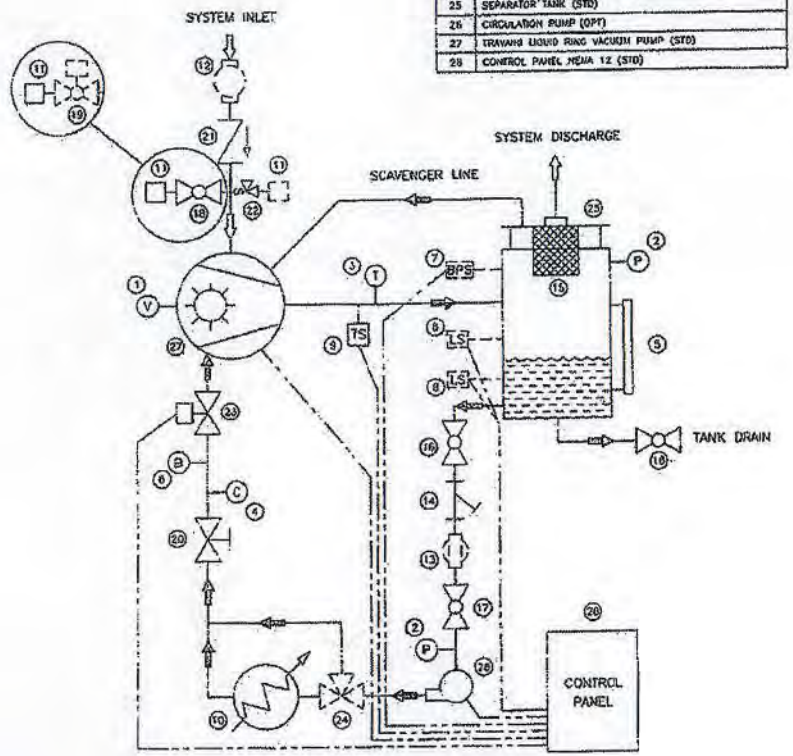


Fig 27 (General Schematic Drawing)

13 - BEARINGS AND MECHANICAL SEALS MAINTENANCE

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

CAREFULLY FOLLOW THE SAFETY PROCEDURES LISTED IN CHAPTER 2.

13.1 - BEARINGS

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

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

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

13.2 - MECHANICAL SEALS

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

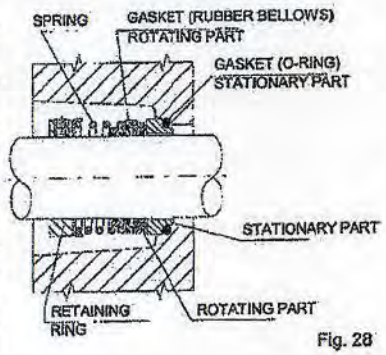


Fig. 28

For mechanical seal shaft size see table 9.
Mechanical seals normally fitted in the vacuum pumps are to DIN 24960 standards. See "Disassembly & Assembly Instructions" for major seal dimensions. Normally mechanical seals do not require maintenance until there is a visible liquid loss (leakage). See "Disassembly & Assembly Instructions" for seal replacement.

Mechanical seals **MUST NOT** run dry! When seals are operated without lubricant and/or flushing liquid their faces and the elastomers may suffer damages beyond repair. It is suggested to check the conditions of the seal faces every approximately 4000 working hours.

Table 9

PUMP MODEL	BEARING			MECHANICAL SEAL	
	Quantity	Type	Grease Quantity each bearing - gr.	Quantity	Diameter mm
TRHE 32-4	1	6302.2RSR		1	16
TRHC and TRSC 32 TRHE 32-20/45/60-TRSE 32	2	6304.2RSR		2	22
TRHE 40-110 - TRSE 40		6305.2RSR			28
TRMA 32-25	1 1	6304.2RSR 6204.2RSR			
TRMB 32-50	1 1	6305.2RSR 6205.2RSR			24
TRMB 32-75	1 1	6306.2RSR 6206.2RSR		1	28
TRMB 40-110	1 1	3208.2RSR 6206.2RSR	—		35
TRMB 40-150	1 1	3208.2RSR 6306.2RSR			
TRVB 40-110/150	2	6208.2RSR			
TRMB 40-200 and 50-300	1 1	3210.2RSR 6308.2RSR			45
TRVB 40-200 and 50-300	1 1	6210.2RSR 6208.2RSR			
TRHC and TRSC 40 TRHE 40-140/190 TRSC and TRSE 50	2	6306.2RSR			35
TRHB 50 - TRVA 50 and 65		6308	20	2	43
TRHB/C 80 - TRSB/C 100		6310	35		55
TRHE 100 - TRSE 125	1 1	6314 NU 314	50		75
TRHA 150 - TRSA 200	2 1	7320B.MB.UA 22320ES.TVPB.C3	180		110

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

14 - TROUBLE SHOOTING: PROBLEMS, CAUSES AND SOLUTIONS

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

Table 10 - LIST OF PROBLEMS

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

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

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

15 - REPAIRING AND REMOVING PUMP FROM THE INSTALLATION

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

FOLLOW THE SAFETY PRECAUTION MEASURES OUTLINED IN CHAPTER 2.

Before working on the pump it is important to:

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

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

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

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

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

16 - SPARE PARTS

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

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

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

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

17 - ENGINEERING DATA

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

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

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

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

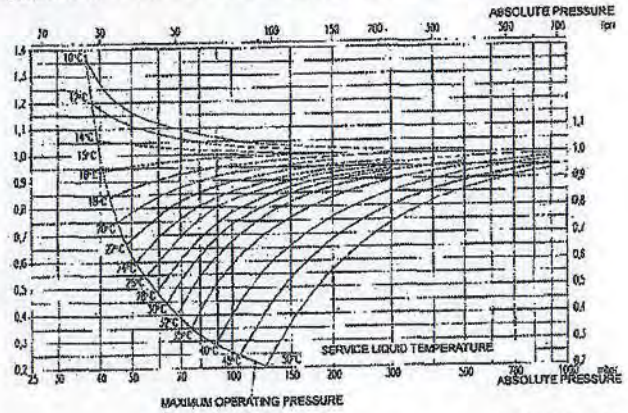


Fig. 29
Single stage pump
(series TRM, TRS, TRV)

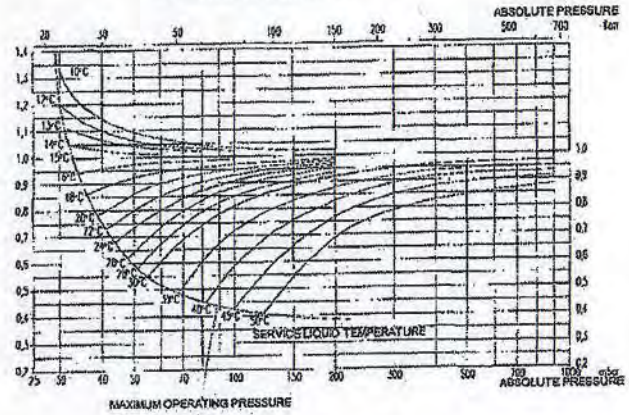


Fig. 30
Two stage pump
(series TRH)

17.2 - SERVICE LIQUID TEMPERATURE CHANGE ACROSS THE PUMP

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

$$Q_T\ (BTU) = Q_c + Q_K + Q_R$$

Where:

Q_c	=	0.9 x BHP x 2545	=	Isothermal compression heat
Q_K	=	m_v x r	=	Condensation heat
Q_R	=	m_g x c_p x ΔT_a	=	Cooling heat (Generally negligible, ignored in calculation of Q_T)

m_v	=	mass condensed incoming vapor in PPH
m_g	=	mass incoming gas in PPH
P	=	absorbed power at operating point in kW
c_p	=	gas specific heat in BTU/1B/°F
r	=	heat of vaporization in BTU's
ΔT_a	=	differential temperature in R, between incoming gas TG and service liquid discharge temperature (T^2 + ΔT)
K	=	Kelvin temperature

Once the Q_T is known it is possible to calculate the differential temperature ΔT of the pump service liquid:

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

Where:

Q_T	=	total heat load before calculated in BTU/hour
Q_A	=	pump service liquid flow in GPM
ρ	=	service liquid density in kg/m³ (water = 1.0)
c_p	=	service liquid specific heat

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

17.3 - OPERATION WITH PARTIAL RECOVERY OF SERVICE LIQUID

Where the working conditions will allow it, the service liquid temperature can be increased utilizing a smaller quantity of fresh liquid from an outside source. A similar flow as the make-up is discharged to the drain while the balance of liquid required by the pump is recirculated. In these cases the service liquid working temperature rises and the pump capacity will require correction per curves of fig. 29 and 30. The system installation will be similar to the schematic of fig. 31. Depending upon the affordable loss of capacity the service liquid temperature T2 may be set and the make-up flow of fresh liquid QF can then be calculated:

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

Where:

Q_F	=	Fresh make-up flow from outside source in m³/h
Q_A	=	Total service liquid flow required for the operating conditions in m³/h
ΔT	=	Service liquid temperature rise (see section 17.2)
T_2	=	Service liquid temperature to pump
T_1	=	Temperature of make-up liquid

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

$Q_A = Q_F$ and $T_2 = T_1$

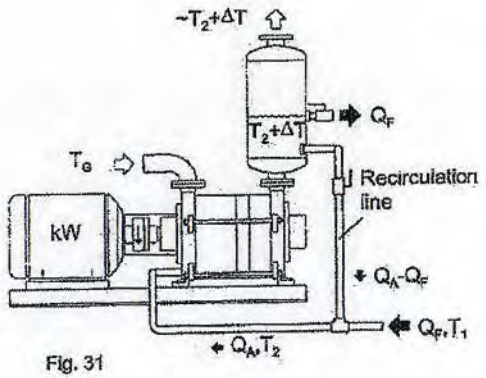
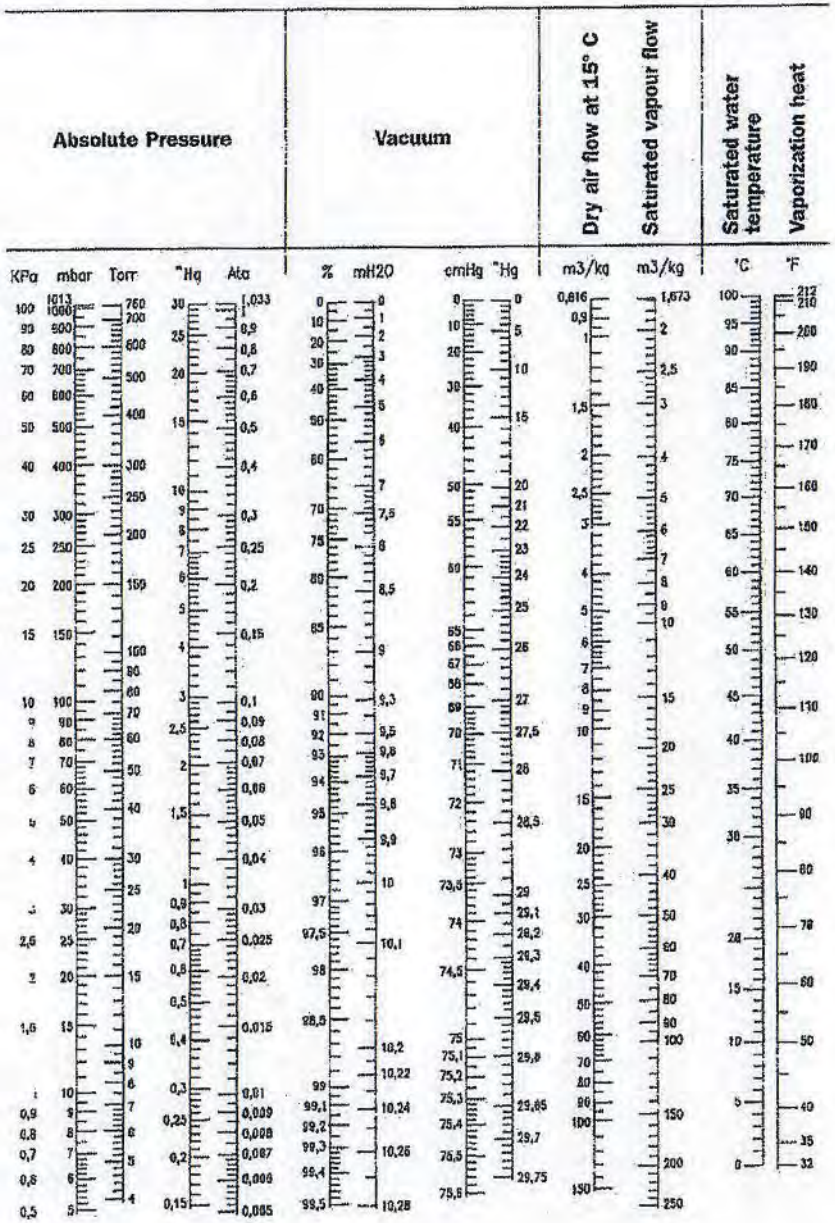


Fig. 31

17.4 - UNIT CONVERSION TABLE



18 - ENGINEERING DATA FOR "WATER SEALED" SYSTEMS

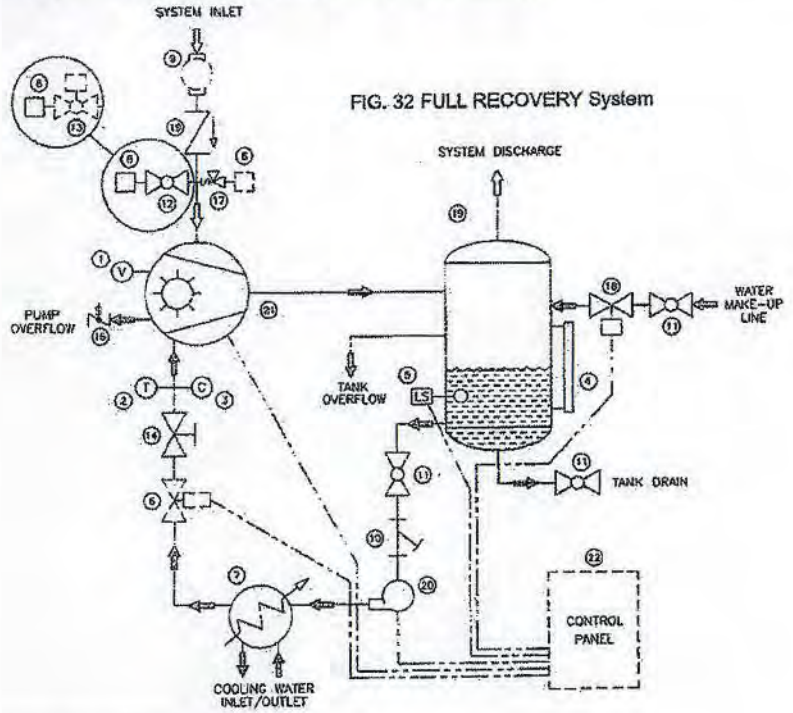


FIG. 32 FULL RECOVERY System

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

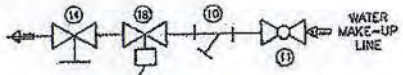


FIG. 32a PARTIAL RECOVERY System

WORKING PRINCIPLE

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

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

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

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

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

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

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

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

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

Table 11 - STANDARD MATERIALS FOR "WATER SEALED" SYSTEMS

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

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

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

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

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

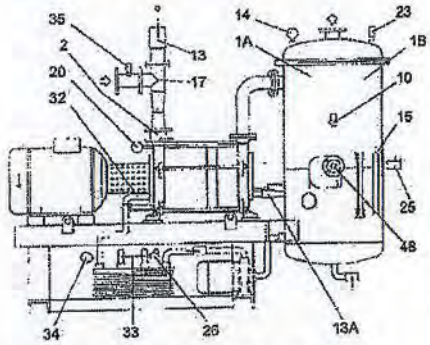


Fig. 34 - Typical accessories and options upon request

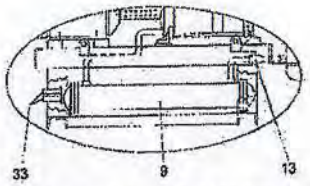


Fig. 35 - Option with Shell & Tube heat exchanger

LEGEND

1	Separator reservoir
1A	Separator reservoir with removable lid
1B	Oil demister
2	Check valve
4	Vacuum pump
6	Electric motor
7	Level gauge
8	Float valve
9	Heat exchanger
10	Solenoid valve liquid make-up
11	Drain valve
12	Isolating valve
13	Service liquid flow regulating valve
13A	By-pass valve
14	Pressure gauge
15	Level switch
17	Air elector
20	Vacuum gauge
22	Circulating pump
23	Pressure relief valve
24	Overflow valve
25	Solenoid valve for overflow
26	Solenoid valve for cooling liquid
27	Thermometer
28	Fill connection
30	Frame
32	By-pass piping
33	Connection cooling lines
34	Temperature switch
35	Vacuum relief valve
48	Automatic drain valve (for systems used as Compressor only)

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

WORKING PRINCIPLE

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

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

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

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

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

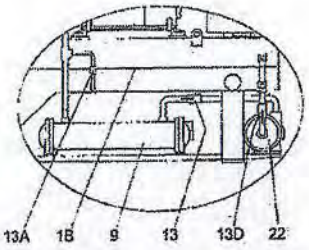


Fig. 38 – Option with Shell & Tube heat exchanger

LEGEND

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

20 - PRODUCT DATA INFORMATION FORM

PUMP model	Serial Number	System Number	Year of mfg.

GAS handled	Capacity	Suction Pressure	Discharge Press.	Temp.
	....cfm	....Torr	....psi	....°C/°F

☐ Lethal ☐ Toxic ☐ Noxious ☐ Corrosive ☐ Malodorous ☐ .....

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

TOTAL WEIGHT	MAXIMUM DIMENSIONS	NOISE (measured at 1 m)
....lbs	X, Y, Z X =....in Y =....in Z =....in	Pressure =....dB(A) Power =....dB(A)

INSTALLATION	SERVICE
☐ Inside ☐ Outside	☐ Continuous ☐ Intermittent
☐ Explosive area ☐	☐ .....

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

COMMENTS

TRAVAINI PUMPS USA®
Liquid Ring & Rotary Vane Vacuum Pumps and Systems

WARRANTY

TRAVAINI PUMPS USA

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

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

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

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

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

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

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

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

Effective as of January 2007

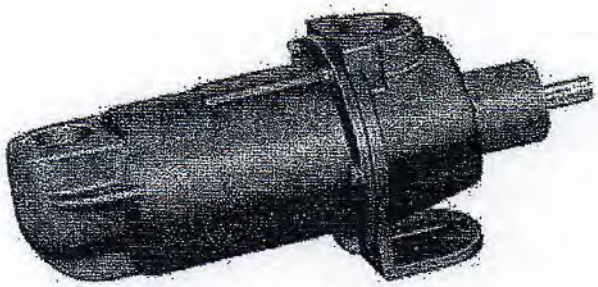
MOYNO

Always the Right Solution™

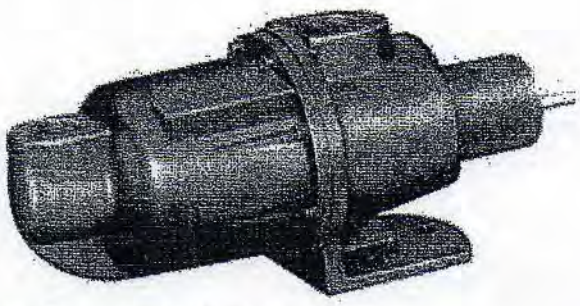
SERVICE MANUAL

MOYNO® 500 PUMPS

300 SERIES
331, 332, 333, 344, 356 AND 367 MODELS



Mechanical Seal Models



Packing Gland Models

DESIGN FEATURES	MODELS				
	33101 34401 33201 35601 33301 36701	33104 34404 33204 35604 33304 36704	33108 33308 33208 34408	34411 35611	35613
Housing:	Cast Iron	AISI 316 SS	Nylon	Cast Iron	AISI 316 SS
Pump Rotor:	Chrome plated 416 SS	Chrome plated 316 SS	Chrome plated 416 SS	Chrome plated 416 SS	Chrome plated 316 SS
Pump Stator:	NBR (Nitrile)	NBR (Nitrile)	NBR (Nitrile)	NBR (Nitrile)	NBR (Nitrile)
Shaft:	416 SS	316 SS	416 SS	416 SS	316 SS
Flexible Joint:	Carbon steel/ NBR	316 SS/ NBR	Carbon steel/ NBR	Carbon steel/ NBR	316 SS/ NBR
Bearings:	Ball (sealed)	Ball (sealed)	Ball (sealed)	Ball (sealed)	Ball (sealed)
Mechanical Seal:	Carbon-ceramic	Carbon-ceramic	Carbon-ceramic	---	---
Packing:	---	---	---	Braided PTFE	Braided PTFE

Note: Alternate elastomers available. Refer to Repair/Conversion kit numbers, page 8.

INSTALLATION

Mounting Position. Pump may be mounted in any position. When mounting vertically, it is necessary to keep bearings above seals to prevent possible seal leakage into bearings.

Pre-Wetting. Prior to connecting pump, wet pump elements and mechanical seal or packing by adding fluid to be pumped into suction and discharge ports. Turn shaft over several times in a clockwise direction to work fluid into elements.

Piping. Piping to pump should be self-supporting to avoid excessive strain on pump housings. See Table 1 for suction and discharge port sizes of each pump model. Use pipe "dope" or tape to facilitate disassembly and to provide seal.

Drive. On belt driven units, adjust belt tension to point of non-slip. Do not overtighten.

On direct drive units, coupling components should be aligned and spaced at least 1/16" apart.

Pump rotation must be clockwise when facing shaft to prevent damage to pump. Check direction of rotation before startup.

Water Flush of Packing (356 Models Only). The packing may be either grease lubricated through a grease fitting in the stuffing box or have plumbing connected to the housing to allow a water flush.

Maximum speed is 1750 rpm.

When the material being pumped is abrasive in nature, it may be advantageous to flush the packing to prevent leakage under packing and excessive shaft wear.

Clean water can be injected through a 1/8" NPT tapped hole that normally houses the grease fitting for lubricating the packing. The water can be permitted to leak axially along the shaft in either direction or can be removed from the second tapped hole in the stuffing box. In both cases, the discharge from the stuffing box should be throttled slightly to maintain 10-15 PSI higher pressure in the stuffing box than is present in the discharge housing.

Table 1. Pump Data

Pump Models	331	332	333	344	356	367
Suction Port (NPT)	3/4*	3/4*	3/4*	3/4*	1-1/2	2
Discharge Port (NPT)	3/4	3/4	3/4	3/4	1-1/4	2
Discharge Pressure (psig)	150	100	50	40	50	50

*08 versions = 1" NPT

Table 2. Temperature Limits

Elastomer	Temperature Limits
*NBR	10°-160°F
*EPDM	10°-210°F
*FPM	10°-240°F

*NBR = Nitrile
*EPDM = Ethylene-Propylene-Diene Terpolymer
*FPM = Fluoroelastomer

OPERATION

Self-Priming. With wetted pumping elements, the pump is capable of 25 feet of suction lift when operating at 1750 rpm with pipe size equal to port size.

DO NOT RUN DRY. Unit depends on liquid pumped for lubrication. For proper lubrication, flow rate should be at least 10% of rated capacity.

