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DESIGN DOCUMENT ANAEROBIC-AEROBIC SEQUENTIAL TREATABILITY STUDY ZONE K (SWMU 166) WITH TRANSMITTAL CNC CHARLESTON SC
7/19/1999
NAVFAC SOUTHERN

DESIGN DOCUMENT
ANAEROBIC-AEROBIC SEQUENTIAL TREATABILITY STUDY
ZONE K (SWMU 166)
CTO-029

Prepared for:

Department of the Navy
Southern Division
Naval Facilities Engineering Command
North Charleston, South Carolina

Prepared by:

EnSafe Inc.
5724 Summer Trees Drive
Memphis, Tennessee 38134
(901) 372-7962

July 19, 1999

Part X
Binder 5

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
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2155 EAGLE DRIVE
NORTH CHARLESTON, S.C. 29419-9010

5090/11
Code 18710
29 July, 1999

Mr. John Litton, P.E.
Director, Division of Hazardous and Infectious Waste Management
Bureau of Land and Waste Management
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201

Subj: SUBMITTAL OF REVISED DESIGN DOCUMENT FOR ANAEROBIC-AEROBIC SEQUENTIAL TREATABILITY SYSTEM ZONE K (SWMU 166)

Dear Mr. Litton:

The purpose of this letter is to submit the enclosed revised Design Document for Anaerobic-Aerobic Sequential Treatability System Zone K (SWMU 166), for Naval Base Charleston. The Design Document is submitted to fulfill the requirements of condition IV.E.2 of the RCRA Part B permit issued to the Navy by the South Carolina Department of Health and Environmental Control and the U.S. Environmental Protection Agency (USEPA).

The Design Document was developed based on comments made by the Department and the USEPA on the Draft Design Document for Anaerobic-Aerobic Sequential Treatability Study for SWMU 166.

The Navy requests that the Department and the USEPA review and provide comment or approval whichever is appropriate. If you should have any questions please contact Billy Drawdy or Tony Hunt at (843) 743-9985 and (843) 820-5525 respectively.

Sincerely,

DAVID P. DODDS
Remedial Project Manager
Installation Restoration III

Encl:
(1) Design Document for Anaerobic-Aerobic Sequential Treatability System - Zone K (SWMU 166), 19 July 1999

Copy to:
SCDHEC (Paul Bergstrand, Mihir Mehta), USEPA (Dann Spariosu)
CSO Naval Base Charleston (Billy Drawdy), SOUTHNAVFACENGCOM (Tony Hunt)

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INTRODUCTION

This design document for the anaerobic-aerobic (A-A) sequencing treatability study at SWMU 166 is based on the Zone K RFI Report and the March, 1999, SWMU 166 Treatability Study Work Plan (TSWP). General and detailed information regarding the site history, hydrogeology, and contaminants of concern can be found in those documents. This design document is intended primarily for use by the contractor and subcontractor in constructing and implementing the treatability study system. However, aquifer testing results, predictive capture zone modeling, and corresponding Figures C-1, C-2, and C-3 are provided in Attachment C to this report. Other relevant figures are discussed and presented in Section 6 of this design document.

The main objective of performing this study is to determine the feasibility of using A-A sequencing to remediate the chlorinated VOC groundwater plume. Though this technology is based on fundamental microbial principles, it has been applied at only a few sites in the United States and is considered an innovative technology. Furthermore, this technology is easily enhanced or inhibited by inherent chemical, geological, and hydrogeological variabilities difficult to reproduce in a laboratory. Therefore, a field-scale treatability study is needed to assess its effectiveness at SWMU 166. Section 3 of the March 1999 TSWP describes objectives in more detail.

Change in Proposed Study Area

Based on aquifer testing results completed in Spring 1999, the study area was relocated from its proposed location as described in the TSWP. Aquifer test results indicate that in order to achieve recirculation of the re-injected groundwater through the study area in less than 3 to 6 months, the distance between reinjection and extraction wells would need to be decreased. This resulting decrease in distance would interfere with daily Naval Annex facility operations. Therefore, the study area was offset about 100 feet south of its originally proposed location. Details of the aquifer test and new study area layout are provided in Attachment C of this document.

CONTRACTOR SCOPE OF WORK

GENERAL

The contractor will provide labor, materials, construction equipment, and supervision as required to install and provide the Navy a complete and operational, sequential in-situ anaerobic-aerobic remediation system. The contractor is to furnish all piping components, including manually operated valves, operational equipment, all structural steel, grout, concrete, concrete masonry blocks, fasteners, anchor bolts, and paint. Groundwater wells will be installed by a separate drilling subcontractor. Items not listed but needed for the completed installation are to be provided by the contractor.

The contractor shall establish onsite temporary utilities and temporary facilities that are required to do the work. The contractor shall promptly repair any damage to these or existing facilities and equipment during the work.

1.0 EQUIPMENT SETTING

1.1 Install the Following Equipment

Blower Unit

Compressor Unit

Nutrient Feed System

Groundwater Pumps

1.2 Install the Following System of Groundwater Wells

Groundwater Extraction Wells

Groundwater Re-injection Wells

Groundwater Sparging Wells

Groundwater Treatability Study Monitoring Wells

2.0 EARTHWORK

2.1 The contractor is responsible for furnishing all labor, equipment, transportation, and operations necessary to clear and grub, bring the site to grade, control dust, and prevent erosion as shown in the drawings.

2.2 The contractor shall protect aboveground or below-grade utilities adjacent to the work area. Existing utilities will not be taken out of service without the specific authorization of the owner or the owner's representative. Before excavation, the contractor shall locate underground utilities within the work area. Accurately locate and record on project record documents any abandoned and active lines that were rerouted or extended. As excavation approaches utilities, the contractor shall hand-excavate to uncover utilities.

2.3 The contractor is responsible for protecting trees, shrubs, lawns, and other features remaining as portion of the final landscape. The contractor shall protect benchmarks, existing structures, fences, manholes, cleanout plugs, and roads.

2.4 Notify the Navy of unexpected subsurface conditions and discontinue work in the area until the Navy provides notification to resume work.

2.5 The contractor shall repair damage promptly, as directed by the owner or the owner's representative.

3.0 CONCRETE

3.1 The contractor is to provide miscellaneous concrete pads, foundations, or grout as required to set equipment and steel to the elevations required. The contractor shall furnish all labor (including full-time onsite supervision), materials, equipment, transportation to job site,

services, permits, and tools necessary to complete concrete installation as shown in the concrete drawings specified herein, subject to requirements of the general conditions.

3.2 The contractor is responsible for replacing damaged or unsuitable concrete pads or foundations as specified by owner or engineer onsite.

4.0 PIPING AND INSTRUMENTATION

4.1 The contractor is to provide and install all piping components, including manually operated valves, strainers, pipe supports, and anchors, and hangers.

All piping indicated is to be installed by the contractor. The contractor will be responsible for field-routing any piping that is not detailed on the plans and elevations and is responsible for determination of the exact routing of all piping. The contractor is to make field measurements to determine actual equipment and tie-in point locations and to locate all interferences. The piping plans provided to the contractor are intended to be used to convey the intent and general arrangement of the piping.

4.2 The contractor is to provide and install all instruments. The contractor is to exercise special care in the handling and installation of the instruments to prevent inadvertent damage to the measuring and controlling elements.

5.0 ELECTRICAL

Before installing any wire or conduit, the contractor shall obtain the exact equipment requirements and shall install wire, conduit, disconnect switches, motor starters, circuit breakers, and other items of correct size for the equipment actually installed. However, wire and conduit sizes shall not be reduced without written approval.

5.1 Codes and Standards

Equipment design, fabrication, testing, performance, and installation shall, unless shown or specified otherwise, comply with the applicable requirements of NFPA 70 and IEEE C2 to the extent indicated by the references.

5.2 Coordination

The installation of the electrical work shall be coordinates with the work of other trades.

5.3 Approval Requirements

Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories (UL), Inc., the label of, listing with reexamination, in UL-05 will be acceptable as sufficient evidence that the items conform to the requirements.

Where materials or equipment are specified to the constructed or tested in accordance with the standards of NEMA, ASTM, or other recognized standards, a manufacturer's certificate of compliance indicating complete compliance of each item with applicable NEMA, ANSI, ASTM or other commercial standards specified will be acceptable as proof of compliance.

5.4 Prevention of Corrosion

Metallic materials shall be protected against corrosion. Equipment enclosures shall be given a rust-inhibiting treatment and the standard finish by the manufacturer.

6.0 FIGURES

As part of this design document, the following relevant figures are included:

- Figure 1 — Equipment Layout

  This figure provides the general layout of the aboveground equipment. Concrete pad and fencing is also presented in this figure.

- Figure 2 — Monitoring Wells and Site Layout

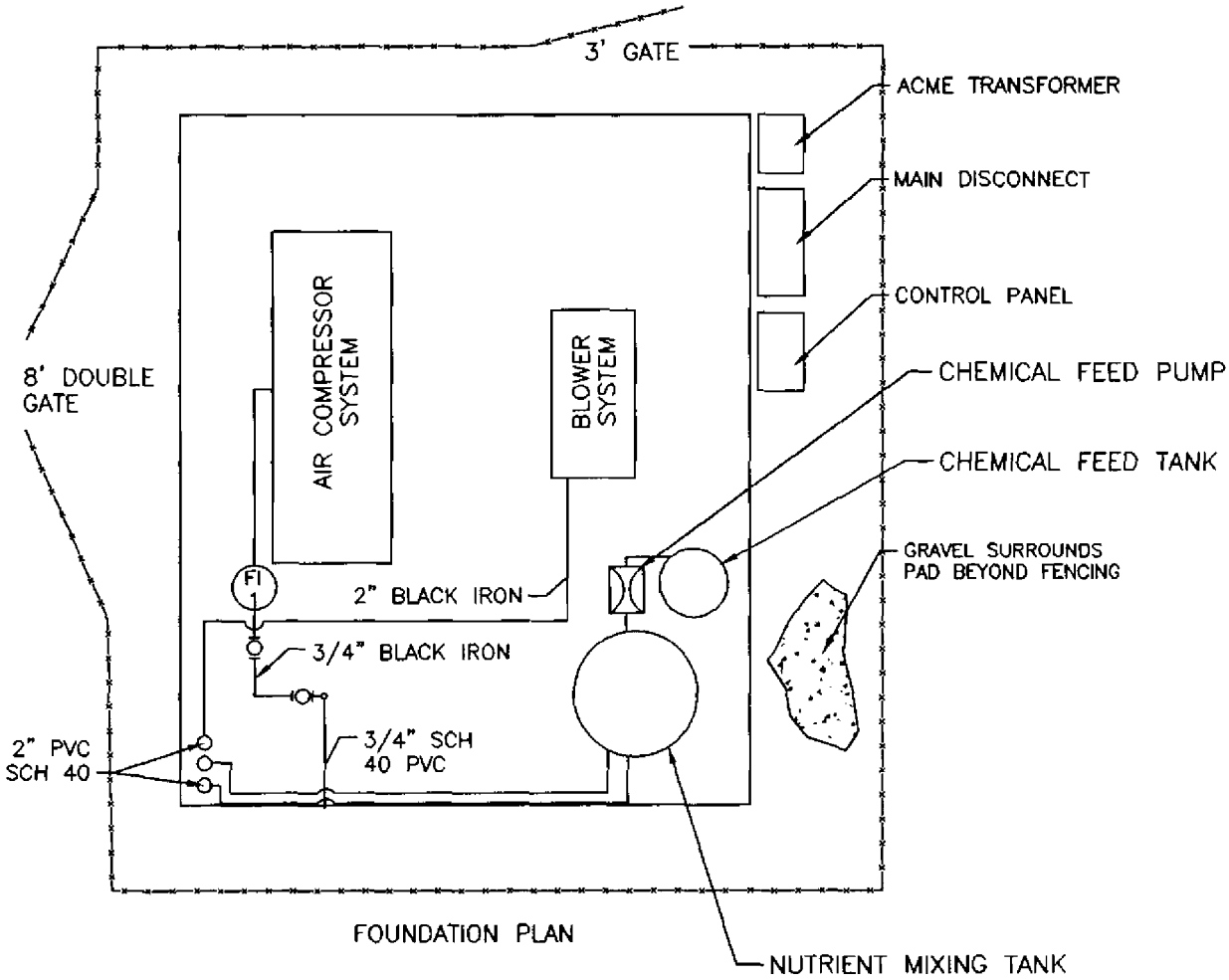
  This figure shows the location of the TS wells, equipment building (Figure 1) and the below ground piping network.

- Figure 3 — Well Vault Detail

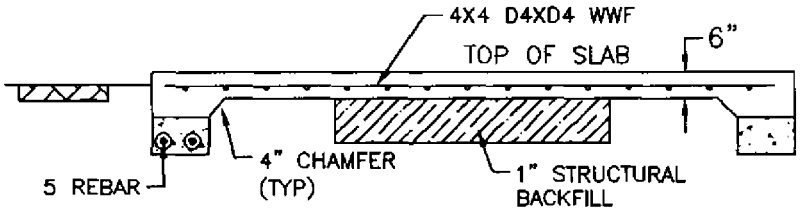
  This figure presents a profile view/detail of a typical well vault for the TS.

- Figure 4 — Typical Air Sparging, Extraction, Injection, and Monitoring Wells for Anaerobic-Aerobic Sequential Treatment System.

  This figure presents a detailed view of a typical air sparging, extraction, injection and monitoring well for the TS. Note the well casing in figure is shown exceeding grade. This if for illustration purposes only.



FOUNDATION PLAN



SECTION A

NOTES:

1. CONCRETE PAD IS COVERED BY A 14'X10' CANOPY SHELTER.
2. FENCING SURROUNDING PAD AREA CONTAINS GREEN PRIVACY SLATS.
3. ALL PIPING INSIDE COVERED PAD IS BLACK IRON.

NOT TO SCALE

ZONE K – SWMU 166
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FIGURE 1
EQUIPMENT LAYOUT

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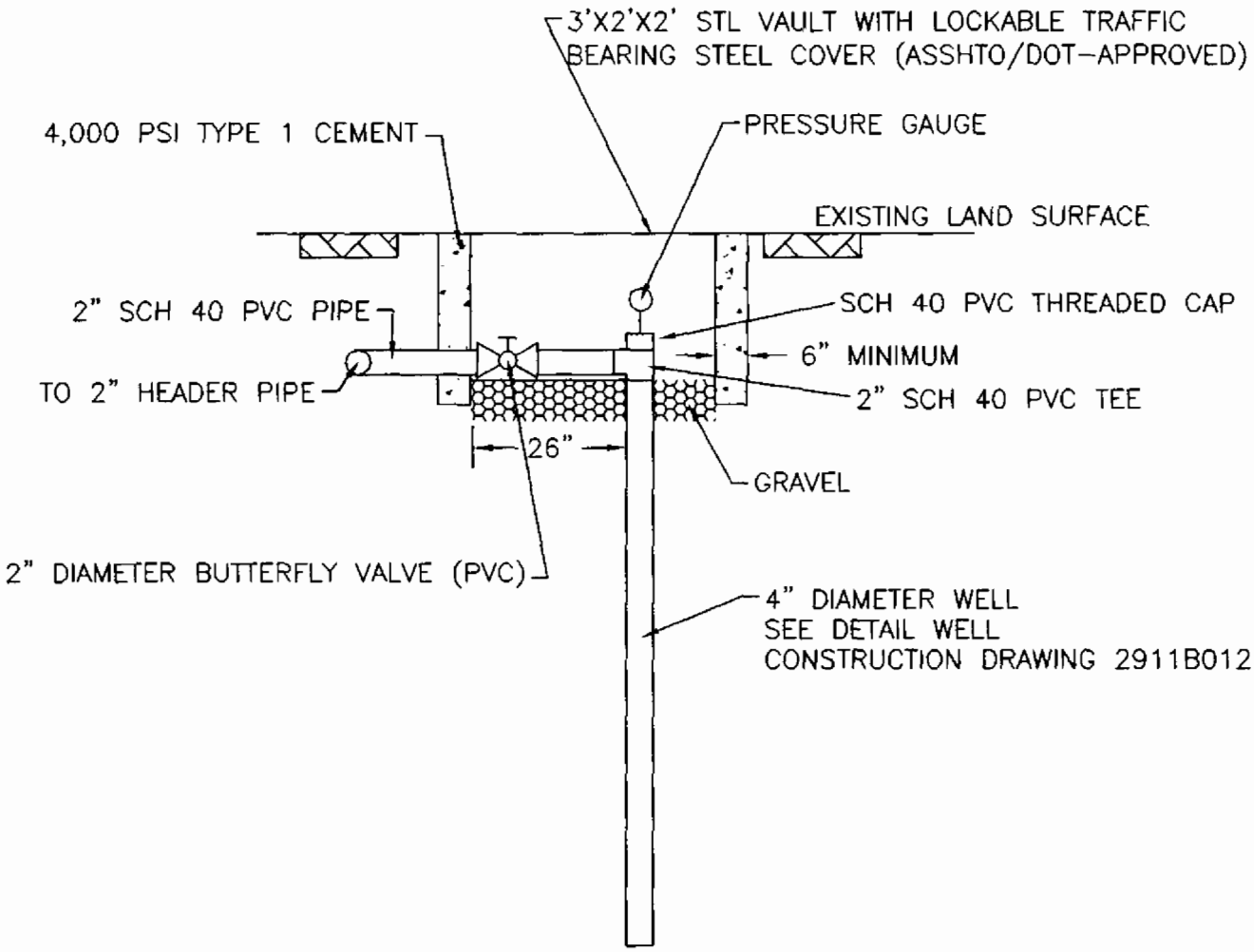

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TREATABILITY STUDY
DESIGN DOCUMENT

FIGURE 3
WELL VAULT DETAIL

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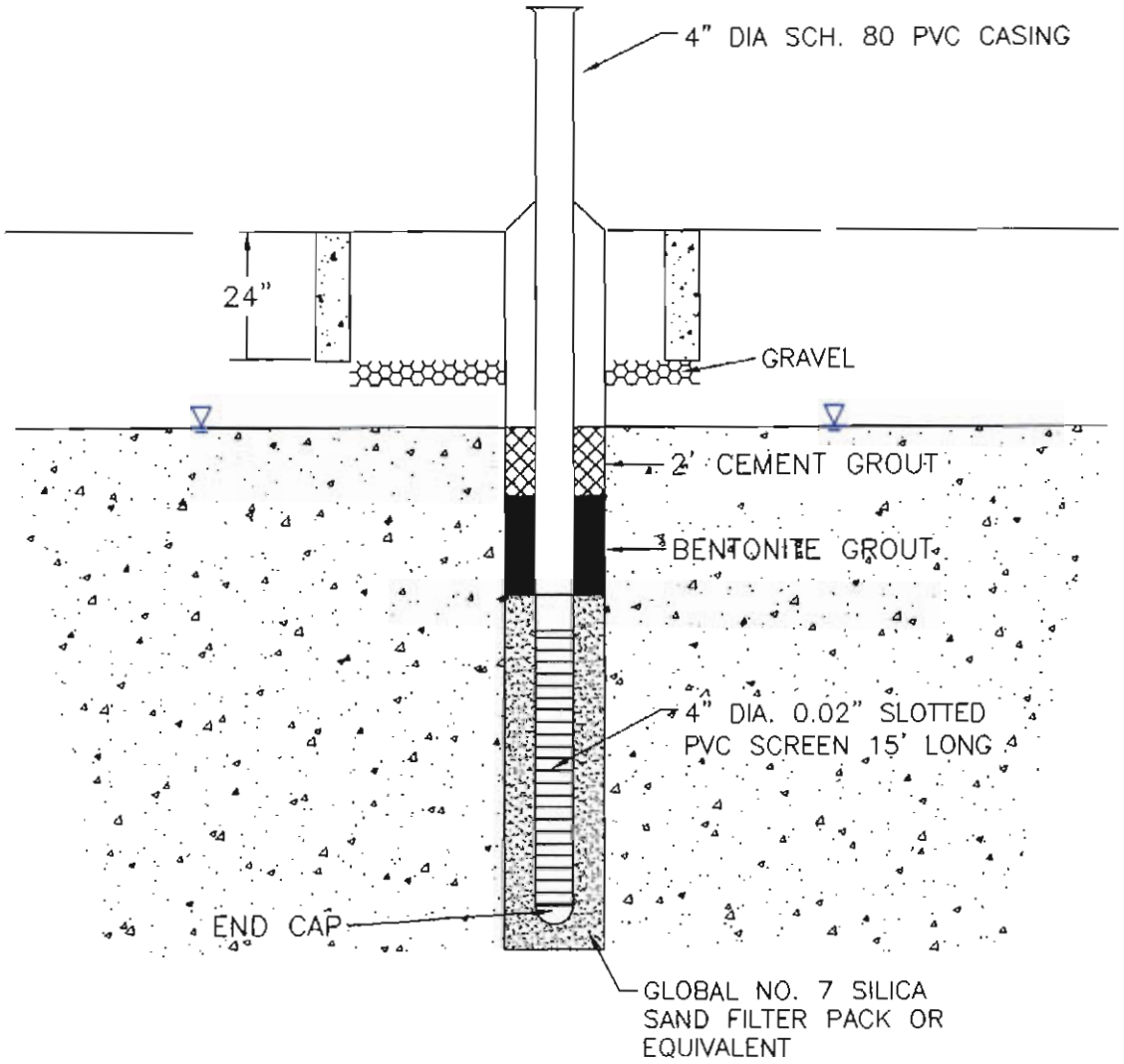


NOT TO SCALE

ZONE K – SWMU 166
AA SEQUENCE
TREATABILITY STUDY
DESIGN DOCUMENT

TYPICAL AIR SPARGING, EXTRACTION, INJECTION, AND MONITORING WELLS FOR ANAEROBIC–AEROBIC SEQUENTIAL TREATMENT SYSTEM

DWG DATE: 04/13/99 | DWG NAME: 2911B012

Attachment A

Specifications

SECTION A — EARTHWORK

CLEARING AND GRUBBING

- Clearing and grubbing shall consist of the removal and disposal of all trees, brush, stumps, roots, grass, and weeds which would prevent construction to the elevations provided on the drawings.

- All material generated as a result of clearing and grubbing activities will be stockpiled onsite at the location identified by the owner.

- The contractor shall provide temporary fences, barricades, covering, or other items required to protect and preserve items to remain and adjacent properties as directed by the owner's representative. Clearing and grubbing shall only be conducted within the area proposed for grading activities. The contractor shall exercise care to ensure that existing trees and vegetation outside the proposed fill or excavation limits are not damaged. The contractor shall restore damage to the condition existing prior to the start of work, unless otherwise directed by and at no cost to the owner.

DUST CONTROL

- The contractor shall conduct operations and maintain the site so as to minimize the creation and dispersion of dust. Dust control shall be used during clearing, transport, compaction, rough grading, well construction, and equipment installation.

EARTHWORK

- No brush, trees, tree roots, stumps, rubbish, sod, muck, frozen, or any other material deleterious to the earthwork shall be placed therein. The contractor will be required, when directed, to remove any materials which the owner or the owner's representative considers objectionable in the earthwork.

- The contractor shall protect aboveground or below-grade utilities adjacent to the work area. Do not take existing utilities out of service without the specific authorization of the

owner or the owner's representative. Before excavation, the contractor shall locate underground utilities within the work area. Accurately locate and record on Project Record Documents any abandoned and active lines that were rerouted or extended. As excavation approaches utilities, the contractor shall hand-excavate to uncover utilities.

- It is the responsibility of the contractor to protect trees, shrubs, lawns, and other features remaining as portion of the final landscape. The contractor shall protect benchmarks, existing structures, fences, manholes, cleanout plugs, and roads.

- Notify the Navy of unexpected subsurface conditions and discontinue work in the area until the Navy provides notification to resume work.

- The contractor shall repair damage promptly, as directed by the owner or the owner's representative.

SECTION B — CONCRETE

SCOPE

Contractor shall furnish all labor (including full time onsite supervision), materials, equipment, transportation to job site, services, permits, and tools necessary to complete the cast-in-place concrete installation as shown on the Contract Drawings and as specified herein, subject to the requirements of the General Conditions.

APPLICABLE CODES, STANDARDS, AND SPECIFICATIONS

All work shall conform to the latest edition of the American Concrete Institute's (ACI) and American Society for Testing Materials (ASTM) standards.

MATERIALS

- Cement: ASTM C150, Type 1 (One brand shall be used throughout the project.)

- Water: Fresh, potable, clean and free from injurious amounts of oils, acids, alkalies, salts, organic materials, or other deleterious matter.

- Aggregate: Well graded, clean, hard, durable, uncoated stone or gravel conforming to ADTM C33, 3/4" to 1 ½".

- Expansion Joint: ASTM Specification D1751-60T.

- Joint Sealant: Federal Specification TT-S-00230, one part type.

- Forms: Commercial standard, moisture-resistant, form plywood (not less than 5/8" thick); metal; or other patent-type forming system that will produce surfaces equal to the plywood.

- Ready-Mix Concrete: Conform to ASTM C94.

CONCRETE MIX REQUIREMENTS

- All concrete shall be minimum compressive strength of f' c= 4,000 psi at 28 days.

- All concrete shall have a maximum slump of 3" for slabs and 5" for other members.

- All concrete shall have a maximum water/cement ratio of 0.50.

FORMS

- The design, materials, and construction of all formwork shall conform to ACI 347.

- All exposed corners shall be chamfered by 3/4" molding.

CONCRETE FINISHES

- All slabs shall be screeded and floated to bring the surface to the required finish elevations with no coarse aggregate visible. After the concrete has stiffened sufficiently to permit the operation, the surface shall be floated at least twice to a uniform, sandy texture.

- Dusting with any material to absorb surface water is prohibited.

- A hard burnished, steel trowel finish with a very light burlap drag shall be provided for all slabs.

- For the exposed sides of pads all depressions, voids, and any honeycombed areas shall be cut back to solid concrete, patched, and ground smooth.

SECTION C — STEEL

SCOPE

The work to be performed under this section of the specifications shall include the furnishing, detailing (including design of all connections), fabrication, and erection of the structural steel framing, columns, beams, bracing, ladders, grating, handrail, and toe-plate.

MATERIALS

Structural Steel: Conform to the applicable provisions of ASTM Standard Specification A36 and the latest codes and standards of the American Institute of Steel Construction (AISC).

All materials shall be stored in a manner that will prevent damage from rusting, impact, and chemicals. All structural shapes shall be clean and straight. Twisted or damaged sections shall not be used.

Bolts: All bolting is to conform to ASTM Specification A-325.

Angle Iron: All L shaped supports are to be standard L 2 X 2 X 1/4 solid metal pieces.

H beams: All H beams are to be standard W 6 X 12 solid metal beams.

Steel plates: All plates will be standard 4' X 8' sheets of metal 1/4" thick.

FABRICATION AND ERECTION

The contractor shall be responsible for the design adequacy of all steel connections.

The erection shall be done in accordance with the latest edition of the AISC specifications, the AWs code, and the OSHA standards.

All column bases shall be set on steel shims of sufficient size to support the dead load of the structure. After the structure has been plumbed, leveled, and bolted, grout beneath the plates per the grout manufacturer's recommended installation instructions.

SECTION D — PIPING

SCOPE

The contractor is to furnish all labor, materials, equipment, services, permits, and tools necessary to complete the piping as shown on the schematic P&ID drawings and the plans, layouts.

Piping is to be installed in accordance with the Pipe Fabrication Institute Standards Fabricating Tolerance, PFI Standard ES-3.

No alternate components or materials shall be substituted without the written approval of the owner or engineer.

LINE IDENTIFICATION

Pipe lines are numbered per the following scheme:

Example: 4"-PW-CS

4"	=	Nominal Pipe Diameter
PW	=	Service
CS	=	Piping Material Specification

SUPPORTS, ANCHORS, AND HANGERS

All piping shall be adequately supported, guided and anchored to prevent excessive vibration, deflection, and stress on equipment. Piping is to be supported such that no stress is placed on the pumps, centrifuge, or other rotating equipment.

Piping shall be arranged and supported to permit removal of equipment for maintenance.

TESTING

All piping is to be hydrostatically tested upon completion of the installation to insure that there are no leaks at flanged, clamped, or welded connections. Testing is to be performed at the system design pressure, 125 psig. Instrument components subject to damage by the hydrostatic test are to be temporarily removed or blinded from the system

SPECIFICATION CARBON STEEL (CS) FITTINGS AND PIPE

Pipe

2" and smaller	ASTM A-53, ASTM A-106 GR.B, or ASTM A-120. Standard weight (schedule 40), commercial, galvanized, threaded ends.
3" and larger	ASTM A-53 GR.B or ASTM A-106 Gr.B, standard weight, commercial, carbon steel, compatible with fittings for grooved pipe as manufactured by Victaulic, Grinnel, or equivalent.

Fittings

2" and smaller	ASTM A-338 or A-197, 300# threaded, malleable iron, galvanized conforming to ANSI B16.3 or ASTM A-126, Gr.B.

3" and larger	Standard Victaulic, Grinnel "Groove-Lock" or equivalent grooved end fittings for IPS piping. Flexible or rigid type fittings per fitting. Follow manufacturer's recommendation for location and service. Follow manufacturer's recommendations for gaskets, bolting, outlet connectors, and flange adaptors for a system to provide 125 psig rating in process water service. (Process water will have a pH of 7 to 10.)
Unions	
2" and smaller	ASTM A-197, 300# malleable iron, or ASTM A-105 Gr. B, 300#, carbon steel, galvanized, ground joint, brass to iron seats.
Flanges	
2" and smaller	ASTM A-105 Gr. 1, carbon steel, 150# flat face, threaded, galvanized, bore to match pipe schedule.
3" and larger	ASTM A-105, Gr. 1 carbon steel, 150# flat face slip-on or weld neck, bore to match pipe schedule.
Bolting	ASTM A-307, Gr. B, hex head machine bolts with heavy hex nuts.
Gaskets	1/16" thick neoprene
Gate, Globe, Ball, Three-way, and Check Valves	
2" and smaller	200# bronze body, threaded ends, bronze or stainless steel trim, specified for water and compressed air service.
Butterfly valves	
3" and larger	As manufactured by Victaulic "Vic 300", Grinnel "Series 7000" or equivalent.

Gasket Strainers

2" and larger	As manufactured by Armstrong, Model SU-10S. Cast Iron body, 304ss 20 mesh screen, flanged pipe connections.

POLYVINYL CHLORIDE (PVC) SCHEDULE 80 FITTINGS AND PIPE

This specification covers the manufacturing requirement for PVC Schedule 80 piping component intended for use in industrial pressure rated fluid handling systems of 140°F or less where resistance to corrosion is of prime importance.

Materials: Pipe and fittings shall be manufactured from PVC compound which meets the requirements of cell classification 12454-B polyvinyl chloride as outlined in ASTM D-1784. PVC shall be gray in color. Pipe and fitting materials shall be specifically formulated with sufficient UV screeners to provide for long term outdoor exposure with no deleterious effects.

Materials from which pipe and fittings are manufactured shall have been tested and listed for conveying potable water by the National Sanitation Foundation (NSF).

Dimensions/Design (IPS size): Fitting components that utilize socket type solvent welded connections shall have socket diameters, lengths and wall thickness as required by ASTM D-2467. Components utilizing taper pipe thread connections. Shall have thread length, diameters and configurations in conformance with ASTM D-2464.

Fittings shall be industrial, heavy duty, hub style.

Flanges shall be one piece solid design or two-part van stone type which utilize the taped, serrated face and full face gasket technique for joining and are compatible with ANSI B16-5 class 150 metal flanges.

Unions shall be the O-ring seal type having interchangeable components with time-union valves for maximum system versatility.

Unions intended for joining dissimilar materials shall be the transition type, which utilize components of the two dissimilar materials, joined with an O-ring to adsorb the thermal expansion coefficient differential.

Pipe shall be as prescribed by ASTM D-1785 for pressure rated piping system.

Pressure Ratings: Socket fittings shall be pressure rated the same as the corresponding size pipe prescribed by ASTM D-1785. Threaded fittings shall be pressure rated at 50% of the rating for socket fittings.

Valves, unions and flanges shall be pressure rated at 150 psi for water service at 73°F, non-shock and have a minimum burst requirements of 3.3 times the rated pressure.

Pipe shall be pressure rated as prescribed by ASTM D-1785.

Markings: Fitting and pipe shall be clearly marked with the manufacturer's name or trademark, material, ASTM number or alternate symbol indicating compliance with NSF standard 14 for the conveyance of potable water, and further indicating compliance with the applicable ASTM standard and country of manufacture.

PVC BALL VALVES ½" THROUGH 1 ½" SIZES

Materials: Major component parts shall be constructed of ½"-1/1/2" PVC — polyvinyl chloride, cell class 12454-B per ASTM D-1784 industrial gray in color.

Dimensions/Valve Design: PVC socket type connectors shall be as required in ASTM D-2466, ASTM D-2467. Threaded type connectors shall be as required in ASTM D-2466 ASTM D-2464.

The valve assembly shall be of uni-valve construction, such that a two-piece body is permanently screwed together to contain seats which are maintained under compressive load against the ball by elastomeric energizing rings. The valves shall have no user serviceable components except handles, and the general design shall stress efficient space utilization and economy.

Flow restriction shall be minimized by full port valve design for sizes ½"-1" and conventional port design for the 1 ½" size.

Valves shall have optional round handles available for safety operation.

Performance: Valves shall be rated for 150 psi service at 73°F water, non shock and have a minimum burst rating of 3.3 times the rated working pressure for maximum safety.

Markings: Valves shall be clearly marked with the manufacturer's name or trademark, size, material of construction, country of manufacture and the NSF-pw SE seal.

PVC BUTTERFLY VALVES 2" THROUGH 10": This specification covers the manufacturing requirements for PVC butterfly valves intended for use in industrial and commercial piping systems.

Materials: Body shall be manufactured from a PVC compound which meets the requirements of cell class 12454-B polyvinyl chloride as outlined in ASTM D-1784.

Disc shall be brass ASTM B-124 with EPDM upper and lower shaft shall be 420 S.S. ASTM-582 O-ring seal material shall be EPDM.

Bearing shall be PTFE bronze centered on steel.

Handle shall be of malleable iron with epoxy coating or PVC with throttling index plates.

Valve Design: Valve body shall be of the wafer design for ease of installation and maintenance and shall be compatible with bolt hole pattern, ANSI B16.5 class 150; B.5.1560 class 150; DN200 ISO 2084 PN10; and DN 200 DIN 2532 PN10.

The shaft shall splined to lock into the disc to ensure positive rotation. The shaft shall be guided by Teflon coated bearings to ensure against deflection. Disc position shall be indicated by the shaft when the Landa is removed.

Markings: Valves shall be clearly marked with the manufacturer's name or trademark, size material of construction, country of origin and pressure rating. Valves additionally bear the NSF-pn SE seal.

Performance: Valves shall be rated bubble-tight at 150 psi at 73°F water, non-shock. The pressure rating shall be based on a minimum safety factor of 3.3.

SECTION E — PUMPS

GROUNDWATER WELL PUMPS

GENERAL

Furnish and install CEE Standard Ap-4 or equal submersible pump(s) to extract 4 USGPM against a total head of 50 feet.

Pump Design

The pumps shall be of the submersible type, down-well controllerless total auto pump system:

- Down-well located (submersible) air operated pump
- Internally controlled require no surface controls or otherwise
- Available for flow-rates at minimum 4 GPM

- No surface mounted control, bleeders, or bubblers.

- Ready to be used immediately without any adjustments

- Pump control will be regulated using a liquid level controller located in the holding tank to turn the pump(s) on and off

- Air requirements maximum 90 psi, 2-4 SCFM.

The total fluid recovery system should be available with the following:

- Material of construction — stainless steel
- High strength reinforced tubing
- A pneumatically driven device that counts the number of pump cycles for maintenance, service, and statistical purposes with minimal loss in air pressure or performance.

SECTION F — BLOWER

Regenerative Blower

- The centrifugal blower unit should deliver substantial air flow at moderate pressure

- Blower should have a direct-drive, high speed, rotating impeller that regenerates or compresses inflow with each revolution.

- Blower should not have gears, belts, motor brushes or sliding vanes that require maintenance, impeller, mounting base.

- Blower should have suction/discharge silencers that reduce noise level to below OSHA standards. Blower should have build-in thermal protection to prevent overheating.

- Totally enclosed motors should operate on 50/60 HZ CSA certified and UL approved.

Sizing

Maximum Pressure in Inches of Water	= 55
HP	= 1
Maximum CFM	= 98
Power	= 230/V/3Φ/60 HZ.

SECTION G — COMPRESSOR

Compressor will be single stage, soil injected, rotary screw type compressor.

Electrical Motor

TEFC, 230/460V, 3-phase, 60HZ, 3600 rpm, Class F insulation.

Starter

Full voltage magnetic starter with 115V-single phase 60 HZ control voltage

Drive

V-belt with automatic tensioning device that provides optimum power transfer and long belt life

Control Panel

Display of discharge pressure, air and lubricant discharge, temperature, operating hours, start-stop switch, power on light, emergency stop button safety system with compressor, on light.

Safety system consists of motor overload, high air and lubricant discharge temperature, wrong direction of rotation, and loss of drive should be signaled by lighted indicators.

Compressor Control

Automatic dual control to run either fully loaded or unloaded with reduced power requirement during idle periods. Idle period is set to allow delayed stop of compressor in case of no air demand.

Air/coolant system

Air intake and cooling air enters the unit through replaceable pre-filter. Pneumatic inlet and vent valve. ASME separator should be equipped with safety relief valve. Oil level sight glass, and quick disconnect fittings for manual verification of separator element contamination. Tank mounted unit. Compressor should be equipped with air drying system.

SECTION H — METERING FEED PUMP

Air-operated Batch Metering Pump

- Air-operated diaphragm should be equipped with a pneumatic controller assembly for pre-set dispensing.

- The controller should monitor the diaphragm pump pulse to allow to accurately control the number of cycles the pump will produce.

- The pump housing is polypropylene; the diaphragm and ball check valves should be teflon.

- Maximum temperature is 150 ^{0}F, maximum pressure 100 psi.

- Pump should have a 1/4" FPT air inlet. Intake and discharge ½" FPT.

SECTION I — GROUNDWATER WELL SYSTEM

System Elements

The groundwater well system to be installed for the treatability study will consist of two extraction wells, four re-injection wells, two air sparging wells, and three treatability study monitoring wells. The location map shows where these wells are placed on the treatability system area.

Groundwater Extraction Wells

Two groundwater extraction wells will be 4-inch polyvinyl chloride (PVC) screened in the deep saturated zone. The wells will have a No. 20 slotted PVC screen of 15 feet length starting from

the base of the underlying Ashley clay formation which forms the relatively impermeable layer underneath the deep saturated treatability zone.

Groundwater Re-injection Wells

Four groundwater re-injection wells will be 4-inch polyvinyl chloride (PVC) screened in the deep saturated zone. The wells will have a No. 20 slotted PVC screen of 15 feet length starting from the base of the underlying Ashley clay formation which forms the relatively impermeable layer underneath the deep saturated treatability zone.

Groundwater Air Sparging Wells

Two groundwater air sparging wells will be 2-inch polyvinyl chloride (PVC) screened in the deep saturated zone. The wells will have a No. 20 slotted PVC screen of 15 feet length starting from the base of the underlying Ashley clay formation which forms the relatively impermeable layer underneath the deep saturated treatability zone.

Groundwater Treatability Study Monitoring Wells

Three groundwater study monitoring wells will be 2-inch polyvinyl chloride (PVC) screened in the deep saturated zone. The wells will have a No. 20 slotted PVC screen of 15 feet length starting from the base of the underlying Ashley clay formation which forms the relatively impermeable layer underneath the deep saturated treatability zone.