Pressure and Temperature Limits. See Table 1 for maximum discharge pressure of each model. Unit is suitable for service at temperatures shown in Table 2.

Storage. Always drain pump for extended storage periods by removing suction housing bolts and loosening suction housing.

TROUBLE SHOOTING

WARNING: Before making adjustments, disconnect power source and thoroughly bleed pressure from system. Failure to do so could result in electric shock or serious bodily harm.

Failure To Pump.

1. Belt or coupling slip: Adjust belt tension or tighten set screw on coupling.
2. Stator torn; possibly excessive pressure: Replace stator, check pressure at discharge port
3. Wrong rotation: Rotation must be clockwise when facing shaft.
4. Threads in rotor or on shaft stripped: Replace part. Check for proper rotation.
5. Excessive suction lift or vacuum

Pump Overloads.

1. Excessive discharge pressure: Check discharge pressure for maximum rating given in Table 1. Check for obstruction in discharge pipe.
2. Fluid viscosity too high: Limit fluid viscosity to 20,000 CP or 100,000 SSU.

Viscosity CP	Limit RPM
1-300	1750
300-1,000	1200
1,000-2,000	700
2,000-5,000	350
5,000-10,000	180
10,000-20,000	100

3. Insufficient motor HP: Check HP requirement.

Noisy Operation.

1. Starved suction: Check fluid supply, length of suction line, and obstructions in pipe
2. Bearings worn: Replace parts; check alignment, belt tension, pressure at discharge port.
3. Broken flexible joint: Replace part, check pressure at discharge port
4. Insufficient mounting: Mount to be secure to firm base. Vibration induced noise can be reduced by using mount pads and short sections of hose on suction and discharge ports.

Mechanical Seal Leakage (Mechanical Seal Models Only).

1. Leakage at startup: If leakage is slight, allow pump to run several hours to let faces run in.
2. Persistent seal leakage: Faces may be cracked from freezing or thermal shock. Replace seal.

Packing Leakage (Packing Models Only).

1. Leakage at startup: Adjust packing as outlined in maintenance instructions

Note: Slight leakage is necessary for lubrication of packing

2. Persistent leakage: Packing rings and/or shaft may be worn. Replace parts as required.

Pump Will Not Prime.

1. Air leak on suction side: Check pipe connections.

MAINTENANCE

General. These pumps have been designed for a minimum of maintenance, the extent of which is routine lubrication and adjustment of packing. The pump is one of the easiest to work on in that the main elements are very accessible and require few tools to disassemble.

Packing Lubrication (356 Models Only). The zerk fitting on the side of the suction housing leads to the lantern ring halves in the mid-section of the packings. At least once a week, inject a small quantity of good quality grease, such as MPG-2 Multi Purpose Grease (Du Bois Chemical), or equivalent, into the zerk fitting to lubricate the packings.

Note: For Model 34411, lubricate packing by applying a liberal amount of grease during assembly.

Packing Adjustment (Packing Models Only). Packing gland attaching nuts should be evenly adjusted so they are little more than finger tight. Over-tightening of the packing gland may result in premature packing failure and possible damage to the shaft and gland.

When the packing is new, frequent minor adjustments are recommended for the first few hours of operation in order to compress and seat the packing. Be sure to allow slight leakage for lubrication of packing.

When excessive leakage can no longer be regulated by tightening the gland nuts, remove and replace the packings in accordance with the DISASSEMBLY and REASSEMBLY instructions. The entire pump need not be disassembled to replace the packings.

Bearing Lubrication. The prelubricated, fully sealed bearings do not require additional lubrication.

PUMP DISASSEMBLY

WARNING: Before disassembling pump, disconnect power source and thoroughly bleed pressure from system. Failure to do so could result in electric shock or serious bodily harm.

To Disassemble Mechanical Seal Models:

1. Disconnect suction and discharge piping.
2. Remove screws (112) holding suction housing (2) to pump body (1). Remove suction housing and stator (21).
3. Remove rotor (22) from flexible joint (24) by turning counter-clockwise (RH thread). Use 3/16 inch diameter punch to remove rotor pin (45) on Model 36701.
4. Flexible joint (24) can be removed from shaft (26) by using a 3/16 inch allen wrench in end of joint (1/4 inch wrench on 356 Models) and turn counter-clockwise. Use 3/16 inch diameter punch to remove shaft pin (46) on Model 36701.
5. Carefully slide mechanical seal (69) off shaft (26). Carefully pry seal seat out of pump body (1). If any parts of mechanical seal are worn or broken, the complete seal assembly should be replaced. Seal components are matched parts and are not interchangeable.
6. The bearings (29) and shaft (26) assembly can be removed from pump body (1) after snap ring (66) has been removed. To remove the assembly, lightly tap the shaft at threaded end using a block of wood to protect the threads. The bearings may be pressed off the shaft.

To Disassemble Packing Models:

1. Disconnect suction and discharge piping.
2. Remove screws (112) which hold suction housing (2) to pump body (1). Remove suction housing and stator (21).
3. Remove rotor (22) from flexible joint (24) by turning in a counter-clockwise direction (RH thread).
4. Flexible joint (24) can be removed by using a 3/16 inch allen wrench in end of joint (1/4 inch wrench on 356 Models) and turn in a counter-clockwise direction.
5. The packing (42) can be removed without removing the shaft (26) using the following procedure:
   a. Remove gland bolts (47).
   b. Slide gland (41) away from packing (42).
   c. Pull out packing (42) (and lantern ring halves (57) on 356 Models) using a packing removing tool.

   Note: Packing can be removed after shaft has been removed by pushing out from pump side of pump body after gland (41) has been detached.
6. The bearings (29) and shaft (26) assembly can be removed from pump body (1) after snap ring (66) has been removed. To remove the assembly, lightly tap the shaft at threaded end using a block of wood to protect the threads.
7. To disassemble shaft assembly, remove snap ring (66A) from shaft (26) and press bearings (29) and bearing spacer (33) off the shaft.

PUMP ASSEMBLY

To Assemble Mechanical Seal Models:

1. Press bearings (29) on shaft (26), and locate slinger ring (77) near bearing on threaded end of shaft.

   Note: When replacing bearings, always press on the inner race when assembling to shaft, and on the outer race when pressing bearings into the housings.
2. Press shaft assembly into pump body (1) securing with snap ring (66).
3. Install mechanical seal (69) using the following procedure:
   a. Clean and oil sealing faces using a clean light oil (not grease).

   Caution: Do not use oil on EPDM parts. Substitute glycerin or soap and water.

   b. Oil the outer surface of the seal seat, and push the assembly into the bore in the pump body (1), seating it firmly and squarely.
   c. After cleaning and oiling the shaft, slide the seal body along the shaft until it meets the seal seat.
   d. Install seal spring and spring retainer on shaft.
4. Thread flexible joint (24) into shaft (26) in a clockwise direction (RH thread). On 356 Models, install seal spacer (69A) and washer (116) before threading flexible joint onto shaft in a clockwise direction. On Model 36701, use shaft pin (46) to pin flexible joint (24) to shaft.
5. Thread rotor (22) onto flexible joint (24) in a clockwise direction (RH thread). On Model 36701, pin rotor (22) to joint using rotor pin (45).
6. Slide stator (21) on rotor (22). On 331 and 332 Models, insert rounded end of stator ring (135) into end of stator prior to installing stator on rotor.
7. Secure stator (21) and suction housing (2), with suction port vertically up, to pump body (1) using screws (112).
8. Proceed as in installation instructions.

To Assemble Packing Models:

1. Press bearings (29), with bearing spacer (33) in between, on shaft (26) and secure in place using snap ring (66A).

   Note: When replacing bearings, always press on the inner race when assembling to shaft, and on the outer race when pressing bearings into the housings.

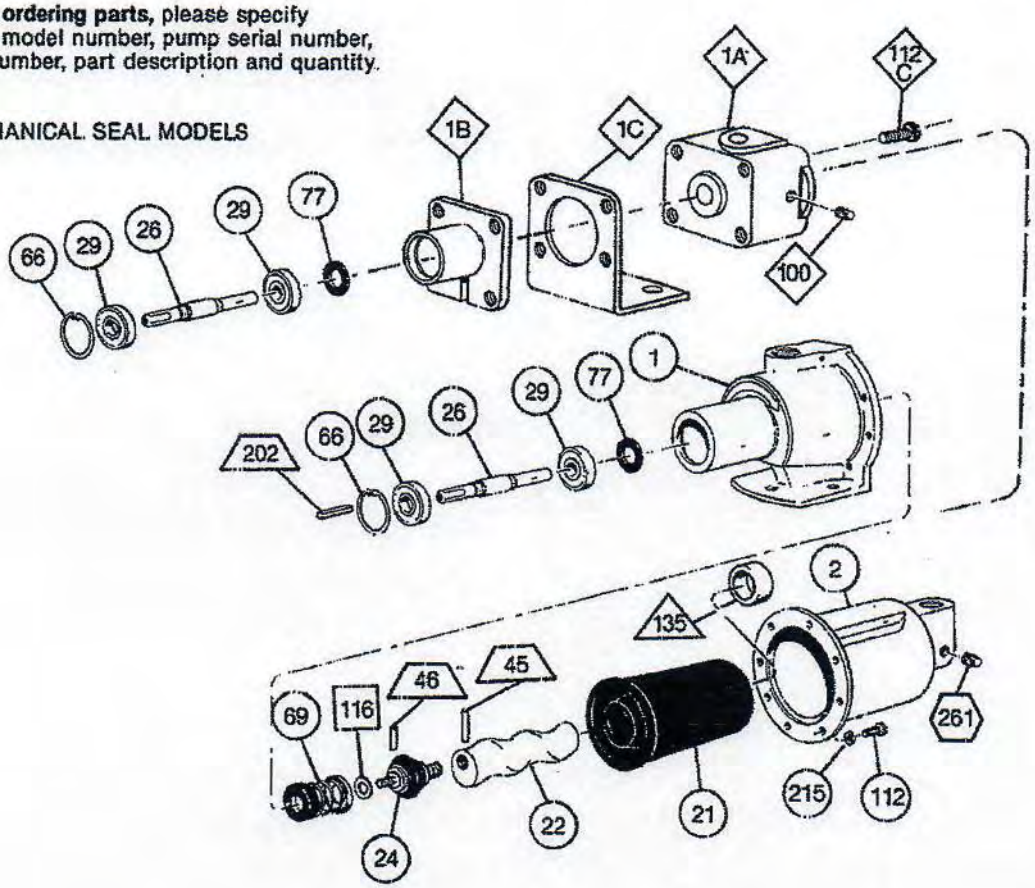
2. Install packing (42) before installing shaft assembly using the following procedure:
   a. Lubricate each individual ring of packing with a grease that is insoluble in the fluid being pumped
   b. Individually assemble each ring of packing loosely in the packing chamber of the pump body (1). Stagger splits on rings. (Four rings, 3/16 inch square required on Model 34411; four rings, 1/4 inch square and two lantern ring halves (57) assembled between two rings on 356 Models)
   c. Loosely install packing gland (41) on pump body (1) using gland bolts (47).
3. Press shaft assembly into pump body (1) positioning slinger ring (77) between packing gland (41) and bearing end of pump body. Secure the shaft assembly with snap ring (66).
4. Thread flexible joint (24) into shaft (26) in a clockwise direction (RH thread).
5. Thread rotor (22) onto flexible joint (24) in a clockwise direction (RH thread).
6. Slide stator (21) on rotor (22). On 331 and 332 Models, insert rounded end of stator ring (135) into end of stator prior to installing stator on rotor.
7. Secure stator (21) and suction housing (2), with suction port vertically up, to pump body (1) using screws (112)
8. Proceed as in installation instructions.

Note: Adjust newly installed packing as described in maintenance procedure.

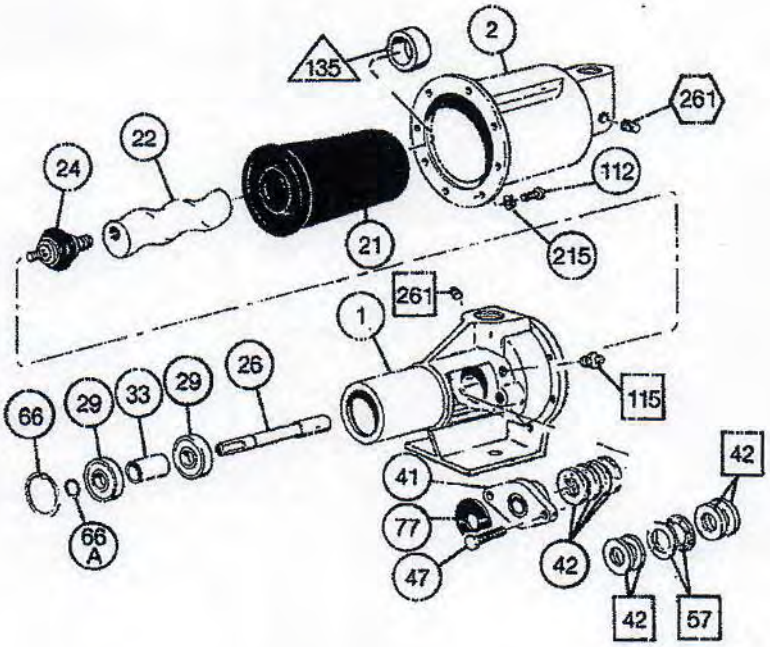
WARNING: Replace belt or coupling guards before reconnecting power.

When ordering parts, please specify pump model number, pump serial number, part number, part description and quantity.

MECHANICAL SEAL MODELS



PACKING MODELS



Used on 332 and 367 only.

Used on 356 only.

Used on 356 and 367 only.

Used on -08 only.

Used on 367 only.

PARTS LIST — 331, 332, 333, AND 344 MODELS

Item No.	Description	Mechanical Seal Models			Packing Gland Models
		33101 33201 33301 34401	33104 33204 33304 34404	33108 33208 33308 34408	34411
1	Pump Body	330-1065-002	330-1910-002		340-1000-001
1A	Discharge Housing			340-2362-000	
1B	Bearing Housing			330-4587-000	
1C	Pump Base			340-2369-000	
2	Suction Housing	330-1064-002	330-1911-002	330-4536-000	330-1064-002
*21	Stator	See Stator section below.			
*22	Rotor	See Rotor section below with circled numbers for each series.			
		①	②	①	①
24	Joint	Carbon Steel/NBR 320-1511-000	316 SS/NBR 320-3759-000	Carbon Steel/NBR 320-1511-000	
26	Drive Shaft	320-1499-000	320-2938-000	320-1499-000	320-2448-000
29	Bearing (2 req.)	630-0502-031			
33	Bearing Spacer				320-1900-000
41	Packing Gland				320-0101-004
42	Packing				340-3396-005
47	Gland Bolt				619-1520-161
66	Snap Ring	320-1506-000			
66A	Snap Ring				320-4182000
69	Mechanical Seal	320-2424-000			
77	Slinger Ring	320-6382-000			320-6384-000
100	Pipe Plug (3 req.)			610-0120-021	
112	Screws (8 req.)	619-1430-103	320-5968-000	619-0860-081	619-1430-103
112C	Screws (4 req.)			61 9-0890-281	
135	Stator Ring (331 -332 only)	320-7812-000			
215	Lock Washer (8 req.)	320-6464-000			

*Recommended spare parts

STATORS		Models			
		331	332	333	344
21	Standard Stator, NBR All Models	340-3501-120	340-3502-120	340-3503-120	340-3504-120
21	EPDM Stator	340-3501-320	340-3502-320	340-3503-320	340-3504-320
21	FPM Stator	340-3501-520	340-3502-520	340-3503-520	340-3504-520
ROTORS					
22	① 416SS - All Models	320-2729-000	330-0906-000	320-1394-000	320-1841-000
22	② 316SS - All Models	320-2933-000	320-2942-000	320-2936-000	320-2934-000

See page 8 for Repair/Conversion Kits

PARTS LIST --- 356 AND 367 MODELS

Item No.	Description	Mechanical Seal Models		Packing Gland Models		Mechanical Seal Model	
		35601	35604	35611	35613	36701	36704
1	Pump Body	Cast Iron 340-0636-000	316SS 340-1550-000	Cast Iron 350-0420-000	316SS 350-0491-000	Cast Iron 350-0423-000	316SS 350-0423-007
2	Suction Housing	350-0280-000	350-0489-000	350-0280-000	350-0489-000	350-0302-000	350-0302-007
*21	Stator	NBR 340-3505-120		NBR 340-3505-120		NBR 340-3506-120	
22	Rotor	416SS 320-2304-000	316SS 320-4431-000	416SS 320-2304-000	316SS 320-4431-000	416SS 330-2042-000	316SS 330-3077-000
24	Flex Joint	Carbon Steel 320-1583-000	316SS 320-4427-000	Carbon Steel 320-1583-000	316SS 320-4427-000	Carbon Steel 320-1749-000	316SS 320-4436-000
26	Drive Shaft	320-1759-000	320-4430-000	320-2765-000	320-4435-000	330-1805-000	330-1805-015
29	Bearing (2 req.)	630-0552-051				630-0552-061	
33	Bearing Spacer			320-2764-000			
41	Packing Gland			320-0003-004	320-0003-007		
*42	Packing			340-3396-008			
45	Rotor Pin					320-4439-002	
46	Shaft Pin					320-4439-001	
47	Gland Bolt			619-1530-241			
57	Lantern Ring Half**			320-6585-000			
66	Snap Ring	320-1758-000				320-2794-000	
66A	Snap Ring			320-3533-000			
*69	Mechanical Seal	320-3945-000				320-1750-000	
69A	Seal Spacer	320-4434-000					
77	Slinger Ring	320-6383-000		320-6385-000		320-6385-000	
112	Screws (6 req.)	619-1530-161				619-1530-161	
115	Zerk Fitting			320-2503-001			
135	Stator Spacer	330-7594-000					
202	Shaft Key					611-0040-240	
215	Lock Washer (6 req.)	623-0010-411					
261	Pipe Plug	610-0120-011	610-0420-010	610-0120-011	610-0420-010	610-0120-011	610-0420-010

*Recommended spare parts.
**2 Required

See page 8 for Repair/Conversion Kits

REPAIR/CONVERSION KIT NUMBERS

ELASTOMER REPAIR/CONVERSION KITS

Item No.	Description	331 Models			332 Models		
		NBR	EPDM	FPM	NBR	EPDM	FPM
—	Kit No.	311-9026-000	311-9025-000	311-9054-000	311-9027-000	311-9038-000	311-9055-000
21	• Stator	340-3501-120	340-3501-320	340-3501-520	340-3502-120	340-3502-320	340-3502-520
24	• Joint	320-1511-000‡	320-6367-000†	320-4670-000†	320-1511-000‡	320-6367-000†	320-4670-000†
69	• Seal	320-2424-000	320-6379-000	320-6501-000	320-2424-000	320-6379-000	320-6501-000
Item No.	Description	333 Models			344 Models		
		NBR	EPDM	FPM	NBR	EPDM	FPM
—	Kit No.	311-9029-000	311-9028-000	311-9056-000	311-9031-000	311-9030-000	311-9057-000
21	• Stator	340-3503-120	340-3503-320	340-3503-520	340-3504-120	340-3504320	340-3504520
24	• Joint	320-1511-000‡	320-6367-000†	320-4670-000†	320-1511-000‡	320-6367-000†	320-4670-000†
69	• Seal	320-2424-000	320-6379-000	320-6501-000	320-2424-000	320-6379-000	320-6501-000

†316SS/with appropriate elastomer.
‡Carbon steel. NBR kits are available only with carbon steel joints; a 316SS/NBR joint for 331-344 Models is available as 320-3759-000.

Item No.	Description	356 Models			367 Models		
		NBR	EPDM	FPM	NBR	EPDM	FPM
—	Kit No. (Mech. Seal Models)	311-9033-000	311-9032-000	311-9058-000	311-9060-000	311-9036-000	311-9124-000
21	• Stator	340-3505-120	340-3505-320	340-3505-520	340-3506-120	340-3506-320	340-3506-520
24	• Flex Joint	320-1583-000‡	320-6369-000†	320-4671-000†	320-1749-000‡	320-6378-000‡	3206515-000‡
69	• Seal	320-3945-000	320-6380-000	320-6510-000	320-1750-000	320-6390-000	320-6517-000
45	• Rotor Pins				320-4439-002	320-4439-002	320-4439-002
46	• Shaft Pin				320-4439-001	320-4439-001	320-4439-001
—	Kit No (Packing Gland Models)	311-9035-000	311-9034-000	311-9059-000			
21	• Stator	340-3505-120	340-3505-320	340-3505-520			
24	• Joint	320-1583-000‡	320-6369-000†	320-4671-000†			

†316SS/with appropriate elastomer.
‡Carbon steel. NBR kits are available only with carbon steel joints; a 316SS/NBR joint for Model 35604 and 35613 pumps is available as 320-4427-000; a 316SS/NBR joint for model 36704 is available as 320-4436-000.

ABRASION RESISTANT SEALS

Elastomer	Models		
	331-344	356	36701
NBR	3206460000	3206505000	3206511000
EPDM	3206502000	3206506000	3206512000
FPM	3206503000	3206507000	3206513000

NBR = Nitrile
EPDM = Ethylene-Propylene-Diene Terpolymer
FPM = Fluoroelastomer

Printed in U.S.A.