Well Specifications

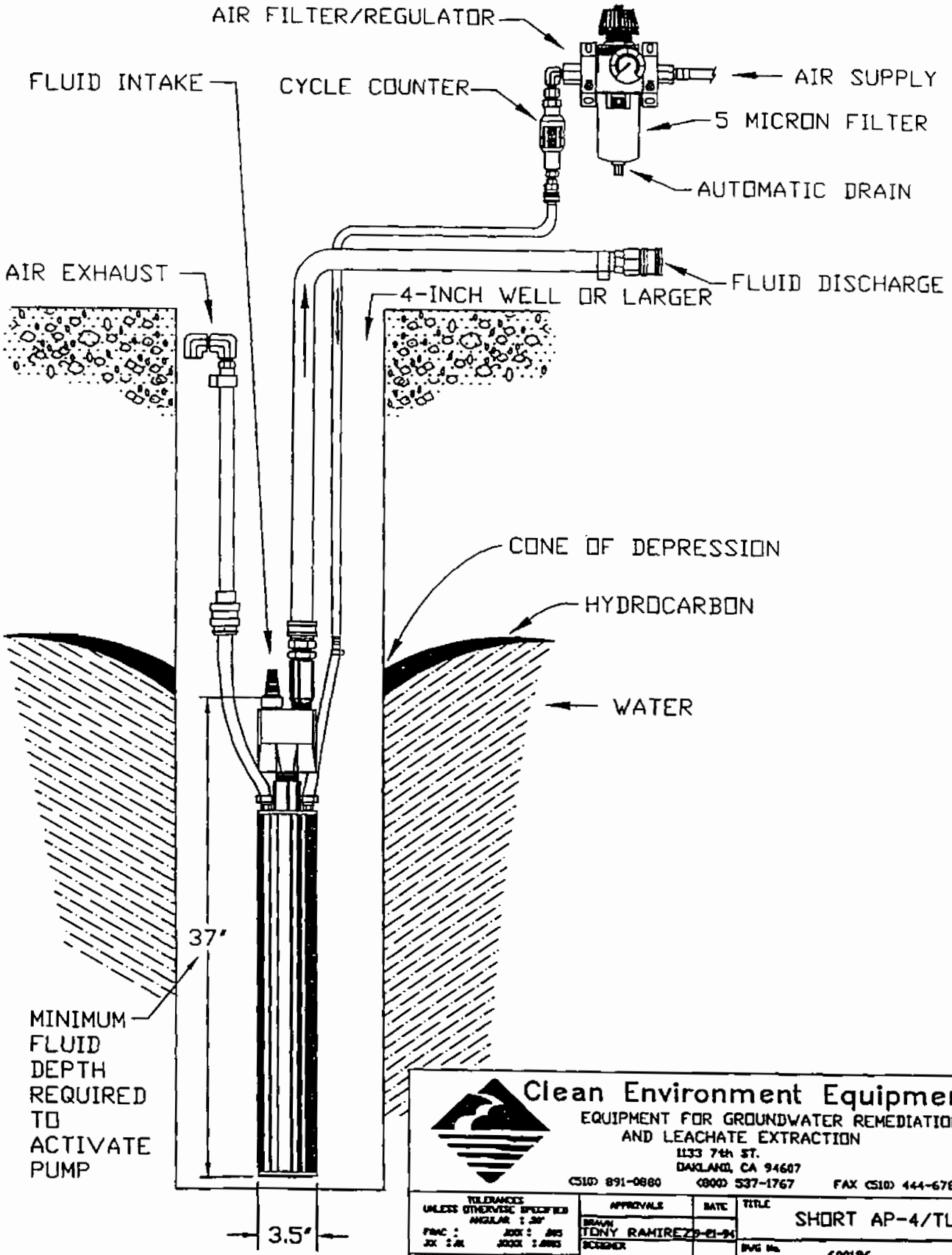
All the wells will be installed in a boring drilled to a depth to target the deeper zone of the aquifer just above the confining Ashley unit. The wells will be flush-mounted at the ground surface and have a well vault. A typical well design and vault design is in Attachment D. The completed drill hole will have an outer diameter of 8 to 12 inches, and should be large enough to accommodate a 2- or 4-inch inside diameter (ID) well screen and standpipe. The wells will be flush-mounted at the ground surface and have a well vault. A typical well design and vault design is in the drawing section, Section 6, of this document (Figures 3 and 4).

After installation, the dewatering test well shall be thoroughly developed by the drill crew for at least 2 hours, using a combination of pumping, surging, and flushing with potable water. All residuals derived from drilling and developing the dewatering the test well will be managed as hazardous waste. Development will be completed when the engineer or geologist has judged the well to be clean and hydraulically responsive.

Attachment B

Instrument Information

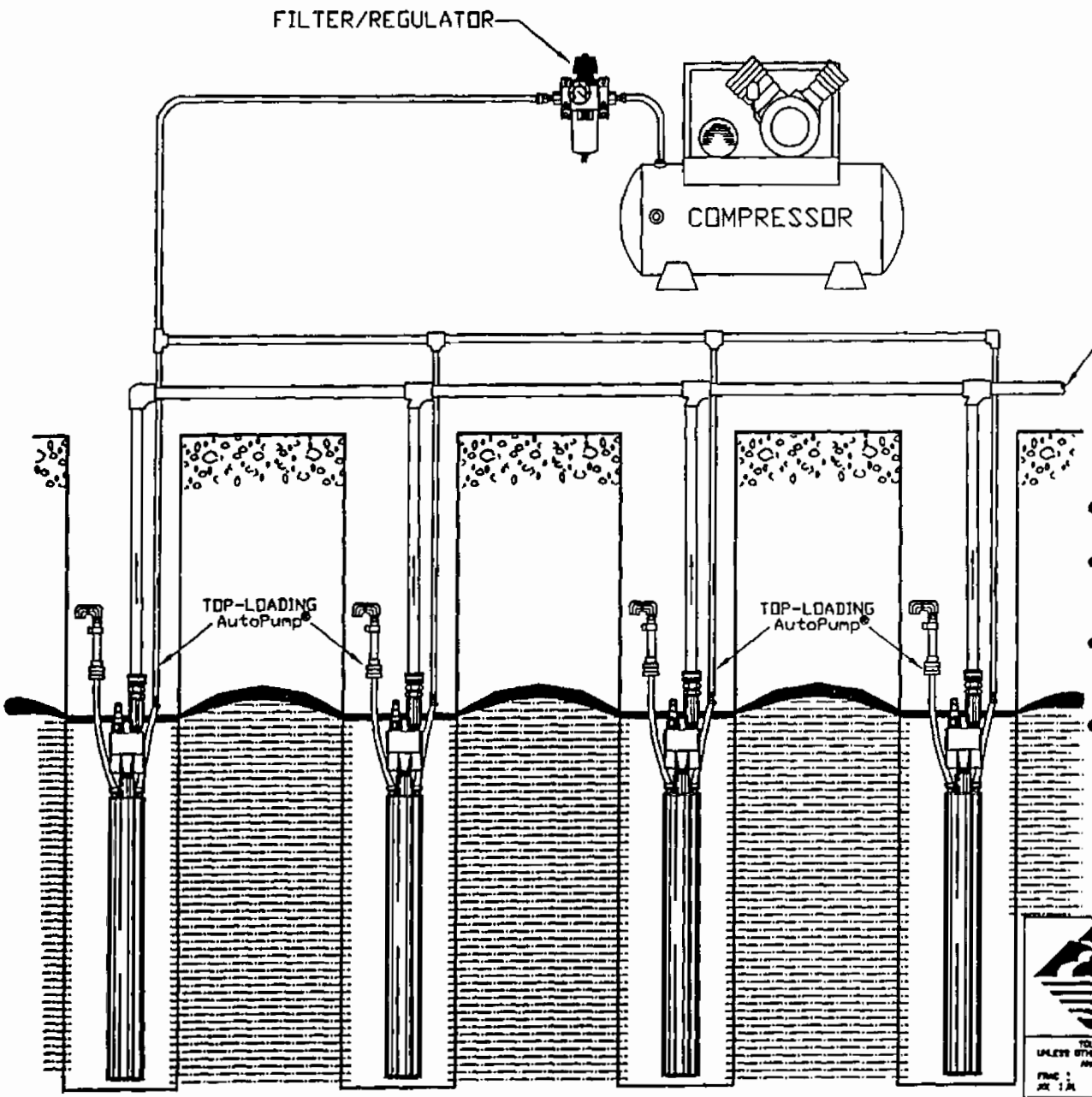
SHORT AP-4/TL
SHORT TOP-LOADING 4-INCH AutoPump®
CONTROLLERLESS TOTAL FLUIDS RECOVERY SYSTEM



Clean Environment Equipment
EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
1133 7th ST.
OAKLAND, CA 94607
(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR : .30' FRAC : XXX : .005 XX : .01 XXX : .005	APPROVALS	DATE	TITLE: SHORT AP-4/TL
	DRAWN: TONY RAMIREZ 9-01-94		DWG No. 600126 REV
MATERIAL	SCREENER		
FINISH	CHECKED		SCALE: NONE SHT 1 OF 1
	APPROVED		

MULTI-WELL SHORT AP-4/TL
CONTROLLERLESS TOTAL FLUIDS RECOVERY SYSTEM



FEATURES & BENEFITS

- A SINGLE 5 MICRON FILTER IS ADEQUATE FOR THE SYSTEM.
- EACH WELL OPERATES INDEPENDENTLY FROM ADJACENT WELLS.
- THE SYSTEM STAYS FULLY PRESSURIZED; AIR IS ONLY CONSUMED 'ON DEMAND'.
- NO BUBBLER SENSORS ARE REQUIRED; THEREFORE THE PUMPS CAN OPERATE UNDER A VACUUM ALLOWING SOIL VENTING.

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1133 7th ST.
OAKLAND, CA 94607
(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

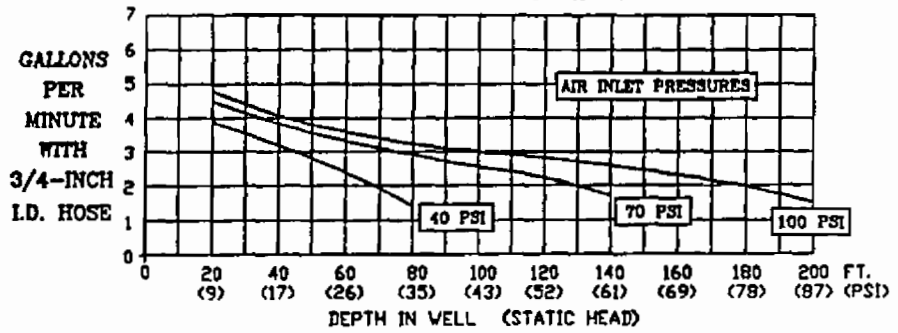
TOLERANCES UNLESS OTHERWISE SPECIFIED: ANGULAR ± .5°	APPROVALS	DATE	TITLE: MULTI-WELL SHORT AP-4/TL
	DRAWN: TONY RAMIREZ	7-21-94	
	DESIGNED		DWG No. 600128 REV
MATERIAL	CHECKED		
FINISH	APPROVED		SCALE: NONE SHT 1 OF 1

SHORT AP-4/TL AutoPump® PERFORMANCE CURVES

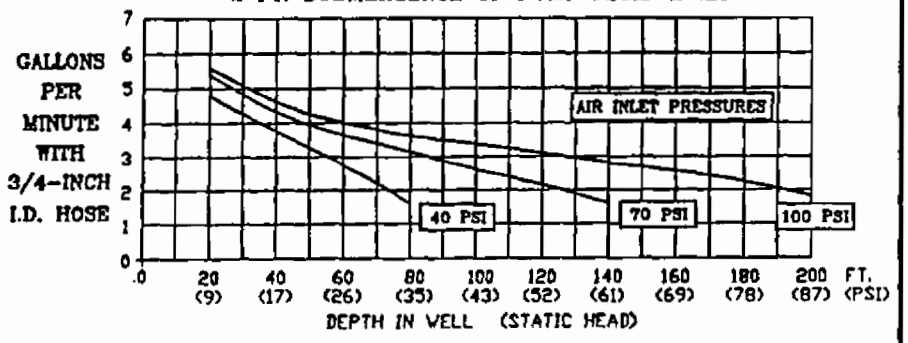
3/4-INCH INSIDE DIAMETER DISCHARGE HOSE

*MAXIMUM FLOW RATES**

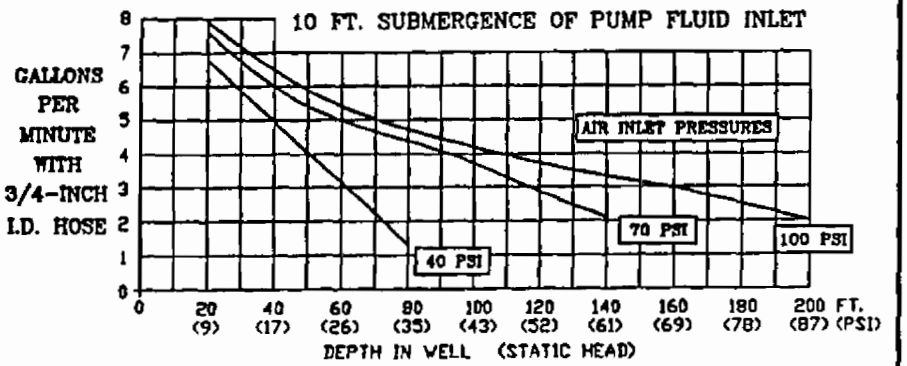
6-INCH SUBMERGENCE OF PUMP FLUID INLET



2 FT. SUBMERGENCE OF PUMP FLUID INLET



10 FT. SUBMERGENCE OF PUMP FLUID INLET

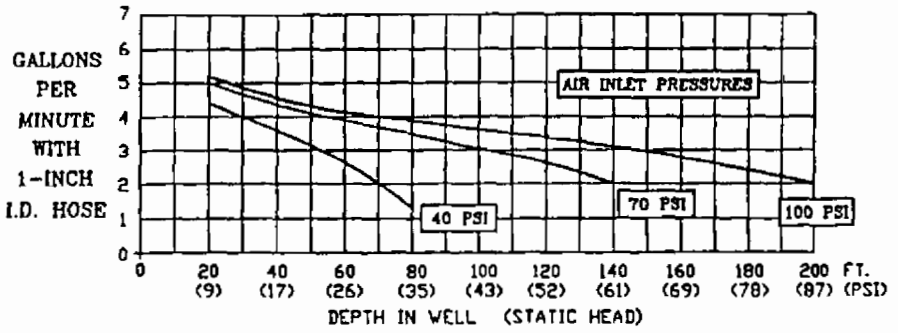


** FLOW RATES MAY VARY WITH ON-SITE CONDITIONS. CALL CEE FOR TECHNICAL ASSISTANCE.*

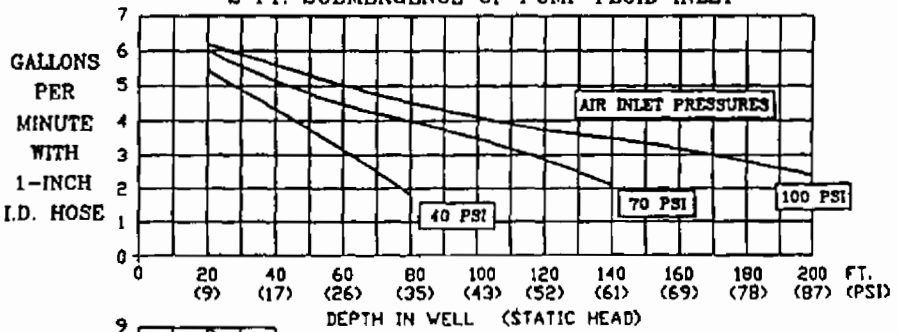
1-INCH INSIDE DIAMETER DISCHARGE HOSE

*MAXIMUM FLOW RATES**

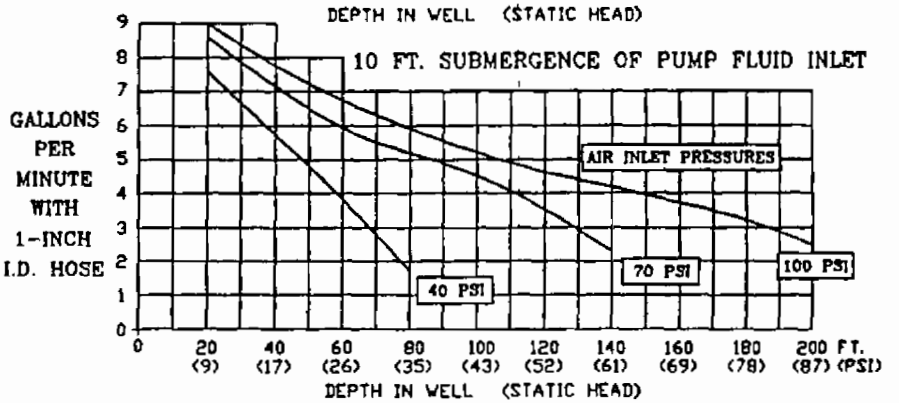
6-INCH SUBMERGENCE OF PUMP FLUID INLET



2 FT. SUBMERGENCE OF PUMP FLUID INLET



10 FT. SUBMERGENCE OF PUMP FLUID INLET



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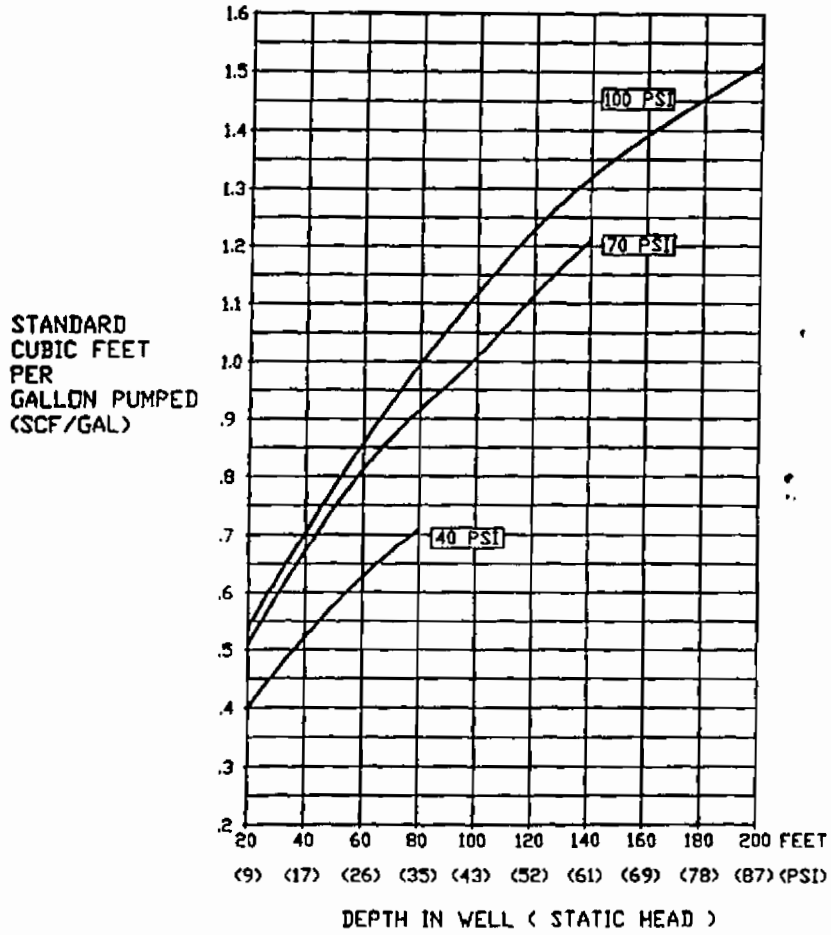
EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
1173 24th ST. OAKLAND CA 94607
(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

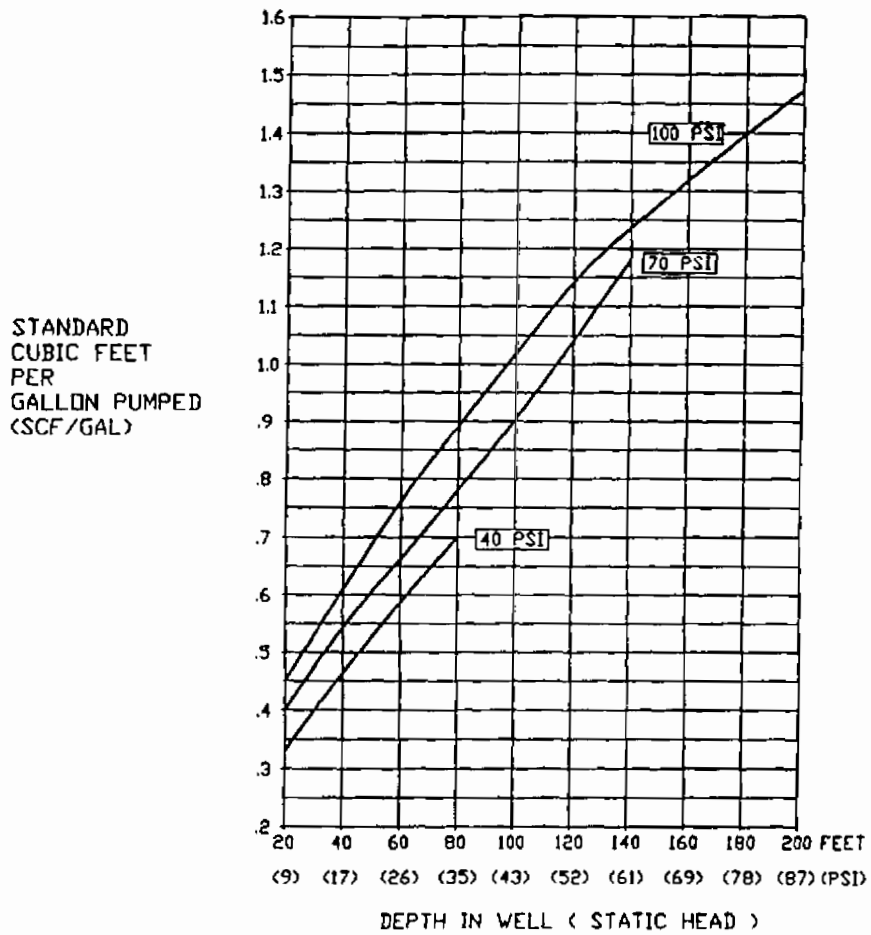
TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR ± .5° FRAC ± XXX ± .005 .XX ± .25 .XXX ± .005	APPROVALS	DATE	TITLE: SHORT AP-4/TL PERFORMANCE CURVES
	DRAWN: TONY RAMIREZ	2-28-94	
MATERIAL	CHECKED		DWG NO. 60987 REV
FINISH	APPROVED		SCALE: NONE SHT OF

SHORT AP-4 AutoPump®
AIR CONSUMPTION CURVES

3/4-INCH I.D. FLUID DISCHARGE HOSE



1-INCH I.D. FLUID DISCHARGE HOSE



MAXIMUM AIR USE IN STANDARD CUBIC FEET (SCF) PER GALLON PUMPED. (SURFACE LINE MAY INCREASE AIR USE.)

SCF/GAL X GPM = SCFM

THIS GRAPH FLOW RATE CURVES

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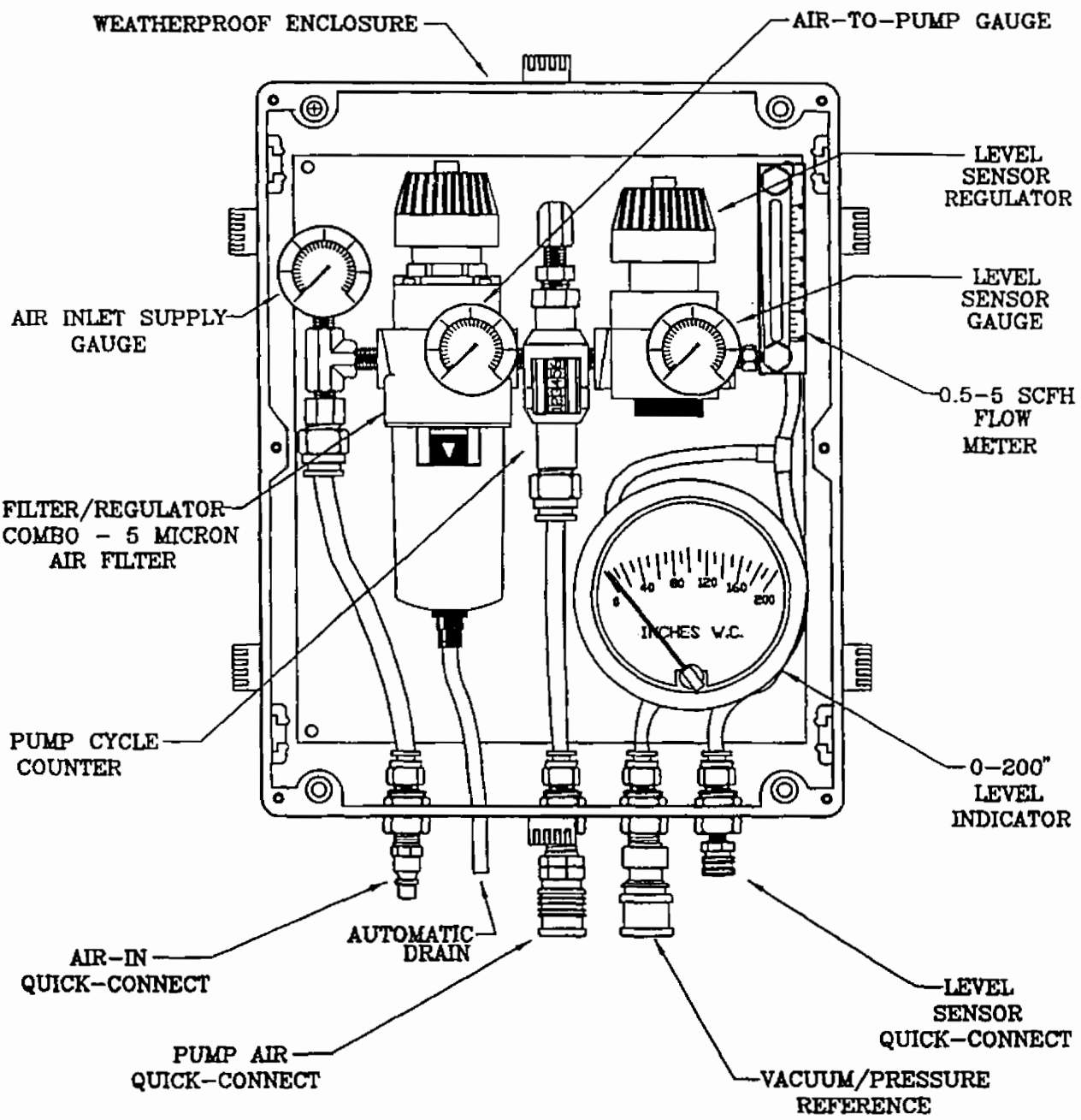
TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR ± .5° FRAC ± .005 XX ± .01 XXX ± .005 XXXX ± .0005	APPROVALS	DATE	TITLE: SHORT AP-4 AutoPump® AIR CONSUMPTION CURVES
	DRAWN TONY RAMIREZ	9-6-94	
	DATA COLLECTED JOEL VASQUEZ	9-6-94	
MATERIAL	CHECKED		DWG No. 600271 REV 9-26-94
FINISH	APPROVED		SCALE NONE SHT OF

AutoPump® DATA MODULE



NOTES:

- ON/OFF VALVE FOR LEVEL INDICATOR NOT SHOWN
- DIFFERENT TYPES OF LEVEL INDICATORS AVAILABLE.
- VACUUM AND/OR PRESSURE GAUGES AVAILABLE.
- ENCLOSURE SIZE VARIES DEPENDENT ON COMPONENTS SPECIFIED IN ENCLOSURE.

FRONT VIEW - COVER REMOVED

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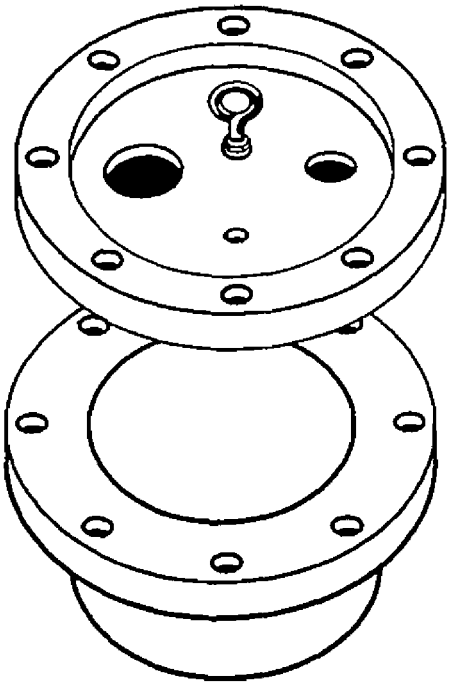
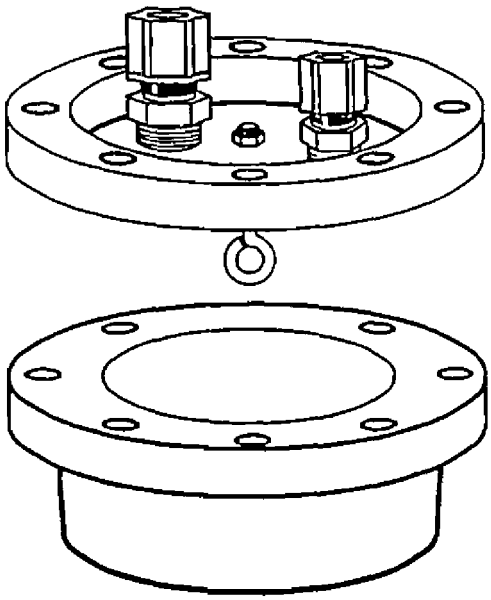
1133 7th ST.
OAKLAND, CA 94607
(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR : ± FRAC : XXX : XXXX :	APPROVALS	DATE	TITLE: AutoPump DATA MODULE
	DRAWN: TONY RAMIREZ 7-21-94		
	DESIGNER		
MATERIAL	CHECKED		DWG No. 600131 REV
FINISH	APPROVED		SCALE: NONE SHT OF

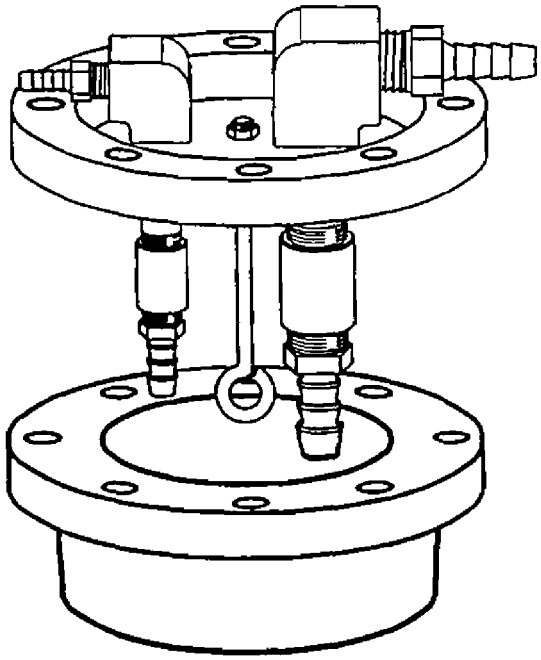
FLANGE WELL CAPS



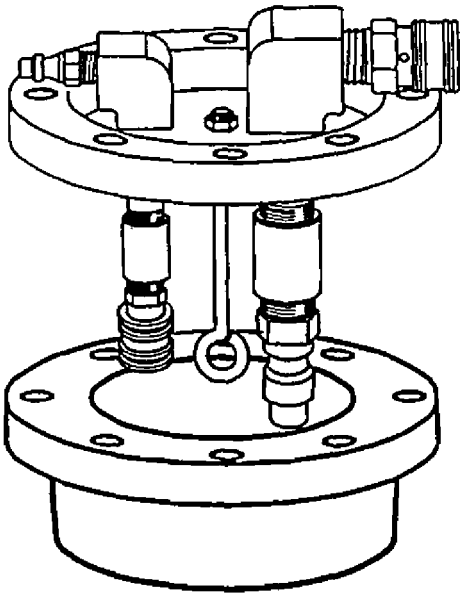
FLANGE WELL CAP WITH
HOLES & EYEBOLT



FLANGE WELL CAP WITH
NYLON COMPRESSION
FITTINGS & EYEBOLT



FLANGE WELL CAP WITH
HOSE BARBS &
EYEBOLT



FLANGE WELL CAP WITH
QUICK-CONNECTS
& EYEBOLT

NOTES:

- AVAILABLE IN SIZES TO ACCOMODATE MANY WELL DIAMETERS.
- EYEBOLTS AVAILABLE ON TOP AND/OR BOTTOM.

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AND LEACHATE EXTRACTION
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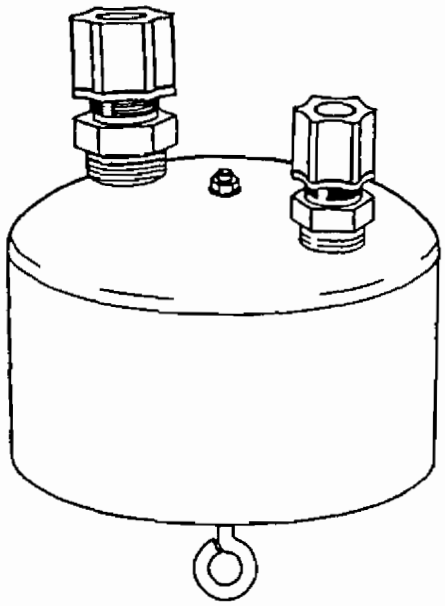
TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR : .5° FRAC : XXX : .005 XX : .01 XXX : .0005	APPROVALS	DATE	TITLE: FLANGE WELL CAPS
	DRAWN: TONY RAMIREZ	8-8-94	
	SCRIBER		
MATERIAL	CHECKED		DWG No. 600201 REV
FINISH	APPROVED		SCALE: NONE SHT 1 OF 1

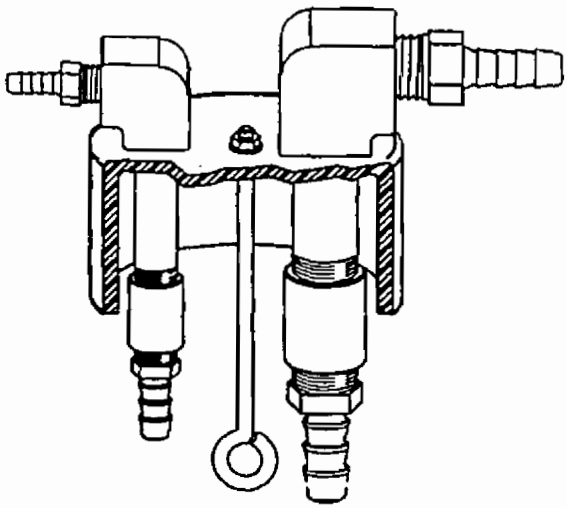
WELL CAPS

WELL CAP WITH
HOLES & EYEBOLT

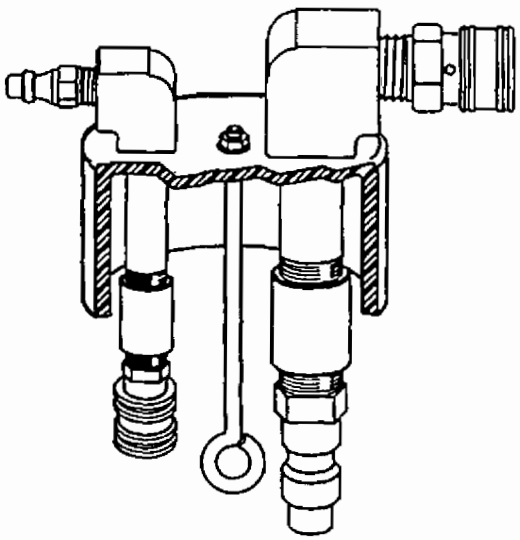
(NON–PRESSURE)



WELL CAP WITH
NYLON COMPRESSION
FITTINGS & EYEBOLT



WELL CAP WITH
HOSE BARBS &
EYEBOLT



WELL CAP WITH
QUICK–CONNECTS
& EYEBOLT

NOTES:

- AVAILABLE IN SIZES TO ACCOMODATE MANY WELL DIAMETERS.
- EYEBOLTS AVAILABLE ON TOP AND/OR BOTTOM.

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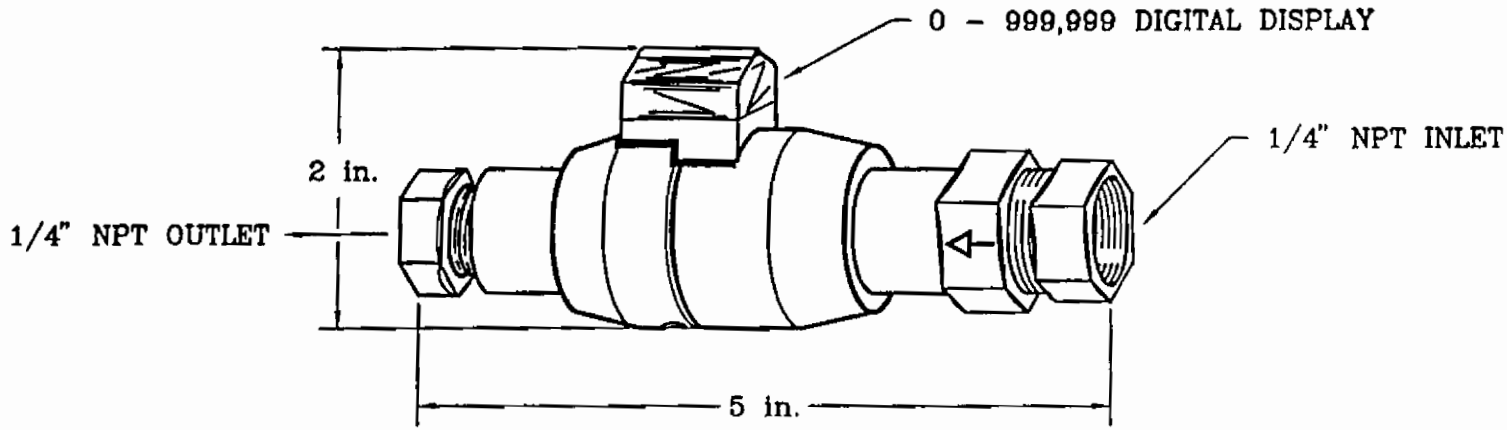
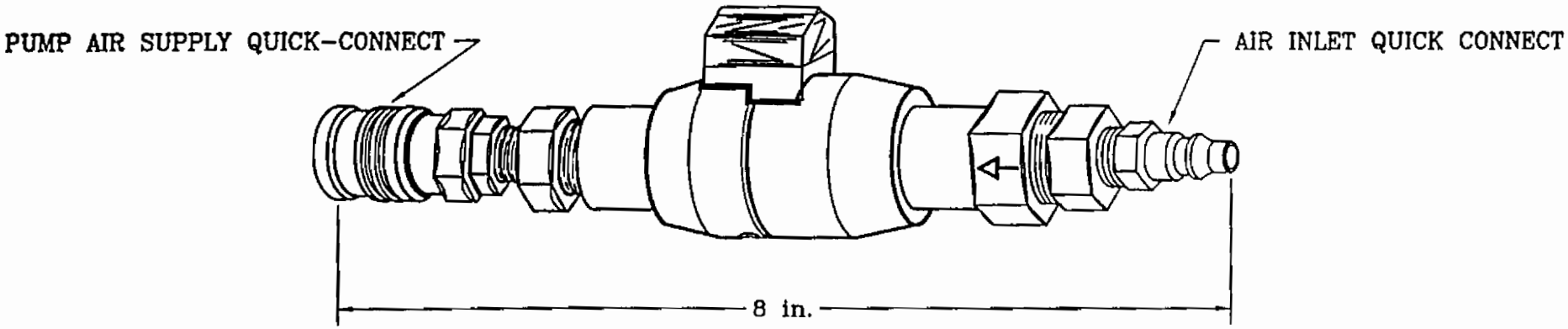
EQUIPMENT FOR GROUNDWATER REMEDIATION
AND LEACHATE EXTRACTION
1333 7th ST.
OAKLAND, CA 94607
(510) 891-0880 (800) 537-4767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR ± .5° FRAC. ± XX ± .01 XXX ± .005 XXXX ± .0005	APPROVALS	DATE	TITLE: WELL CAPS
	DRAWN: TONY RAMIREZ 8-3-94		
	DESIGNER		
MATERIAL	CHECKED		DWG No. 600133 REV
FINISH	APPROVED		SCALE: NONE SHT 1 OF 1





MAXIMUM PRESSURE 200 psi
SHIPPING WEIGHT 1 Lb.

MAGNETIC SLIDE INSIDE THE COUNTER BARREL MOVES AS AIR PASSES.
THE COUNTER INCREMENTS HALF WAY WHEN AIR BEGINS AND FINISHES THE INCREMENT WHEN FLOW CEASES.

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EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
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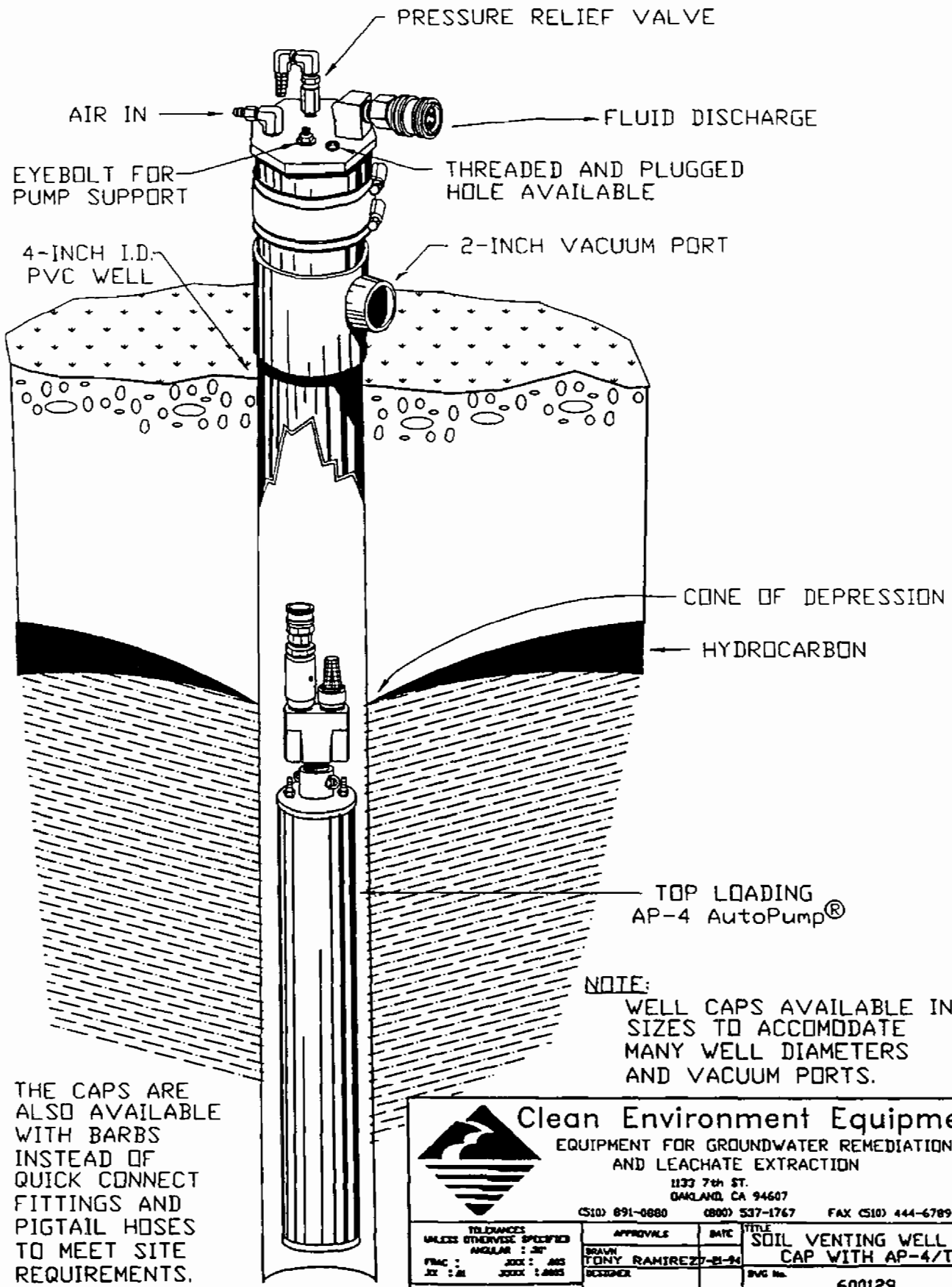
TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR ± .30° FRAC ± .XXX ± .005 .XX ± .01 .XXXX ± .0005	APPROVALS	DATE	TITLE PUMP CYCLE COUNTER
	DRAWN TONY RAMIREZ	7-21-94	
MATERIAL	DESIGNER		DWG No. 600130 REV
FINISH	CHECKED		SCALE NONE SHT OF
	APPROVED		

PUMP CYCLE COUNTER

SOIL VENTING WELL CAP
WITH AP-4/TL AutoPump®



NOTE:
WELL CAPS AVAILABLE IN SIZES TO ACCOMODATE MANY WELL DIAMETERS AND VACUUM PORTS.

THE CAPS ARE ALSO AVAILABLE WITH BARBS INSTEAD OF QUICK CONNECT FITTINGS AND PIGTAIL HOSES TO MEET SITE REQUIREMENTS.

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EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
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OAKLAND, CA 94607
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TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR : .25° FRAC : XXX : .005 XX : .01 XXXX : .0005	APPROVALS	DATE	TITLE: SOIL VENTING WELL HEAD CAP WITH AP-4/TL
	DRAWN TONY RAMIREZ	7-21-94	
	DESIGNER		DWG No. 600129 REV
MATERIAL	CHECKED		
FINISH	APPROVED		SCALE NONE SHT 1 OF 1

The CEE Tank-Full Shut-Off System is a self-contained safety system which can be used to turn off other pneumatic systems in the event of a liquid level rise or a pressure increase in a container (e.g., product recovery tank, oil/water separator, and/or surge tank). This system, which incorporates a dual-sensor safety mechanism, can be "T-ed" to monitor many tanks or containers without the need of adding more TFSO systems. This system consists of a TFSO Tank Unit with a fume/product overflow return, an air-operated control panel, a filter/pressure regulator, and a hose package.

METHOD OF OPERATION

The TFSO System is mounted first in a given series of pneumatic systems and passes compressed air to other "downstream" pneumatic systems as long as a "trip condition" does not exist. A TFSO Tank Unit is attached to each tank where shut-off protection is desired. The TFSO System monitors all TFSO-equipped tanks and if any one of the following conditions exists, the system closes the valve supplying compressed air and exhausts the air, shutting down all "downstream" systems:

- *Liquid Level Rise in the Tank.* If the liquid rises 4 inches above the float guide tube or pushes the float up against the trip button, the system trips.
- *Hoses Are Not Properly Connected or a Hose Leak Exists.* If an improper hose connection is made or there is a cut in one of the sensor hoses, the system will trip.
- *Tube Sensor or Fitting Blockage.* If any of the hoses or fittings become clogged by debris or condensate build-up, causing back pressure of up to 3 to 4 inches of water pressure, the system will trip.
- *Tank Vent or Control Exhaust Blockage.* Dangerous pressure build-up in a container is sensed by the TFSO Tank Unit and causes the system to trip.
- *Tank-Full Reset Button Has Not Been Pushed.* The TFSO System requires the manual pushing of the reset button before continuing operation.
- *Oil/Moisture Enters Controls.* If oil or water from the compressor clogs the sensors, the controls will shut down.

TFSO TANK UNIT

The TFSO Tank Unit has two sensors (a bubbler sensor and a float sensor) and a fume/product overflow return.

The bubbler sensor:

- Is fed a small amount of air which bleeds into the atmosphere or bubbles into the fluid.
- Is the guide tube that the float sensor slides up and down.
- Trips when 3 to 4 inches of water pressure is sensed.

The float sensor:

- Utilizes a 2-piece, hydrocarbon resistant float.
- Is triggered as the float rises with the fluid level coming in contact with a button located on the TFSO Tank Unit. This contact releases the air pressure built up behind the button, tripping the system.

The fume/product overflow return:

- Directs fumes back into the well (or other tanks if desired) under normal conditions to avoid potential hazardous accumulations of explosive fumes.
- Allows fluid to return to the well (or atmosphere or other tanks if desired) should both the bubbler and float sensors fail.

CONTROL PANEL

The Control Panel consists of TFSO circuitry, a pump air valve, air filters, and a pressure regulator; all housed within a NEMA 12 wall-mountable, aluminum enclosure.

The Tank-Full Shut-Off (TFSO) Circuitry:

- Has an overriding safety circuit that stops air flow to downstream pumps (Product, Total Fluids, and/or Water Pumps, etc.) when activated by the TFSO Tank Units.
- Includes a control panel-mounted Status Indicator and Reset Button that allows the operator to assess the condition and to re-start the system.

The air filter/pressure regulator unit:

- Is typically mounted on the Control Panel.
- Consists of a two-stage, 5 micron (first stage) and 0.01 micron (second stage), particulate filter contained in a metal bowl.
- Includes a float-operated condensate drain.
- Includes a pressure regulator that is adjustable from 0-125 psi and is rated for 250 psi.
- Allows for the adjustment of supply air pressure to the value necessary to operate the system.
- Is typically provided with locking-sleeve, hydraulic grade brass quick-connect fittings.

HOSE AND HARDWARE PACKAGE

The hoses supplied with the system are of industrial grade.

- The main air supply hoses equal or surpass Parker 801 specifications.
- The TFSO Sensor Hose consists of a low pressure single-wall PVC tubing.
- All hoses are color coded and equipped with non-interchangeable, brass quick-connect fittings.

SYSTEM REQUIREMENTS/PARAMETERS

The TFSO System:

- Has varying air usage, however, less than 0.7 scfm @ 80 psi is considered appropriate for most applications.
- Requires a 2-inch Female NPT fitting on tank for the TFSO Float (2-inch Male NPT).

SYSTEM OPTION

- Single Sensor TFSO Tank Unit.

MATERIALS OF CONSTRUCTION

The TFSO Tank Unit:

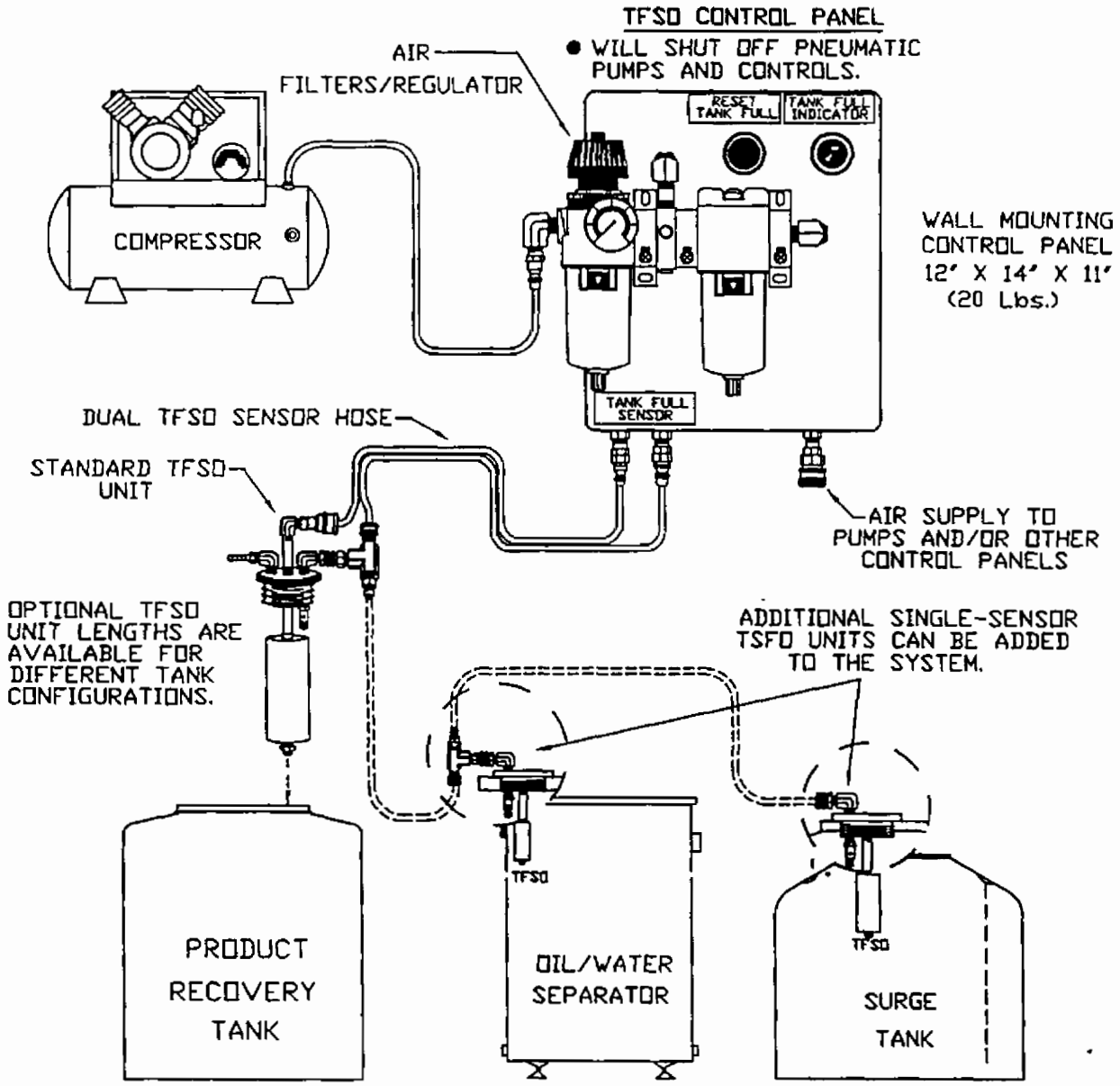
- Hydrocarbon resistant float material
- Stainless Steel
- Brass
- Aluminum

COMPONENT AND SHIPPING WEIGHTS

ITEM	COMPONENT (lb./kg.)	SHIPPING (lb./kg.)
Control Panel	20 / 9.1	23 / 10.4
Tank Unit	2 / 0.9	4 / 1.8
Hose Package	Varies	Varies

DUAL-SENSOR TANK-FULL SHUT-OFF (TFSO) SYSTEM

THE CEE TFSO SYSTEM PROTECTION EXTENDS BEYOND THE CLASSIC PRODUCT TANK-FULL CONDITION. IT ALSO INCLUDES A UNIQUE DUAL SENSOR HOSE FOR ADDED SAFETY. IN ADDITION, ALL EQUIPMENT RECEIVING AIR THAT IS FED BY, AND DOWNSTREAM OF, THE TFSO CONTROL PANEL, INCLUDING FLUID EXTRACTION PUMPS AND SKIMMERS, ARE TURNED OFF DURING "SHUT-DOWN" CYCLES.



- IF ANY SENSOR HOSE IS DISCONNECTED, THE SYSTEM WILL SHUT DOWN.
- IF THE DUAL SENSOR HOSE IS PINCHED OR CUT, THE SYSTEM WILL SHUT DOWN.
- IF ANY SINGLE TANK ARMED WITH A TFSO UNIT SHOULD FILL, THE SYSTEM WILL SHUT DOWN.

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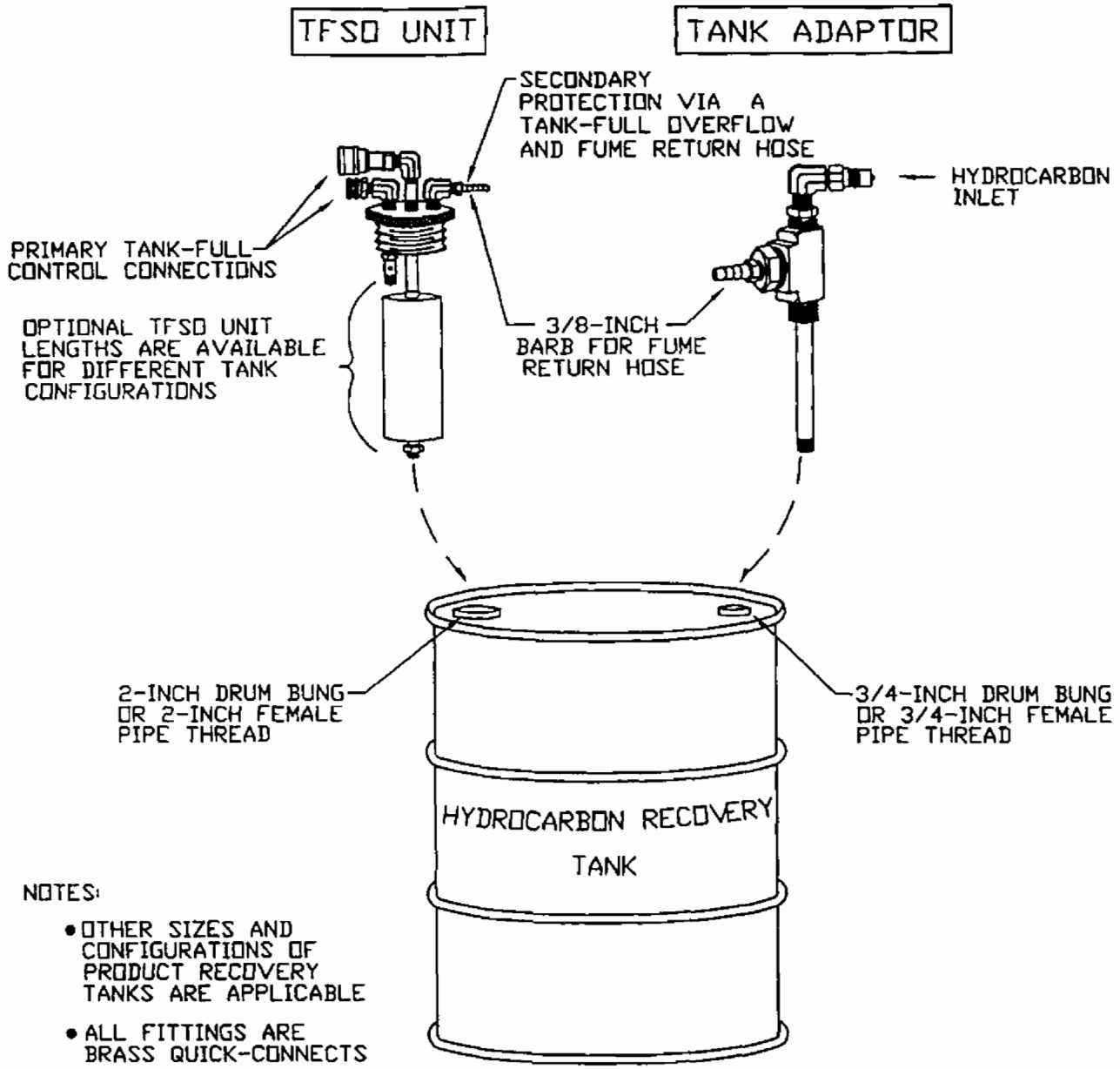
EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
1133 7th ST.
OAKLAND, CA 94607
(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR : 30' FRAC : XX : .01 XXX : .005 XXXX : .0005	APPROVALS	DATE	TITLE: DUAL-SENSOR TANK-FULL SHUT-OFF (TFSO) SYSTEM
	DRAWN TONY RAMIREZ	8-1-94	
	DESIGNER		DWG No. 600197 REV
MATERIAL	CHECKED		
FINISH	APPROVED		SCALE NONE SHT 1 OF 1

TFSO UNIT AND TANK ADAPTOR



NOTES:

- OTHER SIZES AND CONFIGURATIONS OF PRODUCT RECOVERY TANKS ARE APPLICABLE
- ALL FITTINGS ARE BRASS QUICK-CONNECTS

Clean Environment Equipment

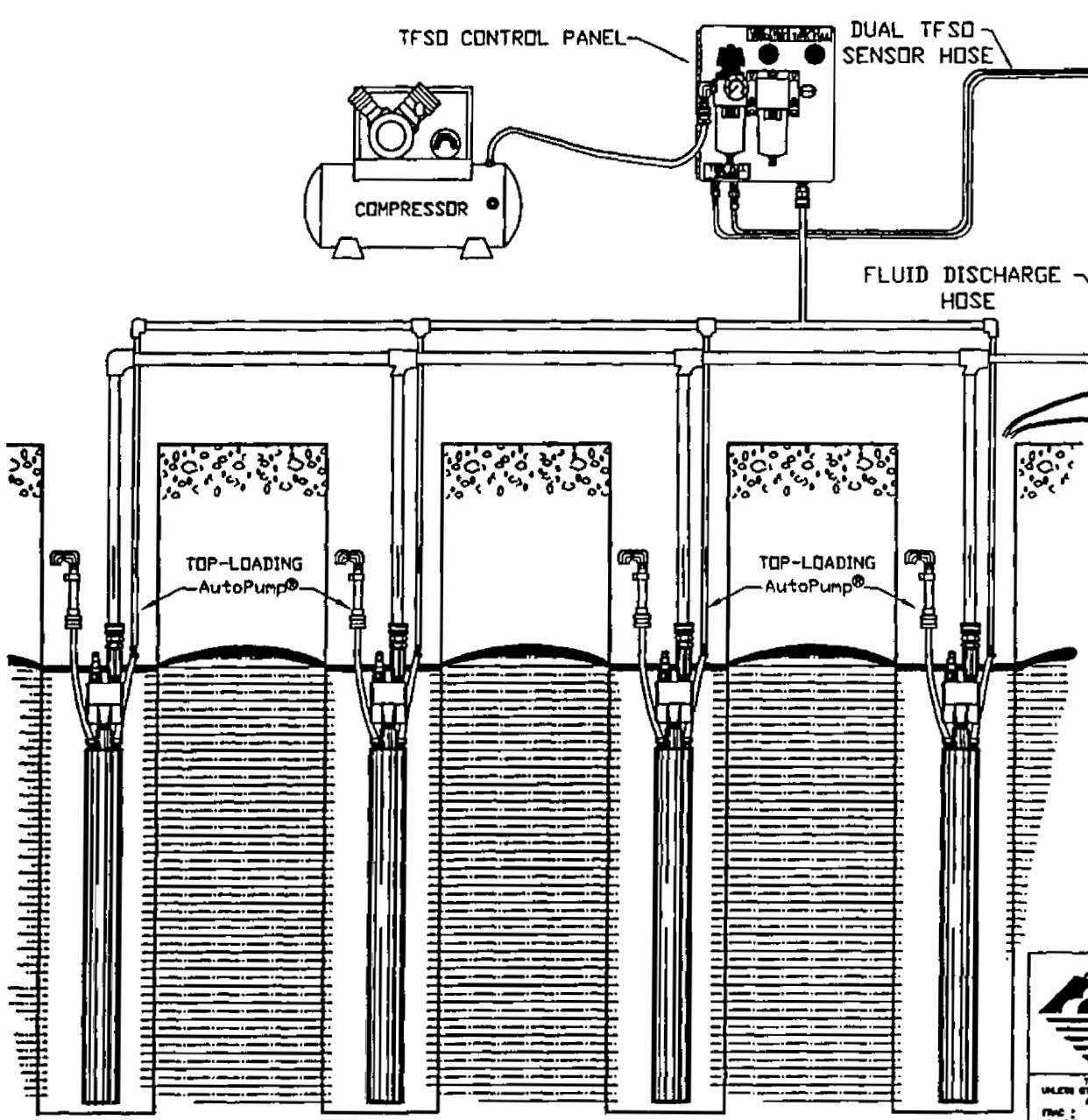
EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION

1133 7th ST.
OAKLAND, CA 94607

(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERVISE SPECIFIED	APPROVALS	DATE	TITLE	TFSO UNIT AND TANK ADAPTOR	
ANGULAR : .30° FRAC : XXX : .005 XX : .01 XXXX : .0005	DRAWN TONY RAMIREZ	8-1-94			
MATERIAL	DESIGNER		DWG No.	600198	REV
FINISH	CHECKED		SCALE	NONE	SHT 1 OF 1
	APPROVED				

TANK-FULL SHUT-OFF SYSTEM WITH MULTI-WELL AP-4/TL CONTROLLERLESS TOTAL FLUIDS RECOVERY SYSTEM



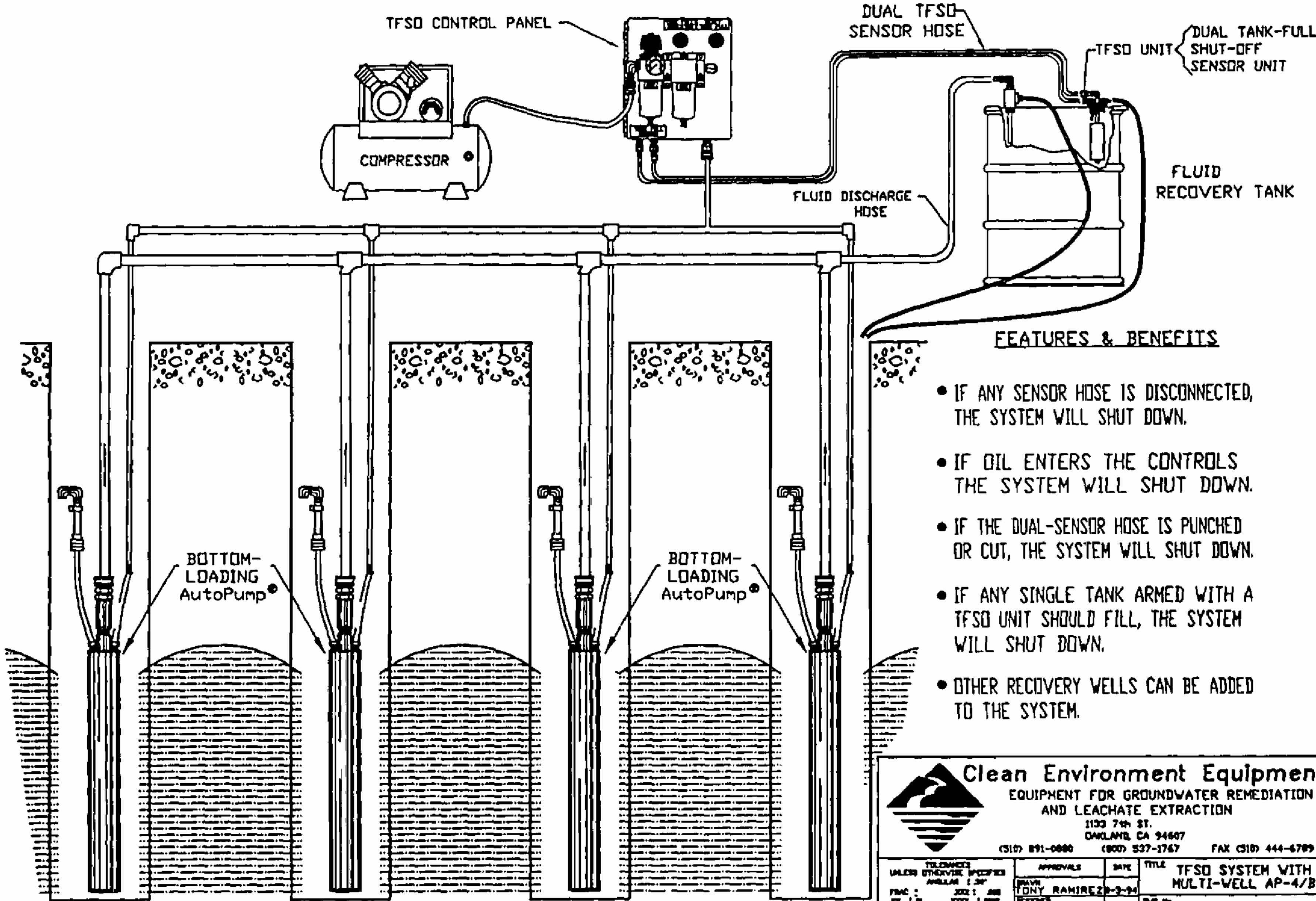
FEATURES & BENEFITS

- IF ANY SENSOR HOSE IS DISCONNECTED, THE SYSTEM WILL SHUT DOWN.
- IF OIL ENTERS THE CONTROLS, THE SYSTEM WILL SHUT DOWN.
- IF THE DUAL-SENSOR HOSE IS PUNCHED OR CUT, THE SYSTEM WILL SHUT DOWN.
- IF ANY SINGLE TANK ARMED WITH A TFSO UNIT SHOULD FILL, THE SYSTEM WILL SHUT DOWN.
- OTHER RECOVERY WELLS CAN BE ADDED TO THE SYSTEM.

Clean Environment Equipment
EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
1133 7th ST.
OAKLAND, CA 94607
(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERWISE SPECIFIED	APPROVALS	DATE	TITLE
ANGULAR ± 30'	DRAWN TONY RAMIREZ 8-94		TFSO SYSTEM WITH MULTI-WELL AP-4/TL
MATERIAL	DESIGNER		DWG NO. 600219 REV
FINISH	CHECKED		SCALE NONE SHT 1 OF 1
	APPROVED		

TANK-FULL SHUT-OFF SYSTEM WITH MULTI-WELL AP-4/BL CONTROLLERLESS TOTAL FLUIDS RECOVERY SYSTEM



FEATURES & BENEFITS

- IF ANY SENSOR HOSE IS DISCONNECTED, THE SYSTEM WILL SHUT DOWN.
- IF OIL ENTERS THE CONTROLS THE SYSTEM WILL SHUT DOWN.
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- IF ANY SINGLE TANK ARMED WITH A TFSO UNIT SHOULD FILL, THE SYSTEM WILL SHUT DOWN.
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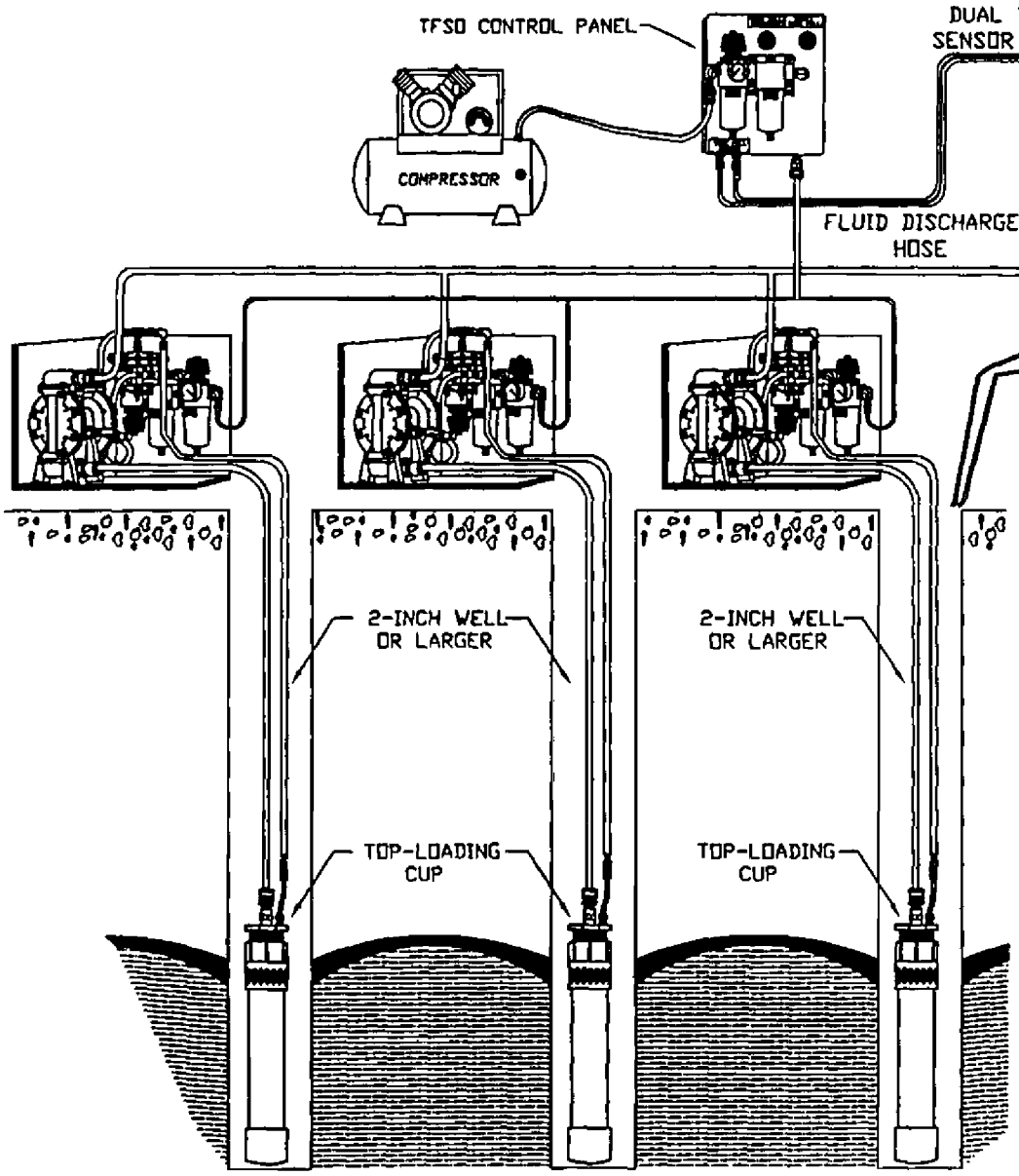
1133 7th ST.
OAKLAND, CA 94607
(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERWISE SPECIFIED	APPROVALS	DATE	TITLE: TFSO SYSTEM WITH MULTI-WELL AP-4/BL
	DRAWN: TONY RAMIREZ	9-3-94	
	DESIGNER		DWG No. 600213
MATERIAL	CHECKED		REV
FINISH	APPROVED		SCALE: NONE; SHT 1 OF 1

TANK-FULL SHUT-OFF SYSTEM
WITH MULTI-WELL ADDP-1/TLC AUTOMATIC
TOTAL FLUIDS RECOVERY SYSTEM WITH TOP-LOADING CUP



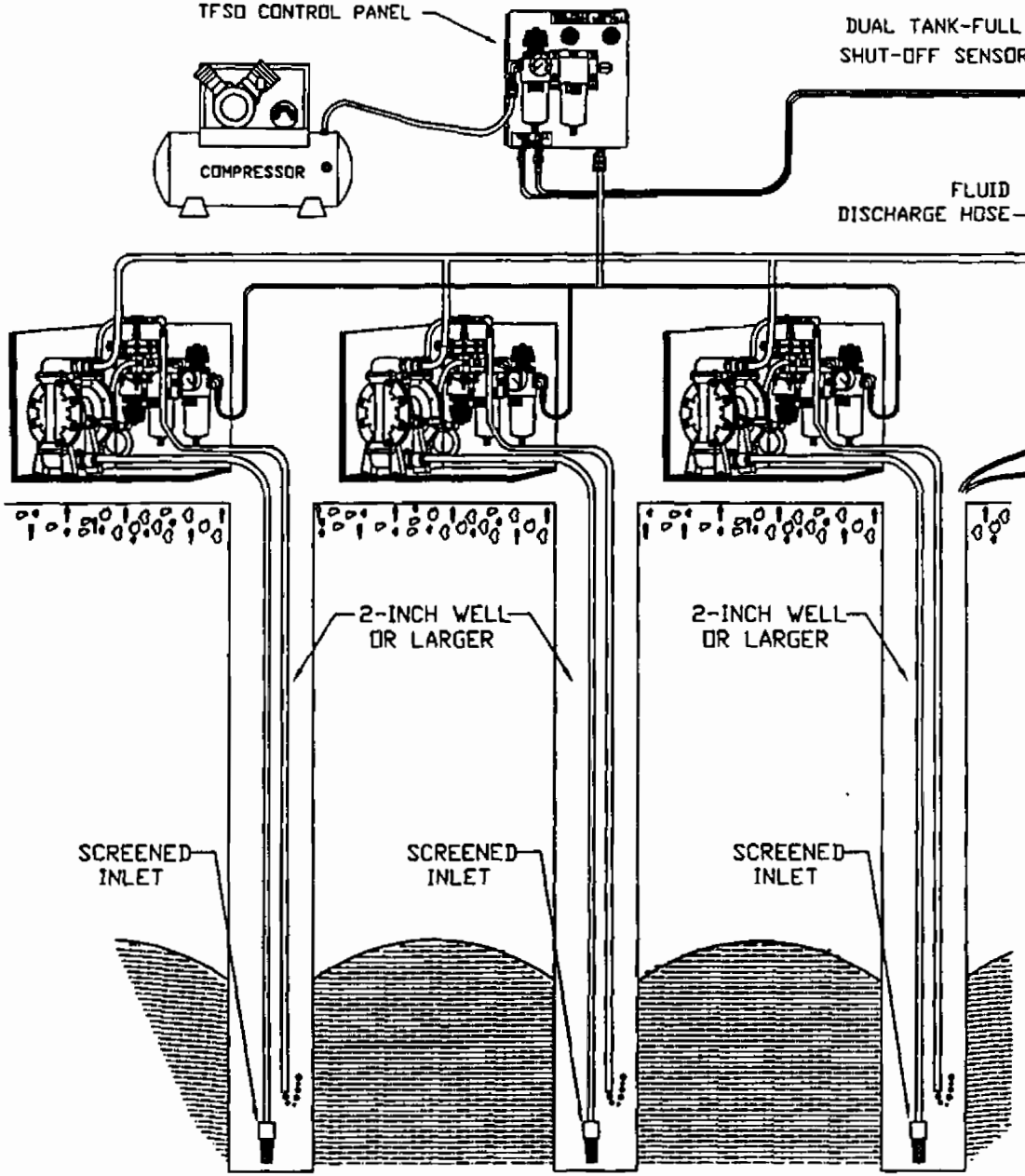
FEATURES & BENEFITS

- IF ANY SENSOR HOSE IS DISCONNECTED, THE SYSTEM WILL SHUT DOWN.
- IF OIL ENTERS THE CONTROLS, THE SYSTEM WILL SHUT DOWN.
- IF THE DUAL-SENSOR HOSE IS PUNCHED OR CUT, THE SYSTEM WILL SHUT DOWN.
- IF ANY SINGLE TANK ARMED WITH A TFSO UNIT SHOULD FILL, THE SYSTEM WILL SHUT DOWN.
- OTHER RECOVERY WELLS CAN BE ADDED TO THE SYSTEM.