MOYNO

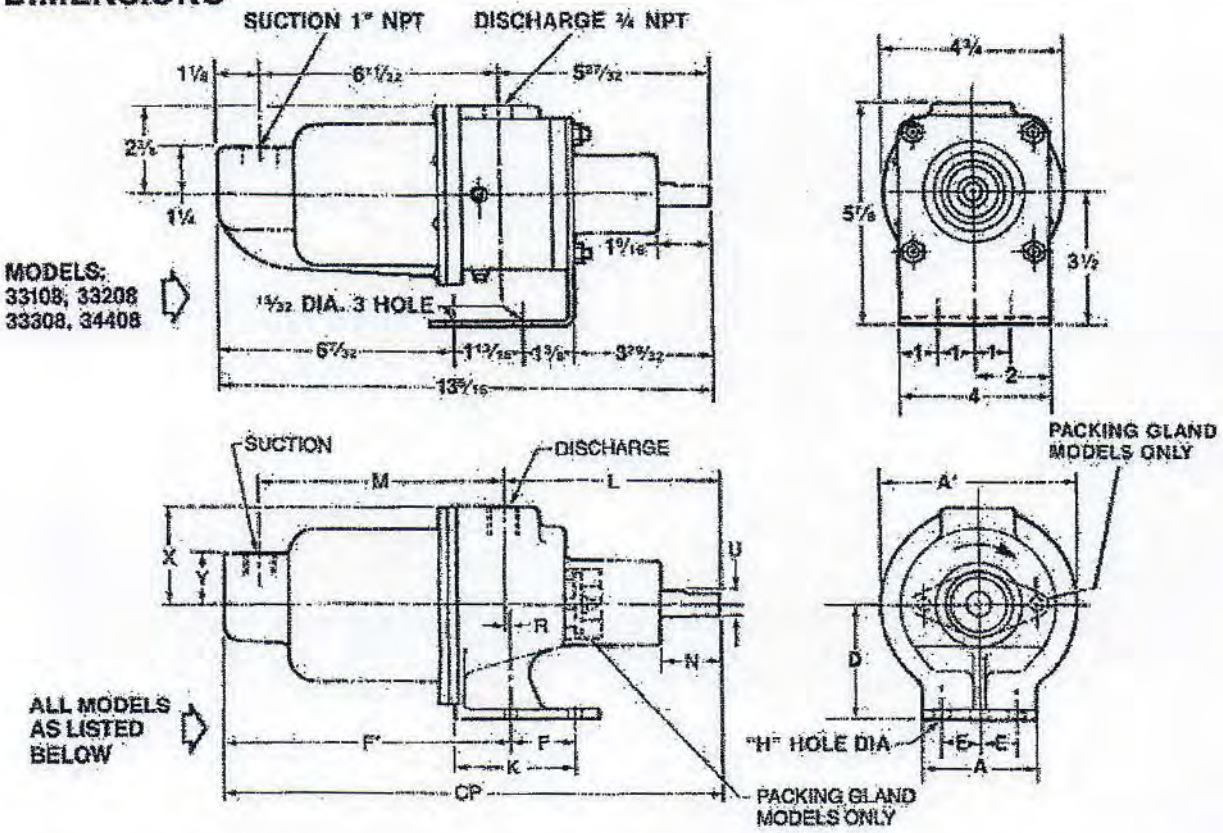
Always the Right Solution™

SPECIFICATION DATA

MOYNO® 500 PUMPS

300 SERIES
331, 332, 333, 344, 356 AND 367 MODELS

DIMENSIONS



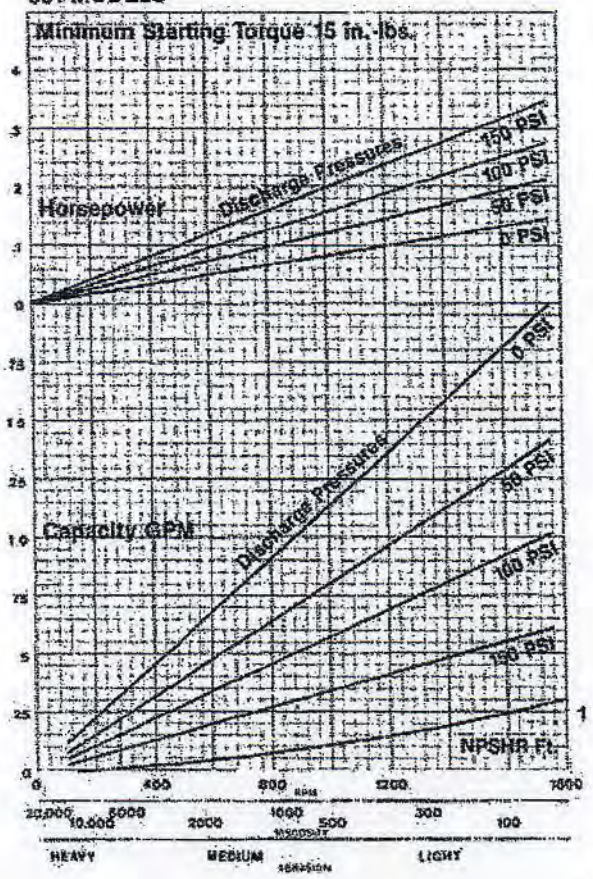
MODELS	CP	A	A¹	D	E	F	F¹	H	K	L	M	N	R	U	X	Y	SUCT (NPT)	DISCH (NPT)
33101, 33201 33301, 33104 33204, 33304 34401, 34404	12 5/8	3 1/8	4 3/4	2 3/4	1	1 13/16	6 15/16	13/32	3 1/32	5 11/16	6 1/16	1 7/16	—	5/8	2 3/8	1 1/4	3/4	3/4
*34411	13 15/16	3 1/4	4 3/4	2 3/4	1 1/8	—	7 9/16	13/32	2 1/8	7	6 1/16	1 3/8	1/4	5/8	2 5/16	1 1/4	3/4	3/4
35601, 35604	17 1/2	6 1/2	7 9/16	4 9/32	1 3/4	2	10 19/32	13/32	4 1/2	7 3/8	8 5/8	2 3/8	15/32	3/4	3 25/32	2 1/8	1 1/2	1 1/4
*35611, *35613	19 3/8	6 1/2	7 9/16	4 9/32	1 3/4	2 1/2	10 19/32	13/32	4	9 11/32	8 5/8	2 13/32	9/16	3/4	3 25/32	2 1/8	1 1/2	1 1/4
36701, 36704	20 15/16	5 1/4	8	4 1/2	2	2 5/16	13	9/16	4 1/16	7 15/16	11 3/16	2 1/8	—	1	4	2 1/2	2	2

*Packing Gland Model

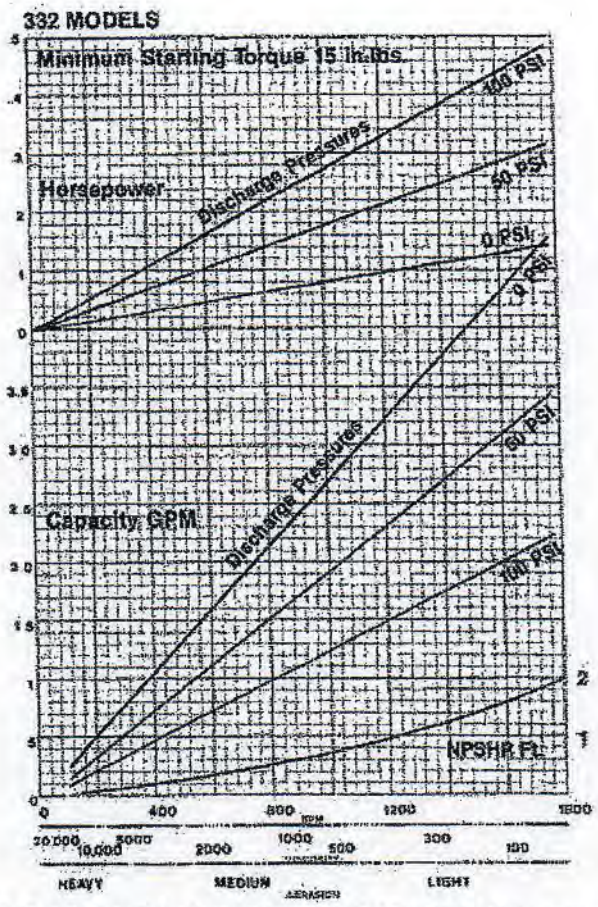
All dimensions are in inches. Specifications subject to change without notice.

331, 332, 333 and 344 MODELS
PERFORMANCE (water at 70°F)

331 MODELS



332 MODELS



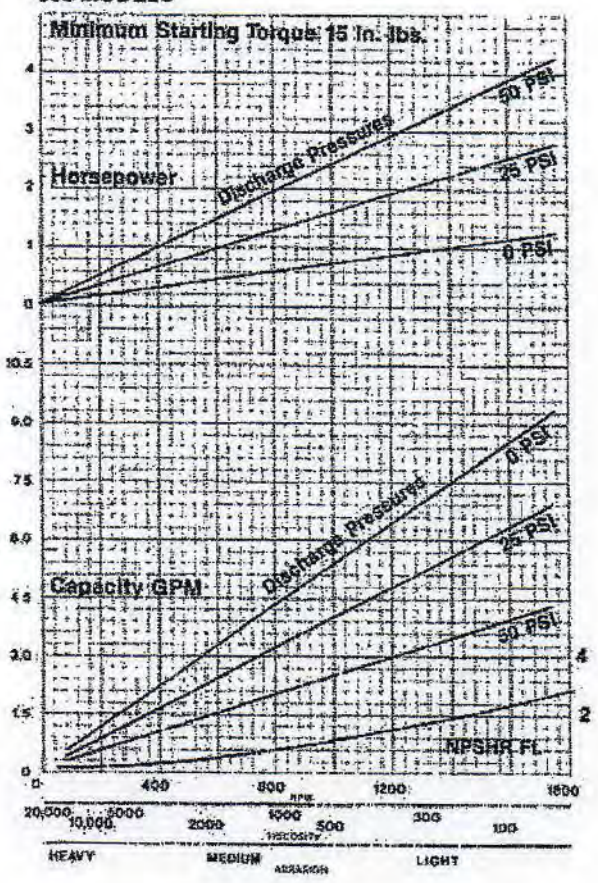
NOTE: For fluids with viscosity over 200 CP (1000 SSU), pump capacity is reduced by 20%.

MATERIALS OF CONSTRUCTION

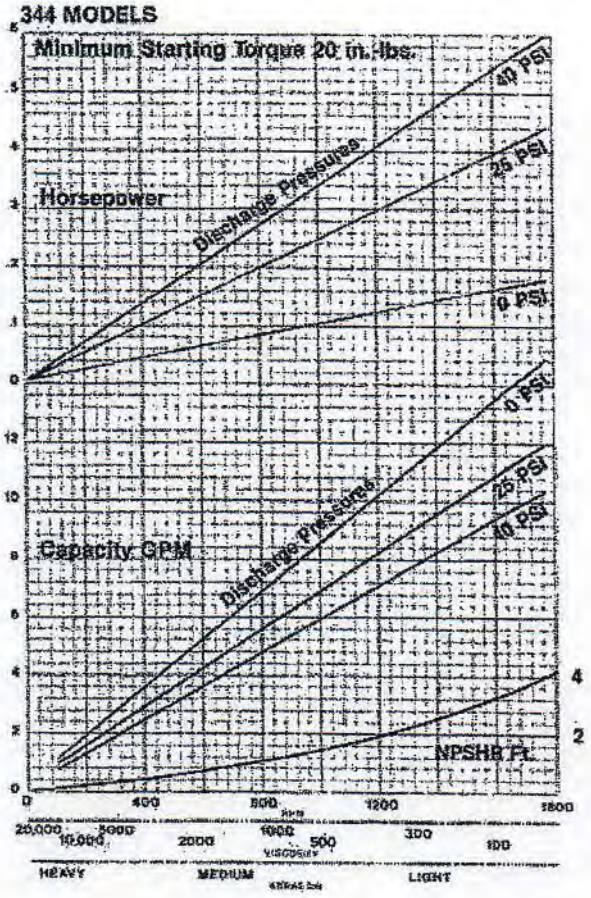
COMPONENT	MODELS			
	33101, 33201 33301, 34401	33104, 33204 33304, 34404	33108, 33208 33308, 34408	*34411
Housing	Cast iron	316 SS	Nylon	Cast iron
Rotor	416 SS/CP	316 SS/CP	416 SS/CP	416 SS/CP
Stator	NBR (Nitrile)	NBR (Nitrile)	NBR (Nitrile)	NBR (Nitrile)
Weight (lbs)	16	16	8	16

* Packing Gland Model
CP = Chrome plated

333 MODELS



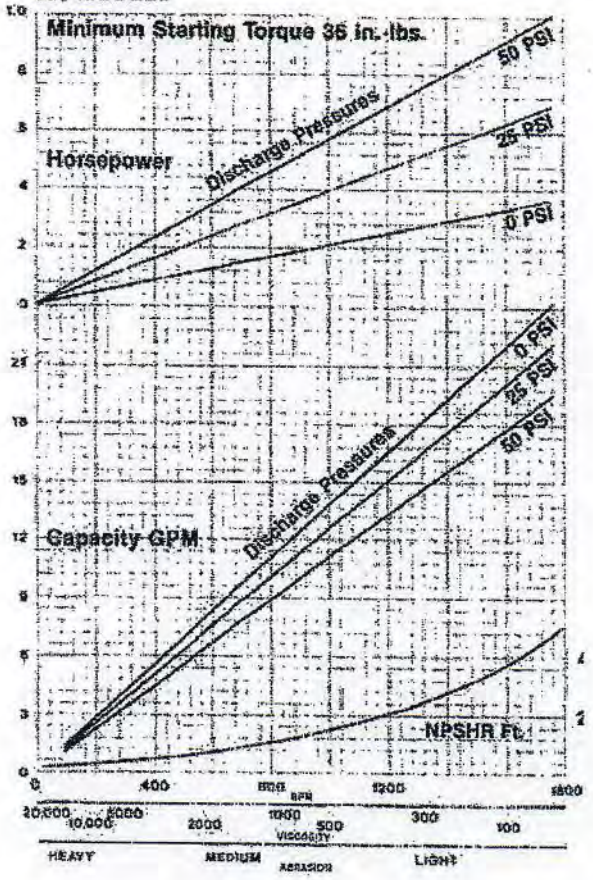
344 MODELS



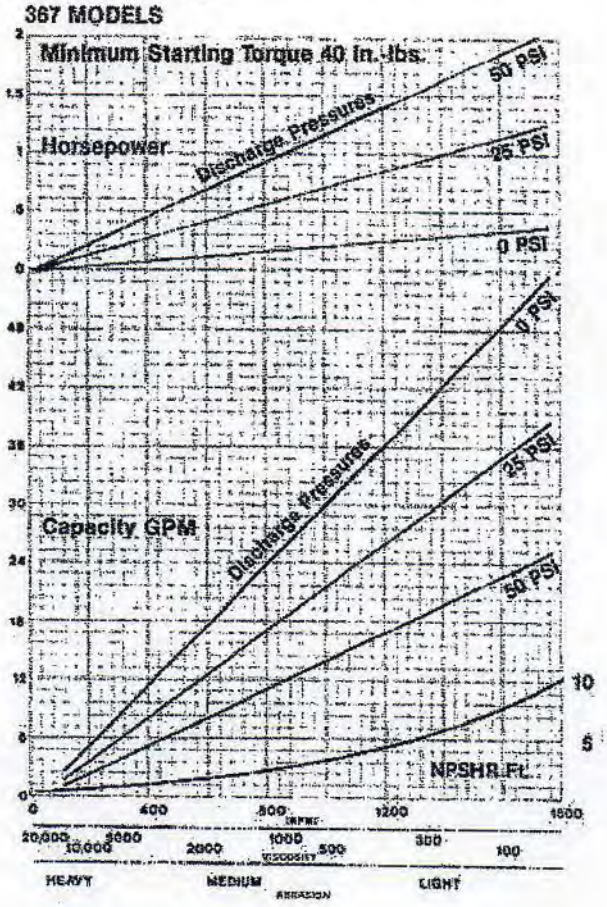
NOTE: For fluids with viscosity over 200 CP (1000 SSU), pump capacity is reduced by 20%.

356 and 367 MODELS PERFORMANCE (water at 70°F)

356 MODELS



367 MODELS



NOTE: For fluids with viscosity over 200 CP (1,000 SSU), pump capacity is reduced by 20%.

MATERIALS OF CONSTRUCTION

COMPONENT	MODELS					
	35601, 35611		35604, 35613		36701	36704
Housing	Cast iron		316 SS		Cast iron	316 SS
Rotor	416 SS/CP		316 SS/CP		416 SS/CP	316 SS/CP
Stator	NBR (Nitrile)		NBR (Nitrile)		NBR (Nitrile)	NBR (Nitrile)
Weight (lbs)	37	40	37	40	54	54

CP=Chrome plated

Printed in U.S.A.

BALDOR • RELIANCE

Integral Horsepower
AC Induction Motors
ODP, WPI, WPII Enclosure
TEFC Enclosure
Explosion Proof

Installation & Operating Manual

2/07

MN400

Table of Contents

Section 1
General Information

Overview This manual contains general procedures that apply to Baldor Motor products. Be sure to read and understand the Safety Notice statements in this manual. For your protection, do not install, operate or attempt to perform maintenance procedures until you understand the Warning and Caution statements. A Warning statement indicates a possible unsafe condition that can cause harm to personnel. A Caution statement indicates a condition that can cause damage to equipment.

Important: **This instruction manual is not intended to include a comprehensive listing of all details for all procedures required for installation, operation and maintenance. This manual describes general guidelines that apply to most of the motor products shipped by Baldor. If you have a question about a procedure or are uncertain about any detail, Do Not Proceed. Please contact your Baldor distributor for more information or clarification.**

Before you install, operate or perform maintenance, become familiar with the following:

- NEMA Publication MG-2, Safety Standard for Construction and guide for Selection, Installation and Use of Electric Motors and Generators.
- The National Electrical Code
- Local codes and Practices

Limited Warranty

1. Most Baldor products are warranted for 18 months from the date of shipment to Baldor's customer from Baldor's district warehouse or, if applicable, from Baldor's factory. Baldor Standard-E® standard efficient motors are warranted for 24 months. Standard-E is limited to three phase, general purpose, 1-200 HP ratings that fall under the Energy Policy Act (EPAct). Baldor Super-E® premium efficient motors are warranted for 36 months. Baldor IEEE841 motors are warranted for 60 months. All warranty claims must be submitted to a Baldor Service Center prior to the expiration of the warranty period.
2. Baldor will, at its option repair or replace a motor which fails due to defects in material or workmanship during the warranty period if:
   a. the purchaser presents the defective motor at or ships it prepaid to, the Baldor plant in Fort Smith, Arkansas or one of the Baldor Authorized Service Centers and
   b. the purchaser gives written notification concerning the motor and the claimed defect including the date purchased, the task performed by the Baldor motor and the problem encountered.
3. Baldor will not pay the cost of removal of any electric motor from any equipment, the cost of delivery to Fort Smith, Arkansas or a Baldor Authorized Service Center, or the cost of any incidental or consequential damages resulting from the claimed defects. (Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above exclusion may not apply to you.) Any implied warranty given by laws shall be limited to the duration of the warranty period hereunder. (Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.)
4. Baldor Authorized Service Centers, when convinced to their satisfaction that a Baldor motor developed defects in material or workmanship within the warranty period, are authorized to proceed with the required repairs to fulfill Baldor's warranty when the cost of such repairs to be paid by Baldor does not exceed Baldor's warranty repair allowance. Baldor will not pay overtime premium repair charges without prior written authorization.
5. The cost of warranty repairs made by centers other than Baldor Authorized Service Centers **WILL NOT** be paid unless first authorized in writing by Baldor.
6. Claims by a purchaser that a motor is defective even when a failure results within one hour after being placed into service are not always justified. Therefore, Baldor Authorized Service Centers must determine from the condition of the motor as delivered to the center whether or not the motor is defective. If in the opinion of a Baldor Authorized Service Center, a motor did not fail as a result of defects in material or workmanship, the center is to proceed with repairs only if the purchaser agrees to pay for such repairs. If the decision is in dispute, the purchaser should still pay for the repairs and submit the paid invoice and the Authorized Service Center's signed service report to Baldor for further consideration.
7. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Safety Notice:

This equipment contains high voltage! Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt installation, operation and maintenance of electrical equipment.

Be sure that you are completely familiar with NEMA publication MG-2, safety standards for construction and guide for selection, installation and use of electric motors and generators, the National Electrical Code and local codes and practices. Unsafe installation or use can cause conditions that lead to serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.

WARNING: **Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.**

WARNING: **Be sure the system is properly grounded before applying power. Do not apply AC power before you ensure that all grounding instructions have been followed. Electrical shock can cause serious or fatal injury. National Electrical Code and Local codes must be carefully followed.**

WARNING: **Avoid extended exposure to machinery with high noise levels. Be sure to wear ear protective devices to reduce harmful effects to your hearing.**

WARNING: **This equipment may be connected to other machinery that has rotating parts or parts that are driven by this equipment. Improper use can cause serious or fatal injury. Only qualified personnel should attempt to install operate or maintain this equipment.**

WARNING: **Do not by-pass or disable protective devices or safety guards. Safety features are designed to prevent damage to personnel or equipment. These devices can only provide protection if they remain operative.**

WARNING: **Avoid the use of automatic reset devices if the automatic restarting of equipment can be hazardous to personnel or equipment.**

WARNING: **Be sure the load is properly coupled to the motor shaft before applying power. The shaft key must be fully captive by the load device. Improper coupling can cause harm to personnel or equipment if the load decouples from the shaft during operation.**

WARNING: **Use proper care and procedures that are safe during handling, lifting, installing, operating and maintaining operations. Improper methods may cause muscle strain or other harm.**

WARNING: **Before performing any motor maintenance procedure, be sure that the equipment connected to the motor shaft cannot cause shaft rotation. If the load can cause shaft rotation, disconnect the load from the motor shaft before maintenance is performed. Unexpected mechanical rotation of the motor parts can cause injury or motor damage.**

WARNING: **Disconnect all electrical power from the motor windings and accessory devices before disassembly of the motor. Electrical shock can cause serious or fatal injury.**

WARNING: **Do not use non UL/CSA listed explosion proof motors in the presence of flammable or combustible vapors or dust. These motors are not designed for atmospheric conditions that require explosion proof operation.**

WARNING: **Motors that are to be used in flammable and/or explosive atmospheres must display the UL label on the nameplate along with CSA listed logo.**

Specific service conditions for these motors are defined in NFPA 70 (NEC) Article 500.

WARNING: **UL Listed motors must only be serviced by UL Approved Authorized Baldor Service Centers if these motors are to be returned to a hazardous and/or explosive atmosphere.**

Caution: **To prevent premature equipment failure or damage, only qualified maintenance personnel should perform maintenance.**

Caution: **Do not over-lubricate motor as this may cause premature bearing failure.**

Caution: **Do not lift the motor and its driven load by the motor lifting hardware. The motor lifting hardware is adequate for lifting only the motor. Disconnect the load from the motor shaft before moving the motor.**

Caution: **If eye bolts are used for lifting a motor, be sure they are securely tightened. The lifting direction should not exceed a 20° angle from the shank of the eye bolt or lifting lug. Excessive lifting angles can cause damage.**

Caution: **To prevent equipment damage, be sure that the electrical service is not capable of delivering more than the maximum motor rated amps listed on the rating plate.**

Caution: **If a HI POT test (High Potential Insulation test) must be performed, follow the precautions and procedure in NEMA MG1 and MG2 standards to avoid equipment damage.**

If you have any questions or are uncertain about any statement or procedure, or if you require additional information please contact your Baldor distributor or an Authorized Baldor Service Center.

Receiving

Each Baldor Electric Motor is thoroughly tested at the factory and carefully packaged for shipment. When you receive your motor, there are several things you should do immediately.

1. Observe the condition of the shipping container and report any damage immediately to the commercial carrier that delivered your motor.
2. Verify that the part number of the motor you received is the same as the part number listed on your purchase order.

Storage

If the motor is not put into service immediately, the motor must be stored in a clean, dry and warm location. Several precautionary steps must be performed to avoid motor damage during storage.

1. Use a "Megger" periodically to ensure that the integrity of the winding insulation has been maintained. Record the Megger readings. Immediately investigate any significant drop in insulation resistance.
2. Do not lubricate bearings during storage. Motor bearings are packed with grease at the factory. Excessive grease can damage insulation quality.
3. Rotate motor shaft at least 10 turns every two months during storage (more frequently if possible). This will prevent bearing damage due to storage.
4. If the storage location is damp or humid, the motor windings must be protected from moisture. This can be done by applying power to the motors' space heater (if available) while the motor is in storage.

Unpacking

Each Baldor motor is packaged for ease of handling and to prevent entry of contaminants.

1. To avoid condensation inside the motor, do not unpack until the motor has reached room temperature. (Room temperature is the temperature of the room in which it will be installed). The packing provides insulation from temperature changes during transportation.
2. When the motor has reached room temperature, remove all protective wrapping material from the motor.

Handling

The motor should be lifted using the lifting lugs or eye bolts provided.

1. Use the lugs or eye bolts provided to lift the motor. Never attempt to lift the motor and additional equipment connected to the motor by this method. The lugs or eye bolts provided are designed to lift only the motor. Never lift the motor by the motor shaft or the hood of a WPII motor.
2. When lifting a WPII (Weather Proof Type 2) motor, do not lift the motor by inserting lifting lugs into holes on top of the cooling hood. These lugs are to be used for hood removal only. A spreader bar should be used to lift the motor by the cast lifting lugs located on the motor frame.
3. If the motor must be mounted to a plate with the driven equipment such as pump, compressor etc., it may not be possible to lift the motor alone. For this case, the assembly should be lifted by a sling around the mounting base. The entire assembly can be lifted as an assembly for installation. Do not lift using the motor lugs or eye bolts provided.

   If the load is unbalanced (as with couplings or additional attachments) additional slings or other means must be used to prevent tipping. In any event, the load must be secure before lifting.

Section 2
Installation & Operation

Overview

Installation should conform to the National Electrical Code as well as local codes and practices. When other devices are coupled to the motor shaft, be sure to install protective devices to prevent future accidents. Some protective devices include, coupling, belt guard, chain guard, shaft covers etc. These protect against accidental contact with moving parts. Machinery that is accessible to personnel should provide further protection in the form of guard rails, screening, warning signs etc.

Location

It is important that motors be installed in locations that are compatible with motor enclosure and ambient conditions. Improper selection of the motor enclosure and ambient conditions can lead to reduced operating life of the motor.

Proper ventilation for the motor must be provided. Obstructed airflow can lead to reduction of motor life.

1. **Open Drip-Proof/WPI** motors are intended for use indoors where atmosphere is relatively clean, dry, well ventilated and non-corrosive.
2. **Totally Enclosed and WPII** motors may be installed where dirt, moisture or dust are present and in outdoor locations.

Severe Duty, IEEE 841 and Washdown Duty enclosed motors are designed for installations with high corrosion or excessive moisture conditions. These motors should not be placed into an environment where there is the presence of flammable or combustible vapors, dust or any combustible material, unless specifically designed for this type of service.

Mounting

The motor must be securely installed to a rigid foundation or mounting surface to minimize vibration and maintain alignment between the motor and shaft load. Failure to provide a proper mounting surface may cause vibration, misalignment and bearing damage.

Foundation caps and sole plates are designed to act as spacers for the equipment they support. If these devices are used, be sure that they are evenly supported by the foundation or mounting surface.

After installation is complete and accurate alignment of the motor and load is accomplished, the base should be grouted to the foundation to maintain this alignment.

The standard motor base is designed for horizontal or vertical mounting. Adjustable or sliding rails are designed for horizontal mounting only. Consult your Baldor distributor or authorized Baldor Service Center for further information.

Alignment

Accurate alignment of the motor with the driven equipment is extremely important.

1. **Direct Coupling**
   For direct drive, use flexible couplings if possible. Consult the drive or equipment manufacturer for more information. Mechanical vibration and roughness during operation may indicate poor alignment. Use dial indicators to check alignment. The space between coupling hubs should be maintained as recommended by the coupling manufacturer.
2. **End-Play Adjustment**
   The axial position of the motor frame with respect to its load is also extremely important. The motor bearings are not designed for excessive external axial thrust loads. Improper adjustment will cause failure.
3. **Pulley Ratio**
   The pulley ratio should not exceed 8:1.
4. **Belt Drive**
   Align sheaves carefully to minimize belt wear and axial bearing loads (see End-Play Adjustment). Belt tension should be sufficient to prevent belt slippage at rated speed and load. However, belt slippage may occur during starting.

   Caution: Do not over tension belts.
5. Sleeve bearing motors are only suitable for coupled loads.

Doweling & Bolting

After proper alignment is verified, dowel pins should be inserted through the motor feet into the foundation. This will maintain the correct motor position should motor removal be required. (Baldor motors are designed for doweling.)

1. Drill dowel holes in diagonally opposite motor feet in the locations provided.
2. Drill corresponding holes in the foundation.
3. Ream all holes.
4. Install proper fitting dowels.
5. Mounting bolts must be carefully tightened to prevent changes in alignment. Use a flat washer and lock washer under each nut or bolt head to hold the motor feet secure. Flanged nuts or bolts may be used as an alternative to washers.

Power Connection

Motor and control wiring, overload protection, disconnects, accessories and grounding should conform to the National Electrical Code and local codes and practices.

Conduit Box

For ease of making connections, an oversize conduit box is provided. The box can be rotated 360° in 90° increments. Auxiliary conduit boxes are provided on some motors for accessories such as space heaters, RTD's etc.

AC Power

Connect the motor leads as shown on the connection diagram located on the name plate or inside the cover on the conduit box. Be sure the following guidelines are met:

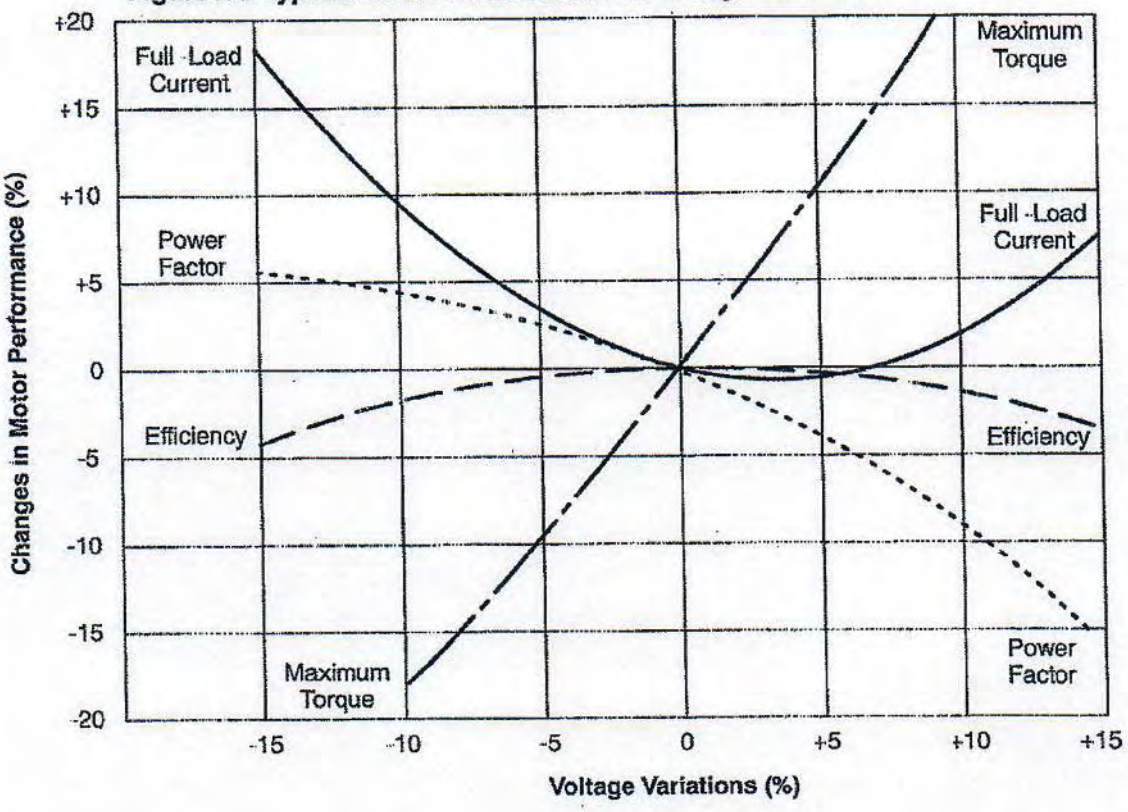
1. AC power is within ±10% of rated voltage with rated frequency. (See motor name plate for ratings).
   OR
2. AC power is within ±5% of rated frequency with rated voltage.
   OR
3. A combined variation in voltage and frequency of ±10% (sum of absolute values) of rated values, provided the frequency variation does not exceed ±5% of rated frequency.

Performance within these voltage and frequency variations are shown in Figure 2-2.

Figure 2-1 Accessory Connections

HEATERS H1 —WW— H2 H1 —WW— H2	One heater is installed in each end of motor. Leads for each heater are labeled H1 & H2. (Like numbers should be tied together).
THERMISTERS T1 —WWW— T2	Three thermisters are installed in windings and tied in series. Leads are labeled T1 & T2.
WINDING RTDS RED RED WHITE	Winding RTDs are installed in windings (2) per phase. Each set of leads is labeled W1, W2, W3, W4, W5, & W6.
BEARING RTD RED RED WHITE	* One bearing RTD is installed in Drive endplate (PUEP), leads are labeled RTDDE. * One bearing RTD is installed in Opposite Drive endplate (FREP), leads are labeled RTDODE. * Note RTD may have 2-Red/1-White leads; or 2-White/1-Red Lead.

Figure 2-2 Typical Motor Performance VS Voltage Variations



First Time Start Up

Be sure that all power to motor and accessories is off. Be sure the motor shaft is disconnected from the load and will not cause mechanical rotation of the motor shaft.

1. Make sure that the mechanical installation is secure. All bolts and nuts are tightened etc.
2. If motor has been in storage or idle for some time, check winding insulation integrity with a Megger.
3. Inspect all electrical connections for proper termination, clearance, mechanical strength and electrical continuity.
4. Be sure all shipping materials and braces (if used) are removed from motor shaft.
5. Manually rotate the motor shaft to ensure that it rotates freely.
6. Replace all panels and covers that were removed during installation.
7. Momentarily apply power and check the direction of rotation of the motor shaft.
8. If motor rotation is wrong, be sure power is off and change the motor lead connections. Verify rotation direction before you continue.
9. Start the motor and ensure operation is smooth without excessive vibration or noise If so, run the motor for 1 hour with no load connected.
10. After 1 hour of operation, disconnect power and connect the load to the motor shaft. Verify all coupling guards and protective devices are installed. Ensure motor is properly ventilated.

Coupled Start Up

This procedure assumes a coupled start up. Also, that the first time start up procedure was successful.

1. Check the coupling and ensure that all guards and protective devices are installed.
2. Check that the coupling is properly aligned and not binding.
3. The first coupled start up should be with no load. Apply power and verify that the load is not transmitting excessive vibration back to the motor though the coupling or the foundation. Vibration should be at an acceptable level.
4. Run for approximately 1 hour with the driven equipment in an unloaded condition.

The equipment can now be loaded and operated within specified limits. Do not exceed the name plate ratings for amperes for steady continuous loads.

Jogging and Repeated Starts Repeated starts and/or jogs of induction motors generally reduce the life of the motor winding insulation. A much greater amount of heat is produced by each acceleration or jog than by the same motor under full load. If it is necessary to repeatedly start or jog the motor, it is advisable to check the application with your local Baldor distributor or Baldor Service Center.

Heating - Duty rating and maximum ambient temperature are stated on the motor name plate. Do not exceed these values. If there is any question regarding safe operation, contact your local Baldor distributor or Baldor Service Center.

Section 3
Maintenance & Troubleshooting

WARNING: **UL Listed motors must only be serviced by UL Approved Authorized Baldor Service Centers if these motors are to be returned to a hazardous and/or explosive atmosphere.**

General Inspection

Inspect the motor at regular intervals, approximately every 500 hours of operation or every 3 months, whichever occurs first. Keep the motor clean and the ventilation openings clear. The following steps should be performed at each inspection:

WARNING: **Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.**

1. Check that the motor is clean. Check that the interior and exterior of the motor is free of dirt, oil, grease, water, etc. Oily vapor, paper pulp, textile lint, etc. can accumulate and block motor ventilation. If the motor is not properly ventilated, overheating can occur and cause early motor failure.
2. Use a "Megger" periodically to ensure that the integrity of the winding insulation has been maintained. Record the Megger readings. Immediately investigate any significant drop in insulation resistance.
3. Check all electrical connectors to be sure that they are tight.

Relubrication & Bearings

Bearing grease will lose its lubricating ability over time, not suddenly. The lubricating ability of a grease (over time) depends primarily on the type of grease, the size of the bearing, the speed at which the bearing operates and the severity of the operating conditions. Good results can be obtained if the following recommendations are used in your maintenance program.

Type of Grease

A high grade ball or roller bearing grease should be used. Recommended grease for standard service conditions is Polyrex EM (Exxon Mobil).

Equivalent and compatible greases include:
Texaco Polystar, Rykon Premium #2, Pennzoil Pen 2 Lube and Chevron SRI.

Relubrication Intervals

Recommended relubrication intervals are shown in Table 3-1. It is important to realize that the recommended intervals of Table 3-1 are based on average use.

Refer to additional information contained in Tables 3-2, 3-3 and 3-4.

Table 3-1 Relubrication Intervals *

NEMA / (IEC) Frame Size	Rated Speed - RPM					
	10000	6000	3600	1800	1200	900
Up to 210 incl. (132)	**	2700 Hrs.	5500 Hrs.	12000 Hrs.	18000 Hrs.	22000 Hrs.
Over 210 to 280 incl. (180)		**	3600 Hrs.	9500 Hrs.	15000 Hrs.	18000 Hrs.
Over 280 to 360 incl. (225)		**	* 2200 Hrs.	7400 Hrs.	12000 Hrs.	15000 Hrs.
Over 360 to 5800 incl. (300)		**	*2200 Hrs.	3500 Hrs.	7400 Hrs.	10500 Hrs.

* Relubrication intervals are for ball bearings.
For vertically mounted motors and roller bearings, divide the relubrication interval by 2.

** For motors operating at speeds greater than 3600 RPM, contact Baldor for relubrication recommendations.

Table 3-2 Service Conditions

Severity of Service	Hours per day of Operation	Ambient Temperature Maximum	Atmospheric Contamination
Standard	8	40° C	Clean, Little Corrosion
Severe	16 Plus	50° C	Moderate dirt, Corrosion
Extreme	16 Plus	>50° C* or Class H Insulation	Severe dirt, Abrasive dust, Corrosion, Heavy Shock or Vibration
Low Temperature		<-29 ° C **	

* Special high temperature grease is recommended (Dow Corning DC44). Note that Dow Corning DC44 grease does not mix with other grease types. Thoroughly clean bearing & cavity before adding grease.

** Special low temperature grease is recommended (Aeroshell 7).

Table 3-3 Relubrication Interval Multiplier

Severity of Service	Multiplier
Standard	1.0
Severe	0.5
Extreme	0.1
Low Temperature	1.0

Some motor designs use different bearings on each motor end. This is normally indicated on the motor nameplate. In this case, the larger bearing is installed on the motor Drive endplate. For best relubrication results, only use the appropriate amount of grease for each bearing size (not the same for both).

Table 3-4 Bearings Sizes and Types

Frame Size NEMA (IEC)	Bearing Description (These are the "Large" bearings (Shaft End) in each frame size)			
	Bearing	Weight of Grease to add * oz (Grams)	Volume of grease to be added	
			in^3	teaspoon
56 to 140 (90)	6203	0.08 (2.4)	0.15	0.5
140 (90)	6205	0.15 (3.9)	0.2	0.8
180 (100-112)	6206	0.19 (5.0)	0.3	1.0
210 (132)	6307	0.30 (8.4)	0.6	2.0
250 (160)	6309	0.47 (12.5)	0.7	2.5
280 (180)	6311	0.61 (17)	1.2	3.9
320 (200)	6312	0.76 (20.1)	1.2	4.0
360 (225)	6313	0.81 (23)	1.5	5.2
400 (250)	6316	1.25 (33)	2.0	6.6
440 (280)	6319	2.12 (60)	4.1	13.4
5000 to 5800 (315-450)	6328	4.70 (130)	9.2	30.0
5000 to 5800 (315-450)	NU328	4.70 (130)	9.2	30.0
360 to 449 (225-280)	NU319	2.12 (60)	4.1	13.4
AC Induction Servo				
76 Frame 180 (112)	6207	0.22 (6.1)	0.44	1.4
77 Frame 210 (132)	6210	0.32 (9.0)	0.64	2.1
80 Frame 250(160)	6213	0.49 (14.0)	0.99	3.3

* Weight in grams = .005 DB of grease to be added

Note: Not all bearing sizes are listed. For intermediate bearing sizes, use the grease volume for the next larger size bearing.

Caution: To avoid damage to motor bearings, grease must be kept free of dirt. For an extremely dirty environment, contact your Baldor distributor or an authorized Baldor Service Center for additional information.

Relubrication Procedure Be sure that the grease you are adding to the motor is compatible with the grease already in the motor. Consult your Baldor distributor or an authorized service center if a grease other than the recommended type is to be used.

Caution: Do not over-lubricate motor as this may cause premature bearing failure.

With Grease Outlet Plug

1. With the motor stopped, clean all grease fittings with a clean cloth.
2. Remove grease outlet plug.

Caution: Over-lubricating can cause excessive bearing temperatures, premature lubrication breakdown and bearing failure.

3. Add the recommended amount of grease.
4. Operate the motor for 15 minutes with grease plug removed. This allows excess grease to purge.
5. Re-install grease outlet plug.

Without Grease Provisions

Note: Only a Baldor authorized and UL or CSA certified service center can disassemble a UL/CSA listed explosion proof motor to maintain it's UL/CSA listing.

1. Disassemble the motor.
2. Add recommended amount of grease to bearing and bearing cavity. (Bearing should be about 1/3 full of grease and outboard bearing cavity should be about 1/2 full of grease.)
3. Assemble the motor.

Sample Relubrication Determination

Assume NEMA 286T (IEC 180), 1750 RPM motor driving an exhaust fan in an ambient temperature of 43° C and the atmosphere is moderately corrosive.

1. Table 3-1 list 9500 hours for standard conditions.
2. Table 3-2 classifies severity of service as "Severe".
3. Table 3-4 shows that 1.2 in^3 or 3.9 teaspoon of grease is to be added.

Note: Smaller bearings in size category may require reduced amounts of grease.

Table 3-5 Troubleshooting Chart

Symptom	Possible Causes	Possible Solutions
Motor will not start	Usually caused by line trouble, such as, single phasing at the starter.	Check source of power. Check overloads, fuses, controls, etc.
Excessive humming	High Voltage.	Check input line connections.
	Eccentric air gap.	Have motor serviced at local Baldor service center.
Motor Over Heating	Overload. Compare actual amps (measured) with nameplate rating.	Locate and remove source of excessive friction in motor or load. Reduce load or replace with motor of greater capacity.
	Single Phasing.	Check current at all phases (should be approximately equal) to isolate and correct the problem.
	Improper ventilation.	Check external cooling fan to be sure air is moving properly across cooling fins. Excessive dirt build-up on motor. Clean motor.
	Unbalanced voltage.	Check voltage at all phases (should be approximately equal) to isolate and correct the problem.
	Rotor rubbing on stator.	Check air gap clearance and bearings.
		Tighten "Thru Bolts".
	Over voltage or under voltage.	Check input voltage at each phase to motor.
	Open stator winding.	Check stator resistance at all three phases for balance.
	Grounded winding.	Perform dielectric test and repair as required.
	Improper connections.	Inspect all electrical connections for proper termination, clearance, mechanical strength and electrical continuity. Refer to motor lead connection diagram.
Bearing Over Heating	Misalignment.	Check and align motor and driven equipment.
	Excessive belt tension.	Reduce belt tension to proper point for load.
	Excessive end thrust.	Reduce the end thrust from driven machine.
	Excessive grease in bearing.	Remove grease until cavity is approximately $^3/_4$ filled.
	Insufficient grease in bearing.	Add grease until cavity is approximately $^3/_4$ filled.
	Dirt in bearing.	Clean bearing cavity and bearing. Repack with correct grease until cavity is approximately $^3/_4$ filled.
Vibration	Misalignment.	Check and align motor and driven equipment.
	Rubbing between rotating parts and stationary parts.	Isolate and eliminate cause of rubbing.
	Rotor out of balance.	Have rotor balance checked are repaired at your Baldor Service Center.
	Resonance.	Tune system or contact your Baldor Service Center for assistance.
Noise	Foreign material in air gap or ventilation openings.	Remove rotor and foreign material. Reinstall rotor. Check insulation integrity. Clean ventilation openings.
Growling or whining	Bad bearing	Replace bearing. Clean all grease from cavity and new bearing. Repack with correct grease until cavity is approximately $^3/_4$ filled.

Suggested bearing and winding RTD setting guidelines

Most large frame AC Baldor motors with a 1.15 service factor are designed to operate below a Class B (80°C) temperature rise at rated load and are built with a Class H winding insulation system. Based on this low temperature rise, RTD (Resistance Temperature Detectors) settings for Class B rise should be used as a starting point. Some motors with 1 0 service factor have Class F temperature rise.

The following tables show the suggested alarm and trip settings for RTDs. Proper bearing and winding RTD alarm and trip settings should be selected based on these tables unless otherwise specified for specific applications.

If the driven load is found to operate well below the initial temperature settings under normal conditions, the alarm and trip settings may be reduced so that an abnormal machine load will be identified.

The temperature limits are based on the installation of the winding RTDs imbedded in the winding as specified by NEMA. Bearing RTDs should be installed so they are in contact with the outer race on ball or roller bearings or in direct contact with the sleeve bearing shell.

Winding RTDs - Temperature Limit In °C (40°C Maximum Ambient)

Motor Load	Class B Temp Rise ≤ 80°C (Typical Design)		Class F Temp Rise ≤ 105°C		Class H Temp Rise ≤ 125°C	
	Alarm	Trip	Alarm	Trip	Alarm	Trip
≤ Rated Load	130	140	155	165	175	185
Rated Load to 1.15 S.F.	140	150	160	165	180	185

Note: • Winding RTDs are factory production installed, not from Mod-Express.
• When Class H temperatures are used, consider bearing temperatures and relubrication requirements.

Bearing RTDs - Temperature Limit In °C (40°C Maximum Ambient)

Bearing Type Oil or Grease	Anti-Friction		Sleeve	
	Alarm	Trip	Alarm	Trip
Standard*	95	100	85	95
High Temperature**	110	115	105	110

Note: * Bearing temperature limits are for standard design motors operating at Class B temperature rise.
** High temperature lubricants include some special synthetic oils and greases.

Greases that may be substituted that are compatible with Polyrex EM (but considered as "standard" lubricants) include the following:

- Texaco Polystar
- Rykon Premium #2
- Chevron SRI #2
- Mobilith SHC-100
- Pennzoil Pennzlube EM-2
- Chevron Black Pearl
- Darmex 707
- Darmex 711
- Petro-Canada Peerless LLG

See the motor nameplate for replacement grease or oil recommendation.
Contact Baldor application engineering for special lubricants or further clarifications.