Clean Environment Equipment
EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
1329 7th ST.
OAKLAND, CA 94607
(510) 891-4888 (888) 337-1767 FAX (510) 444-6709

TOLERANCES UNLESS OTHERWISE SPECIFIED: DECIMAL ± .01	APPROVALS	DATE	TITLE: TFSO SYSTEM WITH MULTI-WELL ADDP-1/TLC
	DRAWN: TONY RAMIREZ	2-17-94	
	REVISED		DWG No. 600218 REV
MATERIAL	CHECKED		
FINISH	APPROVED		SCALE: NONE SHT # 1 OF 1

TANK-FULL SHUT-OFF SYSTEM WITH MULTI-WELL ADDP-1 AUTOMATIC DISSOLVED AND/OR SINKERS RECOVERY SYSTEM



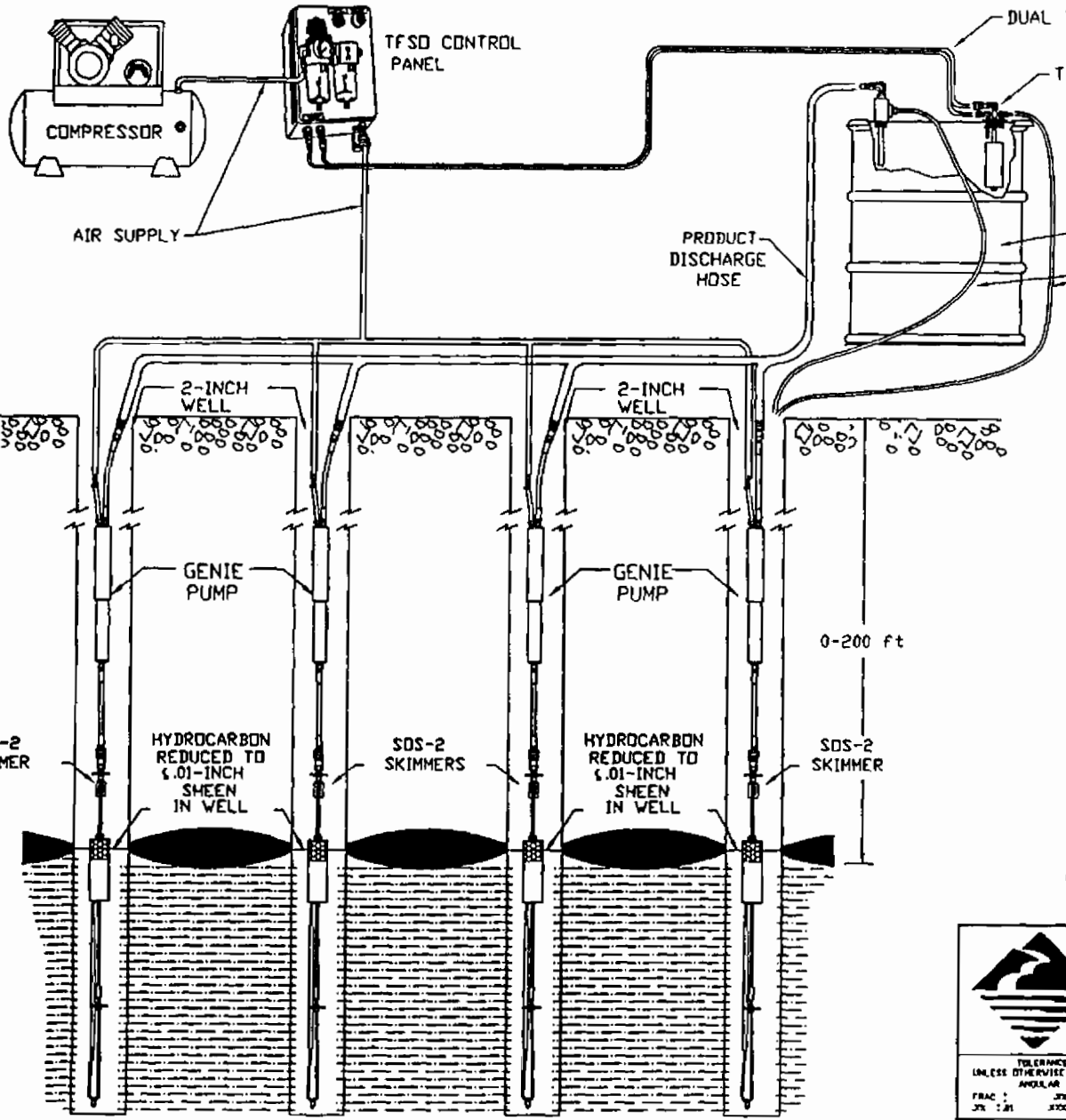
FEATURES & BENEFITS

- IF ANY SENSOR HOSE IS DISCONNECTED, THE SYSTEM WILL SHUT DOWN.
- IF OIL ENTERS THE CONTROLS, THE SYSTEM WILL SHUT DOWN.
- IF THE DUAL-SENSOR HOSE IS PUNCHED OR CUT, THE SYSTEM WILL SHUT DOWN.
- IF ANY SINGLE TANK ARMED WITH A TFSO UNIT SHOULD FILL, THE SYSTEM WILL SHUT DOWN.
- OTHER RECOVERY WELLS CAN BE ADDED TO THE SYSTEM.

Clean Environment Equipment
EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
1333 7th ST.
OAKLAND, CA 94607
(510) 871-9888 (800) 537-1767 FAX (510) 444-6799

TOLERANCES	APPROVALS	DATE	TITLE
UNLESS OTHERWISE SPECIFIED	DRAWN TONY RAMIREZ	10-14-94	TFSO SYSTEM WITH MULTI-WELL ADDP-1
MATERIAL	DESIGNED		DWG NO. 600220 REV
FINISH	CHECKED		SCALE NONE SHT 1 OF 1
	APPROVED		

TANK-FULL SHUT-OFF SYSTEM WITH MULTI-WELL GNE/200/SOS-2 CONTROLLERLESS PRODUCT ONLY RECOVERY SYSTEM



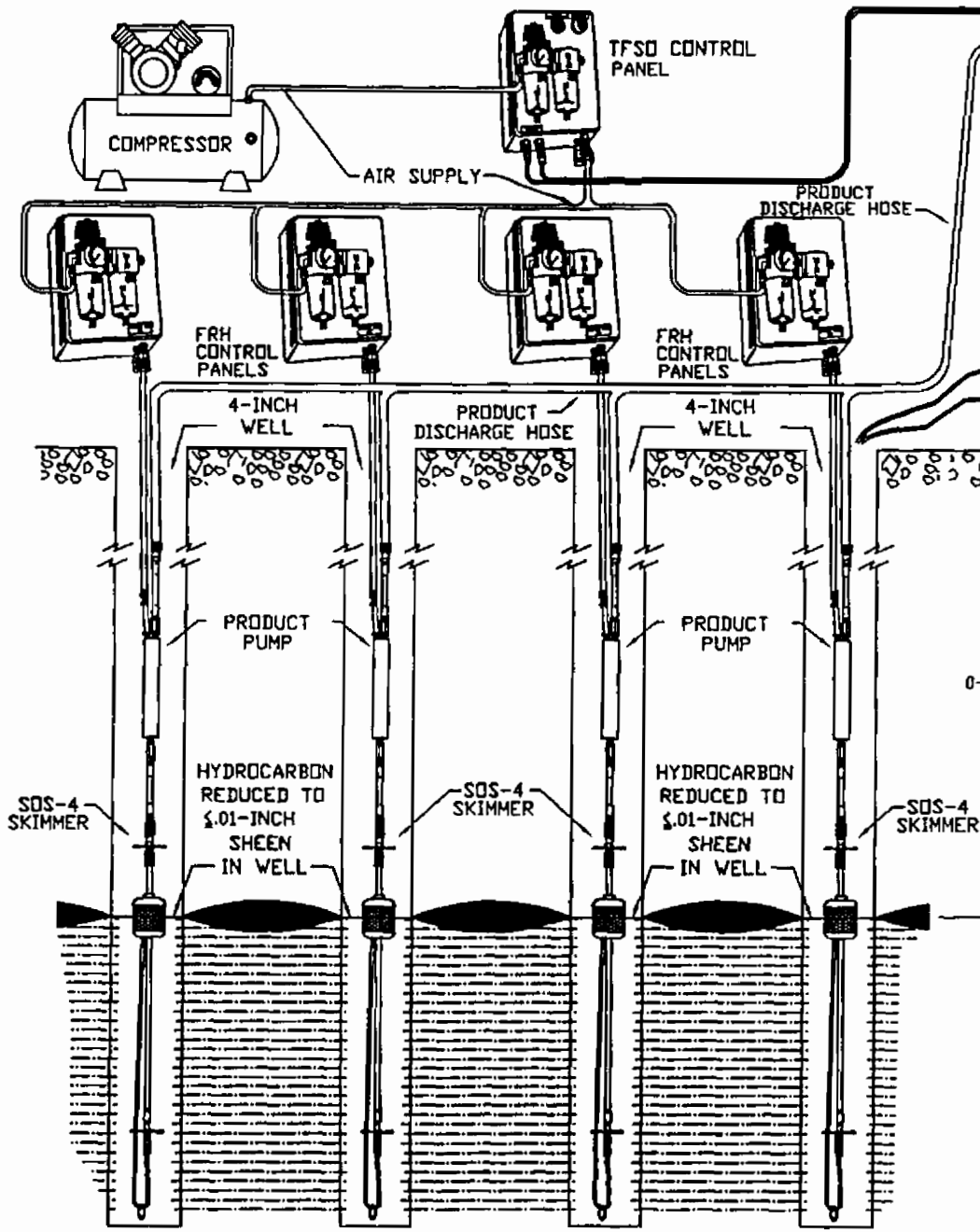
FEATURES & BENEFITS

- IF ANY SENSOR HOSE IS DISCONNECTED, THE SYSTEM WILL SHUT DOWN.
- IF OIL ENTERS THE CONTROLS, THE SYSTEM WILL SHUT DOWN
- IF THE DUAL-SENSOR HOSE IS PUNCHED OR CUT, THE SYSTEM (INCLUDING PRODUCT PUMPS AND SKIMMERS) WILL SHUT DOWN.
- IF ANY SINGLE TANK ARMED WITH A TFSO UNIT SHOULD FILL, THE SYSTEM WILL SHUT DOWN.
- OTHER RECOVERY WELLS CAN BE ADDED TO THE SYSTEM.
- ANY COMBINATION OF SKIMMERS IS APPLICABLE.

Clean Environment Equipment
EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
1133 7th ST
OAKLAND, CA 94607
(510) 891-0880 (800) 337-1767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERWISE SPECIFIED	APPROVALS	DATE	TITLE
ANGULAR ± .30° FRAC ± XTS ± .005 .X ± .01 .XXX ± .005	DRAWN TONY RAMIREZ	2-2-94	TFSO SYSTEM WITH MULTI-WELL GNE/200/SOS-2
MATERIAL	DESIGNER		DWG NO. 600212 REV
FINISH	CHECKED		SCALE NONE SHT 1 OF 1
	APPROVED		

TANK-FULL SHUT-OFF SYSTEM WITH MULTI-WELL FRH/250/SOS-4 AUTOMATIC PRODUCT ONLY RECOVERY SYSTEM



FEATURES & BENEFITS

- IF ANY SENSOR HOSE IS DISCONNECTED, THE SYSTEM WILL SHUT DOWN.
- IF OIL ENTERS THE CONTROLS, THE SYSTEM WILL SHUT DOWN.
- IF THE DUAL-SENSOR HOSE IS PUNCHED OR CUT, THE SYSTEM (INCLUDING PRODUCT PUMPS AND SKIMMERS) WILL SHUT DOWN.
- IF ANY SINGLE TANK ARMED WITH A TFSO UNIT SHOULD FILL, THE SYSTEM WILL SHUT DOWN.
- OTHER RECOVERY WELLS CAN BE ADDED TO THE SYSTEM WITHOUT NEEDING TO ADD ADDITIONAL CONTROL PANELS.
- ANY COMBINATION OF PUMPS AND SKIMMERS IS APPLICABLE.

Clean Environment Equipment
EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION
1133 7th ST.
OAKLAND, CA 94607
(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR ± .30' FRAC ± XX ± .06 .XXX ± .005 .XXXX ± .0005	APPROVALS	DATE	TITLE MULTI-WELL FRH/250/SOS-4 WITH TFSO SYSTEM
MATERIAL	DRAWN TONY RAMIREZ	3-2-96	SYS NO. 600211 REV
FINISH	DESIGNED		SCALE NONE SHT 1 OF 1
	CHECKED		
	APPROVED		

TIME MARK® CORPORATION

Liquid Level Controls and Sensors

Installation Manual

Model 403 Duplex Liquid Level Controller

Model 404 Duplex Liquid Level Sensor

Model 407 Triplex Liquid Level Controller

Model 408 Triplex Liquid Level Sensor

Model 448 Output Relay Module

TIME MARK CORPORATION
11440 East Pine Street • Tulsa, OK 74116
(918)438-1220 • FAX (918)437-7584

87A352

TIMEMARK®
CORPORATION

Liquid Level Controls and Sensors

Installation Manual

Model 403 Duplex Liquid Level Controller

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Model 448 Output Relay Module

TIME MARK CORPORATION
11440 East Pine Street • Tulsa, OK 74116
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87A352

LIQUID LEVEL SENSORS
Models 404 and 408

atures

- Digital display of water depth
- Internal pressure-to-voltage transducer
- 4 adjustable trip points on Model 404, 5 adjustable trip points on Model 408
- Pluggable terminals for easy installation and service
- Solid-state outputs
- 4-20 mA output
- Moisture protected circuits

The Model 404 and 408 Liquid Level Sensors operate in conjunction with a Model 403 or 407 Controller for bubbler-type pumping systems. The Sensor contains an air pressure-to-voltage transducer and requires only a small air compressor capable of 15 psi (pounds per square inch) to operate the system down to approximately 35 feet. For practical purposes, the Models 404 and 408 are functionally identical, with the 408 simply having another sensing level.

The Sensor's solid-state outputs are designed to replace the float switch inputs to the appropriate controller (Model 403 or 407), or to be used with a Model 448 Output Relay Board. A 4-20ma signal output pro- 'des for other control applications. A 3-digit LED .isplay continuously shows the liquid level to a tenth of a foot when the Display Control switch is in the Liquid Level position. Other switch positions are used during calibration of the liquid level trip points. Indicator LEDs illuminate as the levels are reached. A test control allows the trip settings to be checked without actually raising or lowering the liquid level.

Specifications

Model	404	408
No. of outputs	4	5
Input voltage	24 or 120 VAC, ±15%	
Input frequency	47-65 Hz	
Power consumption	2 Watts	
Transient protection	2500 VRMS for 10 ms	
Air pressure input	0 to 15 psi max.	
Input air supply fitting	Requires 3/16" I.D. tubing	
Maximum liquid level	34.6 feet displayed	
Calibration accuracy	±2%	
Repeat accuracy (fixed conditions)	±1%	
Repeat accuracy (0-60°C)	±2%	
Dead Band	0.1 foot	
Switching outputs	Open-collector transistors rated for regulated 12VDC, 10 mA, maximum. Designed as inputs for a 403 or 407 Controller, or the Model 448 Output Relay Board	
Signal outputs	4-20 ma output proportional to 0-40 feet of water	
Operating temperature	-40° to 50°C	
Storage temperature	-20° to 70°C	
Humidity tolerance	0-97% w/o condensation	
Case material	20 ga. steel	
Termination	Removable terminal strip	
Weight	3.5 lbs.	

Figure 8. Model 404 Dimensions

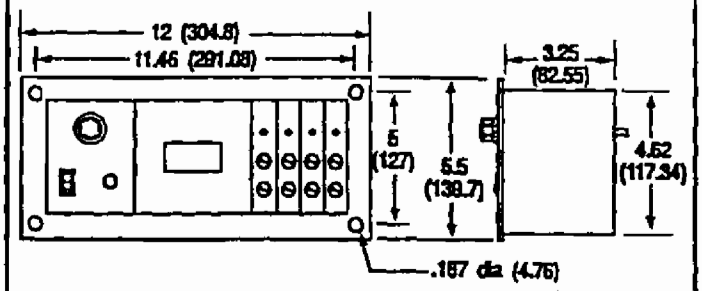
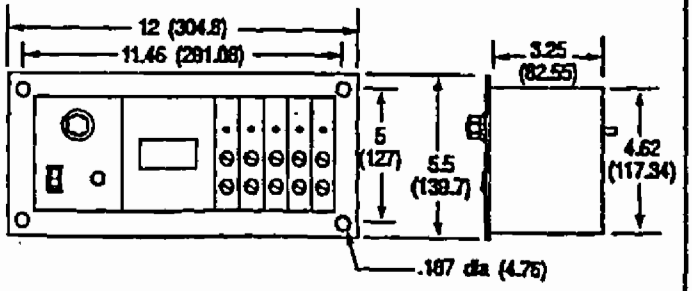


Figure 9. Model 408 Dimensions



INSTALLATION

General Safety

Warning: disconnect power when installing or servicing this device.

- This product should be wired by qualified personnel according to the National Electrical Code and all local codes.
- Do not exceed the output or input ratings as stated in the Specifications.
- Protect the device with properly rated fuses.
- Do not install in damp or moist areas.
- This device should be installed in such a way as to prevent bodily injury or property damage in the event of product failure.

Panel Layout

A Pump running time meter to 99,999.9 hours, non-resettable.

B Indicator LED's illuminate when pumps are running.

C Indicator LED's illuminate when pump is stopped because the remote alarm circuit is open.

D Hand-Off-Auto switch to manually or automatically control the pumps.

E Lead pump selector switch provides an alternating lead pump selection or a fixed lead pump operation of Pump 1 or Pump 2 (or Pump 3 on Model 407).

F Indicator LED's show which pump is the lead pump for the next pumping cycle.

G Momentary switch tests remote alarm bell, light, and illuminates alarm light J.

H Momentary switch silences alarm bell until problem is corrected.

I Momentary switch resets all alarm indicators to return to normal operation.

J Alarm light stays lit until alarm reset switch is pressed.

K Indicator LED's show which level switches are closed.

L Indicator LED illuminates when primary power is applied.

Mounting

1. Mount the Controller in a suitable enclosure.

2. Unplug the terminal connectors from the controller.

3. Referring to the terminal block decal on the controller and the illustration on the next page, make the following connections:

A. Connect a chassis ground to the terminals marked CHS GND.

B. Connect 120 vac operating power to the terminals marked for input voltage.

C. Connect the LOW float switch to the LOW terminals. Polarity is not critical.

D. Repeat step C for the LEAD, LAG, (LAG-LAG) and HIGH terminals.

Figure 3. Model 403 Panel

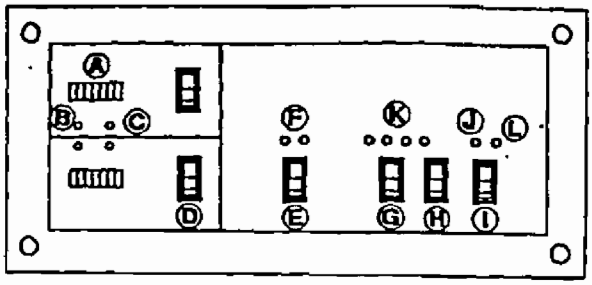
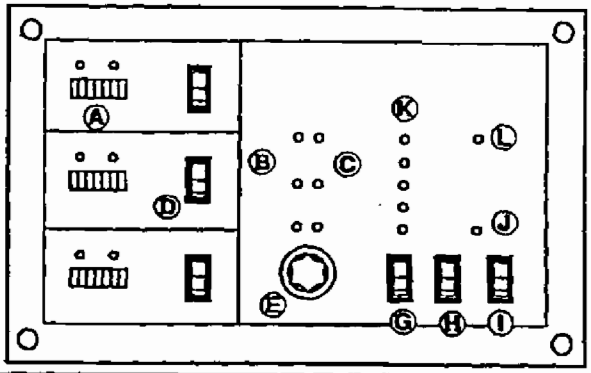


Figure 4. Model 407 Panel



E. The SIGNAL GROUND connection is a common between the Controller and a Liquid Level Sensor. No connection is necessary if the Sensor is not used.

F. The PUMP 1 & 2 REMOTE ALARM (and PUMP 3 on Model 407) terminals should be connected to normally closed (NC) alarm contacts in the motors. If none exist (or are not needed) install a jumper connection between the Pump 1 terminals and a jumper between the Pump 2 terminals (also Pump 3, if Model 407).

G. The POWER FAIL, ALARM BELL, & ALARM LIGHT contacts are not required for proper operation, but are provided for your convenience. If used, connect an audiovisual alarm across the POWER FAIL terminals. The contact is open while power is applied and closes on a loss of power. Connect audible and visual alarms across the ALARM BELL and ALARM LIGHT terminals. These contacts are normally open and will close on a fault (high or remote alarm) condition.

H. Connect the PUMP 1 and the PUMP 2 contacts to the appropriate motor control circuits. These contacts start and stop the pump motors during operation.

4. Set the HOA (hand-off-auto) switches and the LEAD PUMP SELECTOR switch as required.

5. Apply operating power.

Figure 12. Model 404/408 Typical Application

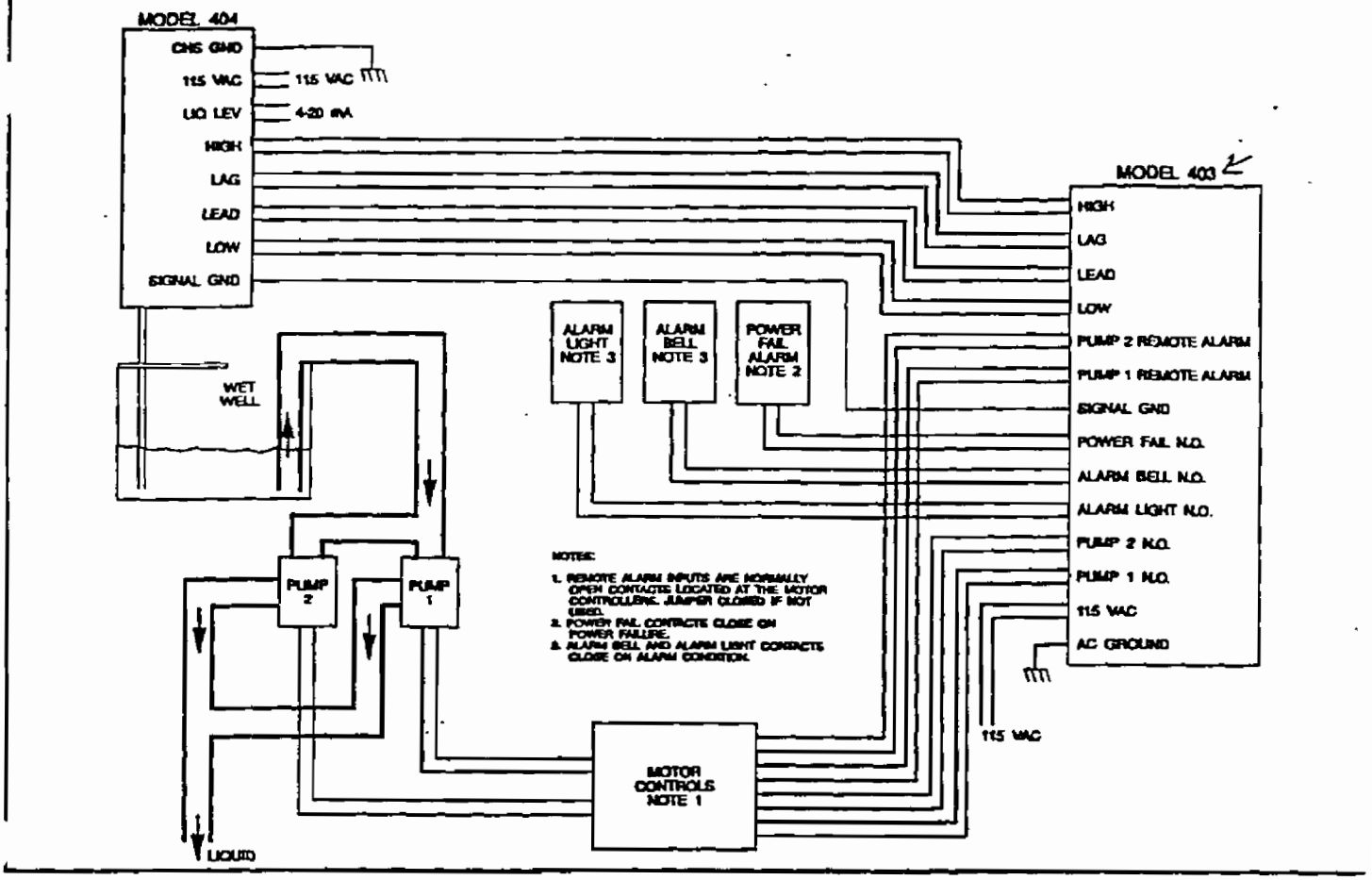


Figure 13. Model 404 Terminal Connections

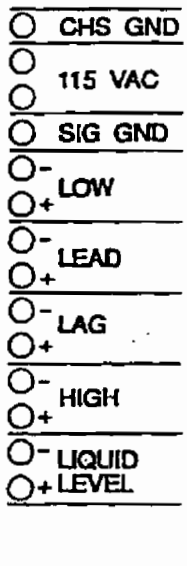
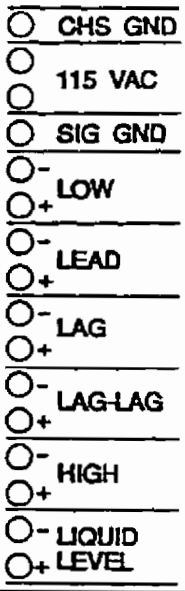


Figure 14. Model 408 Terminal Connections



Troubleshooting

Problem: Erratic and/or unstable operation when used with 403/407.
Cause: Signal ground wire between the two units is not connected.
Solution: Connect signal ground.

Problem: In test position, display reads other than zero with adjustment fully counterclockwise.
Cause: This is a normal condition; fully counterclockwise on the adjustment may be below zero.
Solution: Turn the adjustment slightly clockwise; the display should read zero (or higher).

These devices are not field repairable units. Should one not operate properly during the adjustment or testing procedures, insure that all connections, elec trical and air pressure, are correct. Verify that the proper voltage is applied and check all fuses. Contact the factory if everything is correct and the device still fails to operate. Should the sensor fail during use, contact the factory for instructions on returning the device for repair.

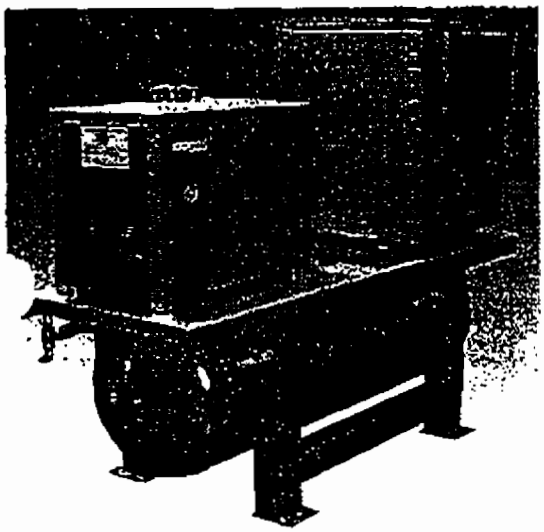
KAESER COMPRESSORS

PACKAGED COMPRESSOR SYSTEMS

Complete Compressed Air Systems

Packaged Systems are Perfect for Many Applications

Kaeser packaged compressor systems are the answer to many challenges. The compact design puts a complete system in a very small space. Factory assembled and tested, they are great for a small shop or manufacturing plant. These packaged systems are also excellent as a back-up system to keep critical equipment operating.



Simplex Packaged Compressor System

Designed for Dependability

Packaged compressor systems match Kaeser's Sigma profile rotary screw compressors with a high efficiency refrigerated dryer, an appropriately sized receiver, and the necessary filters to provide the level of air quality you require.

Rotary Screw Air Compressors

The rotary screw compressor is designed without compression valves or piston rings. Therefore, maintenance is easy. Kaeser's efficient Sigma profile design also produces up to 20% more air per horsepower.

Each compressor is contained in a sound absorbing enclosure. This filtered enclosure keeps the components clean and reduces noise levels to as low as 66 dB(A).

Refrigerated Air Dryers

Kaeser refrigerated dryers cool the compressed air to condense and remove moisture. They produce pressure dew points as low as 35°F. The tube-in-tube smooth surface heat exchanger prevents fouling, and a hot gas by-pass valve eliminates freeze up.

Filtration for Reliable Quality

Compressed air quality is critical for many applications. Kaeser provides customized filtration to ensure your packaged compressor system delivers a dependable supply of high quality air. Filters are available to eliminate particles as small as .01 micron.

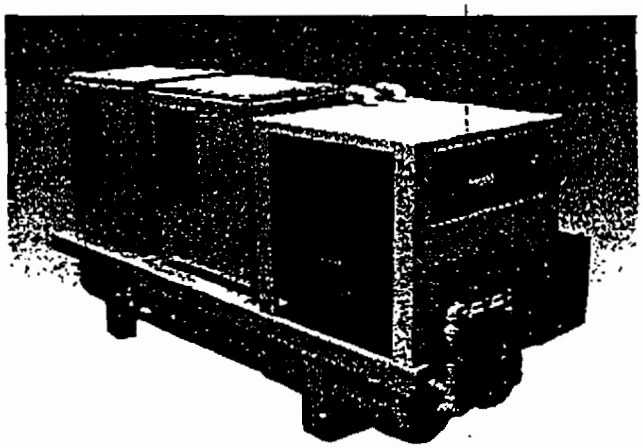
A Complete System

Kaeser Sigma profile rotary screw compressors, refrigerated dryers and filters are matched with an appropriately sized tank to make a reliable, compact system. All inter-connecting piping and wiring is completed at the factory.

Multiple compressor systems include a sequencer. The sequencer saves energy by running only the compressor(s) needed to meet the current demand. Dryers and optional filtration package include by-pass piping to allow servicing without system shutdown.

Kaeser packaged compressor systems are factory engineered to ensure all components are properly sized.

Installation is easy. Simply connect to the electrical system and pipe the package in to your compressed air piping system and you are ready to go.



Duplex Packaged Compressor System

ENGINEERING DATA

Single Compressor Packaged Systems (Simplex)

Compressor Model	Motor HP	Operating Pressure PSIG	Capacity CFM
SX-3	3	100	13
		110	11.5
		145	8.5
		190	5.5
60 GAL. TANK SX-6 125 PSI/20CFM	5 4 KW	100	23
		110	21
		145	17
		190	13
SM-8	7.5	100	32
		110	30
		145	25
		190	20
SM-11	10	100	44
		110	42
		145	36
		190	29
SK-19	15	100	71
		110	68
		145	58
		190	45
SK-26	20	100	96
		110	92
		145	80
		190	65

Dual Compressor Packaged Systems (Duplex)

Compressor Model	Motor HP	Operating Pressure PSIG	Capacity CFM
SX-3	2 x 3	100	26
		110	23
		145	17
		190	11
SX-6	2 x 5	100	46
		110	42
		145	34
		190	26
SM-8	2 x 7.5	100	64
		110	60
		145	50
		190	40
SM-11	2 x 10	100	88
		110	84
		145	72
		190	58
SK-19	2 x 15	100	142
		110	136
		145	116
		190	90
SK-26	2 x 20	100	192
		110	184
		145	160
		190	130

Standard Features:

- SX, SM or SK Sigma screw compressors
- 230/460V TEFC Motor
- Refrigerated air dryer with by-pass piping
- ASME coded receiver tank including:
  - Air pressure safety relief valve
  - Liquid filled pressure gauge
  - Manual drain valve
- Heavy duty steel frame
- Compressors in sound absorbing enclosures
- Sequencer for dual compressor packages

Optional Features:

- KPF and KOR filter package
- Automatic tank condensate drain
- Non-standard operating pressures from 80 psig to 205 psig
- Single phase electrics on SX-3 and SX-6 models
- 208/230V

Specifications are subject to change without notice.

KAESER COMPRESSORS

P.O. Box 946
Fredericksburg, VA 22404
Tel: (540) 898-5500 • FAX: (540) 898-5520

Authorized Distributor:

ISO 9001 REGISTERED COMPANY

KAESER COMPRESSORS

REFRIGERATED AIR DRYERS

High Performance Refrigerated Compressed Air Dryers With Capacities From 5 to 2300 SCFM

Water Seriously dilutes the performance of your compressed air system

Atmospheric air entering a compressor contains water vapor (humidity) In fact, at 75° F and 75% relative humidity, 6 gallons of water enter a typical 25 hp compressor every 8 hours

The process of compression concentrates this water and as the air heats up during compression the water remains vaporized But once the compressed air travels downstream, it cools and the vapor condenses into liquid droplets

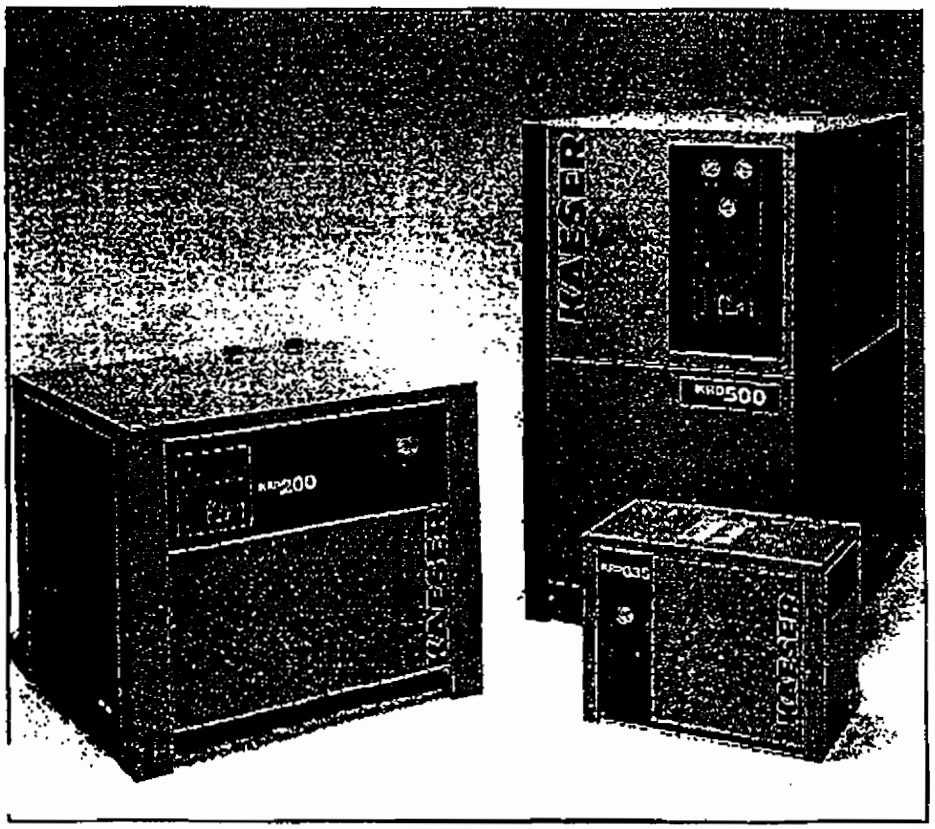
If not removed, this water contaminates the entire compressed air system.

Gradually, corrosion leads to air leaks, pressure drops and scale formation. Maintenance and repair costs on pneumatic equipment increase, products and processes can be ruined, and lost production time is often the result.

The cost of failing to remove water from your compressed air system is high.

KAESER dryers increase productivity and reduce costly maintenance

The proper KAESER air dryer installed in your system provides an economical solution. KRD refrigerated air dryers remove the water from your compressed air system to protect your product, equipment and plant efficiency.



KRD-35, KRD-200 and KRD-500

Designed to be durable, efficient and environmentally friendly

With KRD dryers, compressed air enters a precooler reheater where incoming air is cooled by refrigerated outgoing air. This precooled air requires less energy to dry and the reheated outgoing air eliminates pipe sweating.

The air is refrigerated in a smooth surface, non-fouling tube-in-tube heat exchanger charged with environmentally safe refrigerant. This KAESER design ensures a consistent supply of dry air throughout the life of the dryer. It maintains efficiency without excessive pressure drop or the added cost of a prefilter

Condensed liquid is removed by a high performance separator and is discharged by an automatic drain trap.

The outgoing air now has a reduced pressure dew point; the temperature at which water vapor condenses to liquid (under pressure).

The entire KAESER system is designed to operate efficiently and reliably over a wide range of flows. Temperature in the refrigeration evaporator is precisely controlled by a hot gas by-pass valve for quick response to flow changes. KRD dryers supply compressed air with a consistent pressure dew point and no danger of evaporator freeze-up.

Simple operation with easy to read instrument panel

Models KRD 25 and up feature gauge(s) which conveniently display operational status and provide helpful information during routine maintenance.

ADVANTAGES OF THE KAESER DESIGN

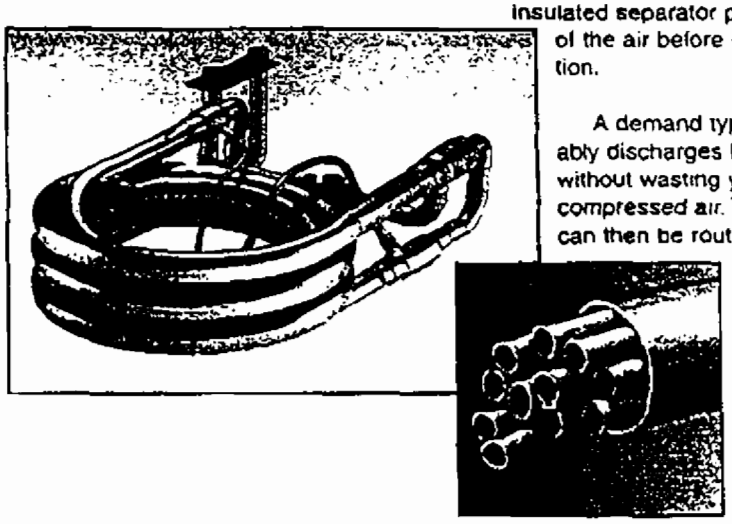
Re-designed Heat Exchangers Provide Maximum Cooling Efficiency

KAESER heat exchangers are all copper tube-in-tube designs The smooth surfaces are non-fouling and self-cleaning to ensure maximum heat transfer. Tube sizes are carefully selected to control fluid velocities and promote turbulence. This maximizes heat transfer and along with the smooth surface design minimizes the pressure drop throughout the life of the dryer

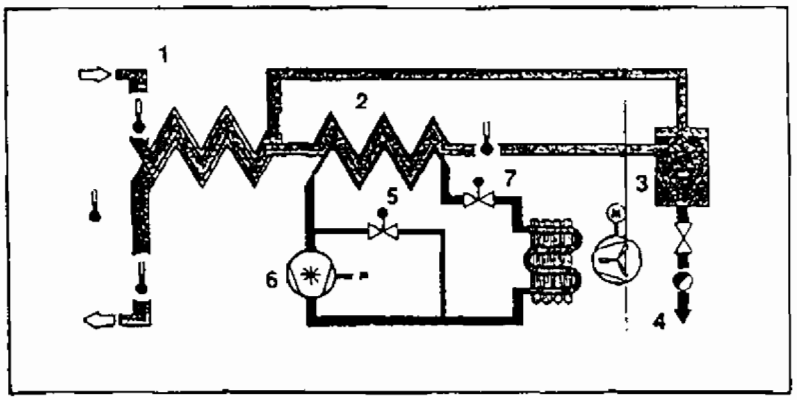
The entire heat exchanger package is encapsulated in a water based urethane foam. In addition to protecting the heat exchanger, this highly effective insulation ensures maximum cooling efficiency

The *Precooler/Reheater* (1) is a large air to air heat exchanger designed to produce the greatest possible dryer efficiency. By precooling the incoming air, the heat load on the refrigeration system is reduced. Reheating the discharge air eliminates any pipe sweating

The smooth surfaces of the *air to refrigerant heat exchanger* (2) are constantly washed by the condensing moisture This unique feature ensures the dryer will not clog up with oil or debris, so you get consistently dry air throughout the life of your system



Heat exchanger with tube-in-tube design



Typical Flow Diagram

Efficient Liquid Separation Over A Wide Range of Flows

Off the shelf separators are not designed to efficiently handle the wide range of flows that are encountered by a typical dryer. The *separator* (3) in a KRD dryer is specifically designed to maintain a 99+% separation efficiency from low flows to well above the rated capacity of the dryer. This ensures that liquid condensed by the heat exchanger does not re-enter your compressed air stream. The fully insulated separator prevents reheating of the air before moisture separation.