Gasho
SINCE 1982
The Leader in Blower & Vacuum Solutions
460 West Gay Street
West Chester, PA 19380
610-692-5650 Fax 610-692-5837
cs@gasho.org

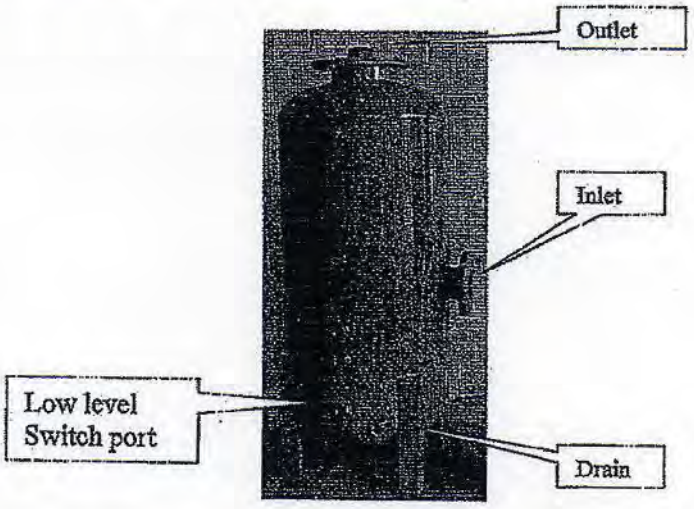
Moisture Separators

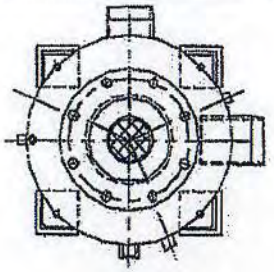
Moisture separators are used to remove water and other liquids from air streams They are typically used on the inlet of vacuum systems to remove water and other contaminants before they enter the vacuum pump The air volume of the moisture separator reduces the velocity of the air stream to allow liquids to precipitate. Up to 95% water removal is possible. The models GX-30 & GX-60 are rated for full vacuum. Other moisture separators are rated to 18 in Hg. higher vacuum ratings available

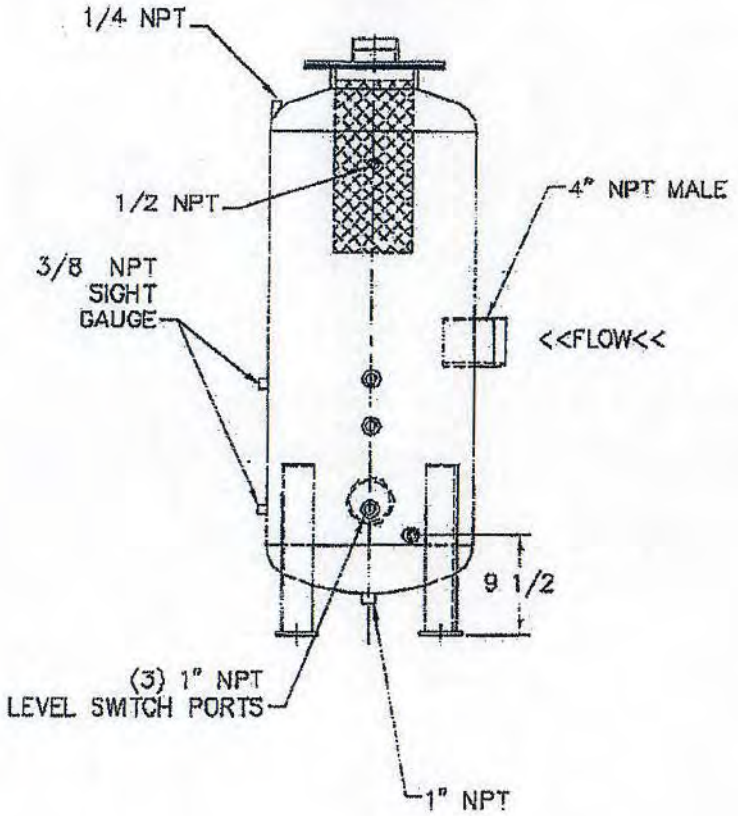
Standard accessories include a sight gauge, drain valve, and a hand operated sludge pump Inside the top of the separators is a basket with "tri-packs" demister material to promote condensation of vapors.

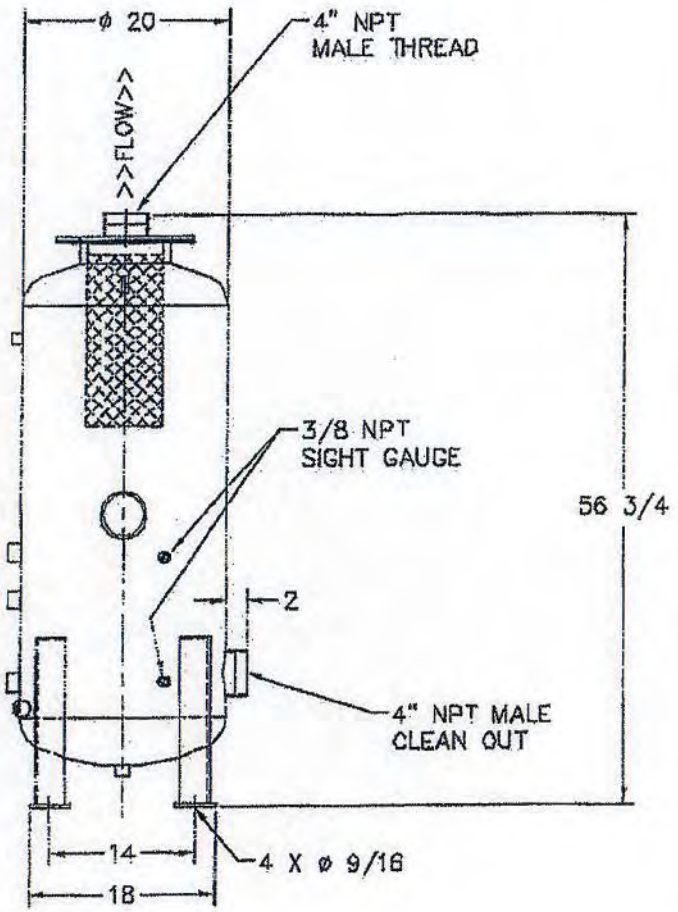
Options include: 1 to 3 level switches, automatic pump down systems, heat tracing, vacuum gauges, and thermometers.

Model Number	Nominal Flow Rate	Liquid Capacity	Diameter (inches)	Height (inches)	Inlet Size	Discharge Size	Cleanout Size
GX-30	250	8	16	47	3"	3"	4"
GX-60	500	22	20	57	4"	4"	4"
GX-90	1200	30	24	57	6" Flange	6" Flange	4"
GX-120	2000	40	24	70	8" Flange	8" Flange	4"
GX-200	2000	95	30	85	8" Flange	8" Flange	4"









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NOTES:
1. FINISH: GRAY ENAMEL.
2. ALL PORTS ARE FEMALE EXCEPT 4"

REV.	DATE	DESCRIPTION
D	6-1-2001	REDRAWN AND REVISED NPT
C	6-13-1998	ADD SIGHT GAUGE

DRAWN BY: ROBINSON — DATE: 8-13-98
APPROVED BY: — DATE:
DIMENSIONS IN INCHES
SCALE: — WEIGHT:
MATERIAL: STEEL — SHEET: 100
SHEET 1 OF 1

J.E.GASHO & Assoc., Inc.
480 W. GAY ST.
WEST CHESTER, PENNSYLVANIA 19380

GX-60 SEPARATOR
60 GAL. VESSEL
22 GAL. LIQ CAPACITY

1000-C-501 D

COMPACT "L" STYLE INLET VACUUM AIR FILTERS
"CSL" Series 3/8" - 3" FPT

APPLICATIONS

- Blowers-Side Channel
- Factory Automation
- Leak Detection
- Medical
- Printing Industry
- Soil Venting/Remediation
- Vacuum Lifters
- Vacuum Packaging
- Vacuum Pumps & Systems
- Woodworking

FEATURES & SPECIFICATIONS

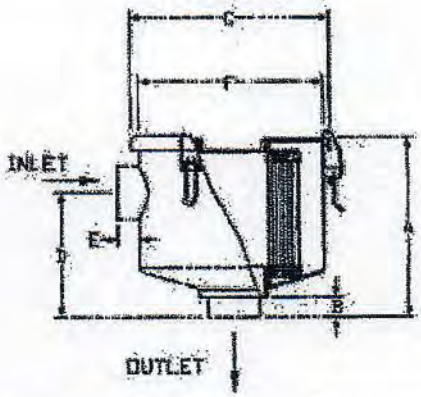
- ;99%+ removal efficiency std: Paper=2 micron, Polyester=5 micron
- Filter change out differential: 10"-15" in H_2O above initial delta P
- Positive sealing O-ring seal system
- Rugged all steel construction with baked enamel finish
- Stainless steel torsion clips for durability
- Vacuum level: Typically $1x10^{-3}$ mmHg ($1.3x10^{-3}$ mbar)
- Brazed fittings for high vacuum duty
- Low pressure drop
- Pressure drop graphs available upon request
- Seamless drawn housings
- Temp (continuous): min -15° F (-26° C) max 220° F (104° C)

OPTIONS

- Activated carbon prefilter to reduce odor
- Alternate Top-to-canister fastening system for low pressure or pulsating systems
- Available in *Stainless Steel*
- Epoxy coated housings
- Extra tap fittings for vacuum gauge
- Larger sizes available
- Special connections
- Support brackets
- Vacuum gauge available
- Various elements available

Click to see larger image.

Line Drawing



***All measurements are shown in standards.**

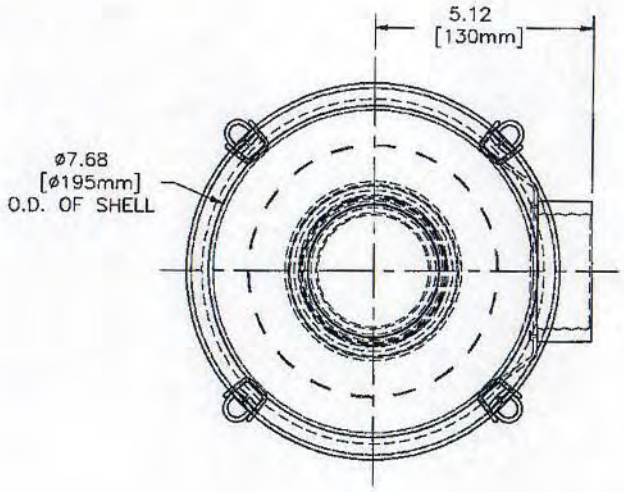
Typical Lead Times:	
Normally in stock	
1 - 2 weeks	5 - 7 weeks
3 - 4 weeks	8 + weeks

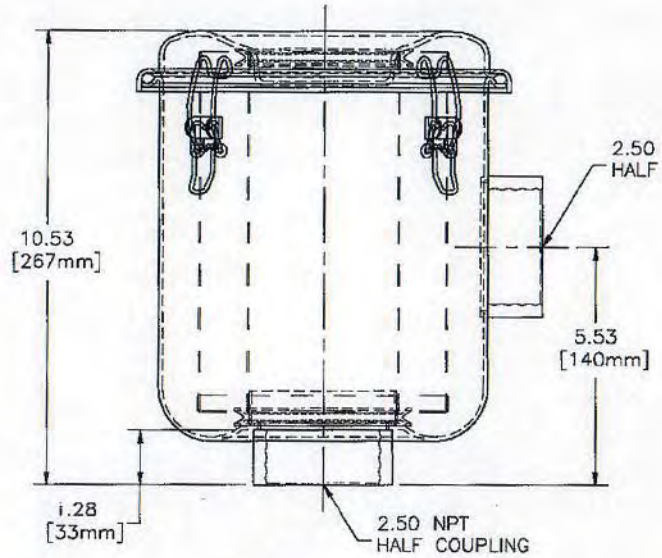
Add To Order	Model Number	Element Type	Inlet in. NPT or FLG	Outlet in. NPT or FLG	Connection Style	Dim A in.	Dim B in	Dim C in.	Dim D in.	Dim E in	Dim F in	Dim G in	Parent Flow SCFM	Element Parent Flow SCFM	Approx. Weight lbs.	CAD
	CSL-850-250HC	Paper	2.5	2.5	FPT	10.5	1.25	8.75	5.5	1.25	7.62	9.25	210	290	15	CAD

Solberg Mfg.
1151 W Ardmore Ave Itasca, IL 60143 (630)773-1363 Fax: (630)773-0727

CSL_1-3

REVISIONS						
ZONE	REV	DESCRIPTION	ECN #	CHG BY	DATE	APP'D





REPLACEMENT ELEMENT# 851	
MATERIAL	POLYESTER
CFM FLOW	290
SURFACE AREA	4.5 SQ. FT.
I.D.	3.50
O.D.	5.88
HEIGHT	8.75

MODEL#	HOUSING MATERIAL	FINISH
CSL-851-250HC	CARBON STEEL	BAKED ENAMEL GREY

UNLESS OTHERWISE SPECIFIED:
- DIMENSIONS ARE IN INCHES
- REF: APPROXIMATE DIMENSIONS, NO TOLERANCES APPLY
- TOLERANCES ARE:

DECIMALS:	.XX ±.25
	.XXX ±.125
ANGLES	±2°

CUSTOMER APPROVAL:

SOLBERG MANUFACTURING INC.
1151 W. ARDMORE AVE.
ITASCA, IL 60143
630/773-1363

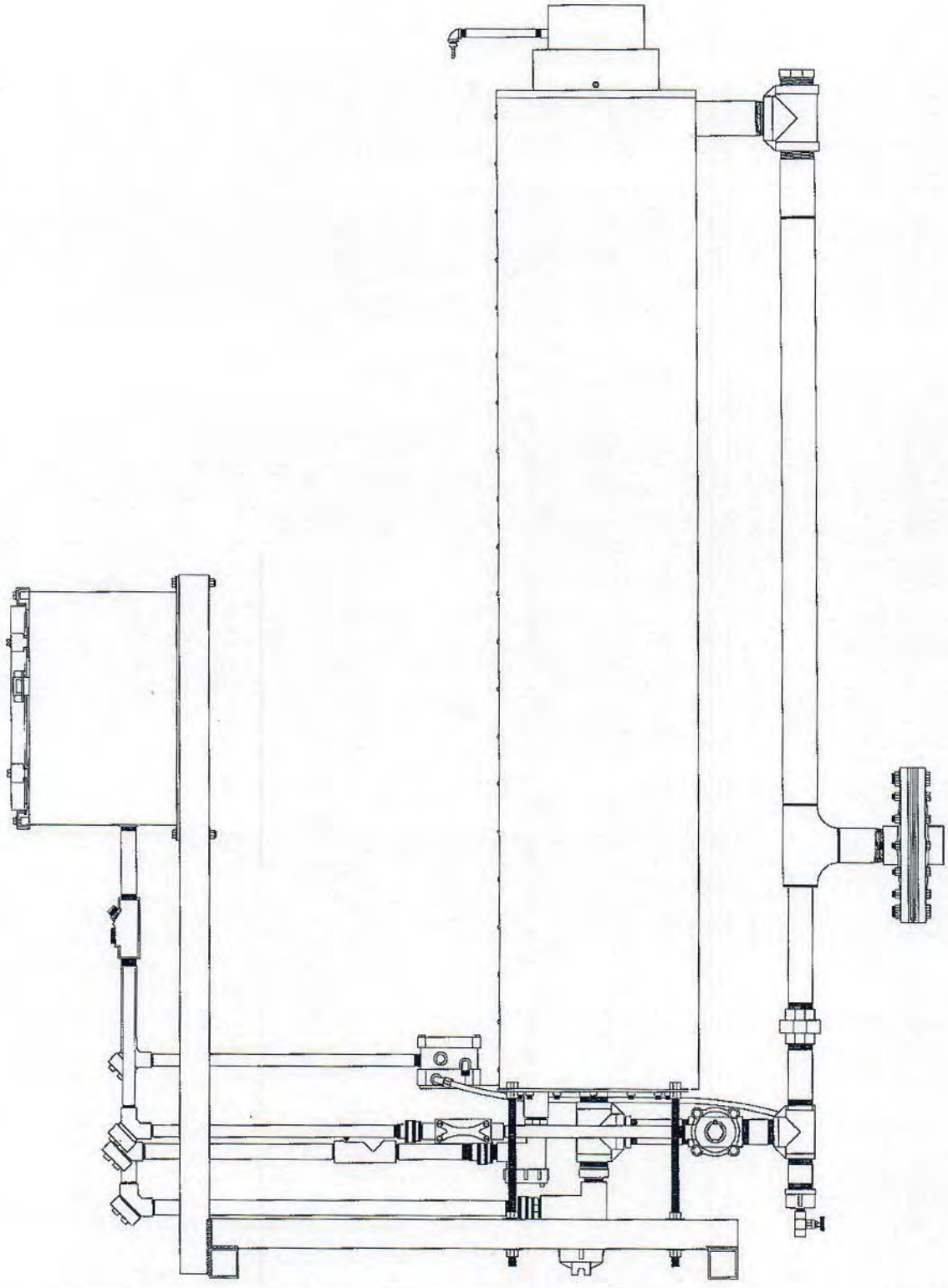
DESCRIPTION: CSL-851-250HC

SALES REP.:			
APPROVALS	DATE	SHEET: 1 of 1	SHEET SIZE: C
DRAWN: CBW	07/11/03	DRAWING NUMBER: SD11065	SCALE: 1:2
APPROVED: M.C.	07/11/03		REV: —

FALMOUTH PRODUCTS CATALYTIC OXIDIZER
FALCO 100 INSTALLATION AND OPERATIONS MANUAL

MANUAL 1997.01 LAST REVISION 02-10-97

TECHNICAL ASSISTANCE: 1-800-340-8125



FALMOUTH PRODUCTS P O. BOX 541 FALMOUTH MA 02541 PHONE 508 548 6686 FAX 508 548 8144

CONTENTS

FALMOUTH PRODUCTS P O BOX 541 FALMOUTH MA 02541 PHONE 508 548 6686 FAX 508 548 8144

FALMOUTH PRODUCTS CATALYTIC OXIDIZER OPERATIONS MANUAL
FALCO 100

(Last revision 02/10/97)

Description: FALMOUTH PRODUCTS CATALYTIC OXIDIZER (FALCO) effects efficient conversion of hydrocarbon contaminates in an air stream to carbon dioxide and water vapor. Combustion occurs in the temperature range 300°C-620°C. Heat is transferred from the hot exhaust stream to the incoming contaminated air, heating it to the catalytic oxidation temperature. This manual covers models delivered since May, 1995.

FALCO is equipped with three programmable controllers. One controller (T1) monitors and responds to a thermocouple sensing the temperature at the upstream end of the catalyst. The second controller (T2) monitors and responds to a thermocouple sensing temperature downstream from the catalyst. The third controller (T3) senses the temperature at an intermediate position inside the catalyst. The T3 controller provides a rapid response to increasing vapor concentration by increasing dilution air and shutting the system down if necessary.

Auxiliary relays in the T1, T2, and T3 controllers shut down the system if the thermocouple temperatures move above or below the set points by selected amounts. If the automatic dilution control does not respond rapidly enough to an increase in vapor line concentration, T2 and T3 will increase to their alarm settings and turn off the system.

FALCO is also equipped with a pressure switch which interrupts the heater circuit if flow is interrupted, for example, due to a thermal protection cut out of the blower or frozen vapor line. If a short power interruption should occur, 5 minutes for example, the unit will resume normal operation. If the interruption persists long enough, T1 or T2 will fall below the selected shutdown limit and the system will remain off until restarted by the operator.

The three controllers regulate the temperature of vapor entering the catalyst. The T1 controller regulates an electric heater, which adds heat to the incoming flow when required. The T2 and T3 controllers both operate a solenoid valve, which reduces the amount of heat recovered in the heat exchanger. The three controllers cooperate in the regulation of a dilution valve that controls the input vapor concentration when the vapor line concentration exceeds a selected input concentration to the catalytic unit. The controllers are programmed to automatically shut down the system if selected temperature limits are exceeded.

Figures 1 and 2 show the basic components of FALCO and a flow schematic.

TRANSPORTATION & STORAGE

FALCO weighs approximately 330 pounds. The wooden base is provided with carrying handles so that the unit can be hand loaded and unloaded from a truck or carried short distances. FALCO is weatherproof while in operation. When FALCO is in storage, however, it should be kept dry.

CAUTION! WHEN FALCO IS NOT OPERATING, ALL OPENINGS MUST BE COVERED TO PREVENT RAIN, DIRT AND RODENTS FROM ENTERING.

INSTALLATION

Place FALCO on a level surface in a **secure** area. Figure 3 illustrates a plan view of a typical installation. Figure 9 shows typical FALCO to blower piping Buried lines from the vapor recovery wells should emerge at the surface within a fenced area In cold climates all vapor lines should be protected from freezing by heat tape and insulation

INSTALLATION LOCATION AND CLASSIFICATION

The FALCO 100 Catalytic Oxidizer may be used to treat Group D flammables with auto ignition temperatures not less than 230°C (T2C). The classified locations are defined as follows:
The interior to the heat exchanger-catalyst assembly is defined as Class I Division 1, using the doctrine in the National Electrical Code regarding gasoline dispensers at service stations.
The Class I, Division 2 classified location is defined as the region extending 18" radially from the heat exchanger-catalyst assembly, and 18" above ground over a 20' radius. The control box of the FALCO 100 is placed outside the Class I, Division 2 classified locations. It is spaced at a 22" radial distance from the heat exchanger-catalyst assembly, and 33" above ground level Seal fittings are provided on all conduits at the boundary of the Class I region, and explosion proof components are used within this region Refer to Figure 11 to clarify classified locations. The FALCO 100 should be installed outside in order to preserve approval ratings The dilution valve control (DVC) is approved for use in Class I Division 2 locations

PVC piping to vacuum side of blower
Beginning at the vapor lines, the **PVC** piping should be installed as follows:

1. Install valves on each separate vapor line These lines should each be equipped with sample and vacuum ports.

2 Combine the vapor lines together into a single line and, if available, install a piece of clear PVC so water can be seen when it is being produced.

3 Run this main vapor line in and out of a large capacity water knockout (30 gallons minimum) On the discharge side of the water knockout install a 2 inch **gate** valve. This valve will control the combined vapor concentrations from the wells.

4 After installing the main vapor line valve (**gate valve**) install a 2 inch PVC T downstream from this valve. Pipe the dilution control valve (DVC) into this T.

5 Pipe from the PVC T into the vacuum side of the blower Install a vacuum gauge between the T and the blower For operation in cold climates all piping on the vacuum side of the blower, including the water knockout, should be insulated and heat taped.

Steel piping on pressure side of blower

Beginning at the blower, the **Steel** piping should be installed as follows: Use Rectorseal #5 pipe thread sealant.
Note: Do not use galvanized pipe or teflon based pipe thread sealants, they may damage the catalyst.

1. Adapt the discharge piping from the blower up to 2 inch pipe. For ease of installation it is advantageous to locate the blower parallel to and next to the catalytic unit. (See figure 9).

2 Install a pipe nipple on the discharge side of the blower. Next, install a union so that the blower may be removed easily for service Install another pipe nipple and an elbow.

3. Extending from the elbow, install steel pipe long enough to reach an elbow mounted on the flame arrester inlet. Include in this steel piping an influent sample port, a pressure gauge and another union if needed. If the blower has been mounted parallel to the catalytic unit this piping can swing to adjust for the height difference between the flame arrester and the blower inlet

NOTE: When using blowers capable of flow rates much greater than 100 CFM, a small recirculation valve connecting the vacuum and pressure sides of the blower must be installed to control airflow.

Water

Most vapor recovery operations produce some water. While water vapor is not a problem, **Liquid water can damage the catalytic unit.** Recognizing that conditions vary widely from site to site, the following strategies should be considered to minimize the transportation of water to the catalytic unit.

1. Slant vapor lines downhill toward the vapor wells

2. Avoid low points that might accumulate slugs of water. If low points can not be avoided, provide a means for draining accumulations

3. In cold climates, heat tape and insulate all pipe that is not buried.

4. Install a water knockout upstream from the blower. Install a vacuum gauge. A bouncing vacuum gauge often means that there is a slug of water in a vapor line. Install a high level switch in the knockout drum

5. Make sure that site check intervals do not exceed the time for water to fill the knockout.

6. Open the drain valve at the bottom of the intake manifold at each site check and drain out water.

ELECTRICAL POWER CONNECTIONS

Control box to breaker box.