A demand type *drain* (4) reliably discharges liquid condensate without wasting your valuable compressed air. The condensate can then be routed to an oil-water separator for ecologically responsible disposal.

Refrigeration System Provides Consistent Dew Point

The non-cycling design of KAESER dryers keeps refrigerant continuously circulating through the system

This results in rapid response to changes in air flow for consistent cooling and the most reliably dry air

The temperature of the heat exchanger must be controlled to provide dew point consistency and prevent freeze ups. To do this, KAESER uses a specially designed *hot gas by-pass valve* (5). Off the shelf valves do not meet our high standards.

The hot gas by-pass valve controls the cooling temperature by allowing some of the refrigerant (in a hot gas state) to bypass the heat exchanger. Injecting the gas after the heat exchanger prevents non-compressible liquid refrigerant from entering the *compressor* (6) and so increase the life span and reliability of the system. This design also prevents the *thermal expansion valve* (7) from over compensating for changes in load (compressed air flow).

With specially designed components and more comprehensive controls, KAESER refrigerated dryers and compressed air systems provide the reliable performance you need

CHOOSING A REFRIGERATED AIR DRYER

Pressure dew point

The pressure dew point of compressed air is the temperature at which water vapor condenses to liquid (under pressure) To ensure no liquid water is present in your system, the pressure dew point of your air must be less than the lowest temperature your compressed air will be exposed to KAESER refrigerated dryers produce pressure dew points as low as 35°F

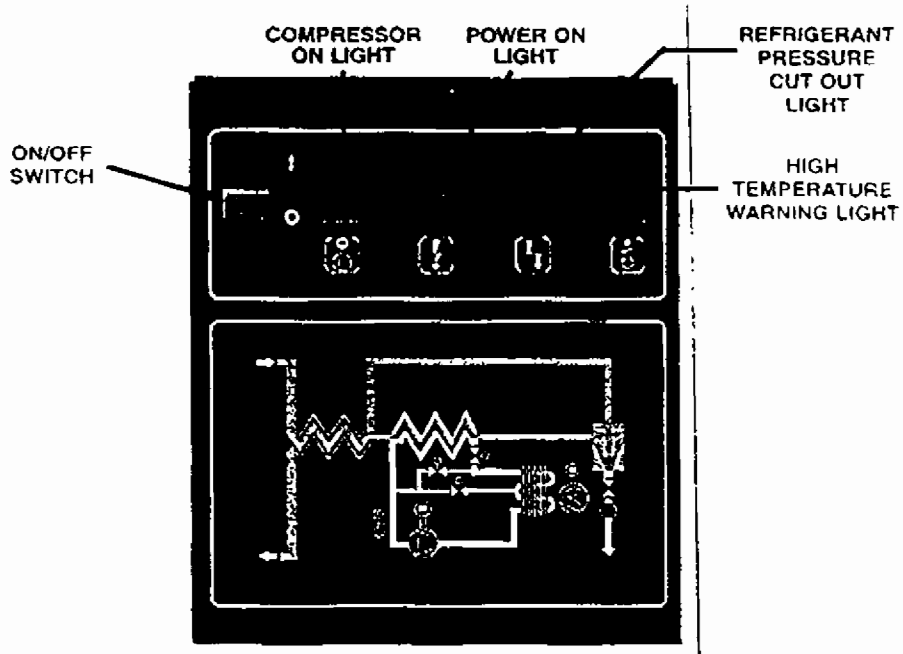
To select the dryer that best fits your needs, there are several factors to consider.

Actual conditions

System pressure: Dryers remove moisture most efficiently at higher system pressure However, the maximum working pressure of the dryer must not be exceeded.

Compressed air temperature: Air heats up during the compression process and cools as it moves downstream. The cooler the air before entering the dryer, the more efficiently the dryer operates. The inlet air temperature should be less than 120°F. If your compressor does not have an aftercooler you may want to consider adding one to your system.

Ambient temperature: High ambient temperatures reduce the efficiency of an air cooled dryer. The ambient temperature should be less than 110°F. If you can not locate the dryer in a cool enough environment, you may want to consider a water cooled model instead



Standard Control Panel

Dryer Location in the Air System

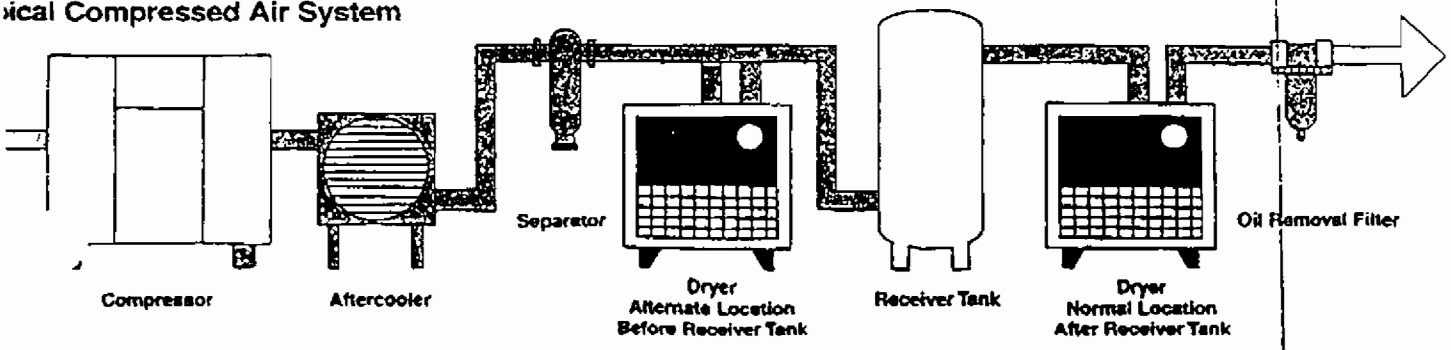
The location of the dryer in your compressed air system is important, because it affects proper sizing of the unit.

Ideally, the dryer is placed *after the receiver tank* because the air begins to cool in the receiver and liquids condense. Reducing liquids in the compressed air improves the performance of your dryer. The receiver also dampens pressure and flow fluctuations to the dryer to help ensure a consistent pressure dew point. When the dryer is located after the receiver it must be sized for your system's maximum compressed air demand.

If you must locate your dryer *before the receiver tank*, you should install a separator ahead of it to remove liquids before the air enters the dryer. You should also reduce the air temperature as much as possible. When located before the receiver, your dryer must be sized for the maximum flow capacity of your compressor(s).

Once you have determined the location of your dryer, follow the easy selection steps on the back page to find the dryer size that is right for you.

ical Compressed Air System



ENGINEERING DATA

Sizing your dryer

KAESER refrigerated dryers are rated for 100°F inlet air at 100 and 100°F ambient temperature. To select a dryer for your ...lication, you must first correct your actual system conditions for these "rated" conditions. To do this, simply write your conditions for the proposed dryer inlet in the yellow areas below. Next, find the correction factors in the table to the right and write them on the bottom line. Multiply your inlet air flow by each factor to get the Minimum Requirement Rated Capacity for your dryer.

Inlet Air Flow (scfm)	Inlet Air Pressure (psig)	Inlet Air Temperature °F	Maximum Ambient Temperature °F	Minimum Required Rated Capacity (scfm)
	Pressure Correction Factor	Inlet Air Temperature Correction Factor	Ambient Temperature Correction Factor	
	X	X	X	=

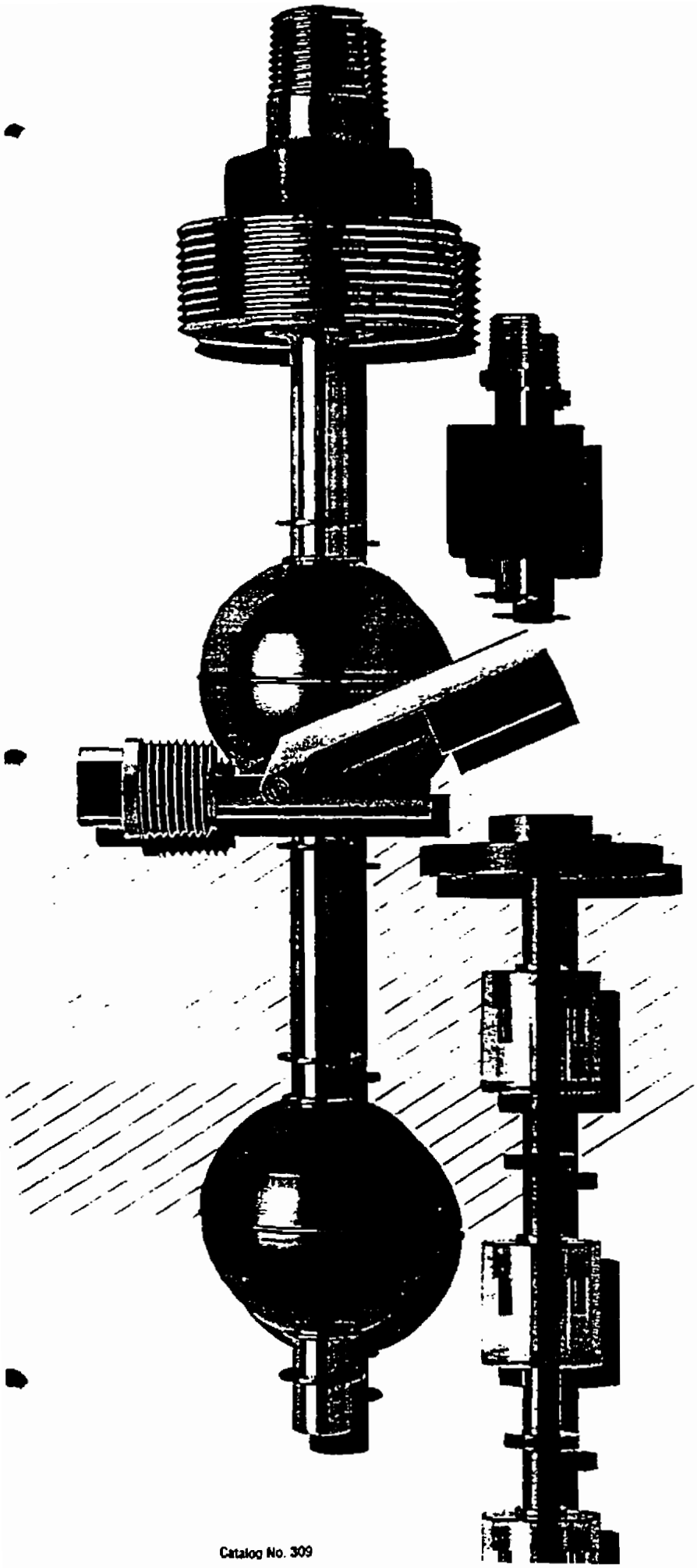
Correction Factors

PSIG	Factor	°F	Factor	°F	Factor
20	1.54	75	.57	75	.86
40	1.25	80	.65	80	.89
60	1.12	85	.75	85	.92
75	1.07	90	.81	90	.94
100	1.00	95	.91	95	.97
110	.97	100	1.00	100	1.00
125	.96	105	1.11	105	1.03
145	.94	110	1.22	110	1.06
175	.91	115	1.33	-	-
195	.90	120	1.43	-	-
250	.87	-	-	-	-
300	.85	-	-	-	-

KAESER Refrigerated Compressed Air Dryers

KRD-005	5	6.5	1.2		115-1-60	1/10	14 x 16 x 15	3/8" OD TUBE	50	Power On Light High Temp. Light
KRD-010	10	13.0	2.5			1/6	14 x 16 x15	3/8" OD TUBE	57	
KRD-015	15	19.5	3.0		115-1-60 230-1-60	1/5	14 x 16 x 15	3/8" OD TUBE	65	
KRD-025	25	32.5	3.0			1/5	21 x 26 x 16	3/4" NPT (M)	131	On/Off Switch Power On Light High Temp. Light (Models KRD-200 and KRD-250 also include Compressor On Light) Gauges: —Suction Pressure
KRD-035	35	45.5	3.0	175 PSIG Standard 300 PSIG Available		1/5	21 x 26 x 16	3/4" NPT (M)	144	
KRD-050	50	65	3.0			1/4	25 x 34 x 22	1" NPT (M)	211	
KRD-075	75	98	3.0		115-1-60 230/208-1-60	1/3	25 x 34 x 22	1" NPT (M)	253	
KRD-100	100	130	3.0			1/2	25 x 34 x 22	1 1/2" NPT (M)	293	
KRD-125	125	163	3.5			3/4	25 x 34 x 22	1 1/2" NPT (M)	302	
KRD-150	150	195	3.0			3/4	25 x 34 x 22	1 1/2" NPT (M)	312	
KRD-175	175	228	3.2			3/4	37 x 36 x 40	2" NPT (M)	470	
KRD-200	200	260	4.7		230/208-3-60 460-3-60	1	37 x 36 x 40	2" NPT (M)	505	
KRD-250	250	325	4.8			1 1/2	37 x 36 x 40	2" NPT (M)	533	
KRD-300	300	390	4.7			1 1/2	37 x 36 x 40	2" NPT (M)	585	On/Off Switch, Power On Light, Compressor On Light, Graphic Control Layout Gauges: —Suction Pressure —Air Inlet & Outlet Pressure
KRD-400	400	520	4.8			2	37 x 36 x 40	3" NPT (M)	655	
KRD-450	450	585	5.0			2	43 x 37 x 44	3" NPT (M)	730	
KRD-500	500	650	3.2			3	65 x 38 x 44	3" NPT (M)	912	
KRD-600	600	780	3.6	200 PSIG Standard 300 PSIG Available		3	65 x 38 x 44	3" NPT (M)	1024	
KRD-700	700	910	4.0			3	65 x 38 x 44	3" NPT (M)	1066	
KRD-800	800	1040	3.6			4	76 x 38 x 50	3" NPT (M)	1288	
KRD-1000	1000	1300	4.2			4	76 x 38 x 44	3" NPT (M)	1365	
KRD-1200	1200	1560	4.1			6	76 x 38 x 44	4" Flange	1486	
KRD-1600[1]	1600[1]	2080	3.9			7 1/2	85 x 48 x 50	6" Flange	2173	
KRD-2000[1]	2000[1]	2600	4.7			10	85 x 48 x 50	6" Flange	2396	
KRD-2300[1]	2300[1]	2990	5.0		460-3-60	12	85 x 48 x 50	6" Flange	2715	

[1]Includes refrigerant pump down system
[2]At rated capacity and 35°F nominal dew point
[3]Other voltages available - contact Kaeser
Specifications are subject to change without notice.



GEMS®

Liquid Level Switches

Catalog No. 309

Installation and Maintenance – continued

Thread Treatment

Sealing

When threading metal threads into a metal coupling, pipe sealant or Teflon® tape is recommended. Due to potential compatibility problems, when sealing plastic threaded units, a compatible pipe sealant such as **No More Leaks™** from Permatex® is recommended.

Tightening

When threading a plastic level switch into a metal coupling, the installer should use a suitable wrench and tighten the threads 1 to 1-1/2 additional turns past hand tight. Over torquing of the threads will result in damage to the plastic mounting plug.

Engagement

The length of mounting threads engaged at installation is important in calculating switch actuation points and the actual length of stem extending into the tank. Use the chart at right to find the thread engagement length (T) for a given NPT size. Factor the T dimension into any calculation of switch actuation levels (L) and overall length (L_0).

NPT	T
1/8"	.27"
1/4"	.39"
1/2"	.53"
3/4"	.55"
1"	.68"
1-1/4"	.71"
2"	.76"
3"	1.20"

Note. This chart serves as a guide only. For critical actuation accuracy, measurements should be made at time of installation

Definition of Variables Used in Examples

A = Mounting length.

T = Thread engagement.

P = Distance from coupling (bung) top to inside surface of tank or bracket.

L = Switch actuation level as measured from inside surface of tank or bracket to fluid surface.

L_1 = Switch actuation level, nominal, as measured from bottom of mounting (based on a liquid specific gravity of 1.0).

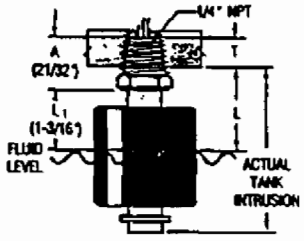
Examples

Standard Single Level Switches

Internally Mounted

LS-1900 Series internally mounted through a 1/4"NPT hole. To calculate L dimension:

$L = L_1 + (A - T)$
$L = L_1 + (21/32" - .39")$
$L = L_1 + .27"$
$L = 1.46"$



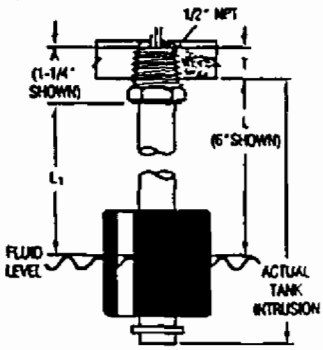
To calculate for Actual Tank Instrusion, substitute the L_0 value in place of L1 in the formula directly above.

Custom Length Level Switches

Internally Mounted

LS-800 Series (Type 1) internally mounted through a 1/2"NPT hole. To calculate L_1 dimension:

$L_1 = L - (A - T)$
$L_1 = 6" - (1\text{-}1/4" - .53")$
$L_1 = 6" - .72$
$L_1 = 5.28"$



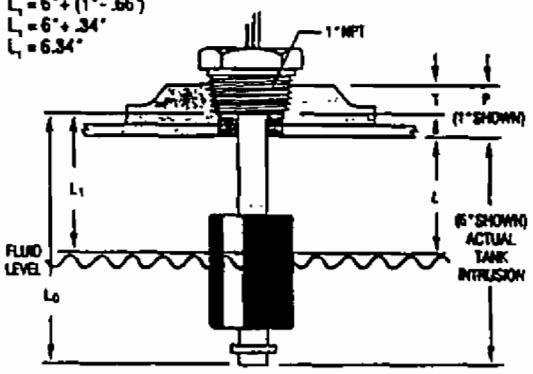
To calculate L dimension, use:
$L = L_1 + (A - T)$

To calculate for Actual Tank Intrusion, substitute the L_0 value in place of L1 in the formula directly above.

Externally Mounted

LS-700 Series (Type 3) externally mounted through a 1"NPT hole. To calculate L_1 dimension:

$L_1 = L + (P - T)$
$L_1 = 6" + (1" - .66")$
$L_1 = 6" + .34"$
$L_1 = 6.34"$



To calculate L dimension, use:
$L = L_1 - (P - T)$

To calculate for Actual Tank Intrusion, substitute the L_0 value in place of L_1 in the formula above.

APPENDIX

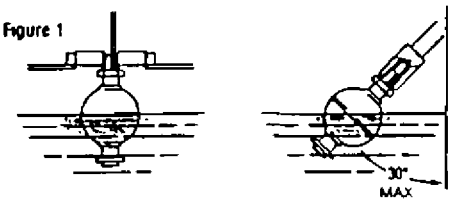
No More Leaks is a trademark of Permatex® Industrial Corp., a subsidiary of Loctite Corp
Teflon is a registered trademark of DuPont Corp.

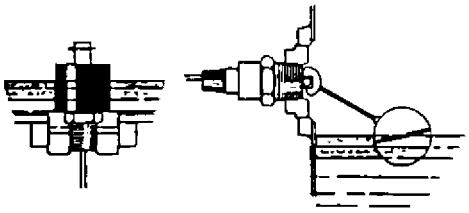
Installation and Maintenance

Orientation

A standard NPT female boss in tank top, bottom or side is all that is required for rapid installation. Units operate normally in any attitude – from the vertical to a 30° inclination – with lead wires up or down. Standard IPS pipe extends units to any intermediate level in the tank. Figure 1.

Figure 1





Accuracy and Repeatability

The accuracy of GEMS level switches is ±1/8" (3.2 mm) of true liquid level. In order to assure the proper accuracy for your liquid, please specify the specific gravity of the media. GEMS will automatically calibrate for the submergence of the float, based on this specific gravity information. Furthermore, accuracy may be enhanced by specifying whether the circuit condition should be measured on decreasing or increasing liquid level. The repeatability of the actuation point is approximately 1/32 inch (.79 mm).

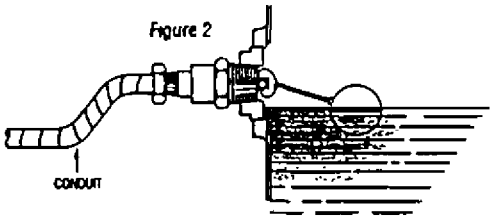
Moisture Protection

When moisture exists in conduit and extension pipes, the potential for this moisture to wick down the wire leads and into the switch assembly exists. Should this happen, the switch will appear to be closed due to a high resistance path through the moisture.

There are several means that can be used to prevent this from happening.

1. Pitch conduit away from the level switch when possible so that condensation will drip away from the level switch assembly. Figure 2.
2. When a vertical run of extension pipe or rigid conduit is used to extend a level switch down from the top of the tank, a non-conductive silicone oil should be used to fill the vertical run. Alternatively, an appropriate potting may be used to fill the vertical run to occupy the space in which condensation will normally form. Figure 3.

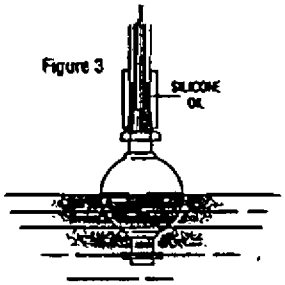
Figure 2



By working closely with your GEMS representative, there are many design considerations that can help lessen the effects of moisture.

1. Consider a product such as the GEMS LS-270 Single Level Switch which has a water-tight molded cable.
2. Consider using a unit with a connector and gasket seal.
3. Consider using moisture resistant heat shrink tubing on the switch capsule assemble.

Figure 3



A WORD OF CAUTION: Most of GEMS level products incorporate a potting cap or are fully potted. Due to the bonding characteristics of the potting to the wire leads, there is no way of assuring a water tight seal at the potting joint. Our potting cap will resist moisture to some degree, but the precautions mentioned above should be used to assure moisture doesn't enter the switch and cause a short.

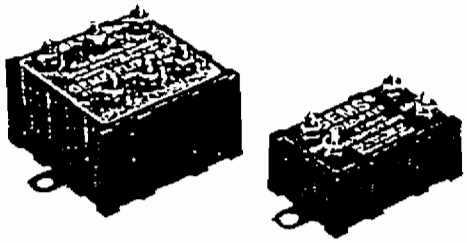
Please refer to the GEMS Instruction Bulletins supplied with products for detailed installation and maintenance procedures.

rovide Operational Versatility with GEMS FLIP-PAK® and LOAD-PAK®

- Rapid, arc-free response. Positive, non-mechanical operation.
- Long, trouble-free service life. Over millions of cycles of operation.
- Low-level switching. A few mA of current controls high-power loads.
- Completely encapsulated construction. Impervious to dust, moisture or foreign material. Tamper-proof, shock and vibration resistant.

GEMS FLIP-PAK® Solid-State Holding Relays.

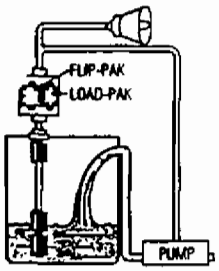
FLIP-PAK solid-state relays provide low current, "start-stop" or "on-off" switching When used with multi-station level switches, FLIP-PAK solid-state holding relays will start and stop industrial motors, pumps and solenoid valves to control the proper liquid level in your tank or vessel. To avoid nuisance shutdowns, FLIP-PAK relays hold their operational state for 1/2 second during momentary power losses. 5 amp units are available for both 120 VAC and 240 VAC applications. Low voltage protection is inherent.



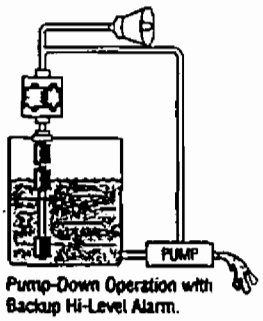
GEMS LOAD-PAK® Solid-State Switching Units.

LOAD-PAK solid-state switches amplify the current handling capabilities of your multi-station level switch. They operate as a 5 amp AC SPST, N.O. switch. LOAD-PAKS are ideal for activating high-powered alarms and pumps.

Typical Applications

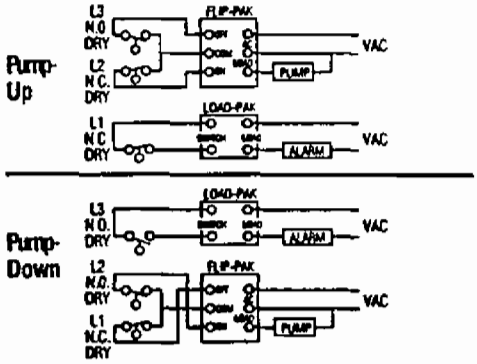


Pump-Up Operation with Backup Low-Level Alarm.



Pump-Down Operation with Backup Hi-Level Alarm.

Wiring Diagrams for Applications Shown at Left.



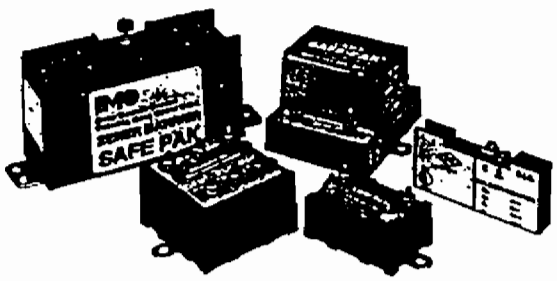
Other GEMS Solid-State Relays and Barriers

Request Catalog No. 177 for more information.

With no moving parts, GEMS relays and barriers are inherently more reliable than their mechanical counterparts. Encapsulated designs are impervious to dust, oil and moisture.

Intrinsically-Safe Types

SAFE-PAK relays render the entire sensor circuit intrinsically safe with no explosion-proof enclosures. Programmable versions offer various switching operations, including N.O., N.C. or latching with optional time delay.



'er Barriers are energy limiting devices that provide intrinsically-safe electrical output to nsor in a hazardous area. Can protect against faults up to 250 volts RMS. Single and annel versions available.

Non-Intrinsically-Safe Types

Solid-state switching units that control line voltage loads with only a few milliamps of sensor input current. Includes general purpose LOAD-PAK and 'latching' FLIP-PAK.

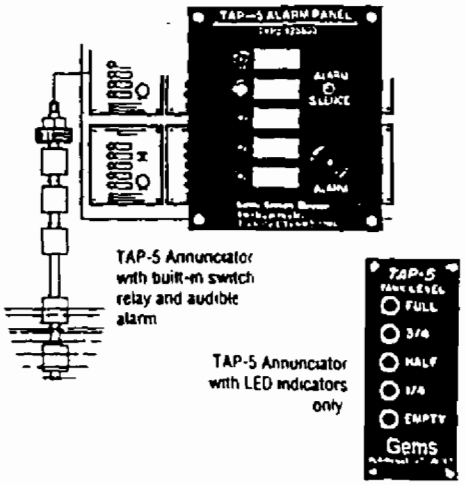
ive-Station Annunciators

- Bright LED Indicators
- Audible Alarm
- Relay Actuation

GEMS TAP-5 Annunciators are used to indicate up to five switch closures. LED's illuminate when a respective switch closes.

- LED indicators light up when switches close; stay 'on' until switches open.
- LED's go off when switches are opened; alarm silence push button shuts off horn and relay.
- Ideal for level switches in this catalog but equally suited for any dry switch closure
- Relay operates remote pumps or other equipment.
- Supplied with blank panel for marking by user.
- Operates with 7 to 14 VDC power; optional converter kit for 9 VDC power available.

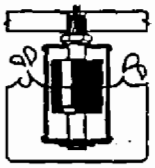
Contact GEMS for Ordering Information.

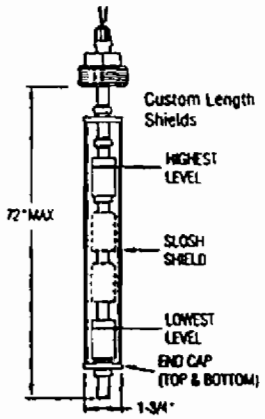


Slosh Shields for Turbulent Liquid

- Reduces nuisance switch actuation caused by liquid motion.

GEMS Slosh Shields protect floats from turbulent or highly contaminated liquids. Slosh shields are available for many standard single level and most custom length switches. Look for units in this catalog with the turbulent liquid icon:


Single Level Shields



Specifications

Material:

Shield: Lexan®, Polypropylene, PVC, 304 Stainless Steel, Brass

End Caps: Polypropylene, PVC, 304 Stainless Steel, Brass

Operating Temperature: 140°F (60°C), Max

Pressure, PSI, Max.: 150

Contact GEMS for Ordering Information.

Electrical Cable and Connectors

This multi-conductor cable is available for most GEMS level switches. It provides extra protection for applications not using conduit for electrical wiring. Typical general purpose cable is shown here. Other special purpose cable is available; consult factory.

Specifications

Insulation Jacket: PVC

Lead Wires: #22 AWG, PVC

Operating Temperature: 176°F (80°C), Max.

Length: Ordered by the foot.

Number of Conductors	Wire Colors
2	Red, Black
3	Red, Black, White
4	Red, Black, White, Green
5	Red, Black, White, Green, Orange
6	Red, Black, White, Green, Orange, Blue
7	Red, Black, White, Green, Orange, Brown, Blue
8	Red, Black, White, Green, Orange, Brown, Blue, Yellow

Optional Connectors

GEMS offers many types of optional electrical connectors for use on our liquid level switches. Typical options include:

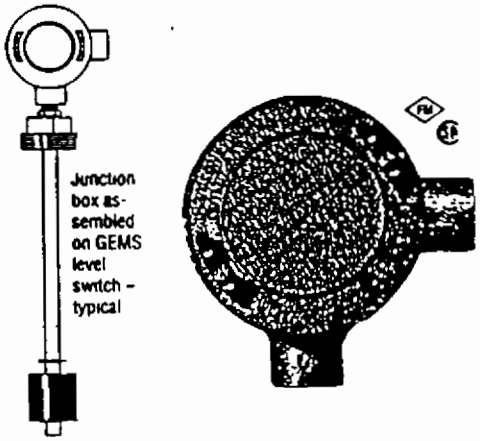
- AMP Mate-N-Lock™ Series
- Packard Weatherpack™ Series
- Spade Terminals
- Ring Terminals

Contact the factory for the availability of these connectors, or others of your choice.

ectrical Junction Boxes

- Explosion-Proof
- Watertight
- FM Approved or CSA Listed Types

GEMS Feraloy J-boxes simplify wiring or load-handling capabilities for many of the level switches shown in this catalog. They mount directly onto any level switch with a 1/2"NPT conduit connector. Junction box and level switch must be assembled at the factory to maintain explosion-proof approvals. Look for units in this catalog with the J-box icon:

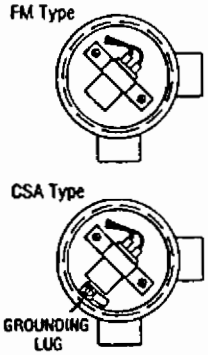


FM Approved for Class I, Division 1, Group D; CSA Listed.

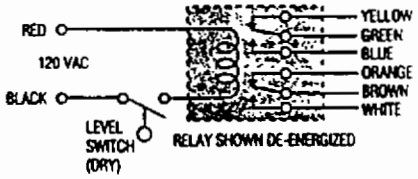
Junction Boxes with DPDT Relays

Used for controlling high current loads and/or multiple loads.

Relay Specifications
Configuration: DPDT.
Input Voltage: 120 VAC, 50/60 Hz.
Contact Ratings: 10 amp, 227 VAC, 1/2 HP, 250 VAC, 1/3 HP, 120 VAC, 10 amp, 30 VDC, resistive

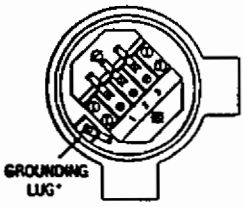
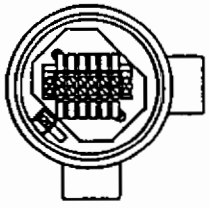
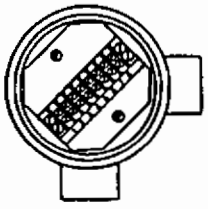
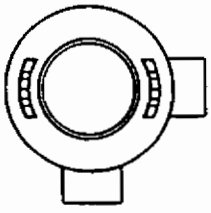


DPDT Relay Wiring Diagram



Junction Boxes with Terminal Blocks

- Terminals are screw-type with terminal lugs supplied for wire connections.

3-Pin Terminal	6-Pin Terminal	8-Pin Terminal	Lead Wire Output	ABS Plastic
				

* Grounding lug supplied on CSA Listed version only.

How To Order

Select the suitable type J-box in the table below. Order by Part Number.

Type	Part Number		
	FM Approved**	CSA Listed	Non-Approved
DPDT	76270	130550	–
3-Pin Terminal Block	55633	130549	–
6-Pin Terminal Block	–	130548	–
8-Pin Terminal Block	75975	–	–
Wire Output	–	145722	–
lastic	–	–	75970

**Class I, Division 1, Group D

Electrical Specifications

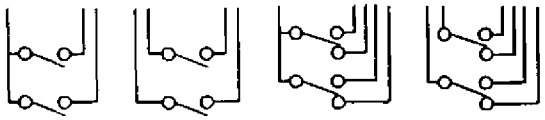
Switch (N.O. or N.C.):
SPST: 20 VA or 100 VA
SPDT: 20 VA

Lead Wires: #18 AWG, 24"L., Polymeric (except as noted in Wiring Color Code chart at right.)

Approvals: LS-800 Series switches are U.L. Recognized – File No. E45168; CSA Listed – File No. 30200

Typical Wiring Diagrams
For clarity, only two actuation levels are shown in each group diagram

GROUP I SPST | GROUP II SPST | GROUP III SPDT | GROUP IV SPDT



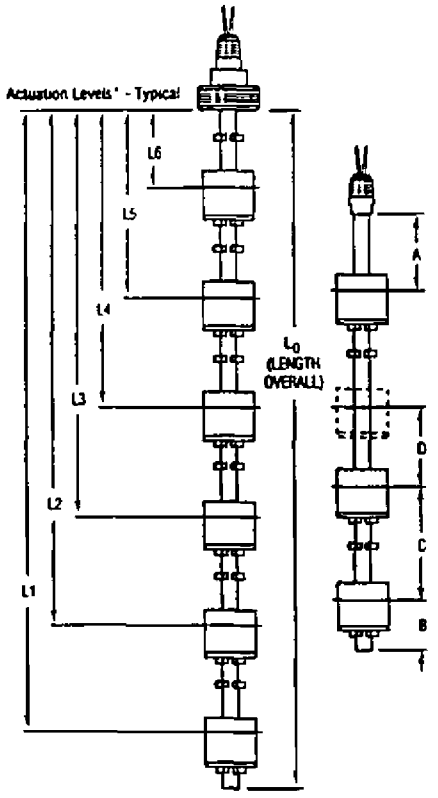
Wiring Color Code

Tinted area designates U.L. Recognized wiring configurations.

	SPST Switches			SPDT Switches 20 VA				
Wiring	Group I	Group II		Group III		Group IV		
Com. Wire	Black	None		Black		None		
	NO/NC	SW. Com.	NO/NC	NO	NC	SW Com	NO	NC
L1	Red	Red	Red	Red	Wh/Red	Red	Wh/Red	Wh/Blk/Red
L2	Yellow	Yellow	Yellow	Yellow	Wh/Yel	Yellow	Wh/Yel	Wh/Blk/Yel
L3	Blue	Blue	Blue	Blue	Wh/Blue	Blue	Wh/Blu	Wh/Blk/Blu
L4	Brown	Brown	Brown	Brown	Wh/Brn	Brown	Wh/Brn	Wh/Blk/Brn
L5	Orange	Orange	Orange	Orange	Wh/Orn	Orange	Wh/Orn	Wh/Blk/Orn
L6	Gray	Gray	Gray	Gray	Wh/Gra	Gray	Wh/Gra	Wh/Blk/Gra

Notes: 1. Non-U.L. Recognized units (white areas) use #22 AWG, 24"L., Teflon* Lead wires
2. Units with 100VA switches are not U.L. Recognized or CSA Listed

Actuation Level Dimensions



* Actuation level distances and L_0 (overall unit length) are measured from inner surfaces of mounting plug or flange.
** Length Overall $L_0 = L_1$ + Dimension B. See Mounting Types for Maximum Length values

Switch actuation levels are determined following the guidelines below.

All units 72"or less L_0 with Stainless Steel or Buna N floats. Also Type 5 units over 72"L_0 with Buna N floats:
A = 1-1/2"(38.1 mm) minimum distance to highest level (2", Type 5 only).
B = 2"(50.8 mm) minimum distance from end of unit to lowest level.
C = 3"(76.2 mm) minimum distance between levels.
D = 1/4"(6.3 mm) minimum distance between actuation levels (Note: One float for two levels can be used only when low level is N.C. dry and high level is N.O. dry).

Types 1, 3, 4, and 5 units with stainless steel float, Part Number 15666:
A = 1-5/8"(41.3 mm) minimum distance to highest level (2", Type 5 only).
B = 2-1/2"(63.5 mm) minimum distance from end of unit to lowest level.
C = 4"(101.6 mm) minimum distance between level.
D = 1/4"(6.3 mm) minimum distance between actuation levels (Note: One float for two levels can be used only when low level is N.C. dry and high level is N.O. dry).

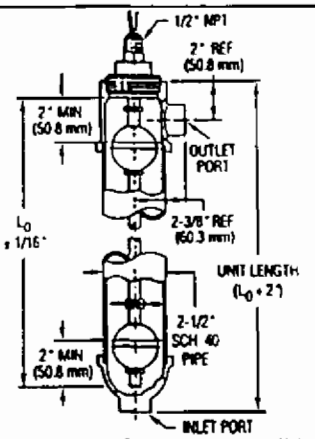
Notes:
1. A, B and C dimensions based on a liquid specific gravity of 1.0.
2. One float for two levels can be used only when 20VA switch is used.
3. Actuation levels are calibrated on descending fluid level, with water as the calibrating fluid, unless otherwise specified.
4. Tolerance on actuation levels is ±1/8"(3.2 mm).

LS-800 Series - continued

Mounting Types – continued

Type 5 External Mounting units are ideal for tanks with limited access to taps or bottoms.

Type 5 External Mount



Housing Material	Brass	316 Stainless Steel
Stem and Mounting	Brass	316 Stainless Steel
Port Sizes	3/4" NPT	1" NPT
Max. Length (Lo)	140" (355.6 cm)	
Float Stops**	Beryllium Copper	S.S. ARMCO PH-15-7 MO

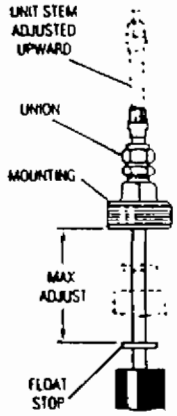
** Units greater than 72" overall length are supplied with collars with setscrews (made of same material as stem and mounting) in place of float-stop rings. Collars are optional on units less than 72" overall length. Units requiring 316 SS float stops must be special ordered with 316 SS collars instead of grip rings.

LS-800-A Series Adjustable Mounting

Available for LS-800 Series Mounting Types 2, 3 and 4.

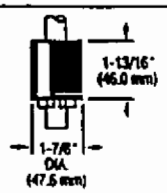
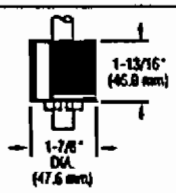
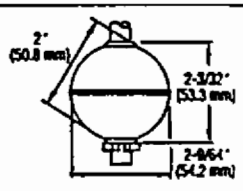
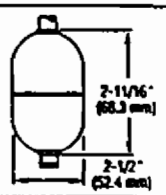
Special cinch-nut on mounting allows stem to travel up or down for fine tuning the actuation points. The extent of adjustment depends on unit length and distance from mounting to highest float stop. When ordering, specify "LS-800-A" as Series Type.

Note: Maximum overall length is limited to 72" with this option



Float Types

A single float type is selected for use at all actuation points.

Float Material	**Buna N**		**316 Stainless Steel**	
Compatible Mounting Types	2	1, 3, 4, 5	1, 3, 4, 5 (Units ≤72")	3, 4, 5 (Units >72")
Float Dimensions				
Part Number	26032	10558	14569	15666
Operating Temperature	Water: to 180°F (82.2°C) Oil: -40°F to +230°F (-40°C to +110°C)		-40°F to +300°F (-40°C to +148.9°C)	
Min. Media Specific Gravity	.75	.55	.80	.75

Pressure Ratings Chart (PSI, Max.)

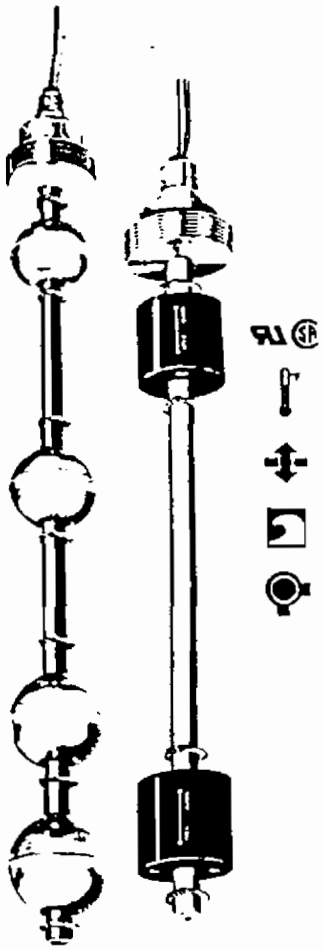
			Float Part Number			
			26032	10558	14569	15666
Mounting Type	1, 2, 3		150		750	300
	4		150			
	5	Brass	100 @ +70°F (21.1°C)			
		316 S.S.	150		750	300

Large Size – Metallic

LS-800 Series

- Stainless Steel or Brass Mountings
- 1 to 6 Actuation Levels
- Lengths to over 11 feet
- U.L. Recognized, CSA Listed

Rugged construction and multiple options provide the LS-800 Series with exceptional versatility. Longer and more substantial than other metallic models, the LS-800 is capable of supporting larger, more buoyant floats, and is physically stronger for better reliability in contaminated or turbulent media. This series offers SPST or SPDT switches, and a choice of mountings, floats and materials that can be configured for a wide range of applications in water, oils, chemicals and corrosive liquids.



Temperature Sensing

To save space and simplify wiring GEMS can incorporate a temperature sensor in the end of the float stem on any model type LS-800. Two sensor types are available: Transducers for continuous output, and Thermostats for switch actuation. See Page 42 for details.

Adjustable Mounting

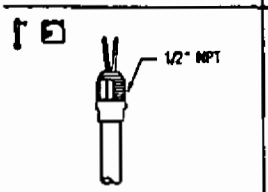
vs stem to travel up and down for fine ıg your actuation points. See Page 32 for details.

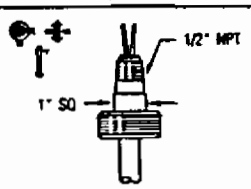
Junction Boxes

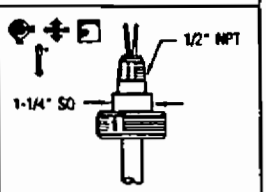
Simplify wiring with optional terminal strip J-boxes. Feraloy versions are explosion-proof (Some FM Approved) and water tight. See Page 43 for details.

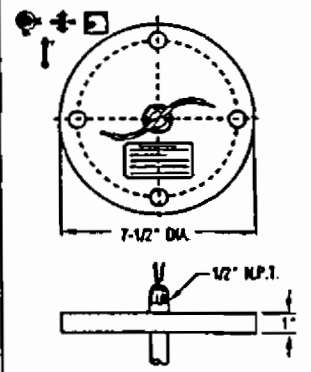
Mounting Types

Each mounting type can be configured with stem lengths (L_0) and float material indicated in the table below. Mountings are also continued on following page.







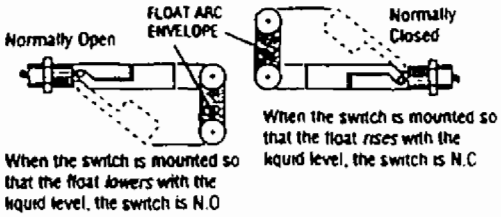


	Type 1 1/2" NPT	Type 2 1-1/4" NPT	Type 3 2" NPT	Type 4 3", 150# Dia. Flange
Stem and Mounting Material	Brass or 316 Stainless Steel			Flange: Carbon Steel or 316 S.S. Stem: 316 S.S.
Length (Lo)	36" (91.4 cm)	60" (152.4 cm)	140" (355.6 cm)	
...ating Position	Vertical ± 30° Inclination			
Float Stops**	Brass Units: Beryllium Copper Grip Rings; Stainless Steel Units: S.S. ARMCO PH-15-7MO Grip Rings			

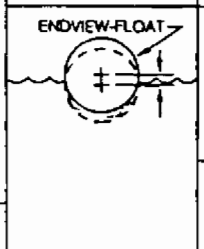
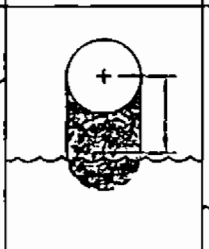
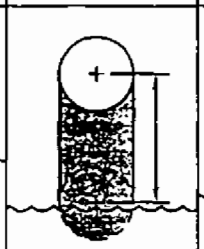
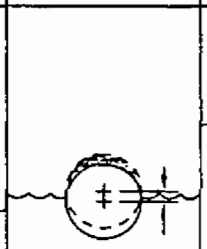
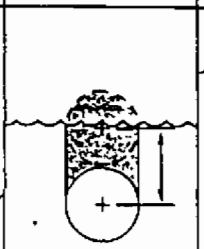
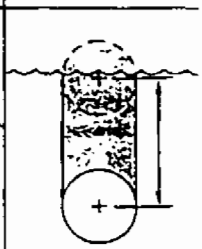
** Units greater than 72" overall length are supplied with collars with setscrews (made of same material as stem and mounting) in place of float-stop rings. Collars are optional on units less than 72" overall length. Units requiring 316 SS float stops must be special ordered with 316 SS collars instead of grip rings.

Switch Operation

Depending on the mounting position, the float on these switches can either rise or lower with the liquid level. By rotating the switch 180°, the switch operation can be Normally Open or Normally Closed. Arrows on exterior of mounting indicate N.O. when pointing up.



Point of Operation in Specific Gravity of 1.0

		N.O. Dry Configuration			N.C. Dry Configuration		
		Contact Closes As Level Rises	Contact Opens As Level Falls	Float Arc Envelope	Contact Closes As Level Falls	Contact Opens As Level Rises	Float Arc Envelope
							
Mounting Type	Part Number						
1	76141	.00	.65	2.00	.25	.90	2.00
1	76142	.00	.65	1.95	.50	1.00	1.95
2	76145	.125	1.00	2.75	.50	1.44	2.75
3	76147	.00	.65	2.25	.25	.90	2.25
3	76148	.00	.65	2.25	.50	1.00	2.25
4	76151	.125	1.00	2.75	.50	1.44	2.75
Alum. Body	113830	.00	.59	1.35	.25	.90	1.35

Dimensions expressed in inches.

How To Order

Select Part Number based on specifications required.

Mounting Type	Materials		Min. Liquid Sp. Gr.	Operating Temperature	Switch* SPST	Part Number
	Stem and Mounting	Float				
1	Polysulfone		.75	-40°F to +225°F (-17.8°C to +107.2°C)	20 VA	76141
1	Ryton® R-4		.98	-40°F to +300°F (-17.8°C to +148.9°C)		76142
2	Ryton® R-4		.80	-40°F to +300°F (-17.8°C to +148.9°C)		76145
3	Polysulfone		.75	-40°F to +225°F (-17.8°C to +107.2°C)		76147
3	Ryton® R-4		.98	-40°F to +300°F (-17.8°C to +148.9°C)		76148
4	Ryton® R-4		.80	-40°F to +300°F (-17.8°C to +148.9°C)		76151
Alum. Body	Aluminum 380	Polysulfone	.80	-40°F to +225°F (-40°C to +107.2°C)	10 VA	113830

*See "Electrical Data" on Page 3 for more information.

GEMS

Small Size – Non-Metallic–continued

LS-7 Series – Side Mounted

These low-cost units are ideal for high volume use in small tanks and vessels. Polysulfone or Ryton® construction offers broad compatibility in water, oils and chemicals.

Type 1 – External Mounting

Polysulfone or Ryton®.

Type 2 – External Mounting

Ryton® only.

Type 3 – Internal Mounting

Polysulfone or Ryton®.

Type 4 – Internal Mounting

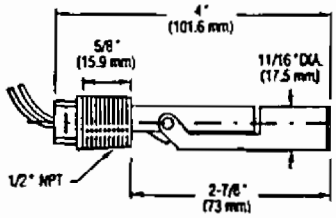
Ryton® only.

Aluminum Body Type – External Mounting

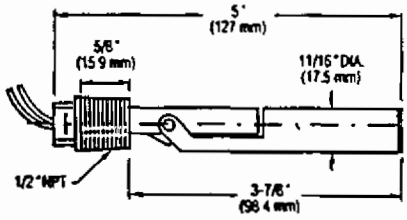
Polysulfone float.

Dimensions

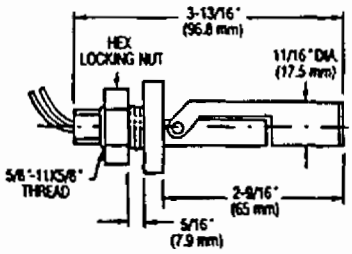
Type 1



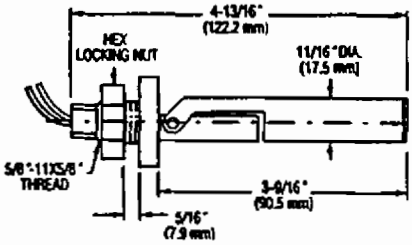
Type 2



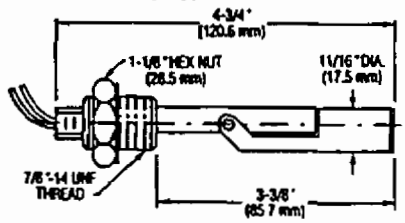
Type 3



Type 4



Aluminum Body Type



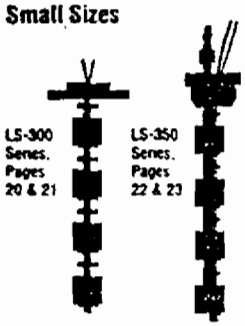
Common Specifications

Operating Pressure: 150 PSI, Max. @ 70°F.
Electrical Termination: No. 22 AWG, 24"L., PVC or Teflon® Lead Wires.
Approvals: All LS-7 Series switches (except Aluminum Body Type) are U.L. Recognized – File No. E45168, and are CSA Listed-File No. 30200.
Mounting Attitude: Horizontal.

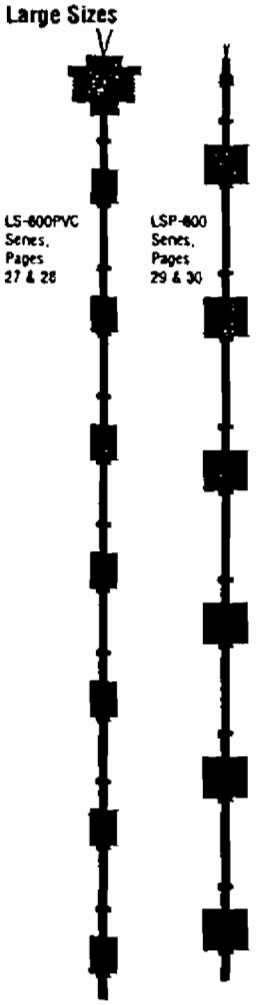
Custom Length Level Switches – 1:15 Scale

Non-Metallic Versions

Small Sizes



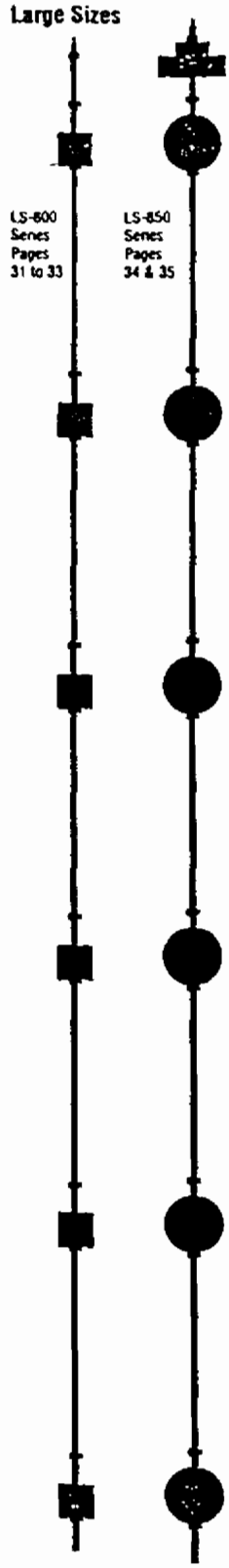
Large Sizes



Metallic Versions

Small Size

Large Sizes



Icon Key

The icons shown below are used throughout this catalog to indicate the availability of the following options:

- – Integrated Temperature Sensor
- – Explosion-Proof Junction Boxes with Terminal Strips
- – Lexan® Slosh Shields

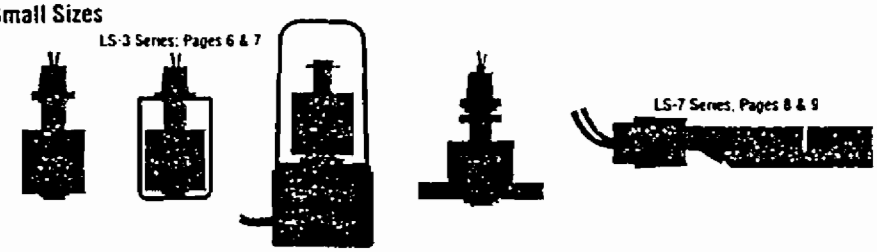
Level Switch Overview

The silhouettes shown here provide an overview of GEMS level switch products and their size relationship. Standard Single Level versions are shown on this page, at a scale of 1:3. Typical Custom Length versions appear opposite, at a scale of 1:15.

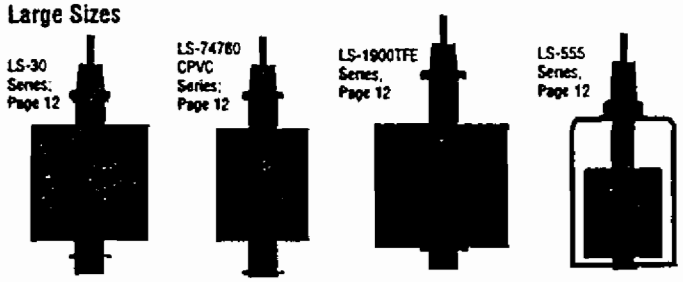
Standard Single Level Switches – 1:3 Scale

Non-Metallic Versions

Small Sizes

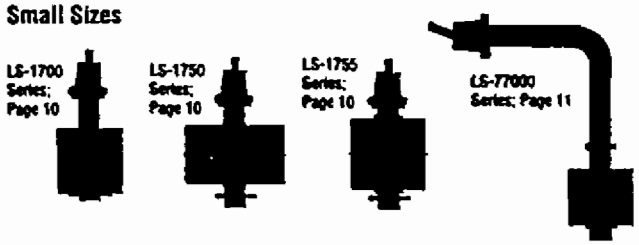


Large Sizes

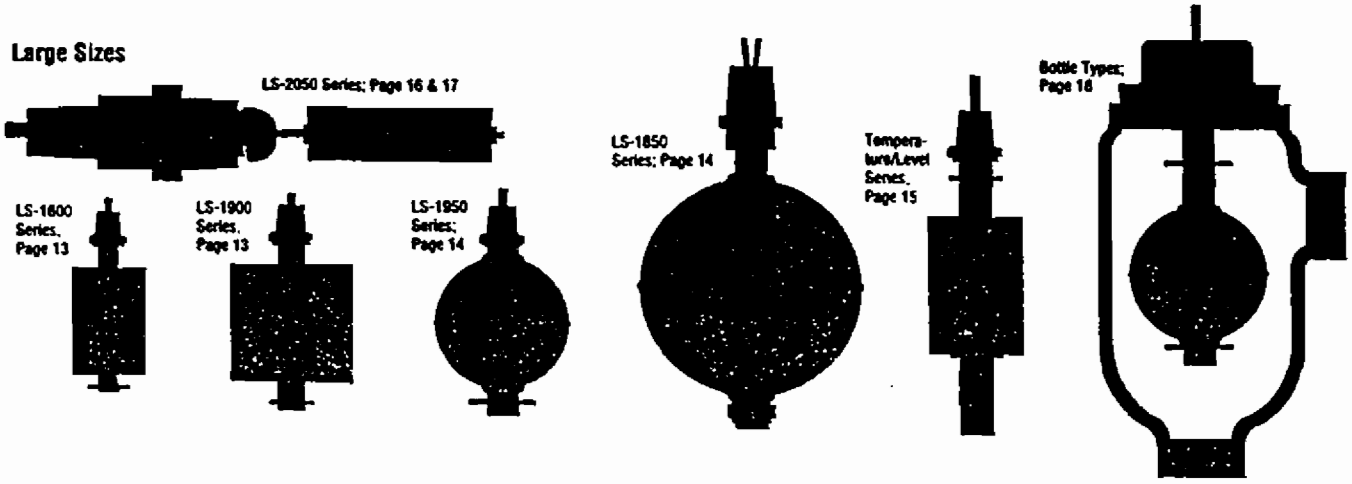


Metallic Versions

Small Sizes



Large Sizes



Electrical Data

Standard reed switches in GEMS level switch units are hermetically-sealed, magnetically actuated, make-and-break type. Switches are SPST or SPDT, and rated 20 VA. See the chart below for maximum load characteristics of GEMS level switches.

GEMS Sensors Division would be pleased to run life tests on our level switches with your specific load, and issue a report indicating the approximate number of cycles that can be expected.

U.L. Recognized Units: Switches showing a U.L. listing are rated for 10 VA, 20 VA, or 50 VA as shown below.

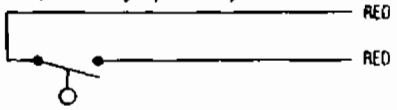
Switch Rating – Maximum Resistive Load

VA	Volts	Amps AC	Amps DC
10 General Use	0-50	.2	.13
	120	.08	N.A.
	100	N.A.	.3
20 Pilot Duty	0-30	.4	.3
	120	.17	.13
	240	.08	.06
50 General Use	0-50	0.5	0.5
	120	.4	.4
	240	.2	.2
100*	120	.8**	N.A.
	240	.4	N.A.

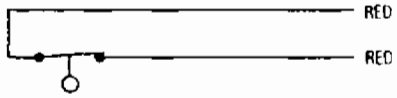
* Level switch units with 100 VA switches are not U.L. Recognized.
** Limited to 50,000 operations

Typical Wiring Diagrams

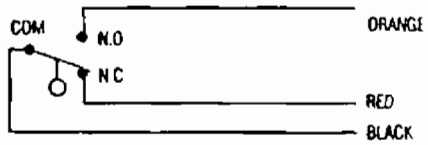
SPST, Normally Open - Dry



SPST, Normally Closed - Dry



SPDT, Shown Dry



Explosion-Proofing and Intrinsic Safety

GEMS offers optional CSA Listed and FM Approved, explosion-proof junction boxes for many level switch models. Compatible level switches are indicated throughout this catalog by the small icon, . Information on explosion-proof J-boxes is found in the Accessories section of this catalog.

For intrinsically-safe installations, nothing performs better than GEMS Zener Barriers and SAFE-PAK® Relays. These solid-state devices render the entire sensor circuit intrinsically-safe without explosion-proof enclosures. Latching version relays can control pump-up/pump-down operations. See Page 45 for more information.

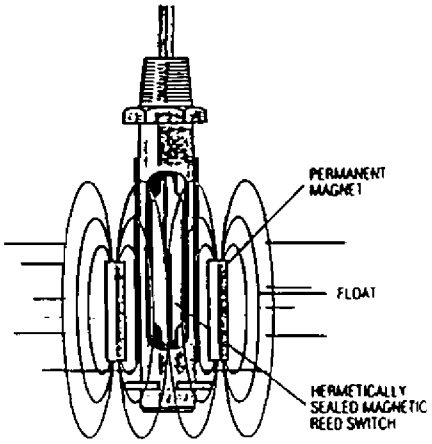
Explosion-Proof Junction Boxes

Intrinsically-Safe Relays and Barriers

General Operating Principle

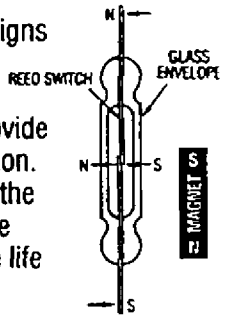
GEMS Level Switches operate on a direct, simple principle. In most models, a float encircling a stationary stem is equipped with powerful, permanent magnets. As the float rises or lowers with liquid level, the magnetic field generated from within the float actuates a hermetically sealed, magnetic reed switch mounted within the stem. The stem is made of non-magnetic metals or rugged, engineered plastics. When mounted vertically, this basic design provides a consistent accuracy of ±1/8 inch. Multi-station versions use a separate reed switch for each level point being monitored.

Side-mounted units use different actuation methods because of their horizontal attitude. The basic principle, however, is the same: as a direct result of rising or falling liquid, a magnetic field is moved into the proximity of a reed switch, causing its actuation.



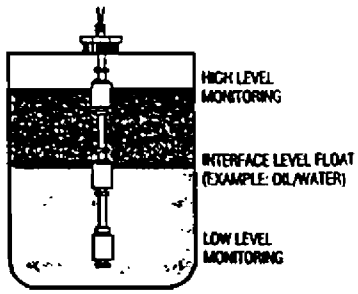
Reed Switch Reliability

The durable construction of these reed switch designs ensures long, trouble-free service. Because the effects of shock, wear and vibration are minimized, these hermetically sealed switches provide precise repeatability with no more than 1% deviation. The switch actuation points remain constant over the life of the unit. See "Reed Switch Protection" in the Appendix section for information on extending the life of GEMS Level Switches.



Liquid Interface Monitoring

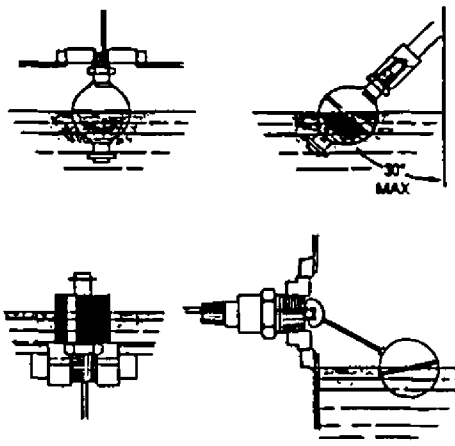
In addition to monitoring the surface level of liquids, many GEMS Level Switches can be used to sense the interface point between dissimilar liquids sharing the same tank. Monitoring water condensation in fuel storage tanks, and separating chemical emulsions in process systems are two typical application examples. Multi-station level switches can be configured to monitor this interface point in addition to high and low liquid levels. Contact GEMS Sensors Division with your specific application.



Installation and Maintenance

A standard NPT female boss in tank top, bottom or side is all that is required for rapid installation. Units operate normally in any attitude - from the vertical to a 30° inclination - with lead wires up or down. Standard IPS pipe extends units to any intermediate level in the tank.

Details and tips for installation and maintenance of GEMS Level Switches are found in the Appendix section of this catalog.



GEMS Liquid Level Switches

From a Company You Can Count On

Within this catalog you'll find a comprehensive selection of quality liquid level switches for most any single or multi-point level sensing need.

These float type sensors provide on-off switch action for a variety of requirements:

Pump-Up and Pump-Down Operations

High, Low or Intermediate Level Alarms

Motor or Solenoid Valve Actuation

Safety Interlocks

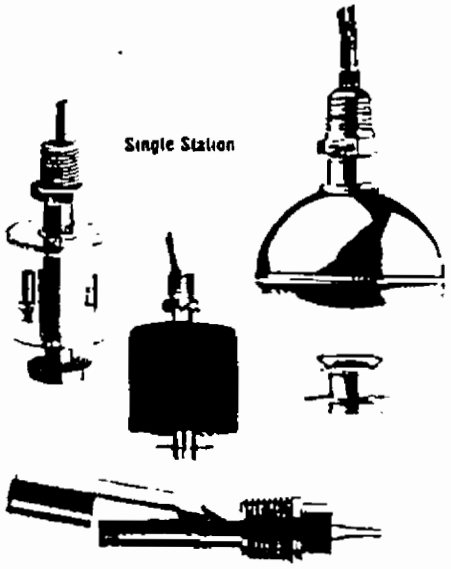
For more than 35 years, OEM design engineers and general industrial customers have selected rugged GEMS Level Switches to ensure reliable, accurate liquid level sensing.

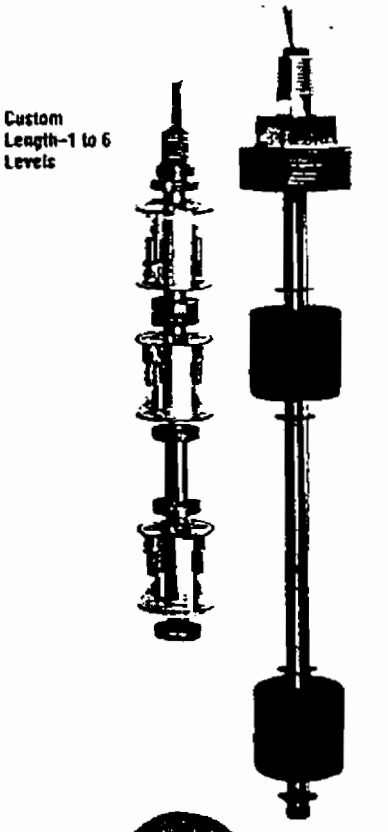
Designed for a broad range liquids, including water, oils, fuels and chemicals, GEMS Level Switches are versatile performers. Here are just a few general areas where you can find them currently in service:

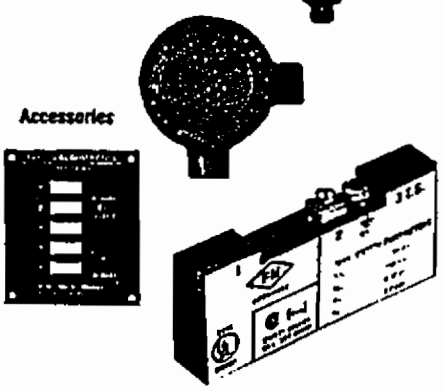
- ☐ Large Storage Tanks
- ☐ Appliances
- ☐ Medical Equipment
- ☐ Automotive
- ☐ Dispensing Systems
- ☐ Cooling and Refrigeration Systems
- ☐ Small Reservoirs
- ☐ Agricultural Equipment
- ☐ Marine
- ☐ Utilities

Gems Sensors Division, Plainville, Connecticut

GEMS Sensors is a division of Imo Industries Inc. IMO is a leader in selected markets for instrumentation and controls, engineered products and their support service. The IMO family of companies has been serving businesses for more than a century. Its range of products include sducers, pressure and temperature switches, pumps, clamps, nectors, engines, turbines, compressors, gears and more.



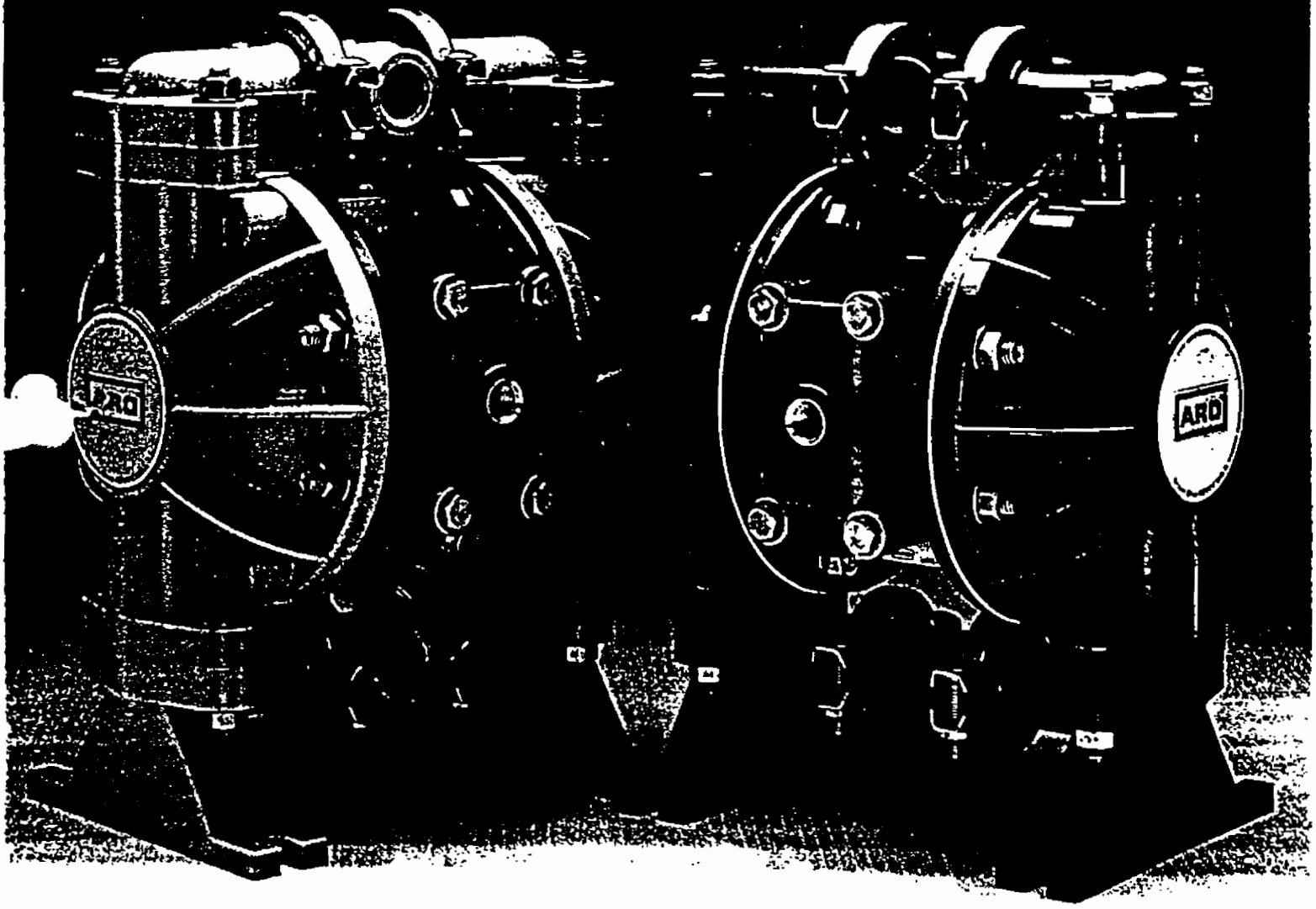




ARO

1/2" Diaphragm Pumps

Non-Metallic Construction



The Ultimate Non-Metallic, Air-Operated Twin Diaphragm Pump

Inlet & Outlet Ports Rotate to Any Position

The inlet and outlet manifolds provide mounting and plumbing versatility.

Variable Delivery Rate

The flow rate is variable from 0-13 GPM. Simply adjust the inlet air pressure from 0-100 PSI to achieve the desired flow rate.

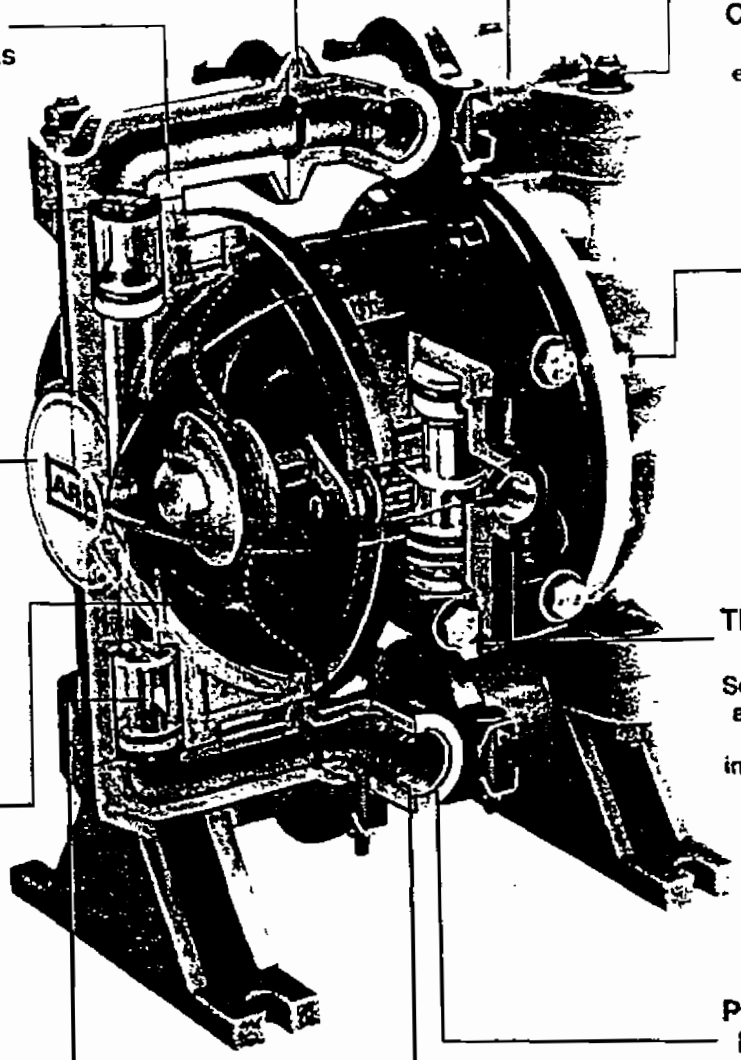
Standard Split-Manifold Design Allows Multiple Installation Configurations

The unique split-manifold design with threaded ports allows the pump to be configured in four (4) different ways without expensive accessories:

- Single Inlet / Single Outlet
- Single Inlet / Dual Outlet
- Dual Inlet / Dual Outlet
- Dual Inlet / Single Outlet

Corrosion-Resistant Clamps and Fasteners

To assure chemical and environmental compatibility, all metallic fasteners are constructed of Series 300 stainless steel.



The End Caps Bolt Directly to The Pump's Center Body

This design provides a positive seal between the end caps and the pump body. It also assures precise alignment of parts and provides for easy re-assembly.

Choose From Two Body Materials

For a broad range of chemical compatibility, the wetted sections of the pump are constructed of either polypropylene or PVDF (Kynar®).

The Air Valve Is Easily Removed

Separate access to the main air valve allows the user to perform maintenance or inspection without disturbing the fluid section of the pump.

Your Choice of Three Diaphragm Materials

Three different diaphragm materials are available to provide material compatibility for your installation. Choose from neoprene, polyurethane, or Teflon®.

Positive Priming Provides Easy Start-Ups

The check-valves are located close to the diaphragm to assure positive self-priming.

Check-Valve Options Meet Wide Range of Fluid Handling Requirements

The standard ball-check valves are for low-viscosity fluids while the duck-bill check valves are for fluids that have fibers or high solids content.

Pump Fluids with Suspended Solids Content up to 3/32" in Diameter

The fluid section has no packings, close-fitting or sliding parts. This allows the pump to handle fluids with suspended solids content up to 3/32" in diameter.

KYNAR® is a registered trademark of the Pennwalt Corporation.
TEFLON® is a registered trademark of the DuPont Corporation.

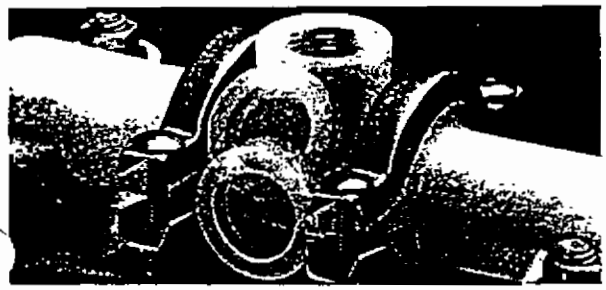
Unique Manifold Design Allows Maximum Installation Flexibility

3-Piece Manifold Fits Your Piping Requirements

The three-piece, inlet and outlet manifolds of this pump have been designed for maximum installation versatility. No additional accessories are required to utilize the pump in any of the possible installation configurations shown to the right.

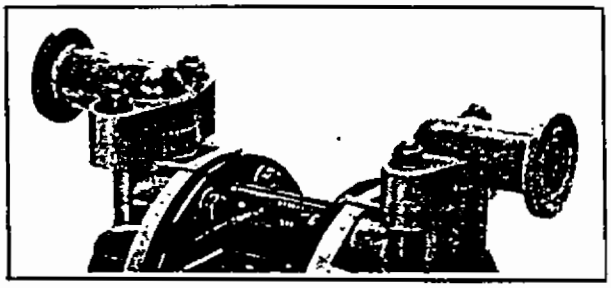
Each of the three sections of the inlet and outlet manifolds have a 1/2 NPT(F) threaded port for installation convenience.

Inlet and Outlet Rotates 360°



The center section of each manifold rotates 360° to accomodate precise piping alignment.

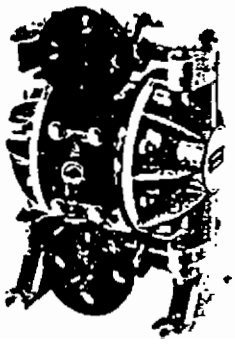
Convertible Manifolds



With the center section removed and each manifold end rotated 180°, the pump can be plumbed for dual inlet or dual outlet operation.

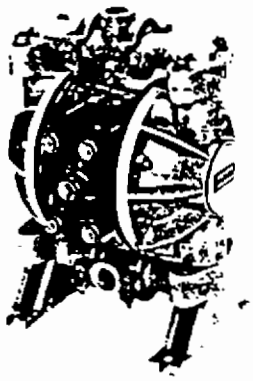
Accepts Standard Flanges

This pump was also designed to accomodate standard flange connectors. Unlike other 1/2" inlet/outlet pumps, there is sufficient room to install standard flange connections directly to both the inlet and outlet manifold of the pump without modification.