FALCO control box is connected by 3/4" rigid metal conduit to the breaker box (not supplied). Explosion proof seal fittings should be installed in line with the conduit just below the control box and the breaker box

Three circuits feed power to FALCO through the 3/4 conduit.
All wires should be stranded.

1. A 40 amp. 240 volt breaker supplies power to the electric heater (7300 watts) through two # 8 wires At sites with 208 volt power, an auto-transformer must be used to step up the voltage to 240 volts on the heater circuit.

2. A second 240 volt breaker (size depends on blower horsepower) supplies power for the blower through two wires (wire size depends on blower horsepower)

3. A third 15 amp 120 volt breaker supplies power to the terminal block through two # 12 wires

A grounding wire is run from the control box grounding bar through the conduit and attached to a grounding rod at the base of the breaker box.

Feed Conduit

1. Remove the control panel retaining nuts and carefully lower the top of the control panel out of the box until it is horizontal. Take care not to pull on the wires Slide the panel four inches inward so it is bearing on the bottom two studs and is face down on the foam pad.

2. Run 3/4" conduit with seals from the breaker box to the control box

   Pull the following seven wires through the 3/4" conduit
   One pair of #8 for the heater
   One pair appropriately sized for the blower (usually two # 12)
   One pair of # 12 for the controls
   One #10 ground wire.

CONTROL CIRCUIT

The (120 volt) control circuit may be wired as follows: Neutral lead (white) is attached to the terminal marked "N" on the terminal block Hot lead (colored) is attached to the other side of the terminal block.

GROUND

FALCO may be grounded as follows: Locate the grounding bar inside the control box. Run a grounding wire (Green) (#10) from the bar, through the 3/4" conduit and the breaker box to the grounding rod.

HEATER

Wire the heater as follows: Locate the heater relay on the back left hand side of the control box Attach the two #8 wires (240 volt) to the two posts on the bottom of the heater relay.

BLOWER

Install 1/2 inch rigid conduit with seals between the blower and the control box. Install an explosion proof union at the blower end so that the blower may be removed for service.

The following presents two methods for installing the extraction blower In the first case, the line voltage for the blower is switched by a contactor in the FALCO control panel. In the second case, the contactor in the control panel controls the coil of a remotely mounted motor starter, which controls the line voltage to the blower.

Wire the blower as follows:

Case #1 Locate the motor relay on the back of the control panel. Two of the terminals on the motor relay should be supplied with power from the breaker box (240 volts blower line). The blower load should be attached to the opposing two terminals. Thermal overload protection may be wired as follows. Locate the two thermal wires at the blower. Extend these wires through the 1/2 conduit and into the control box. Splice overload wires in series with the wire between terminal 27 on the T1 temperature controller and the hot side of the coil on the motor relay. A service loop is provided

for installation. If the blower overheats, the thermal switch on the motor will open the motor relay and shut down the blower

Case #2 If a separate motor starter is to be used with the blower, then run a jumper wire from the hot side of the terminal block to one terminal on the motor relay. Next run a wire from the opposing terminal on the motor relay to the motor starter coil (hot side) The line voltage to the blower is controlled by the motor starter

Caution : The T1 temperature controller MUST control the blower.

BLOWER GROUND

Ground the blower as follows: Run a grounding wire (green) from the case of the blower through the 1/2" conduit and attach it to the grounding bar inside the control box

DILUTION VALVE CONTROL SYSTEM (DVC)

1. Install 1/2" rigid conduit with a seal at the control box end. This conduit should be run along the ground to below the DVC box. Next, extend the conduit upward at least 18 inches off the ground toward the base of the DVC box. A seal fitting should be installed at the end of the rigid conduit Liquid tight conduit should be installed between the seal and the DVC box The liquid tight will provide enough flexibility to adjust the box for drive belt tension

2. Pull 4 # 14 wires (white, yellow, brown, and green) through the 1/2" rigid conduit that is installed between the control box and the DVC. Starting at the control box, make the following terminations: Connect the white wire to the 120 volt terminal block (neutral side) on the back of the control panel. Connect the green wire to the grounding bar inside the oxidizer control box. Connect the two colored wires (yellow and brown) to the two wires secured to the right hand side of the control box (yellow and brown). Next open up the DVC box and locate the white, yellow, brown and green wires that were pulled into the box through the 1/2" conduit. Check for correct operation before permanently splicing these wires with crimp connectors.

Verify correct operation as follows. It may help to see explanation of setpoints on page 9.
With FALCO running, turn the DVC switch on and off (while heater is in operation-L1 lit on T1 temperature controller). Verify that the DVC will turn on and off when the switch is cycled The heater may turn on and off at this time so watch carefully. Next, check for proper rotation. When the DVC switch is in the **ON** position, be sure that the valve **CLOSES (Clockwise rotation)** when the **heater** is **ON** and the valve **OPENS (Counterclockwise rotation)** when the **solenoid** is **ON**. If these rotations are wrong, then switch the two colored wires (brown and yellow) which were secured with wire nuts inside the DVC box Once proper rotation and switch control has been verified, make final connections with crimp connectors.

CAUTION : IT IS ESSENTIAL THAT THE DVC ROTATION BE CORRECT.

Secure control panel with 3/8 nuts

CONTROLLER OPERATION

The control parameters have been set by FALMOUTH PRODUCTS before delivery With the exception of the temperature setpoints, control settings will normally not be changed by the operator. If circumstances seem to indicate a need to change controller programming, please consult with Falmouth Products before changing any programming. The setpoints are adjusted on the controllers by pressing the up or down buttons. Holding down the button will effect a continuous, **accelerating** change Pressing a button momentarily will produce a 1° change.

There are alarms that turn off the system (blower and heater) if the temperatures exceed set limits

On the T1 controller, shutdown occurs when the T1 temperature (process) becomes greater than the T1 setpoint by 175°C, or less than the T1 setpoint by 60°C.

On the T2 controller, shutdown occurs when the T2 temperature (process) becomes greater than the T2 setpoint by 20°, or less than the T2 setpoint by 300°C.

The T3 controller is programmed to shut the system down when the process temperature reaches 600°C.

The AUTO/MAN button, the right hand button on the controller, is used to reset the alarm after an alarm limit temperature has been exceeded. To reset the alarm, the temperature must be within the alarm limit. Interruption of power will also reset the alarm. **Caution! Do not reset the alarm or restart until temperatures have dropped below normal set points.**

DILUTION VALVE CONTROL

Some vapor recovery systems supply stable input concentrations which decrease slowly over time. Other systems yield concentrations which fluctuate up and down The DVC is designed to respond to **gradual** increases or decreases in vapor line concentrations, to maintain a nearly constant input concentration

The automatic dilution valve (DVC) accurately maintains a selected input concentration during periods when the vapor line concentration exceeds the maximum permitted input concentration to the catalytic unit. A sprocket on the DVC drives a chain, which in turn drives a sheave on the gate valve, moving the valve gate toward either open or close.

The DVC is assembled with the dilution valve on an aluminum plate (See figure 7). The assembly also includes an L bracket that is mounted to an aluminum box that protects the DVC from the elements. The DVC assembly should be fastened to a post, wall or fence using the four holes in the back of the L bracket. Mount the DVC at shoulder level so that it can be easily seen and adjusted.

CAUTION! After putting the DVC in operation, observe the shaft rotation when the heater light (L1) is lit on the T1 controller. This rotation should close the dilution valve. Conversely, if the solenoid is actuated and the output relay light is lit, (L1) on the T2 or T3 controller, the DVC should open the dilution valve. If neither the solenoid or the heater is activated, the dilution valve should not rotate. Refer to figure 5.

Note: There is an indicator pin on the left hand side of the valve which shows valve position. When the pin is out all the way, the valve is closed. When the pin is in all the way, the valve is open. Each mark on the DVC pin equals one turn of the valve.

DISCUSSION OF COLD STARTUP

The unit is first heated up (using the electric heater) to a temperature where it can react hydrocarbons. Once the unit has achieved the reactive temperature, vapors are slowly fed in. Hydrocarbons have a heating value of approximately 19,000 BTU/pound. Input concentrations result in a temperature rise across

the catalyst The temperature entering the catalyst (untreated vapors) is lower then the temperature exiting (treated vapors) The greater the concentrations of hydrocarbon vapor entering the unit, the greater the temperature rise (ΔT) across the catalyst. To achieve proper start up of the oxidizer this temperature rise across the catalyst must be carefully controlled. If the concentrations entering the oxidizer are too high, the control systems will not be able to regulate the resulting temperature increase The system controls (heater, solenoid valve and dilution control) help to regulate **gradual** fluctuations in input concentrations. The alarms on the temperature controllers will shut down the system if set temperature limits are exceeded.

The following start-up procedure must be followed to avoid the danger of costly damage to the system. Vapors initially recovered may be saturated with hydrocarbon. **Keep in mind that a substantial period of time is required to reach new equilibrium temperatures after a valve adjustment has been made.** About one minute is required after an adjustment in the dilution valve or the vapor well, to see an effect on T2. If an excessive adjustment has been made, one minute of no change in temperature will be followed by rapidly accelerating temperature. T3 responds much more quickly, and provides an early indication of increased concentration. During a relatively rapid rise in vapor line concentration, T3 responds early to cool the system by opening the dilution valve. References to hydrocarbon concentration in this manual refer to **total hydrocarbon** concentrations in the air stream.

It is helpful during the startup to keep in mind the alarm settings
On the T1 controller the alarm settings are **+175°** and **-60° C**, relative to the T1 setpoint.
On the T2 controller the alarm settings are **+20°** and **-300° C**, relative to the T2 setpoint
The T3 controller alarm is tripped if the T3 process temperature reaches **600°C.**

If the process temperatures exceed these limits the system will shut down.

T1 setpoint 330°C	alarm +175 shutdown 505°	alarm -60 shutdown 270°
T2 setpoint 600°C	alarm + 20 shutdown 620°	alarm -300 shutdown 300°
T3 setpoint 580°C	alarm 600 shutdown 600°	(process alarm)

For example:
If the T1 setpoint is 330° and the temperature drops to 265°, the system will shut down and the alarm will flash 330°/LO To clear the alarm condition, lower the setpoint to within the alarm limit, and push the AUTO/MAN key
It may be necessary to push AUTO/MAN more than once to reset the alarm.

COLD STARTUP-PROCEDURE

1. **OPEN** the dilution valve completely, and move the dilution control switch to off

2. **CLOSE** the main vapor line valve so that the unit is warmed up on fresh air **only.**

3. Turn the heater switch to **OFF.**

4. Turn on the three controllers by switching on the power Depending on the initial temperatures and temperature settings, the blower may or may not stay on. The initial temperatures will frequently deviate from the setpoint enough to cause an alarm condition. If this is the case, the lower display will alternately flash the nature of the alarm HI (high) or LO (low), and back to the setpoint. If the blower does not stay on because an alarm limit has been exceeded, change the setpoint to be within the alarm limit and press the AUTO/MAN button to reset the alarm. (See figure 5) **Make sure that the blower is turning in the correct direction and that there is flow through the unit.** Flow through the unit may be verified by opening the input sample port or the bleed valve at the bottom of the intake manifold.

5. Adjust the T1 controller setpoint upward to a value not more than 60° above the T1 temperature, and not greater than 330° C.

   Adjust the T2 controller setpoint upward to a value not more than 300° above the T2 temperature, and not greater than 600°C

   Adjust the T3 set point to 580°C

   For Example: If on cold start up, the ambient temperature on the temperature controllers is 20°C, then T1 could be set at 60°C, T2 at 300°C, and T3 at 580°C

6. Move the heater switch to **ON**. Move the dilution control switch to the **OFF** position. Observe that the temperatures begin to rise

   Bringing the unit up to temperature may involve several adjustments in setpoint, while taking care to stay within alarm limits. **In bringing FALCO up to temperature, keep the T2 setpoint 100° or more above the T1 setpoint.**

After T1, T2, and T3 exceed 200 °C, it is critical to proceed cautiously with the next step in the operation, which is to begin feeding hydrocarbon vapors to FALCO. At the startup, (or early in a recovery operation after the well has been shut in for an extended period) vapors from a recovery well may be above the lower explosive limit.

CAUTION !
If the vapor line is opened too quickly the automatic controls may not respond fast enough to prevent overheating and costly damage to the catalyst.

7. With T1 and T2 now greater than 200 °C, and with the dilution valve fully open, begin opening the gate valve on the vapor recovery line in 1/4 turn increments, waiting one minute or more between adjustments to observe the effect on T2 and T3. T3 should respond within 10 seconds of making the adjustment, and will increase rapidly. More than a minute is required for T2 to begin responding to the adjustment. Control adjustments of the vapor line valve so that T3 does not increase too rapidly. **Two seconds per degree** is a reasonable rate of increase for T3. After a delay, T2 will begin increasing. **Four seconds per degree** is a reasonable rate of increase for T2.

CAUTION ! IF THE T3 OR T2 TEMPERATURES BEGIN TO RISE VERY RAPIDLY, OR APPEAR TO BE OUT OF CONTROL TURN SYSTEM OFF IMMEDIATELY USING THE POWER SWITCH. CLOSE ALL VAPOR WELLS AND OPEN THE DILUTION VALVE FULLY. START AGAIN USING SMALLER INCREMENTS. HOWEVER, DO NOT RESTART UNTIL THE T2 TEMPERATURE DROPS BELOW 575° OR TO THE SETPOINT, WHICHEVER IS LOWER. UPON RESTART, OBSERVE CLOSELY: IF T2 IS INCREASING INSTEAD OF DECREASING SHUT DOWN AGAIN AND WAIT LONGER TO RESTART THE SYSTEM.

CAUTION ! IF THE T3 OR T2 TEMPERATURES EXCEED 620 °C DO NOT ATTEMPT TO BLOW OUT THE SYSTEM BY RESTARTING THE BLOWER AND OPENING THE DILUTION VALVE-LEAVE THE SYSTEM OFF UNTIL TEMPERATURES DROP BELOW 580°C

8. After the T1 temperature reaches 275°C, increase the T1 setpoint to 330°C. After the T2 temperature reaches 310 °C increase the T2 setpoint to 600°C and increase the T3 set point to 580°C

The procedure for **completing** the startup depends on whether the vapor line concentration is high, low, or medium

High Vapor Concentration

In the case where the vapor line concentration is very high, (at the start of a vapor recovery operation, concentrations over 20,000 ppmv are common) the vapor stream must be diluted to below 2600 ppmv. At sites with very high vapor line concentration and low flow resistance in the vapor system, the catalytic unit may reach full operating temperature, and maximum input concentration without fully opening the vapor line The gate valve on the vapor line is then left restricted to provide sufficient flow through the dilution assembly. The dilution valve should be slowly adjusted to the half way position (three slots showing on the indicator pin) using 1/4 turn adjustments before it is put into automatic operation. Then it may compensate for both increases and decreases in vapor line concentration.

Adjust the vapor concentration in increments until, either the vapor line valve is fully open, or until T3 approaches about 570 °C. As the T3 or T2 temperatures approach their setpoints the solenoid will begin to actuate. When this happens, a clicking sound will be heard, and "L1" will flash to the left of the setpoint window on the T2 controller and on the right of the window on the T3 controller. The system should be left in automatic operation with the dilution valve closed approximately half way and the gate valve opened as much as possible **At very high concentration sites,** it may not be possible to open the gate valve more then a turn or so. Since the dilution valve will be closing automatically over time as the T1 controller process temperature approaches setpoint, it is important to carefully watch the closing rate of the dilution valve. If the dilution valve were to fully close with the gate valve open only one turn, it is possible that the blower would overheat due to restricted airflow. Continue to open the gate valve in small increments, without exceeding 570°C on the T3 or T2 controllers, each time the site is visited.

The T1 setpoint should still be at 330°, but the T1 temperature may be above the setpoint. After temperature equilibrium is established, observe the value of _T (the temperature difference between T1 and T2). If for example, T1 = 340°C and T2 = 540°C then _T is 540-340 or 200°C the input concentration may be estimated by multiplying _T by 8 Therefore, the input concentration is approximately 200 * 8 or 1600 PPM.
As explained earlier, for the system to be operated on autodilution, the dilution valve should be positioned at least 2 turns toward closed. This provides room for an opening adjustment in case the vapor line concentration increases. When the vapor line concentration is very high at the start of an operation, it may be necessary to restrict the valve on the vapor line to compensate for the restriction on the dilution valve.

Observe the operation of the auto dilution system. When the L1 lights up on the T2 controller, indicating that the solenoid is active, the sprocket on the DVC should be observed to move so that the dilution valve is being opened. Conversely, when L1 is lit on the T1 controller, indicating that the heater is on, the DVC should be moving the dilution valve toward the closed position. After correct operation of the DVC has been established, the input concentration that is automatically maintained by the DVC can be increased by an adjustment of the solenoid bypass

Solenoid bypass.

The solenoid valve on the oxidizer allows a portion of the input flow to bypass the heat exchanger, mix with the preheated vapors and then enter the catalyst. The bypass flow reduces heat exchange efficiency, allowing higher input concentrations. The input concentration maintained by the automatic dilution control (DVC) is increased by increasing the solenoid bypass adjustment.
Note: Serial number is stamped on the frame below the control box on the right mounting foot

Adjustment of units with serial number 95-100-24 and earlier.
To make this adjustment, remove the screw from the side of the solenoid valve. (See figure 6) The adjustment screw is pointed, is approximately 1.4" long, and should have two flat washers spacing its head from the bottom of the valve Remove one or two of the washers, replace the screw into the valve, and tighten.

Adjustment of units with serial number 95-100-25 and later.
To make this adjustment refer to figure 6.

- Remove the outer dust cap from the screw on the side of the solenoid valve The adjusting screw under the cap has flats on either side
- Grasp the flats with your thumb and index finger and twist it so that five threads show between the inner edge of the flat and the threaded adaptor.
- Next, turn the adjusting screw clockwise (in) three turns so that the adjusting screw now has two threads showing between the inner edge of the flat and the treaded adaptor. When two threads are showing, the maximum adjustment has been made. **Do not exceed two threads showing.**
- Replace the outer dust cap.

Observe the T1 controller and the DVC. The heater may begin to cycle after a short time, and the DVC will commence making very small adjustments of the dilution valve toward closed. Allow 15 minutes for a new equilibrium to be established, and observe the T1 and T2 temperatures A larger _T will be observed, indicating a larger input concentration

Controlling Input Concentration

When the vapor line concentration is relatively high, the automatic dilution control (DVC) controls the vapor concentration fed to the oxidizer. The input concentration maintained by the automatic dilution control (DVC) is a function of heat recovery efficiency. When heat recovery efficiency is decreased, the input concentration maintained by the DVC increases. On the FALCO 100 there are two methods for adjusting heat recovery efficiency, in order to adjust input concentration. One relatively limited method is to adjust the manual bypass on the solenoid valve (see page12)

Removal of helixes from the heat exchange tubes is a more effective method for increasing the input concentration maintained by the DVC, and enables adjustment to higher inlet vapor concentrations.

Helix removal
Note: FALCO 100 units with serial #96-100-13 and earlier have two helixes in each heat exchanger tube (right and left helixes nest together before insertion).

Prepare for helix removal as follows:

1. Open the dilution valve and close the main vapor line valve Run the blower for ten minutes with the heater off so that the unit may cool.
2. Turn off the oxidizer.
3 Close the manual bypass on the solenoid valve. (See page 12).
4. Arrange a place to stand safely and comfortably next to the heat exchanger 30" to 40" off the ground.
5 Remove the stack and stack adapter
6. Have gloves, long nose pliers, and masking tape.

Removal:

Caution: Wear gloves ! The helixes may be sharp and hot. Tug gently on the helix with long nose pliers to slide it up so it may be gripped by hand Complete removal by hand Tape all the helixes that have been removed into a bundle. Take care not to damage any of the helixes with a severe bend. Place in secure storage. Later when the vapor line concentration falls to around 1300 ppmv, the helixes should be re-inserted into the heat exchange tubes to conserve electric power.

All, or a portion of the helixes may be removed from the heat exchange tubes to increase the input concentration maintained by the DVC. Falmouth Products tests have shown that removal of 18 helixes is very nearly as effective as removing all of the helixes. Therefore, to save labor up to 18 may be removed. It isn't critical which are removed. However, it is preferred that they be removed in a dispersed, 'checkerboard' pattern.

After the vapor line concentration has declined to a degree that the heater indicator light on the T1 controller shows that the heater is on for a significant portion of the cycle, the helixes should be placed back in the tubes.

Helix replacement: Prepare by following steps 1-6 above.

Caution: Wear gloves.

Dual helix units: Before re-inserting the helixes, observe a pair of helixes closely. Note that each pair contains a right hand and a left hand helix, which intermesh in a regular manner. The pair must be properly meshed as it enters the tube Take care not to cripple the helixes with a severe bend. If a pair does not slide in freely, it may not be properly meshed. Withdraw the helixes and try again, fitting them more carefully as they enter the tube.
Single helix units: Orientation is unimportant

Moderate Concentration
If the vapor line concentration is low enough, it may be possible to fully open the vapor line **using 1/4 turn adjustments waiting 1 full minute between adjustments as discussed above**, and then nearly or completely close the dilution valve using the same technique.

After the vapor line is open, loosen the belt on the dilution control, and begin manually closing the dilution valve in 1/4 turn adjustments, waiting more than one minute between adjustments to observe the effects on T3 and T2. Temperatures should not exceed 580°C on T2 or T3 If the temperatures are approaching the 580°C setpoint on the T3 controller, the solenoid valve will be cycling and the dilution valve will be opening to cool the unit down. It is wise to set the system up at temperatures slightly less then the 580°C maximum. Between 560°C and 570°C or less is a good choice.

Startup is now complete, if the vapor line concentration is moderate, as we assumed. After the temperatures reach equilibrium a good estimate of the concentration of input vapor in ppmv is obtained by multiplying the difference between T2 and T1 by 8. See discussion in high concentration section.

Low concentration
If the concentration in the vapor recovery line is low, proceed through the opening of the recovery line valves to their desired adjustments and complete closing of the dilution valve using 1/4 turn adjustments waiting 1 full minute between adjustments as discussed above

Declining input concentrations are accompanied by decreasing temperatures. After the end of the dilution phase, if the input concentrations have continued to decline, the heater light will be on for gradually increasing portions of the 8 second cycle. After the heater is on for more than 2 seconds, the manual bypass adjustment on the solenoid valve should be reversed. If this adjustment is not made, and the bypass is left open, heater life may be shortened, and power consumption will be significantly increased during operation at low concentrations.

Eliminating the manual bypass may be accompanied by an upward drift of T1, T2 and T3 The temperatures may increase until the solenoid begins cycling (a clicking sound will be heard). Observe the new equilibrium established after the adjustment It may be necessary to slightly open the dilution valve in order to keep T2 and T3 below 570°C.

As the input concentration declines below 1400 ppm, the T1 setpoint may need to be increased in order to maintain high conversion efficiency. At 1400 ppm a T1 setpoint of 330°C is a good choice At 400 ppm and lower concentrations, a setpoint of 340°C may be required to maintain conversion efficiency If the catalyst is damaged, a higher T1 temperature setpoint may be required. Higher temperatures will shorten heater life, therefore the T1 setpoint should not be allowed to exceed 370°C when operating on the heater. To maximize heater life, when operating at low vapor concentrations, operate at the lowest temperature that will yield satisfactory destruction efficiency, but not below 330 °C or above 370° This limitation refers to the T1

setpoint, not the actual temperature, which can substantially exceed the T1 setpoint under certain conditions. At low concentrations, as output temperatures decline, it may be necessary to reset the T2 setpoint to 550° instead of 600° to keep the T2 temperature from dropping down to its negative alarm of 300° C. By changing the setpoint to 550°C the T2 temperature will be able to drop down to 250°C before tripping an alarm.