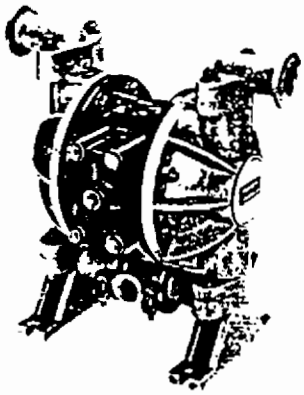
Single Inlet / Single Outlet

Pump from a single fluid source to a single dispensing point.



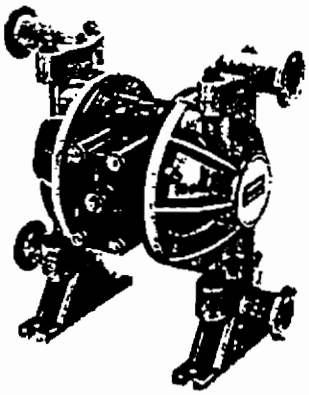
Single Inlet / Dual Outlet

Pump from a single fluid source to two separate dispensing points.



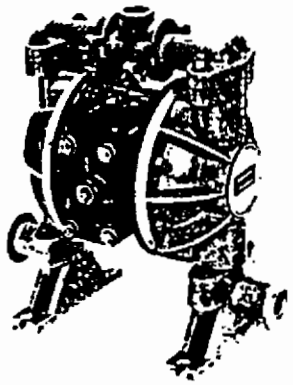
Dual Inlet / Dual Outlet

Pump from two fluid sources to two separate dispensing points.



Dual Inlet / Single Outlet

Blend two fluids in equal volumes by pumping from two material sources to one dispensing point.



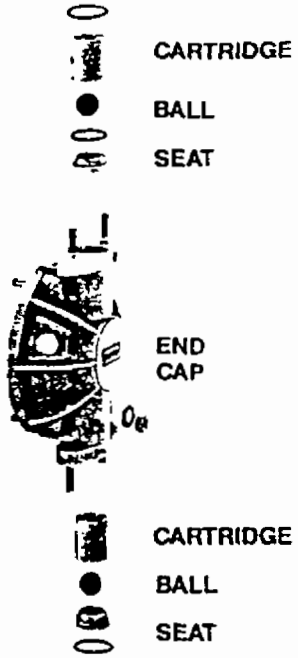
Unique Designs for Fluid Flow and Air Control

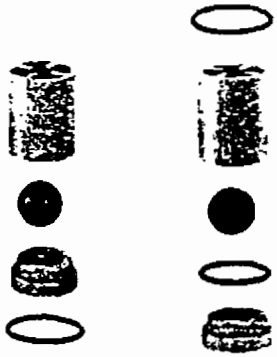
The Check-Valve Cartridge Assembly Simplifies Replacement and Minimizes Cost

The unique check-valve assembly utilizes a cartridge-concept design which allows easy replacement at minimal cost.

Unlike other designs that mold the check-valve assembly into the end cap or manifold, the modular ARO® design allows single-part interchangeability for each of the four required check-valves.

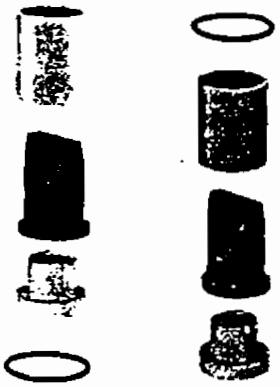
This design also allows two entirely different check-valve types to be used interchangeably in the same housing.





Ball-Checks Provide Positive Priming

The standard ball-checks are used for most fluids. They provide smooth positive priming, maximum suction-lift, and a high delivery rate. They will pass suspended solids up to 3/32" in diameter.



Duck-Bill Checks Pass Fibers

Duck-bill checks are for fluids that are fiber-filled have a high-solids content. Because of the unique cartridge design the duck-bill check-valve assembly can be inverted so that fluid flow can be reversed to prevent settling of solids.

How It Used To Be

Other diaphragm pump manufacturers use a mechanical trip or a single-stage valve to control the reciprocating motion of the diaphragms. Mechanical trips need to be replaced often because the detent device and/or the springs lose their recoil tension.

Diaphragm pumps equipped with a single-stage valve are susceptible to stalling. When one of these pumps is operated at slow cycle speeds, or used to pump heavy material, the over-travel of the diaphragm is reduced and so is the duration of the shift signal. This condition may cause the valve to only partially shift or stop completely. Either of these conditions will keep the pump from running.

State Of The Art Improved

The ARO 1/2" Diaphragm Pump uses a two-stage valve to control the reciprocating motion of the pump. A pilot valve supplies a pilot signal to the power valve throughout the entire stroke or cycle of the pump.

The pilot valve is not connected to the diaphragm connecting rod or the diaphragms. The pilot valve is oriented between the air chambers so that mechanical force moves the pilot valve to the signal position, which in turn shifts the power valve. (See Figure 1).

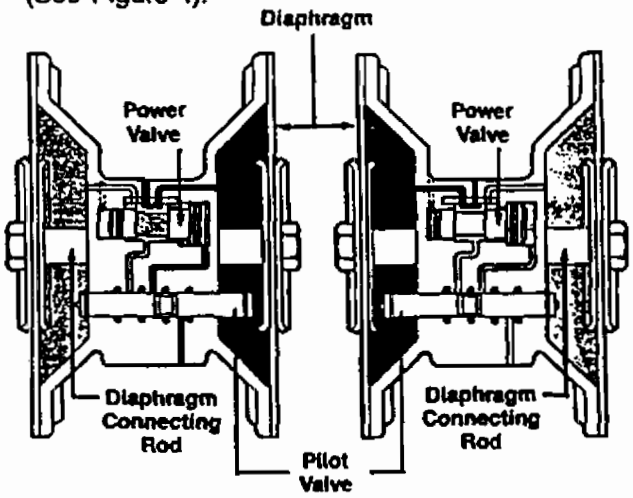


FIGURE 1 FIGURE 2

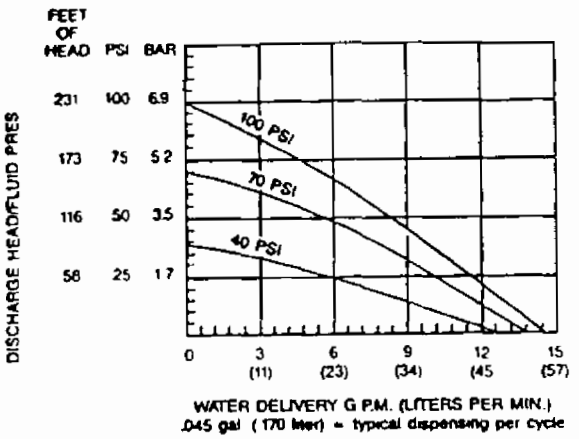
The air from the power valve continues to shift the pilot valve and hold it in position, even after the mechanical force is removed (See Figure 2).

This action positions the pilot valve for the next cycle and maintains the pilot signal throughout the entire cycle of the pump.

This improved design allows you to run the ARO 1/2" Diaphragm Pump at slow cycle speeds and with heavy materials without the pump stalling and stopping the flow of production materials.

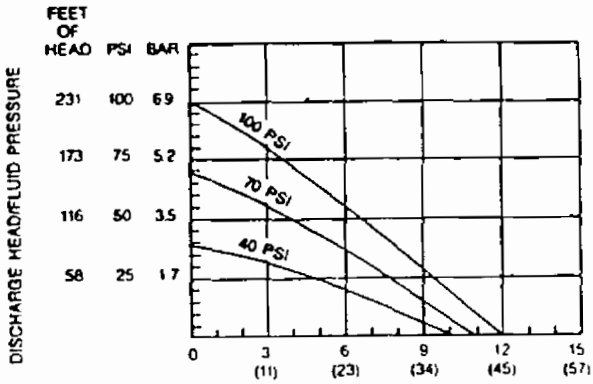
Performance Data

NEOPRENE DIAPHRAGM WITH BALL-CHECKS



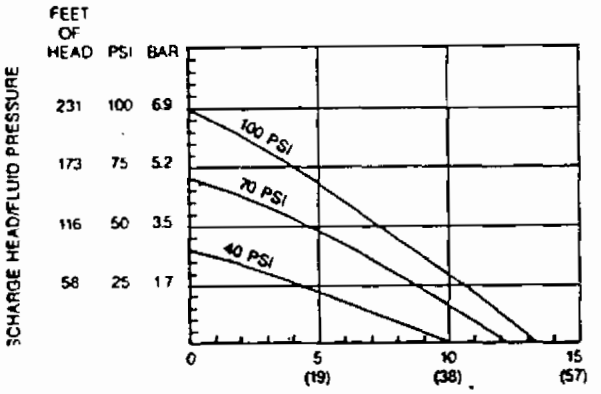
.045 gal. (.170 liter) = typical dispensing per cycle

NEOPRENE DIAPHRAGM WITH DUCK-BILL CHECKS



.040 gal. (.151 liter) = typical dispensing per cycle

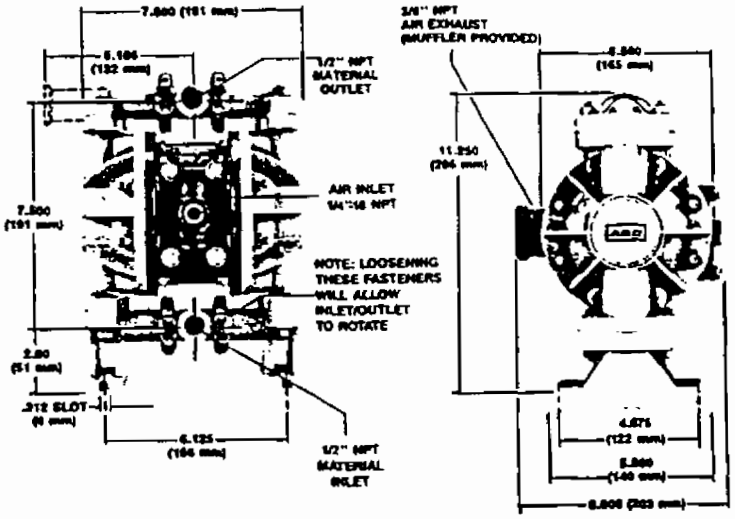
TEFLON DIAPHRAGM WITH BALL-CHECK



.038 gal. (.144 liter) = typical dispensing per cycle

$$\text{HEAD IN FEET} = \frac{\text{PSI} \times 2.31}{\text{SPECIFIC GRAVITY}}$$

DIMENSIONS



SPECIFICATIONS

MODEL	CENTER BODY CONSTRUCTION	DIAPHRAGM & CHECK CONSTRUCTION	O-RING CONSTRUCTION	AIR:FLUID RATIO	MAXIMUM GALLONS (litres) PER MINUTE	AIR INLET	FLUID INLET	FLUID OUTLET	MAXIMUM OPERATING PRESSURE (bar)	MAXIMUM SOLIDS DIAMETER INCHES	WEIGHT LBS. (kg)
Polypropylene Ball-Check Valve											
666053-311	POLYPROPYLENE	NEOPRENE	NEOPRENE	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	7.5 (3.4)
666053-322	POLYPROPYLENE	BUNA "N"	BUNA "N"	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	7.5 (3.4)
666053-333	POLYPROPYLENE	VITON	VITON	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	7.5 (3.4)
666053-344	POLYPROPYLENE	TEFLON	TEFLON	1:1	13 (49)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	7.5 (3.4)
666053-361	POLYPROPYLENE	DELRIN	NEOPRENE	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	7.5 (3.4)
666053-388	POLYPROPYLENE	URETHANE	URETHANE	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	7.5 (3.4)
PVDF Ball-Check Valve											
666054-411	POLYPROPYLENE	NEOPRENE	NEOPRENE	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	10.3 (4.7)
666054-422	POLYPROPYLENE	BUNA "N"	BUNA "N"	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	10.3 (4.7)
666054-433	POLYPROPYLENE	VITON	VITON	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	10.3 (4.7)
666054-444	POLYPROPYLENE	TEFLON	TEFLON	1:1	13 (49)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	10.3 (4.7)
666054-461	POLYPROPYLENE	DELRIN	NEOPRENE	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	10.3 (4.7)
666054-488	POLYPROPYLENE	URETHANE	URETHANE	1:1	14 (53)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	3/32	10.3 (4.7)
Polypropylene Duck-Bill Type											
666053-022	POLYPROPYLENE	BUNA "N"	BUNA "N"	1:1	12 (45)	1/4 (F)	1/2 (F)	1/2 (F)	100 (6.9)	FIBERS	7.5 (3.4)

Material of Construction

POLYPROPYLENE — Polypropylene has a broad range of chemical resistance, high-fatigue endurance, superior abrasion resistance with low coefficient of friction. It is resistant to most acids, alkalis, and saline solutions even at higher temperatures. It is also resistant to higher aliphatic solvents and polar substances.

POLYPROPYLENE has a temperature range of 35° to 150°F. (2° to 65°C).

The POLYPROPYLENE used in this pump is UV stabilized.

PVDF — POLYVINYLIDENE FLOURIDE (KYNAR) — is a tough engineering thermoplastic that offers a unique balance of properties. PVDF has mechanical strength and toughness, high abrasion resistance, high thermal stability, and high dielectric strength. PVDF is resistant to most chemicals and solvents, ultra violet and nuclear radiation, weathering, and fungi.

PVDF has a temperature range of 10° to 200° F (-12° to 93°C)

The PVDF used in this pump is UV stabilized.

Accessories

Air Line Connection Kits

MODEL	DESCRIPTION	INLET
66073-1	AIR LINE CONNECTION KIT — For use with 1/2" and 1" Diaphragm Pumps. Kit includes Miniature Series Piggyback Filter/Regulator (w/29575 gauge) model 129121-400, 1/4" NPT female thread coupler, 1/4" NPT male thread connector, 1/4" NPT x 2-1/2" long pipe nipple and a 5 foot long air hose with 1/4" NPT male thread — each end.	1/4" NPT

Pressure Relief Valve

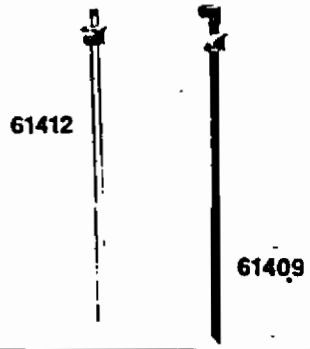
MODEL	DESCRIPTION	INLET THREAD (NPT)	OUTLET THREAD (NPT)
93368-1	PRESSURE RELIEF VALVE — is preset to 125 psi (±10 psi). To be used in systems where thermal expansion or excess backpressure can develop in the fluid lines. Valve should be installed in a piping tee located near the outlet of the pump. Tubing or hose will be required to return bleed-off to fluid container.	1/4-18 (M)	1/4-18 (M)
		Body constructed of brass with Buna "N" O-ring and stainless steel spring.	

Wall Mounts

MODEL	DESCRIPTION
76763	WALL MOUNT — Provides secure wall mounting for 1/2" Diaphragm Pump.

Siphon Tube

MODEL	DESCRIPTION	USE WITH	FLUID OUTLET NPT
61409	SIPHON TUBE — PVC tube with bung adapter. For 55-gallon drums. Can be cut for smaller containers.	1/2" Diaphragm Pump and Siphon Hose	1/2 (F)
61412	SIPHON TUBE — Threads directly into pump inlet. Includes standard bung adapter. Schedule 80 PVC pipe.	1/2" Diaphragm Pump	1/2 (M)



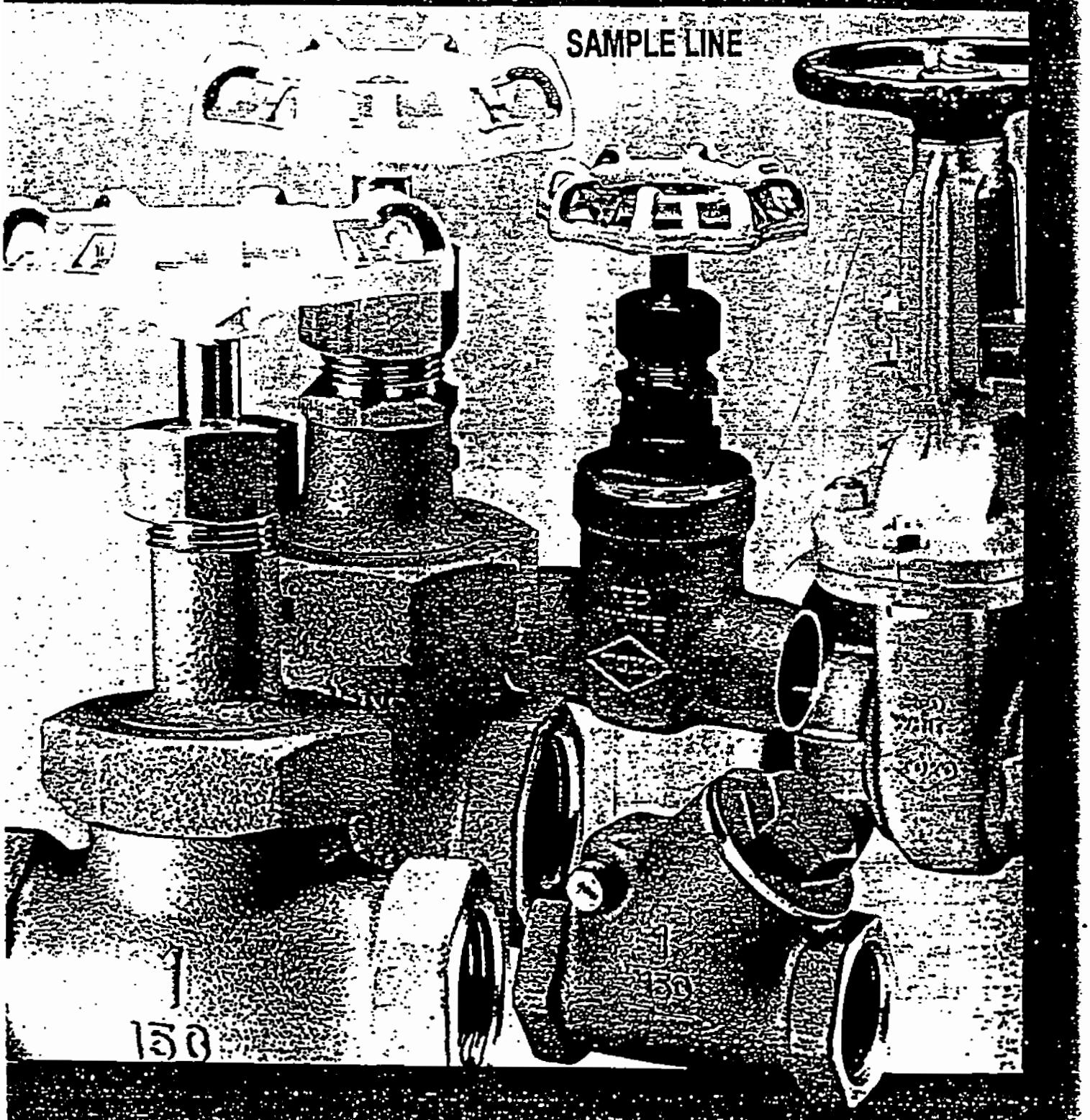
Siphon Hose

1/2" I.D. 11/16" O.D.	Thiokol Tube Neoprene Cover	2 Fabric Wire Braid Working Pressure — 200 P.S.I. (14 bar)		1/2" I.D. 13/16" O.D.	Polymer Tube Polyurethane Cover	Polyester Braid Working Pressure — 2750 P.S.I. (190 bar)	
622581-XXX	1/2 NPT(M) x 1/2 NPT(M)	—		628084-XXX	1/2 NPT(M) x 1/2 NPT(M)	—	

RED-WHITE
VALVE CORP.

Commercial & Industrial Valves

Bronze and Iron Valves
Bronze and Brass Ball Valves
Cast Steel Ball Valves
Stainless Steel Ball Valves
Butterfly Valves



Catalog No. 32

ASCO®

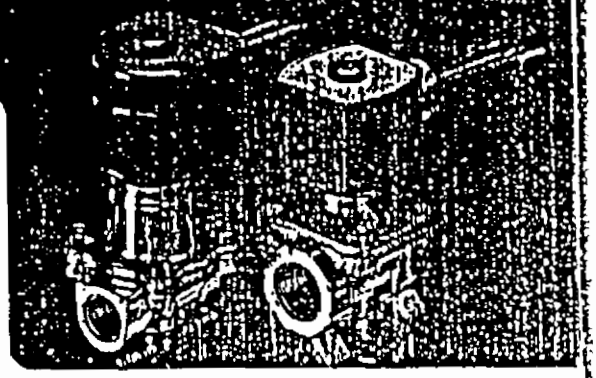
2, 3 and 4 way Solenoid Valves

2 WAY PILOT OPERATED
General Service Solenoid Valves

Brass or Stainless Steel Bodies • 3/8" to 2½" N.P.T.

Red-Hat | Red-Hat II

8210 SERIES



Specifications

Solenoid Enclosures: Valves listed in this series have either Red-Hat metal solenoid enclosures or Red-Hat II molded epoxy solenoids. Red-Hat II valves are identified by the change letter "G" in their catalog numbers, e.g., 8210G1, and are shown in red.

Standard Enclosures:
Red-Hat — Type 1 General Purpose
Red-Hat II — Types 1, 2, 3, 3S, 4 and 4X Combination General Purpose and Watertight.

Optional Enclosures:
Red-Hat — Types 5, 7 and 9 Combination Explosionproof and Raintight. To order, add prefix "EF" to catalog number. Except Catalog Numbers 8210B57, 8210B58 and 8210B59)*9
Red-Hat II — Types 5, 3S, 4, 4X, 6, 6P, 7 and 9 Combination Explosionproof and Watertight. To order, add prefix "EF" to catalog number.

Additional constructions are available. See the Optional Electrical Features Section, page 11, contains descriptions and ordering information for: Open Frame Solenoids • Junction Box Enclosures • Panel Mount Constructions.

Electrical: Standard Voltages:
24, 120, 240, 480 volts, AC, 60 Hz (or 110, 220 volts, AC, 50 Hz)
6, 12, 24, 120, 240 volts, DC
Other voltages are available when required.

Coil: Continuous duty molded Class F or H, as listed.

Nominal Ambient Temperature Ranges: Red-Hat and Red-Hat II Valves/AC Construction: 32°F to 125°F.
Red-Hat Valves/DC Construction: 32°F to 77°F (104°F occasionally).
Red-Hat II Valves/DC Construction: 32°F to 104°F.
Refer to Engineering Section for details.

Valve Parts In Contact with Fluids:
Body — Brass or Stainless Steel, as listed
Seals and Discs — Buna "N" or Teflon*, as listed
Disc Holder — Nylon, as listed
Core Tube — 305 s.s.
Core and Plugnut — 430F s.s.
Springs — 302 s.s.
Shading Coil — Copper (brass body). Silver (stainless steel body)

Approvals: CSA certified.
UL listed as indicated. Refer to Engineering Section for details.

Ordering Information:
Important: We must have catalog number, voltage and Hertz, operating pressure and fluid handled. Use strainers with solenoid valves.

*DuPont Co. trademark

CATIONS

Pipe Size (ins.)	Orifice Size (ins.)	Cv Flow Factor	Operating Pressure Differential (psi) Min.	Max. AC: Air-Inert Gas	Max. AC: Water	Max. AC: Light Oil @ 300 SSU	Max. DC: Air-Inert Gas	Max. DC: Water	Max. DC: Light Oil @ 300 SSU	Max. Fluid Temp. °F. AC	Max. Fluid Temp. °F. DC	Standard Solenoid Enclosures Red-Hat–Type 1 Red-Hat II–Types 1,2,3,3S,4 and 4X: Brass Body Catalog Number	Brass Body Constr. Ref. No. ⑭	Brass Body UL Listing	S.S. Body Catalog Number	S.S. Body Constr. Ref. No. ⑭	S.S. Body UL Listing	Wall Rating/ Class of Coil Insulation ⑪ AC	Wall Rating/ Class of Coil Insulation ⑪ DC
NORMALLY CLOSED (Closed when de-energized), Buna "N" or Teflon® Seating																			
3/8	3/16	1.5	①	150	125	—	40	40	—	180	150	8210G73⑥	1P	•	8210G36⑥	1P	•	6.1/F	11.6/F
3/8	1/4	3	0	150	150	—	40	40	—	180	150	8210G93	5D	o	—	—	—	10.1/F	11.6/F
3/8	1/4	3	5	200	150	135	125	100	100	180	150	8210G1	6D	o	—	—	—	6.1/F	11.6/F
3/8	1/4	3	5	300	300	300	—	—	—	175	—	8210G6	5D	o	—	—	—	17.1/F	—
1/2	1/4	2.2	①	150	125	—	40	40	—	180	150	8210G15⑥	2P	•	8210G37⑥	2P	•	6.1/F	11.6/F
1/2	3/8	4	0	150	150	—	40	40	—	180	150	8210G94	5D	o	—	—	—	10.1/F	11.6/F
1/2	3/8	4	0	150	150	125	40	40	—	175	[illegible]	—	—	—	8210G87	7D	•	17.1/F	11.6/F
1/2	3/8	4	5	200	150	135	125	100	100	180	150	8210G2	6D	o	—	—	—	6.1/F	11.6/F
1/2	3/8	4	5	300	300	300	—	—	—	175	—	8210G7	5D	o	—	—	—	17.1/F	—
3/4	3/8	5	0	150	150	125	40	40	—	175	150	—	—	—	8210G88	7D	•	17.1/F	11.6/F
3/4	3/4	5	5	125	125	125	100	90	75	180	150	8210G9	9D	o	—	—	—	6.1/F	11.6/F
3/4	3/4	5	0	150	150	—	40	40	—	180	150	8210G95	8D	o	—	—	—	10.1/F	11.6/F
3/4	3/4	6.5	5	250	150	100	125	125	125	180	150	8210G3	11D	o	—	—	—	6.1/F	11.6/F
3/4	3/4	6	0	350	300	200	200	180	180	200	77	8210B26⑫⑥	10P	⑮	—	—	—	15.4/F	30.6/H
1	1	13	0	150	125	125	100	100	80	180	77	8210B54⑥	31D	⑮	8210B89	15D	⑮	15.4/F	30.6/H
1	1	13	5	150	150	100	125	125	125	180	150	8210G4	12D	o	—	—	—	6.1/F	11.6/F
1	1	13.5	0	300	225	115	—	—	—	200	—	8210B27	14P	•	—	—	—	20/F	—
1¼	1¼	15	0	150	125	125	100	100	80	180	77	8210B55⑥	32D	⑮	—	—	—	15.4/F	30.6/H
1¼	1¼	15	5	150	150	100	125	125	125	180	150	8210G8	16D	o	—	—	—	6.1/F	11.6/F
[illegible]	1¼	22.5	0	150	125	125	100	100	80	180	77	8210B56⑥	33D	⑮	—	—	—	15.4/F	30.6/H
	1	22.5	5	150	150	100	125	125	125	180	150	8210G22	18D	•	—	—	—	6.1/F	11.6/F
1½	1¼	43	5	150	125	90	50	50	50	180	150	8210G100	20P	•	—	—	—	6.1/F	11.6/F
2½	1¼	45	5	150	125	90	50	50	50	180	150	8210G101	21P	•	—	—	—	6.1/F	11.6/F

SPECIFICATIONS (continued)

Pipe Size (Inc.)	Orifice Size (Ins.)	Cv Flow Factor	Operating Pressure Differential (psi) Min.	Max. AC Air-Inert Gas	Max. AC Water	Max. AC Light Oil @ 300 SSU	Max. DC Air-Inert Gas	Max. DC Water	Max. DC Light Oil @ 300 SSU	Max. Fluid Temp. °F. AC	Max. Fluid Temp. °F. DC	Standard Solenoid Enclosures Red-Hat–Type 1 Red-Hat II–Types 1, 2, 3, 3S, 4 and 4X Brass Body Catalog Number	Brass Body Constr. Ref. No. (a)	Brass Body UL Listing	S.S. Body Catalog Number	S.S. Body Constr. Ref. No. (a)	S.S. Body UL Listing	Watt Rating/ Class of Coil Insulation AC	Watt Rating/ Class of Coil Insulation DC
NORMALLY OPEN (Open when de-energized), Buna "N" Seating (Nylon Disc Holder, except as noted)																			
¼	¼	3	0	150	150	125	125	125	80	180	150	8210G31	23D	•	—	—	—	10.1/F	11.6/F
¼	¼	3	5	250	200	200	250	200	200	180	180	8210G11 ⓒ ⓓ	39D	•	—	—	—	10.1/F	11.6/F
½	¼	4	0	150	150	125	125	125	80	180	150	8210G33	23D	•	—	—	—	10.1/F	11.6/F
½	⅜	3	0	150	150	100	125	125	80	180	150	—	—	—	8210H30	37D	•	10.1/F	11.6/F
½	⅜	4	5	250	200	200	250	200	200	180	180	8210G12 ⓒ ⓓ	39D	•	—	—	—	10.1/F	11.6/F
¾	¼	5.5	0	150	150	125	125	125	80	180	150	8210G35	25D	•	—	—	—	10.1/F	11.6/F
¾	⅜	3	0	150	150	100	125	125	80	180	150	—	—	—	8210G34	38D	•	10.1/F	11.6/F
¾	¾	6.5	5	250	200	200	250	200	200	180	180	8210C13	24D	•	—	—	—	15.4/F	16.8/F
1	1	13	0	125	125	125	—	—	—	180	—	8210B57 ⓒ ⓔ	34D	•	—	—	—	20/F	—
1	1	13	5	150	150	125	125	125	125	180	180	8210D14	26D	•	—	—	—	15.4/F	16.8/F
1¼	1¼	15	0	125	125	125	—	—	—	180	—	8210D58 ⓒ ⓕ	35D	•	—	—	—	20/F	—
1¼	1¼	15	5	150	150	125	125	125	125	180	180	8210D18	26D	•	—	—	—	15 4/F	16.8/F
1½	1¼	22.5	0	125	125	125	—	—	—	180	—	8210B59 ⓒ ⓔ	36D	•	—	—	—	20/F	—
1½	1¼	22.5	5	150	150	125	125	125	125	180	180	8210D32	29D	•	—	—	—	15.4/F	16.8/F
2	1¼	43	5	125	125	125	125	125	125	180	150	8210103	30P	•	—	—	—	15.4/F	16.8/F
2½	1¼	45	5	125	125	125	125	125	125	180	150	8210104	27P	•	—	—	—	15.4/F	16.8/F

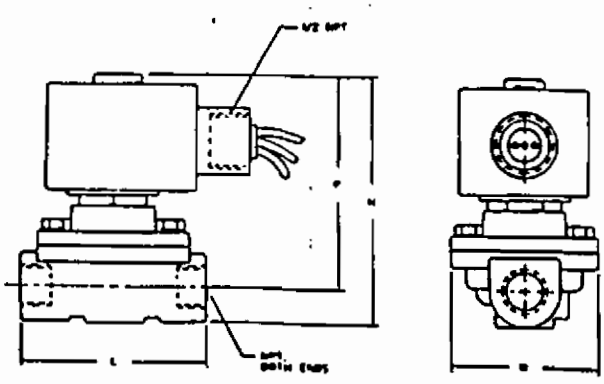
Notes: (a) 5 psi on Air; 1 psi on Water.
(b) Valve provided with Teflon main disc.
(c) Valve includes Ufilem (G.E. trademark) piston.
(d) Letter "D" denotes diaphragm construction; "P" denotes piston construction.
(e) UL listed as General Purpose Valve on AC voltage only
(f) Valves not available with Explosionproof enclosures.
(g) On 50 Hertz service, the watt rating for the 6.1/F solenoid is 8.1 watts.
(h) AC Construction also has nylon seating.
(i) No disc holder.
(j) Stainless Steel disc holder
(k) DC construction must have solenoid mounted vertical and upright.

ELECTRICAL INFORMATION

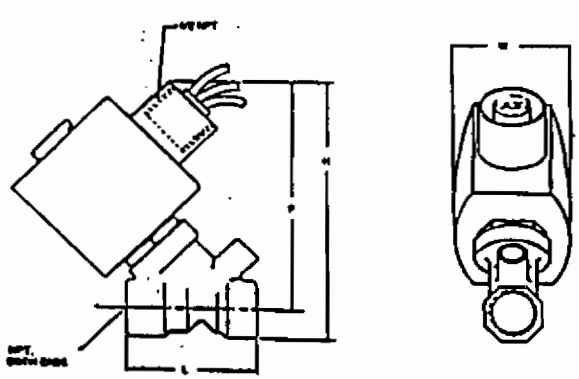
Standard Coil and Class of Insulation	Watt Rating and Power Consumption DC Watts	AC Watts	AC VA Holding	AC VA Inrush	Spare Coil Part No. General Purpose AC	General Purpose DC	Explosionproof AC	Explosionproof DC
F	—	6.1	16	40	238210	—	238214	—
F	11.6	10.1	25	70	238610	238710	238614	238714
F	16.8	15.4	27	160	99257	97617	99257	97617
F	—	17.1	40	93	238610	—	238614	—
F	—	20	43	240	99257	—	99257	—
H	30.6	—	—	—	—	74073	—	74073

DIMENSIONS (in inches)

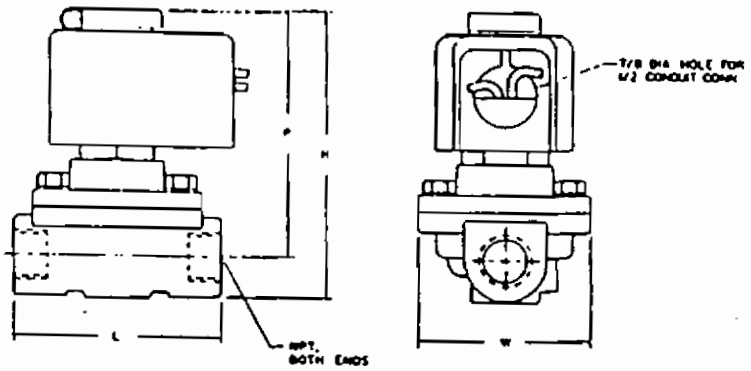
Constr. Ref. 5, 6, 7, 8, 9, 11, 12, 16, 18, 20, 21, 23, 25, 37, 38



Constr. Ref. 1, 2



Constr. Refs. 10, 14, 15, 24, 26–36



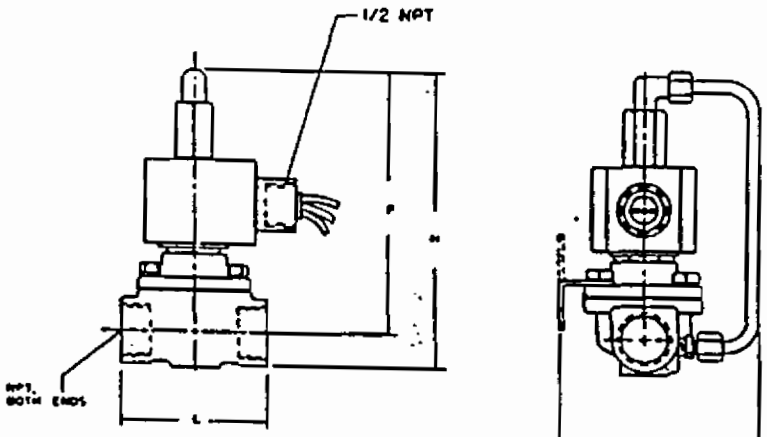
Constr. Ref. No.	K	L	P	W
1*	3 21/32	1 29/32	3 13/32	1 11/16
2*	4 3/16	2 9/32	3 21/32	1 11/16
5	3 29/32	2 3/4	3 11/32	2 3/16
6*	3 13/32	2 3/4	2 27/32	2 3/16
7	4 3/32	2 13/16	3 1/16	2 3/16
8	4 3/16	2 13/16	3 1/16	2 3/16
9*	3 3/16	2 13/16	3	2 3/16
10*#	5 3/16	2 13/16	4 15/32	2 3/16
11*	4 3/32	3 29/32	3 17/32	2 3/4
12*	5 3/16	3 3/4	4	2 13/16
14#	6 11/32	3 13/16	5 23/32	3 3/4
15*	5 13/32	3 3/4	4 15/32	3 21/32
16*	5 3/16	3 29/32	4	3 3/4
18*	6 3/16	4 3/4	4 3/32	3 3/4
20*	7 3/16	5 1/16	4 9/16	4 11/16
21*	7 3/16	5 1/2	4 9/16	5 3/16
23	4 11/32	2 3/4	3 29/32	2 9/32
24	5 3/16	3 29/32	4 1/16	2 3/4
25	4 3/16	2 13/16	3 13/16	2 9/32
26	6 11/32	3 3/4	4 29/32	2 13/16
27	8 1/32	5 1/2	5 13/32	5 3/16
28	6 11/32	3 29/32	4 29/32	3 3/16
29	7 1/32	4 3/16	5 1/16	3 3/4
30	8 1/32	5 3/16	5 13/32	4 11/16
31*	6 3/16	3 3/4	5 3/4	3 3/4
32*	6 1/2	3 29/32	5 1/2	3 3/4
33*	6 3/16	4 3/16	5 3/4	3 29/32
34#	6 29/32	3 3/4	6 9/32	3 3/4
35#	7 11/32	3 29/32	6 11/32	3 3/4
36#	7 29/32	4 3/16	6 9/16	3 29/32
37	4 29/32	2 13/16	3 29/32	2 13/32
38	4 29/32	2 13/16	3 1/16	2 13/32
39	5 1/2	2 3/4	4 13/16	3 13/16

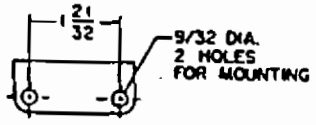
IMPORTANT: Valves may be mounted in any position, except as noted.

#Valve must be mounted with solenoid vertical and upright.

*DC dimensions slightly larger.

Constr. Ref. 39



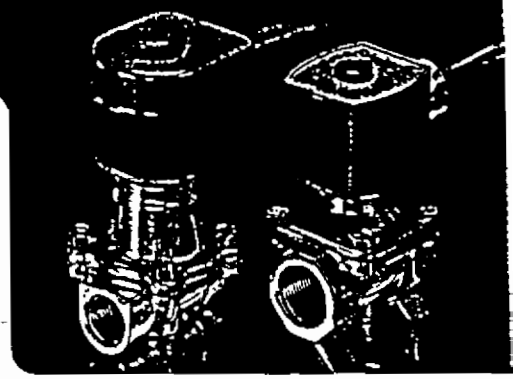


OPTIONAL MOUNTING BRACKET

2 WAY PILOT OPERATED
General Service Solenoid Valves

Brass or Stainless Steel Bodies • 3/8" to 2½" N.P.T.

ASCO
Red-Hat • Red-Hat II
8210 SERIES



Specifications

Solenoid Enclosures: Valves listed in this series have either Red-Hat metal solenoid enclosures or Red-Hat II molded epoxy solenoids. Red-Hat II valves are identified by the change letter "G" in their catalog numbers, e.g., 8210G4, and are shown in red

Standard Enclosures:
Red-Hat — Type 1 General Purpose

Red-Hat II — Types 1, 2, 3, 3S, 4 and 4X Combination General Purpose and Watertight.

Optional Enclosures:
Red-Hat — Types 3, 7 and 9 Combination Explosionproof and Raintight. To order, add prefix "EF" to catalog number. (Except Catalog Numbers 8210B57, 8210B58 and 8210B59)④

Red-Hat II — Types 3, 3S, 4, 4X, 6, 6P, 7 and 9 Combination Explosionproof and Watertight. To order, add prefix "EF" to catalog number.