Troubleshooting

Blower Problems

1. Problem: FALCO controls turn on and flash LO or HI, but blower will not start

   Possible solution: An alarm limit has been exceeded, interrupting the blower relay. The controllers flash the alarm condition and the setpoint alternately. Bring unit to within alarm limits and clear alarms When unit starts a snap will be heard. This is the blower relay being activated.

2. Problem: FALCO controls turn on, no alarms present, blower will not start

   Possible cause: Thermal protection on the blower or on a motor starter has interrupted the blower relay and stopped blower A float switch on the water knockout, if present, may have interrupted the motor relay Thermal cutout on a blower may trip due to a high vacuum when the dilution valve closes. As the dilution valve closes, the amperage draw on the blower motor increases. If the blower trips its thermal overload, flow is stopped to FALCO and the heater turns off. Temperatures then drop until a low alarm is shown on the controllers Verify that the blower is not exceeding its maximum vacuum and pressure ratings Check that air is allowed to circulate freely across the blower motor.

   Check amperage draw on the blower motor. If a motor starter has been used, check the adjustment of the overload relay on the starter and adjust appropriately for motor horsepower.

3. Problem: FALCO controls turn on, no alarms present, blower will not start and blower circuit breaker has tripped.

   Possible cause: Does blower spin over freely? Blowers that have been outside for long periods without operating may freeze up. Ice or corrosion may have accumulated preventing a restart, and tripping the circuit breaker.

4 Problem: Blower starts but no flow gets to FALCO

   Possible causes:
   Dilution valve and vapor line closed
   Very tight soil conditions.
   Improper blower rotation.
   Piping from blower discharge to FALCO is broken or plugged.
   Broken drive belt or couplings on blower

Heater problems

1. Problem: FALCO starts but will not warm up

   Possible causes:
   Heater switch in off position.
   Breaker for heater in off position.

Improperly adjusted controller setpoints If controller setpoints are not adjusted properly FALCO will not warm up. This will cause the soleniod to be activated and reduce heat exchange efficiency. Make sure the T2 setpoint is 100°C greater than the T1 set point

Little or no air flow to unit Check for air flow at sample port or needle valve at base of intake manifold. FALCO is equipped with a pressure switch that disables the heater circuit, protecting the heater from low flow conditions. This switch disables the heater circuit at approximately 30 CFM or less.

Remove the steel tube that runs from the intake manifold to the pressure switch Make sure it is free of obstructions Make sure the high and low pressure ports on the pressure switch are unobstructed

2. Problem: FALCO warms up but not all the way to 200° C System needs to be up to this temperature before feeding in hydrocarbon vapors

Probable causes:
Improper adjustment of controller setpoints. Setpoints need to be gradually increased during the warm-up period.
Heat exchanger bypass may need to be adjusted See figure 6.
Low voltage to the heater circuit. Voltage should be 240 Volts.

High flow rate entering FALCO. Flows exceeding 120 CFM will make warm up difficult. It may be necessary to **partially** restrict the dilution valve to achieve 200° C If 200°C still cannot be achieved, start-up may proceed from 180° C, however, adjustments should be made **slowly** to vapor line allowing **two** minutes between adjustments until temperatures are up to 230°C. Do not introduce hydrocarbon vapors into FALCO if input temperatures are less then 180°C.

Controller problems
Problems with the temperature controllers are rare. It is possible for the controllers to exhibit unusual behavior if they are too cold, or get wet The control box has a thermostatically controlled electric heater inside that will keep the controllers at the appropriate temperatures for proper operation (above 30° F). **In very cold conditions (outside temperatures of less then 25° F) the outside of the control box must be insulated.**

1. Alarm can not be cleared with the Auto/Man key

Possible cause: process temperatures are not within alarm limits.

2. Controllers will not turn on

Possible cause:
Circuit breakers are not turned on at the breaker box If the controllers still will not turn on, turn **off** the main circuit breaker and check the 2 fuses (5 x 20 mm mini fuse 1 5 Amp.) mounted on the control panel.

3. After pushing the Auto/Man key to clear an alarm, a number appears on the screen (0-100) which is not the setpoint.
Possible cause:
This is the output relay load in percent. This appears if the controller is on lockout code 0 instead of lockout code 2. If this happens, pushing the Auto/Man key twice in quick succession should return the setpoint.

Problems with conversion efficiency

It should be noted that FALCO does not destroy methane completely at its normal operating temperatures. Therefore when using a Flame Ionization Detector methane may show up in the output emissions. Methane tends to be present at older gasoline spills By taking two output samples, one with an activated carbon tip, and one without, the non-methane emissions may be determined. If conversion efficiency is being determined based on input and output concentrations it will be necessary to subtract the methane from concentrations entering FALCO as well as exiting

At low input concentrations the percentage destruction efficiency is generally lower then the destruction at high input concentrations. This is due to the lower average treatment temperature at low input concentration. However the absolute emission while operating at low input concentration is generally lower than while operating at high input concentrations
For example: assume the input concentrations are 2000 PPM and emissions are 10 PPM. Then conversion is 10/2000= 005 or 99 5% conversion However, if the input concentration is 100 PPM and the emissions are 10 PPM, then the conversion is 10/100= 1 or 90% conversion. The conversion efficiency may then be lower but the overall emissions are the same.

High output emissions

Possible causes:

1. High methane concentrations in the influent stream.
   Check for methane with a carbon tip if using an F I. D
   Improperly calibrated test instrument
   Check calibration of your test instrument

2. Low influent temperature
   Check T1 setpoint if you are operating at low concentrations with the heater on. Normal setpoint is 330°. This setpoint may be increased in increments of 5°C to a maximum of 360°C Check emissions after FALCO has reached equilibrium after each increase in setpoint. Increasing input temperatures generally will increase conversion efficiency.

3. High influent flow rate
   Check flowrate in CFM going into FALCO. The FALCO 100 is designed for flow rates up to 100 CFM. Higher flow rates decrease residence time in the catalyst reducing destruction efficiency. At high input concentrations, slightly higher flow rates may yield acceptable conversion because of higher operating temperatures. At low input concentrations and high flow rate, the electric heater may have trouble maintaining high enough input temperatures for good conversion.

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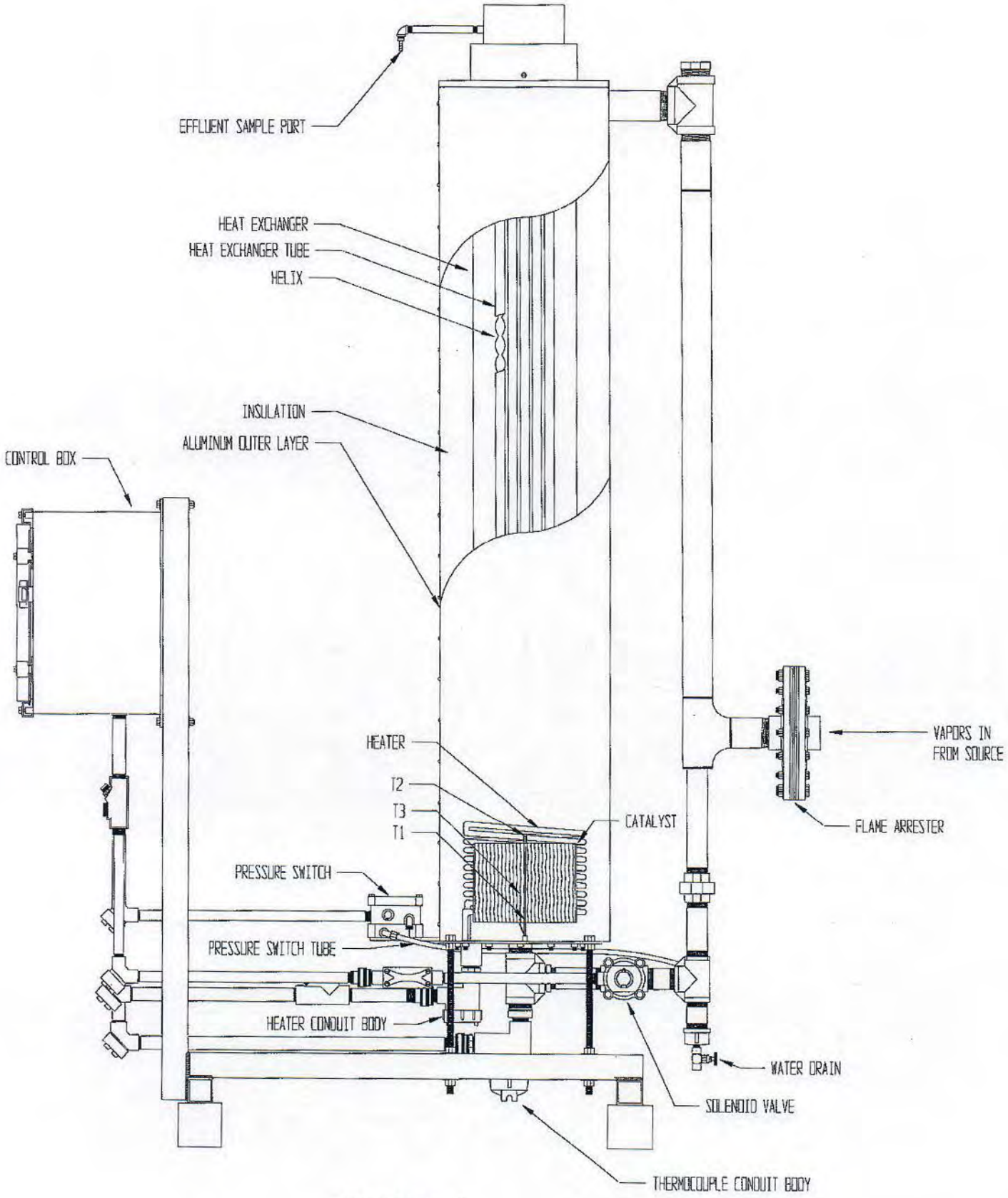

FIGURE 1
FALCO 100 MAJOR COMPONENTS

LAST REVISION: 02-10-97

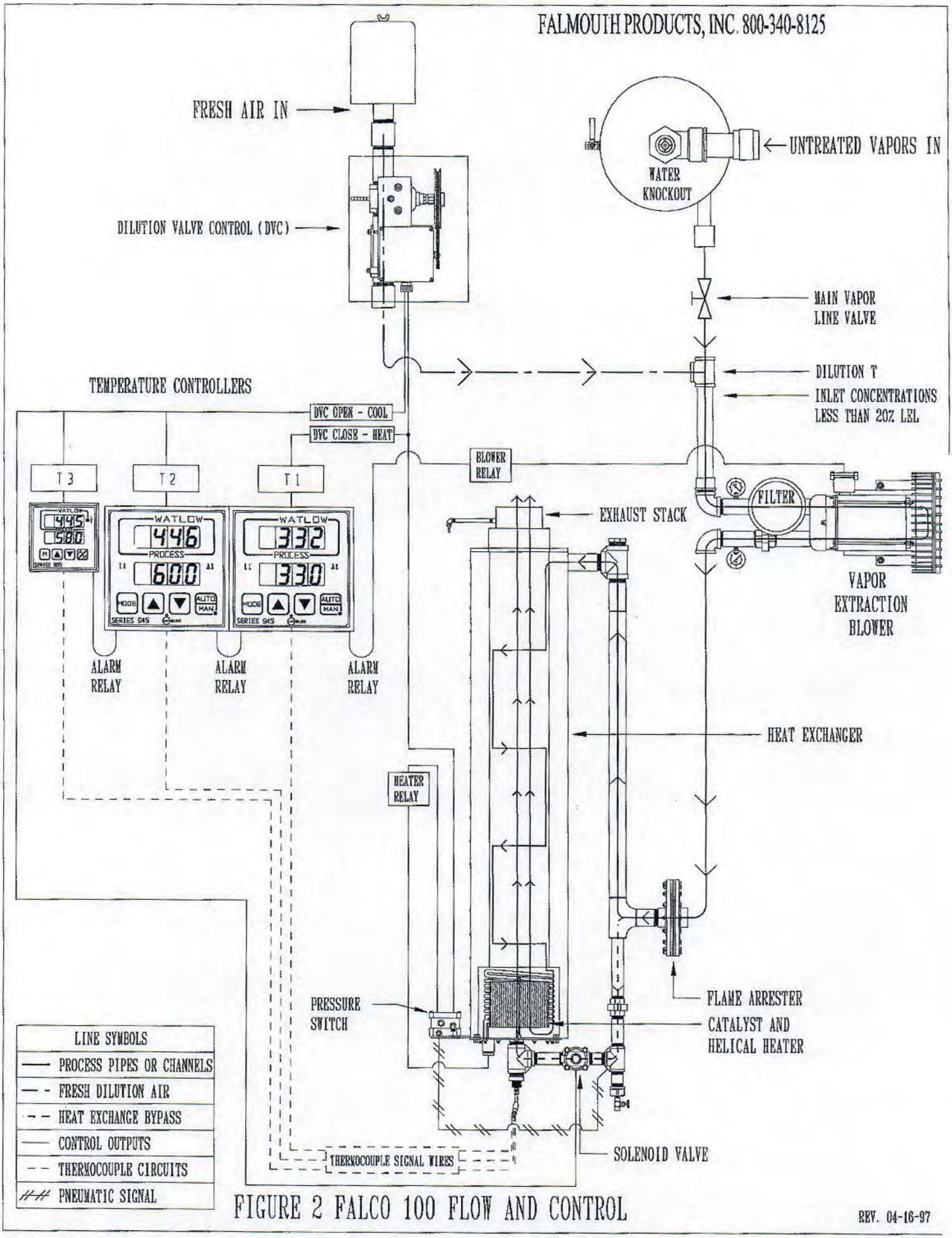

FIGURE 2 FALCO 100 FLOW AND CONTROL

REV. 04-16-97

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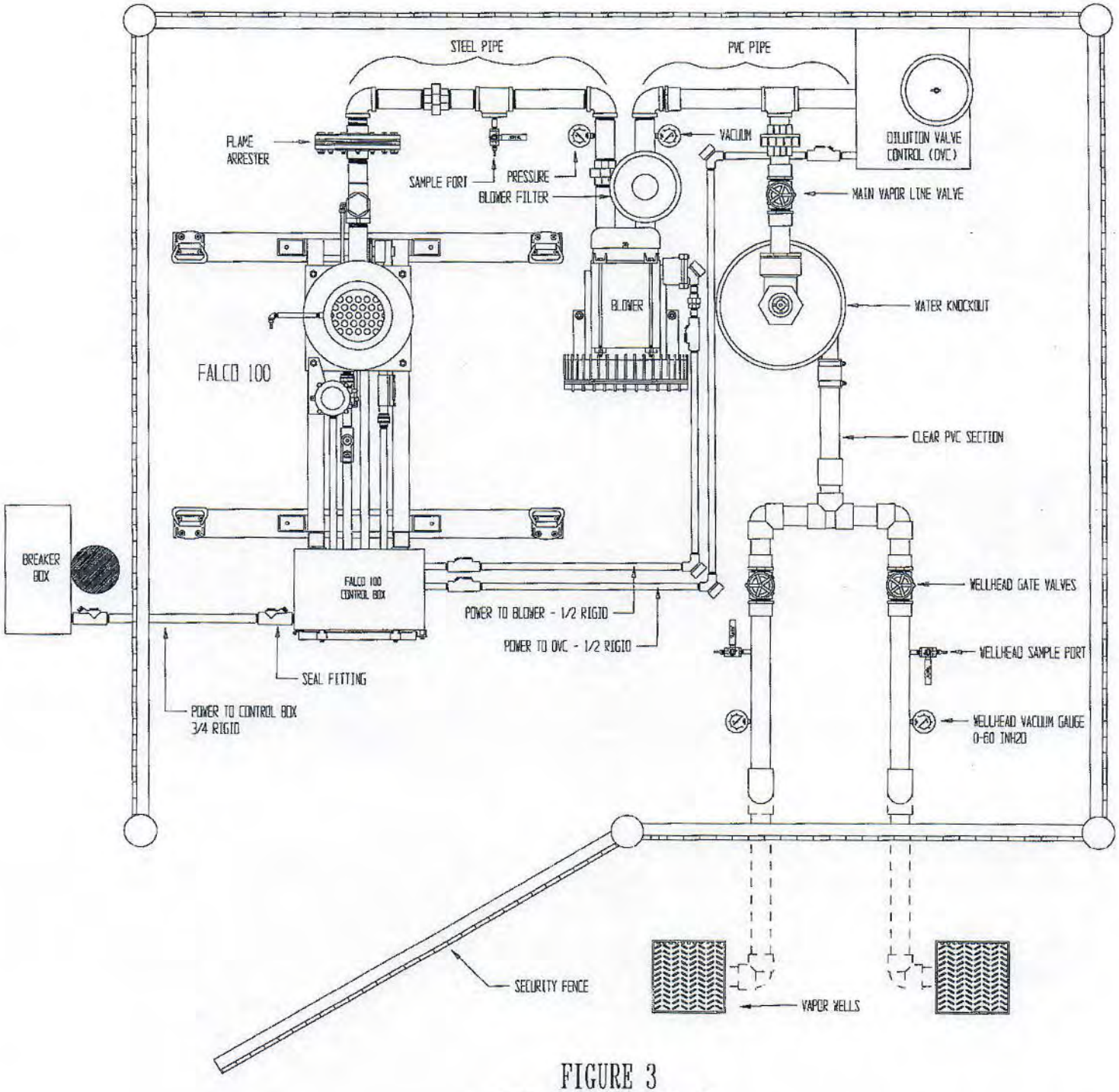

FIGURE 3
SITE PLAN FALCO 100

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HEIGHT TO VENT PIPE 7'

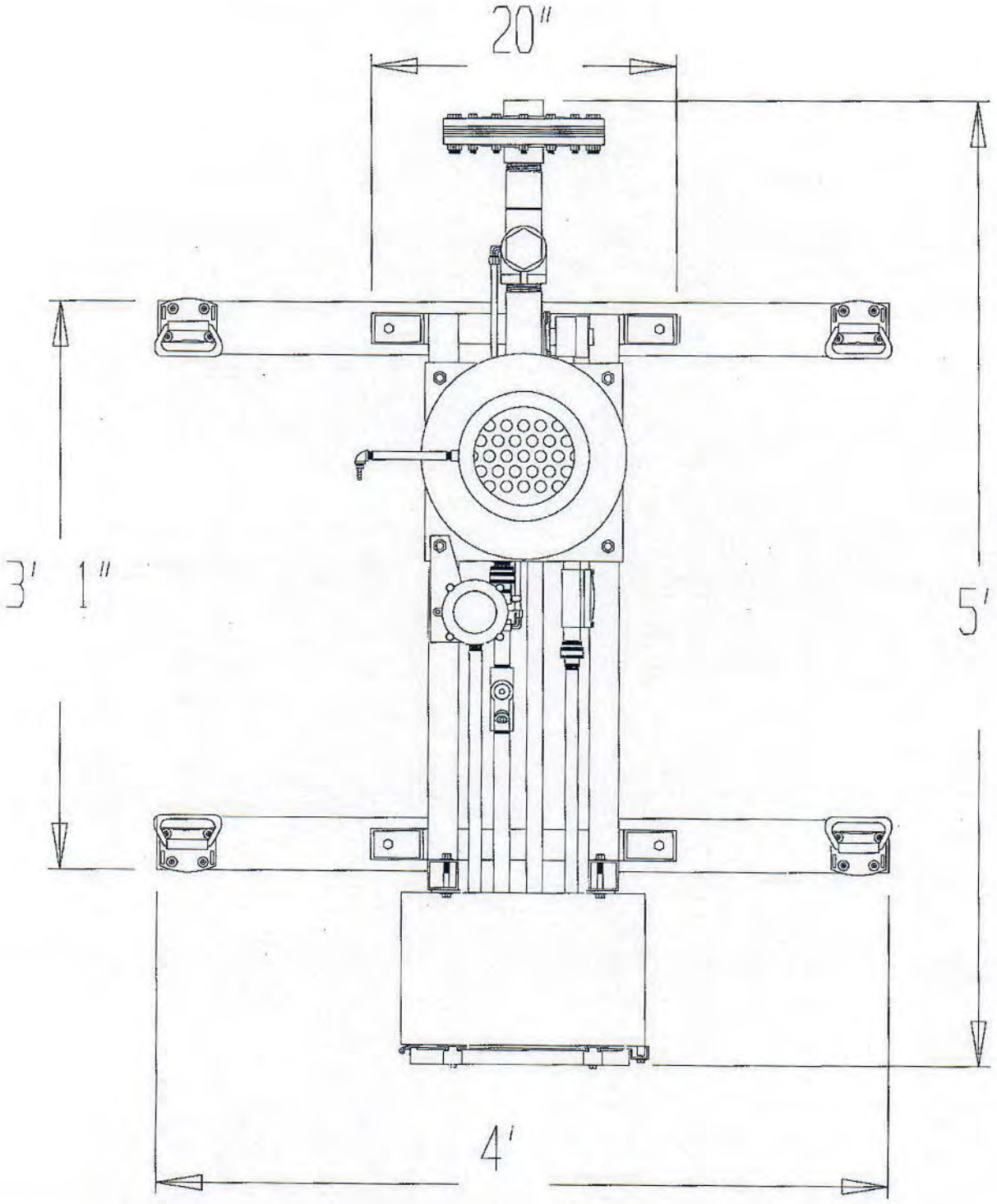

FIGURE 4
FALCO 100 PLAN VIEW

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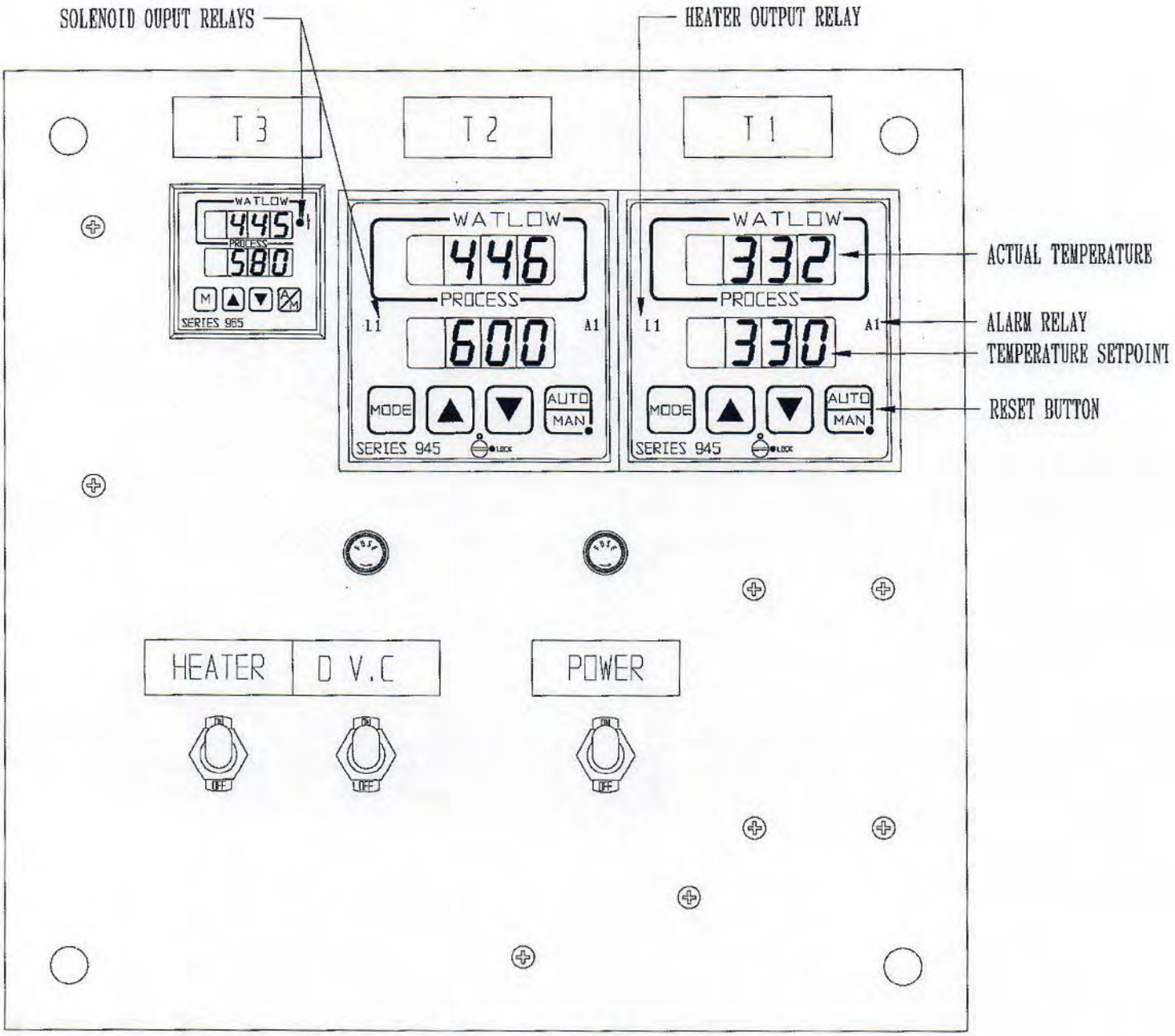

FIGURE 5
CONTROL PANEL

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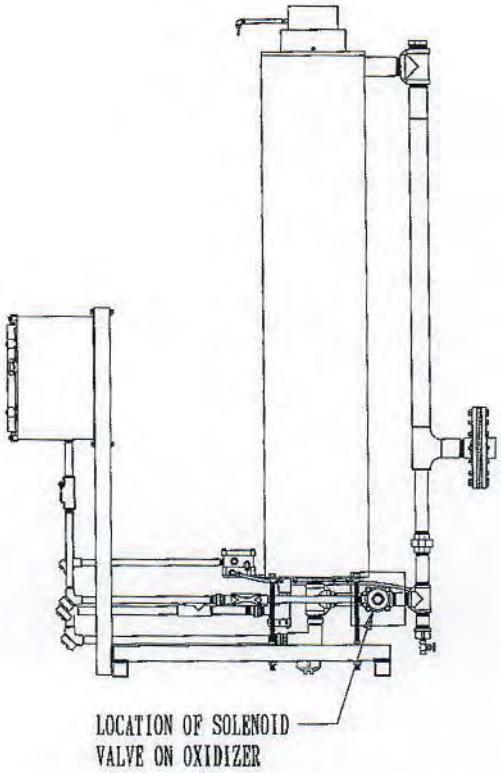
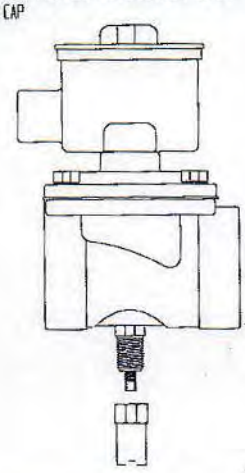


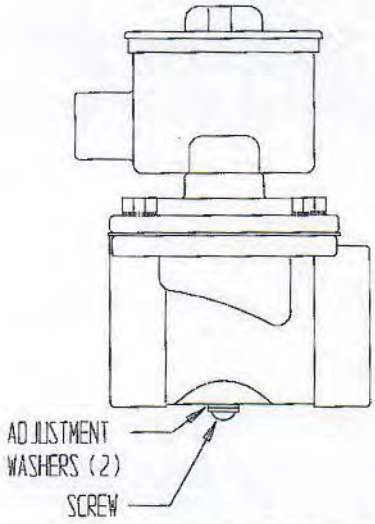
BYPASS ADJUSTMENT PROCEDURE
SERIAL NUMBERS 95-100-25 AND LATER

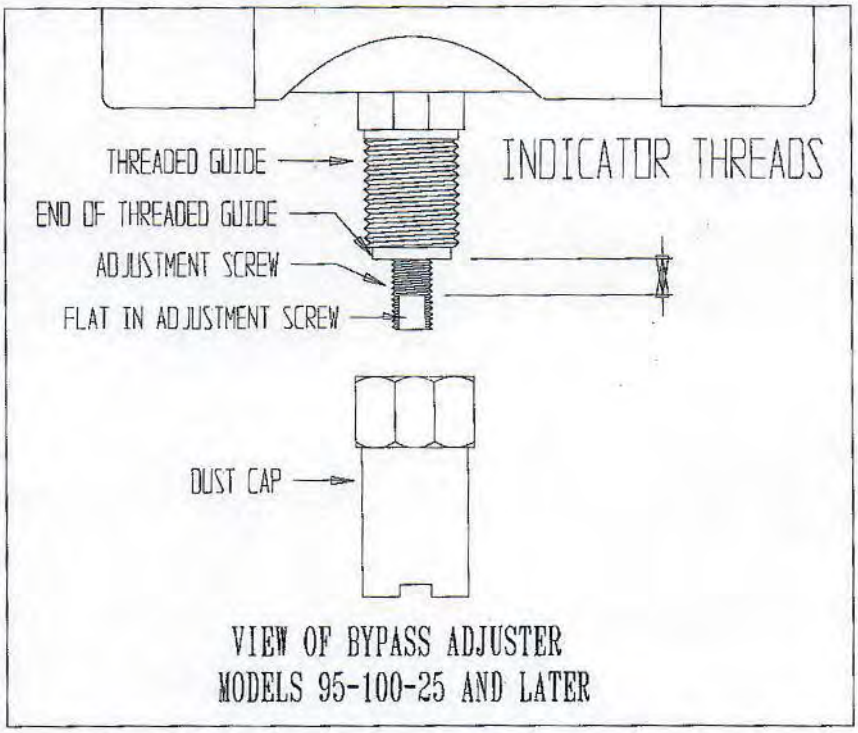
1 REMOVE DUST CAP.
2 SCREW ADJUSTMENT SCREW SO THAT FIVE INDICATOR THREADS ARE SHOWING BETWEEN END OF THREADED GUIDE AND INNER FLAT IN ADJUSTMENT SCREW
3 ADJUSTMENT SCREW MAY BE SCREWED IN (CLOCKWISE) SO THAT A MINIMUM OF TWO INDICATOR THREADS ARE SHOWING BETWEEN END OF THREADED GUIDE AND FLAT IN ADJUSTMENT SCREW. DO NOT SCREW PAST TWO THREADS!
4 THE RANGE OF ADJUSTMENT IS 2-5 INDICATOR THREADS SHOWING BETWEEN END OF THREADED GUIDE AND FLAT IN ADJUSTMENT SCREW DO NOT EXCEED THESE SETTINGS!
5 REPLACE DUST CAP



BYPASS ADJUSTMENT PROCEDURE
SERIAL NUMBERS 95-100-24 AND BEFORE

1 REMOVE SCREW
2 REMOVE 1 OR BOTH WASHERS
3 REINSTALL SCREW





VIEW OF BYPASS ADJUSTER
MODELS 95-100-25 AND LATER

FIGURE 6
FALCO 100 SOLENOID VALVE ADJUSTMENT PROCEDURE

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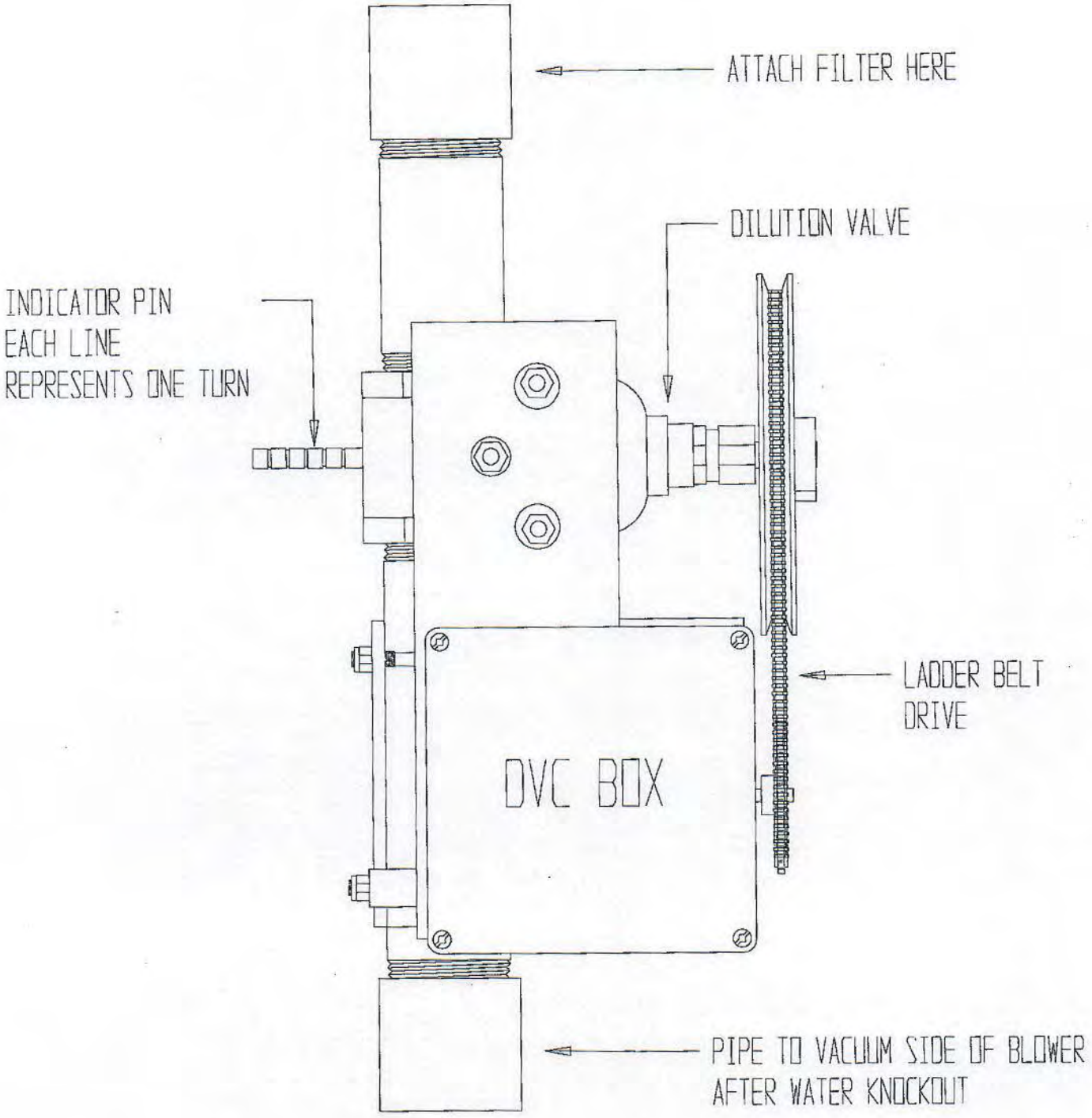

FIGURE 7
DILUTION VALVE CONTROL

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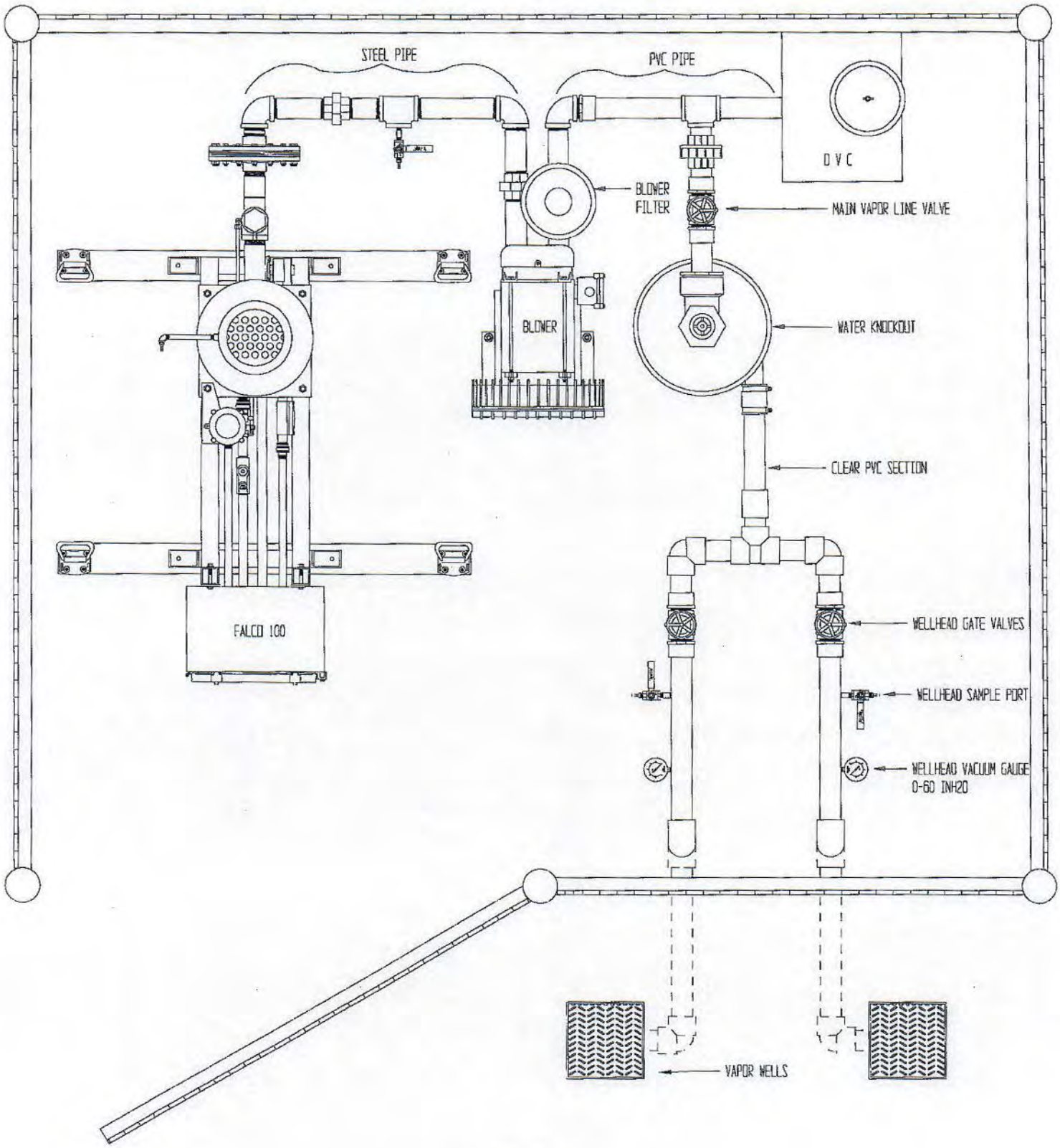

FIGURE 9
SUGGESTED PIPING LAYOUT

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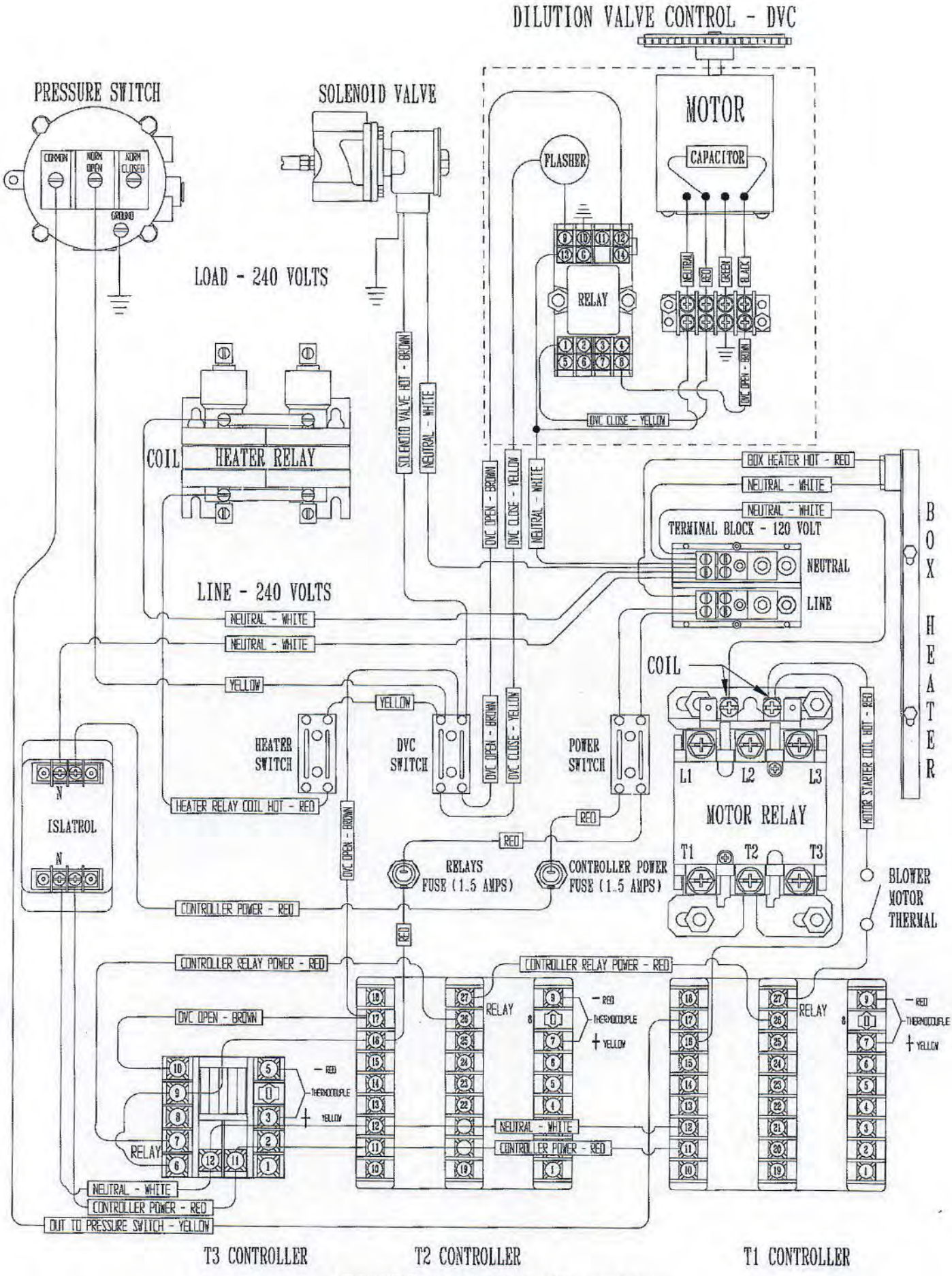

FIGURE 10 FALCO 100 WIRING

REVISED 01-26-98

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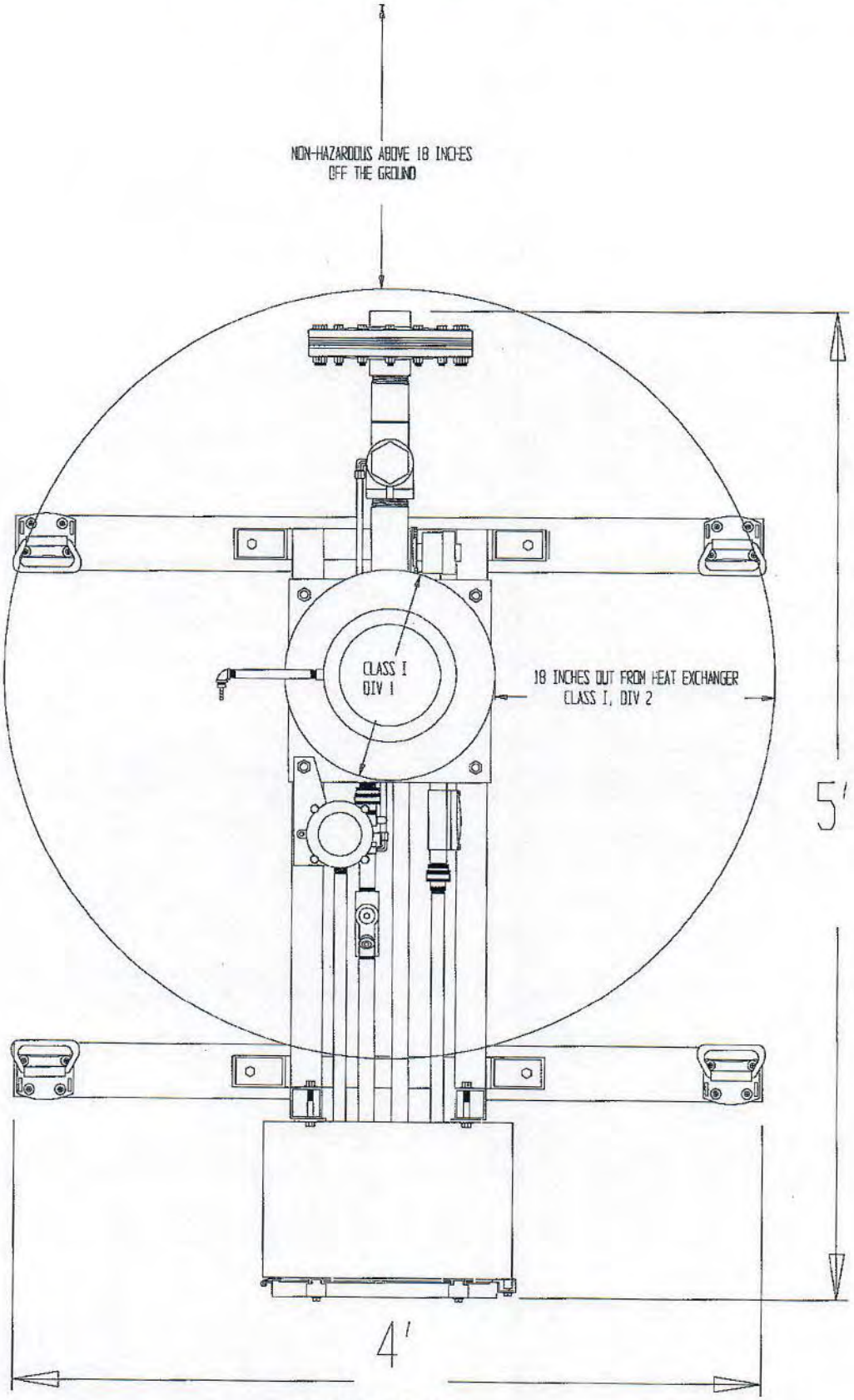

FIGURE 11
DEFINING CLASSIFIED LOCATIONS

LAST REVISION: 09-23-96