Additional constructions are available. The Optional Electrical Features Section, page 11, contains descriptions and ordering information for: Open Frame Solenoids • Junction Box Enclosures • Panel Mount Constructions.

Electrical: Standard Voltages
24, 120, 240, 480 volts, AC, 60 Hz
(or 110, 220 volts, AC, 50 Hz)

6, 12, 24, 120, 240 volts, DC

Other voltages are available when required.

Coil: Continuous duty molded Class F or H, as listed.

Nominal Ambient Temperature Ranges: Red-Hat and Red-Hat II Valves/AC Construction: 32°F. to 125°F.

Red-Hat Valves/DC Construction: 32°F. to 77°F. (104°F. occasionally).

Red-Hat II Valves/DC Construction: 32°F. to 104°F.
Refer to Engineering Section for details

Valve Parts in Contact with Fluids:
Body — Brass or Stainless Steel, as listed
Seals and Discs — Buna "N" or Teflon*, as listed
Disc Holder — Nylon, as listed
Core Tube — 305 s.s.
Core and Plugnut — 430F s.s
Springs — 302 s.s.
Shading Coil — Copper (brass body), Silver (stainless steel body)

Approvals: CSA certified.
UL listed as indicated. Refer to Engineering Section for details.

Ordering Information:
Important: We must have catalog number, voltage and Hertz, operating pressure and fluid handled. Use strainers with solenoid valves.

*DuPont Co. trademark

SPECIFICATIONS

Pipe Size (ins.)	Orifice Size (ins.)	Cv Flow Factor	Operating Pressure Differential (psi) Min.	Max. AC Air-Inert Gas	Max. AC Water	Max. AC Light Oil @ 300 SSU	Max. DC Air-Inert Gas	Max. DC Water	Max. DC Light Oil @ 300 SSU	Max. Fluid Temp.°F. AC	Max. Fluid Temp.°F. DC	Standard Solenoid Enclosures Red-Hat–Type 1 Red-Hat II–Types 1,2,3,3S,4 and 4X Brass Body Catalog Number	Brass Body Constr. Ref. No. ②	Brass Body UL Listing	S.S. Body Catalog Number	S.S. Body Constr. Ref. No. ②	S.S. Body UL Listing	Watt Rating/ Class of Coil Insulation ② AC	Watt Rating/ Class of Coil Insulation ② DC
NORMALLY CLOSED (Closed when de-energized), Buna "N" or Teflon① Seating																			
3/8	3/8	1.5	①	150	125	—	40	40	—	180	150	8210G73③	1P	•	8210G36③	1P	•	6.1/F	11.6/F
3/8	5/8	3	0	150	150	—	40	40	—	180	150	8210G93	5D	o	—	—	—	10.1/F	11.6/F
3/8	5/8	3	5	200	150	135	125	100	100	180	150	8210G1	6D	o	—	—	—	6.1/F	11.6/F
3/8	5/8	3	5	300	300	300	—	—	—	175	—	8210G6	5D	o	—	—	—	17.1/F	—
1/2	7/16	2.2	①	150	125	—	40	40	—	180	150	8210G15③	2P	•	8210G37③	2P	•	6.1/F	11.6/F
1/2	5/8	4	0	150	150	—	40	40	—	180	150	8210G94	5D	o	—	—	—	10.1/F	11.6/F
1/2	5/8	4	0	150	150	125	40	40	—	175	150	—	—	—	8210G87	7D	•	17.1/F	11.6/F
1/2	5/8	4	5	200	150	135	125	100	100	180	150	8210G2	6D	o	—	—	—	6.1/F	11.6/F
1/2	5/8	4	5	300	300	300	—	—	—	175	—	8210G7	5D	o	—	—	—	17.1/F	—
3/4	5/8	5	0	150	150	125	40	40	—	175	150	—	—	—	8210G88	7D	•	17.1/F	11.6/F
3/4	3/4	5	5	125	125	125	100	90	75	180	150	8210G9	9D	o	—	—	—	6.1/F	11.6/F
3/4	3/4	5	0	150	150	—	40	40	—	180	150	8210G95	8D	o	—	—	—	10.1/F	11.6/F
3/4	3/4	6.5	5	250	150	100	125	125	125	180	150	8210G3	11D	o	—	—	—	6.1/F	11.6/F
3/4	3/4	6	0	350	300	200	200	180	180	200	77	8210B26②④	10P	⑤	—	—	—	15.4/F	30.6/H
1	1	13	0	150	125	125	100	100	80	180	77	8210B54④	31D	⑤	8210D89	15D	⑤	15.4/F	30.6/H
1	1	13	5	150	150	100	125	125	125	180	150	8210G4	12D	o	—	—	—	6.1/F	11.6/F
1	1	13.5	0	300	225	115	—	—	—	200	—	8210B27	14P	•	—	—	—	20/F	—
1¼	1⅛	15	0	150	125	125	100	100	80	180	77	8210B55④	32D	⑤	—	—	—	15.4/F	30.6/H
1¼	1⅛	15	5	150	150	100	125	125	125	180	150	8210G8	16D	o	—	—	—	6.1/F	11.6/F
½	1¼	22.5	0	150	125	125	100	100	80	180	77	8210B56④	33D	⑤	—	—	—	15.4/F	30.6/H
1½	1¼	22.5	5	150	150	100	125	125	125	180	150	8210G22	18D	•	—	—	—	6.1/F	11.6/F
2	1¾	43	5	150	125	90	50	50	50	180	150	8210G100	20P	•	—	—	—	6.1/F	11.6/F
2½	1¾	45	5	150	125	90	50	50	50	180	150	8210G101	21P	•	—	—	—	6.1/F	11.6/F

8210 SERIES (continued)

SPECIFICATIONS (continued)

Pipe Size (Inc.)	Orifice Size (Ins.)	Cv Flow Factor	Operating Pressure Differential (psi) Min.	Max. AC Air-Inert Gas	Max. AC Water	Max. AC Light Oil @ 300 SSU	Max. DC Air-Inert Gas	Max. DC Water	Max. DC Light Oil @ 300 SSU	Max. Fluid Temp. °F. AC	Max. Fluid Temp. °F. DC	Standard Solenoid Enclosures Red-Hat-Type 1 Red-Hat II–Types 1, 2, 3, 3S, 4 and 4X Brass Body Catalog Number	Brass Body Constr. Rel. No. ④	Brass Body UL Listing	S.S. Body Catalog Number	S.S. Body Constr. Rel. No. ④	S.S. Body UL Listing	Watt Rating/ Class of Coil Insulation AC	Watt Rating/ Class of Coil Insulation DC
NORMALLY OPEN (Open when de-energized), Buna "N" Seating (Nylon Disc Holder, except as noted)																			
3/8	5/16	3	0	150	150	125	125	125	80	180	150	8210G33	23D	•	—	—	—	10.1/F	11.6/F
3/8	5/16	3	5	250	200	200	250	200	200	180	180	8210G11①⑤	39D	•	—	—	—	10.1/F	11.6/F
1/2	5/16	4	0	150	150	125	125	125	80	180	150	8210G34	23D	•	—	—	—	10.1/F	11.6/F
1/2	5/16	3	0	150	150	100	125	125	80	180	150	—	—	—	8210G30	37D	•	10.1/F	11.6/F
1/2	5/16	4	5	250	200	200	250	200	200	180	180	8210G12①⑤	39D	•	—	—	—	10.1/F	11.6/F
3/4	5/8	5.5	0	150	150	125	125	125	80	180	150	8210G35	25D	•	—	—	—	10.1/F	11.6/F
3/4	5/8	3	0	150	150	100	125	125	80	180	150	—	—	—	8210G36	38D	•	10.1/F	11.6/F
3/4	3/4	6.5	5	250	200	200	250	200	200	180	180	8210C13	24D	•	—	—	—	15.4/F	16.8/F
1	1	13	0	125	125	125	—	—	—	180	—	8210B57①⑧	34D	•	—	—	—	20/F	—
1	1	13	5	150	150	125	125	125	125	180	180	8210D14	26D	•	—	—	—	15.4/F	16.8/F
1 1/4	1 1/8	15	0	125	125	125	—	—	—	180	—	8210B58⑤⑧	35D	•	—	—	—	20/F	—
1 1/4	1 1/8	15	5	150	150	125	125	125	125	180	180	8210D18	28D	•	—	—	—	15.4/F	16.8/F
1 1/2	1 1/4	22.5	0	125	125	125	—	—	—	180	—	8210B59⑤⑧	36D	•	—	—	—	20/F	—
1 1/2	1 1/4	22.5	5	150	150	125	125	125	125	180	180	8210D32	29D	•	—	—	—	15.4/F	16.8/F
2	1 3/4	43	5	125	125	125	125	125	125	180	150	8210103	30P	•	—	—	—	15.4/F	16.8/F
2 1/2	1 3/4	45	5	125	125	125	125	125	125	180	150	8210104	27P	•	—	—	—	15.4/F	16.8/F

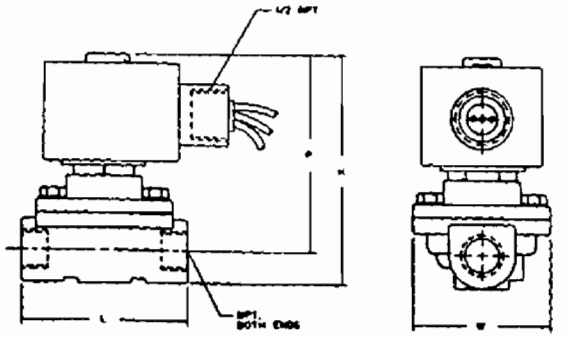
Notes:
① 5 psi on Air; 1 psi on Water
② Valve provided with Teflon main disc
③ Valve includes Ultem (G.E. trademark) piston.
④ Letter "D" denotes diaphragm construction; "P" denotes piston construction
⑤ UL listed as General Purpose Valve on AC voltage only.
⑥ Valves not available with Explosionproof enclosures
⑦ On 50 Hertz service, the watt rating for the 6 1/F solenoid is 8.1 watts
⑧ AC Construction also has nylon seating
⑨ No disc holder.
⑩ Stainless Steel disc holder
⑪ DC construction must have solenoid mounted vertical and upright

ELECTRICAL INFORMATION

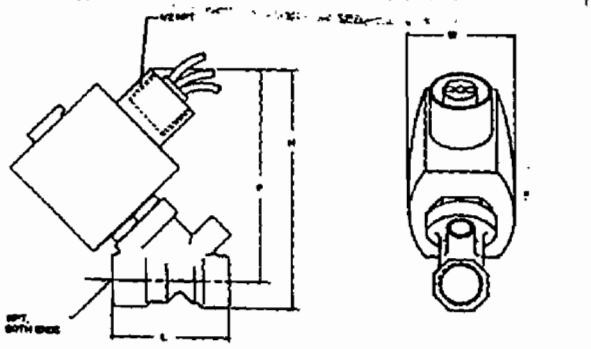
Standard Coil and Class of Insulation	Watt Rating and Power Consumption DC Watts	AC Watts	AC VA Holding	AC VA Inrush	Spare Coil Part No. General Purpose AC	General Purpose DC	Explosionproof AC	Explosionproof DC
F	—	6.1	16	40	238210	—	238214	—
F	11.6	10.1	25	70	238610	238710	238614	238714
F	16.8	15.4	27	160	99257	97617	99257	97617
F	—	17.1	40	93	238610	—	238614	—
F	—	20	43	240	99257	—	99257	—
H	30.6	—	—	—	—	74073	—	74073

DIMENSIONS (in inches)

Constr. Rel. 5, 6, 7, 8, 9, 11, 12, 16, 18, 20, 21, 23, 25, 37, 38

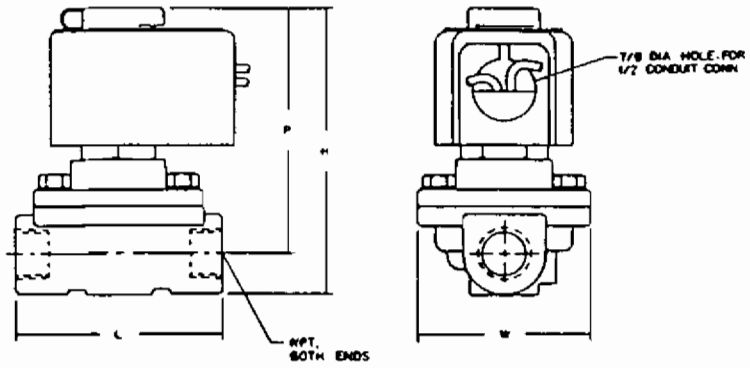


Constr. Rel. 1, 2



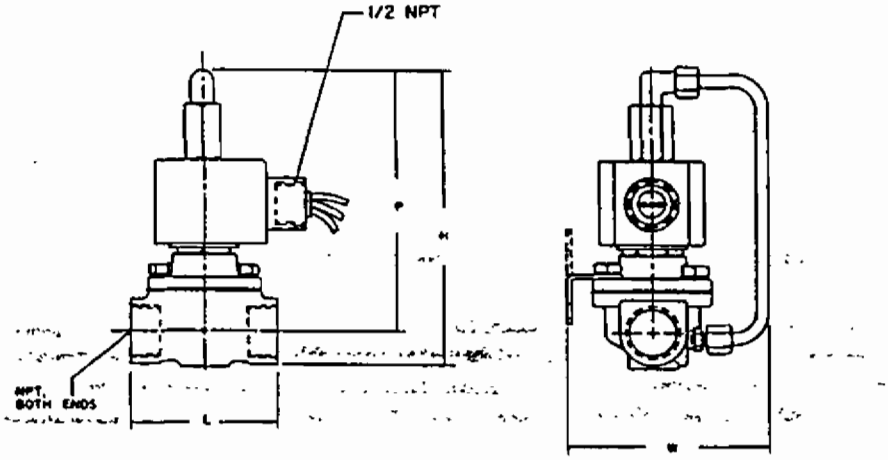
DIMENSIONS (in inches)

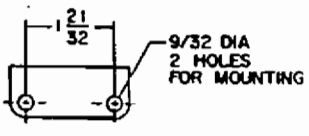
Constr. Refs. 10, 14, 15, 24, 26–36



Constr. Ref. No.	H	L	P	W
1*	3 21/32	1 29/32	3 13/32	1 11/16
2*	4 3/16	2 9/32	3 21/32	1 11/16
5	3 29/32	2 3/4	3 11/32	2 3/16
6*	3 13/32	2 3/4	2 27/32	2 3/16
7	4 3/32	2 13/16	3 7/16	2 3/16
8	4 1/8	2 13/16	3 7/16	2 3/16
9*	3 3/8	2 13/16	3	2 3/16
10*#	5 1/4	2 13/16	4 19/32	2 3/16
11*	4 5/32	3 25/32	3 17/32	2 3/4
12*	5 3/8	3 3/4	4	2 15/16
14#	6 17/32	3 15/16	5 23/32	3 1/4
15*	5 11/32	3 3/4	4 15/32	3 27/32
16*	5 3/8	3 21/32	4	3 3/8
18*	6 1/8	4 3/8	4 5/32	3 3/4
20*	7 5/16	5 1/16	4 9/16	4 11/16
21*	7 5/16	5 1/2	4 9/16	5 3/16
23	4 11/32	2 3/4	3 25/32	2 9/32
24	5 1/16	3 25/32	4 7/16	2 3/4
25	4 9/16	2 13/16	3 15/16	2 9/32
26	6 17/32	3 3/4	4 29/32	2 15/16
27	8 7/32	5 1/2	5 15/32	5 3/16
28	6 17/32	3 21/32	4 29/32	3 3/8
29	7 1/32	4 3/8	5 1/16	3 3/4
30	8 7/32	5 1/16	5 13/32	4 11/16
31*	6 1/16	3 3/4	5 1/4	3 1/4
32*	6 1/2	3 21/32	5 1/2	3 1/4
33*	6 7/8	4 3/8	5 3/4	3 29/32
34#	6 29/32	3 3/4	6 1/32	3 1/4
35#	7 11/32	3 21/32	6 11/32	3 1/4
36#	7 21/32	4 3/8	6 3/16	3 29/32
37	4 21/32	2 13/16	3 29/32	2 13/32
38	4 21/32	2 13/16	3 7/16	2 13/32
39	5 1/2	2 3/4	4 13/16	3 13/16

Constr. Ref. 39





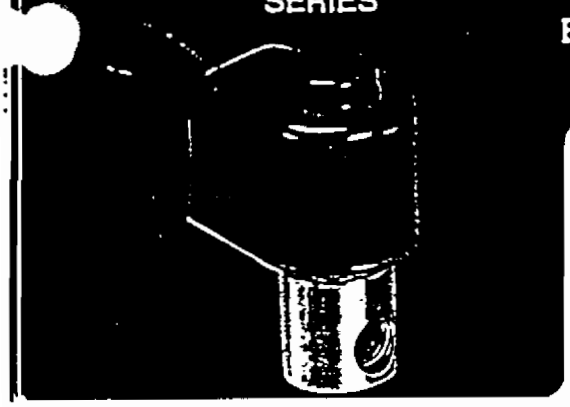
OPTIONAL MOUNTING BRACKET

IMPORTANT: Valves may be mounted in any position, except as noted.

#Valve must be mounted with solenoid vertical and upright.

*DC dimensions slightly larger.

ASCO
Red-Hat
LONG LIFE
SERIES



2 WAY LONG LIFE
Quiet Operating Solenoid Valves

Brass or Aluminum Bodies • ⅛" to 2" N.P.T. • Air and Inert Gas Only

General Description

These are standard Red-Hat solenoid valves modified to extend the cycling life when handling dry air and gas by eliminating metal-to-metal contact. In addition, the internal AC hum and the metallic click heard when the solenoid is energized have been virtually eliminated.

All valves listed are suitable for both rapid cycling and continuous energization.

Specifications

Solenoid Enclosures: Valves listed in this series use the Red-Hat metal solenoid enclosure.

Standard Enclosures:
Red-Hat — Type 1 General Purpose

Optional Enclosures:
Red-Hat — Type 7 (C and D) Explosionproof which also meets Types 3 and 9. To order, add prefix "EF" to catalog number.

Additional constructions are available. The Optional Electrical Features Section, page 11, contains descriptions and ordering information for: Open Frame Solenoids • Junction Box Enclosures • Panel Mount Constructions.

Electrical: Standard Voltages:
24, 120, 240, 480 volts, AC, 60 Hz

Consult local ASCO sales office for DC voltages.

Coil: Continuous duty molded Class A diode coil.

Nominal Ambient Temperature Range: 32°F to 77°F (104°F occasionally).
Refer to Engineering Section for details

Installation: For optimum life, the solenoid should be installed vertical and upright.

Approvals: CSA certified. UL Listed General Purpose Valves—8262 Series only. Refer to Engineering Section for details.

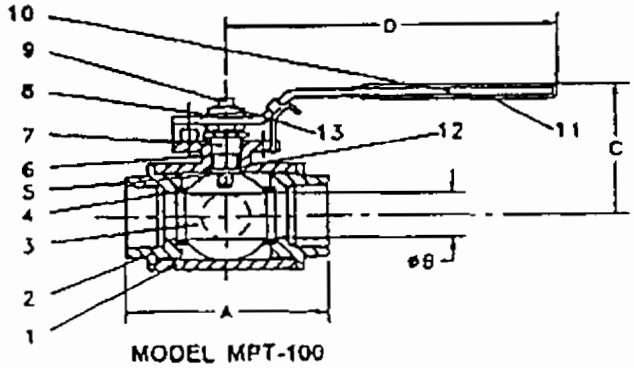
Ordering Information:
Important: We must have catalog number, voltage and Hertz, operating pressure and fluid handled. Use strainers with solenoid valves.

SPECIFICATIONS

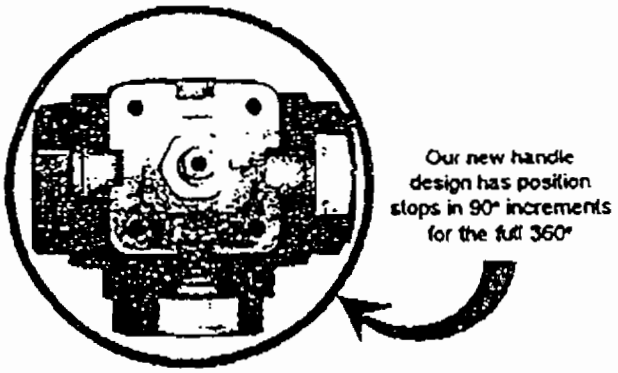
Pipe Size (ips.)	Orifice Size (ins.)	Cv Flow Factor	Operating Pressure Differential (psi) Min.	Operating Pressure Differential (psi) Max. AC Air-Inert Gas	Max. Fluid Temp. °F. AC	Body Material	Standard Solenoid Enclosures Red-Hat–Type 1 Catalog Number	Watt Rating/ Class of Coil Insulation ① AC
5 MILLION CYCLE CAPABILITY								
NORMALLY CLOSED (Closed when de-energized)								
⅜	⅜	3	5	125	140	Brass	8210D1Q	13.4/A
½	½	4	5	125	140	Brass	8210D2Q	13.4/A
¾	¾	4.5	5	125	140	Brass	8210D9Q	13.4/A
1	1⅛	13	1	20	140	Aluminum	8215959Q	13.4/A
1¼	1⅛	15	1	20	140	Aluminum	8215960Q	13.4/A
1½	1⅛	20	1	20	140	Aluminum	8215970Q	13.4/A
2	2½₂	34	1	20	140	Aluminum	8215980Q	13.4/A
NORMALLY OPEN (Open when de-energized)								
⅜	⅜	3	5	125	140	Brass	8210C11Q	13.4/A
½	⅜	4	5	125	140	Brass	8210C12Q	13.4/A
¾	¾	4.5	5	125	140	Brass	8210C13Q	13.4/A
1	1⅛	13	1	20	140	Aluminum	8215990Q	13.4/A
1¼	1⅛	15	1	20	140	Aluminum	82151000Q	13.4/A
1½	1⅛	20	1	20	140	Aluminum	82151010Q	13.4/A
2	2½₂	34	1	20	140	Aluminum	82151020Q	13.4/A
20 MILLION CYCLE CAPABILITY								
NORMALLY CLOSED (Closed when de-energized)								
⅛	⅛	.35	0	125	140	Brass	8262770Q	13.4/A
¼	⅛	.35	0	125	140	Brass	8262C232Q	13.4/A
¼	7/32	.85	0	50	140	Brass	8262B208Q	13.4/A
NORMALLY OPEN (Open when de-energized)								
⅛	⅛	.09	0	125	140	Brass	8262C91Q	13.4/A
¼	⅛	.09	0	125	140	Brass	8262C32Q	13.4/A

Note: ① VA Requirements, Inrush and Holding: 19VA

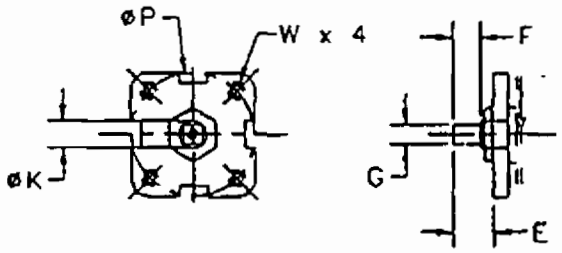
MODEL MPT-100
3 WAY STANDARD PORT BALL VALVE 800 WOG



MODEL MPT-100

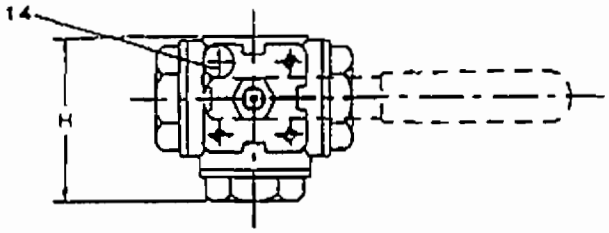


Our new handle design has position stops in 90° increments for the full 360°



BILL OF MATERIALS:

NO.	PART NAME	QTY.	MATERIAL
1	BODY	1	CF8M TYPE-316
2	END CAP	3	CF8M TYPE-316
3	BALL	1	SS-316
4	SEAT	4	REINFORCED PTFE
5	STEM	1	CF8M TYPE-316
6	PACKING	1	PTFE
7	GLAND NUT	1	SS-304
8	WASHER	2	SS-304
9	STEM CAP NUT	1	SS-304
10	HANDLE	1	SS-304
11	PLASTIC COVER	1	VINYL PLASTISOL
12	THRUST WASHER	1	PTFE
13	FLAT WASHER	1	SS-304
14	STOP PIN	1	SS-304



Valve Stem Seals and Seats 100% tested by 100 psig air under water for bubble tight integrity

SPECIFICATIONS

Body Test Pressure:	1200 PSIG Hydrostatic
Pressure Rating:	800 PSI WOG

NOTE: Now Available 3 Way Valve with Quick-Clamp Sanitary Ends - Model MPC-100. Consult Factory for Additional Information

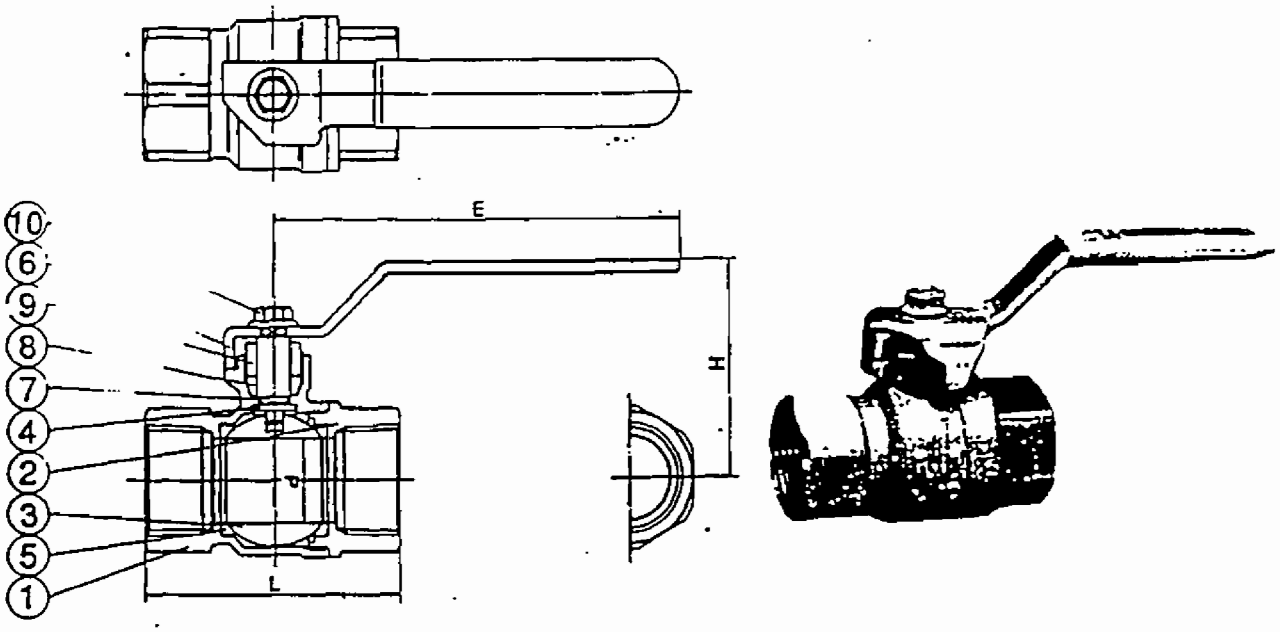
DIMENSIONS:

VALVE SIZES	1/4"	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
A	3.11	3.11	3.11	3.43	4.25	4.88	5.31	6.45
B	0.37	0.37	0.47	0.60	0.79	0.98	1.26	1.57
C	2.4	2.4	2.4	2.8	3.3	3.3	3.5	4.0
D	6.2	6.2	6.2	6.2	7.3	8.0	9.2	9.2
H	2.42	2.42	2.42	2.83	3.34	3.80	4.23	5.41
APP WEIGHT (LBS)	1.8	1.8	1.8	2.5	4.3	6.5	9.0	15.5
VALVE TORQUE (in-lbf)	50	80	90	120	160	300	480	800
E	0.4	0.4	0.45	0.6	0.7	0.95	0.95	0.97
F	0.21	0.21	0.29	0.29	0.46	0.60	0.60	0.62
G	0.36	0.36	0.36	0.36	0.36	0.44	0.44	0.555
K	0.47	0.47	0.47	0.47	0.47	0.59	0.59	0.725
P	1.65	1.65	1.65	1.97	1.97	1.97	2.76	2.76
W	1/4-20UNC	1/4-20UNC	1/4-20UNC	1/4-20UNC	1/4-20UNC	1/4-20UNC	5/16-18UNC	5/16-18UNC

FIG. NO. 5044F

600-POUND BRASS/BRONZE BALL VALVES

Full port, 2-piece body, blowout-proof stem, lever handle, screwed ends.



Working Pressures

Working Pressure Non-Shock (psi)		Test Pressure (psi)	
Steam	Cold Water, Oil,Gas	Shell (water)	Seat (Air)
150	600	100	100

Nomenclature and Materials

1	Body	Forged brass	B283-C37700
2	Body end piece	Forged brass	B283-C37700
3	Ball	Forged brass, Hard chromium plated	B283-C37700
4	Stem	Forged brass	B124-C37700
5	Seat	Teflon®	
6	Lever handle	Steel, Zinc plated	A36
7	"O" ring	Viton®	
8	Gland packing	Teflon®	
9	Gland	Forged Brass	B283-C37700
10	Handle bolt	Steel, Zinc plated	A36

® Dupont's trade name

Dimensions Unit: Inch

Size / Mark	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
L	1.89	1.89	2.20	2.64	3.03	3.19	3.70	4.33	5.55	6.42	7.40
H	1.46	1.46	2.09	2.24	2.56	2.80	3.11	3.43	4.41	4.80	5.51
E	3.15	3.15	3.54	3.54	4.92	4.92	5.51	5.51	7.87	7.87	11.02
d	0.39	0.39	0.59	0.79	1.00	1.26	1.57	2.00	2.56	3.15	4.00

Cv Factor

	8.0	8.0	15.0	30.0	60.0	110	130	360	450	620	1200

Torque Rating

ft-lbs	0.72	0.72	1.30	1.80	2.29	4.33	6.50	8.67	14.46	25.35	36.20

Weight

lbs	0.33	0.31	0.41	0.80	1.28	1.84	2.70	4.20	7.75	12.20	18.95

Note:
Extension stem and T (Wing) Handle are available on request.

RED-WHITE VALVE CORP.

01/91

INSTALLATION AND MAINTENANCE INSTRUCTIONS

2-WAY INTERNAL PILOT OPERATED SOLENOID VALVES HUNG DIAPHRAGM — 3/8, 1/2 AND 3/4 N.P.T. NORMALLY CLOSED OPERATION

BULLETINS
8210
8211

ASCO

Form No. V-5825

DESCRIPTION

Bulletin 8210's are 2-way, normally closed, internal pilot operated solenoid valves. Valve body and bonnet are of brass construction. Standard valves have a General Purpose, NEMA Type 1 Solenoid Enclosure.

Bulletin 8211's are the same as Bulletin 8210's except the solenoids are equipped with an enclosure which is designed to meet NEMA Type 4 Watertight, NEMA Type 7 (C or D) Hazardous Locations - Class I, Group C or D, and NEMA Type 9 (E, F or G) Hazardous Locations - Class II, Group E, F or G. The explosion-proof/watertight solenoid enclosure is shown on a separate sheet of Installation and Maintenance Instructions, Form No. V-5380.

Bulletin 8210 and 8211 valves with suffix 'HW' in the catalog number are specifically designed for hot water service.

OPERATION

Normally Closed: Valve is closed when solenoid is de-energized and opens when solenoid is energized.

MANUAL OPERATOR (Optional)

Valves with suffix 'MO' in catalog number are provided with a manual operator which allows manual operation when desired or during an interruption of electrical power. To operate valve manually, push in knurled cap and rotate clockwise 180°. Disengage manual operator by rotating knurled cap counterclockwise 180° before operating electrically.

MANUAL OPERATOR LOCATION (Refer to Figure 3)

Manual operator (when shipped from factory) will be located over the valve outlet. Manual operator may be relocated at 90° increments by rotating valve bonnet. Remove bonnet screws (4) and rotate valve bonnet with solenoid to desired position. Replace bonnet screws (4) and torque in a crisscross manner to 110 ± 10 inch pounds.

If valve is installed in system and is operational, proceed in the following manner:

WARNING: Depressurize valve and turn off electrical power supply.

1. Remove retaining cap or clip and slip the entire solenoid enclosure off the solenoid base sub-assembly. CAUTION: When metal retaining clip disengages, it will spring upwards.
2. Remove bonnet screws (4) and rotate valve bonnet to desired position.
3. Replace bonnet screws (4) and torque in a crisscross manner to 110 ± 10 inch pounds.
4. Replace solenoid enclosure and retaining clip or cap.

INSTALLATION

Check nameplate for correct catalog number, pressure, voltage and service.

TEMPERATURE LIMITATIONS

For maximum valve ambient and fluid temperatures refer to chart. The temperature limitations listed are for UL applications. For non UL applications, higher ambient and fluid temperature limitations are available. Consult factory. Check catalog number on nameplate to determine maximum temperatures.

Construction	Coil Class	Catalog Number Prefix	Maximum Ambient Temp. °F.	Maximum Fluid Temp. °F.
A-C Construction (Alternating Current)	A	None or DA	77	180
	F	DF or FT	122	180
	H	HT	140	180
D-C Construction (Direct Current)	A, F or H	None, FT or HT	77	150
Catalog Numbers Suffixed 'HW' A-C Construction (Alternating Current)	A	None or DA	77	210
	F	DF or FT	77	210
	H	HT	122	210

POSITIONING/MOUNTING

Valve may be mounted in any position. For mounting bracket (optional feature) dimensions, refer to Figure 1.

PIPING

Connect piping to valve according to markings on valve body. Apply pipe compound sparingly to male pipe threads only; if applied to valve threads, it may enter the valve and cause operational difficulty. Pipe strain should be avoided by proper support and alignment of piping. When tightening the pipe do not use valve as a lever. Wrenches applied to valve body or piping are to be located as close as possible to connection point. **IMPORTANT: Valves with suffix 'HW' in the catalog number have a special diaphragm material which is specifically compounded for hot water service. This material can be attacked by oil and grease. Wipe the pipe threads clean of cutting oils and use teflon tape to seal pipe joints.**

IMPORTANT: For the protection of the solenoid valve, install a strainer or filter suitable for the service involved in the inlet side as close to the valve as possible. Periodic cleaning is required depending on the service conditions. See Bulletins 8600, 8601 and 8602 for strainers.

WIRING

Wiring must comply with Local and National Electrical Codes. Housings for all solenoids are provided with connections for 1/2 inch conduit. The general purpose solenoid enclosure may be rotated to facilitate wiring by removing the retaining cap or clip. CAUTION: When metal retaining clip disengages it will spring upwards. Rotate to desired position. Replace retaining cap or clip before operating.

NOTE: Alternating Current (A-C) and Direct Current (D-C) Solenoids are built differently. To convert from one to the other, it is necessary to change the complete solenoid including the solenoid base sub-assembly and core assembly.

SOLENOID TEMPERATURE

Standard catalog valves are supplied with coils designed for continuous duty service. When the solenoid is energized for a long period, the solenoid enclosure becomes hot and can be touched with the hand for only an instant. This is a safe operating temperature. Any excessive heating will be indicated by the smoke and odor of burning coil insulation.

MAINTENANCE

WARNING: Turn off electrical power and depressurize valve before making repairs. It is not necessary to remove valve from pipe line for repairs.

Form No. V-5825 PRINTED IN U.S.A. 1975 Automatic Switch Co.

ASCO Valves
FLORHAM PARK, NEW JERSEY 07932

ASCO

CLEANING

A periodic cleaning of all solenoid valves is desirable. The time between cleanings will vary, depending on media and service conditions. In general, if the voltage to the coil is correct, sluggish valve operation, excessive leakage or noise will indicate that cleaning is required.

REVENTIVE MAINTENANCE

1. Keep the medium flowing through the valve as free from dirt and foreign material as possible.
2. While in service, operate valve at least once a month to insure proper opening and closing.
3. Periodic inspection (depending on media and service conditions) of internal valve parts for damage or excessive wear is recommended. Thoroughly clean all parts. Replace any parts that are worn or damaged.

IMPROPER OPERATION

1. **Faulty Control Circuit:** Check electrical system by energizing solenoid. A metallic click signifies the solenoid is operating. Absence of the click indicates loss of power supply. Check for loose or blown-out fuses, open circuited or grounded coil, broken lead wires or splice connections.
2. **Burned-Out Coil:** Check for open circuited coil. Replace coil if necessary.
3. **Low Voltage:** Check voltage across coil leads. Voltage must be at least 85% of nameplate rating.
4. **Incorrect Pressure:** Check valve pressure. Pressure to the valve must be within range specified on nameplate.
5. **Excessive Leakage:** Disassemble valve and clean all parts. Replace worn or damaged parts with a complete Spare Parts Kit for best results.

COIL REPLACEMENT (Refer to Figure 2)

Turn off electrical power supply and disconnect coil leads. Proceed in the following manner:

1. Remove retaining cap or clip, nameplate and cover. CAUTION: When metal retaining clip disengages, it will spring upwards.
2. Remove spring washer, insulating washer and coil. Insulating washers are omitted when a molded coil is used.
3. Reassemble in reverse order of disassembly paying careful attention to exploded view provided for identification and placement of parts.

AUTION: Solenoid must be fully reassembled as the housing and internal parts are part of and complete the magnetic circuit. Place insulating washer at each end of coil if required.

VALVE DISASSEMBLY (Refer to Figures 2 and 3)

Depressurize valve and turn off electrical power supply. Proceed in the following manner:

1. Remove retaining cap or clip and slip the entire solenoid enclosure off the solenoid base sub-assembly. CAUTION: When metal retaining clip disengages, it will spring upwards.
2. Unscrew solenoid base sub-assembly and remove bonnet gasket.
3. Remove valve bonnet screws (4) and valve bonnet.
4. For normal maintenance, it is not necessary to disassemble the manual operator (optional feature) unless external leakage is evident. To disassemble remove stem pin, manual operator stem, stem spring and stem gasket.
5. Remove core spring, core/diaphragm sub-assembly and body gasket. CAUTION: Do not damage or distort hanger spring between core/diaphragm sub-assembly.
6. All parts are now accessible for cleaning or replacement. Replace worn or damaged parts with a complete Spare Parts Kit for best results.

VALVE REASSEMBLY

1. Reassemble in reverse order of disassembly paying careful attention to exploded views provided for identification and placement of parts.
2. Replace body gasket and core/diaphragm sub-assembly. Locate the bleed hole in core/diaphragm sub-assembly approximately 45° from the valve outlet.
3. Replace core spring with wide end in core first; closed end protrude from top of core.
4. If removed, replace manual operator stem, stem spring, stem gasket and stem pin.
5. Replace valve bonnet and bonnet screws (4). Torque bonnet screws (4) in a crisscross manner to 110 ± 10 inch pounds.
6. Replace bonnet gasket and solenoid base sub-assembly. Put solenoid base sub-assembly to 175 ± 25 inch pounds.
7. Replace solenoid enclosure and retaining cap or clip.
8. After maintenance, operate the valve a few times to be sure of proper opening and closing.

SPARE PARTS KITS

Spare Parts Kits and Coils are available for ASCO valves.
Parts marked with an asterisk (*) are supplied in Spare Parts Kits.

ORDERING INFORMATION FOR SPARE PARTS KITS
When Ordering Spare Parts Kits or Coils Specify Valve Catalog Number, Serial Number and Voltage.

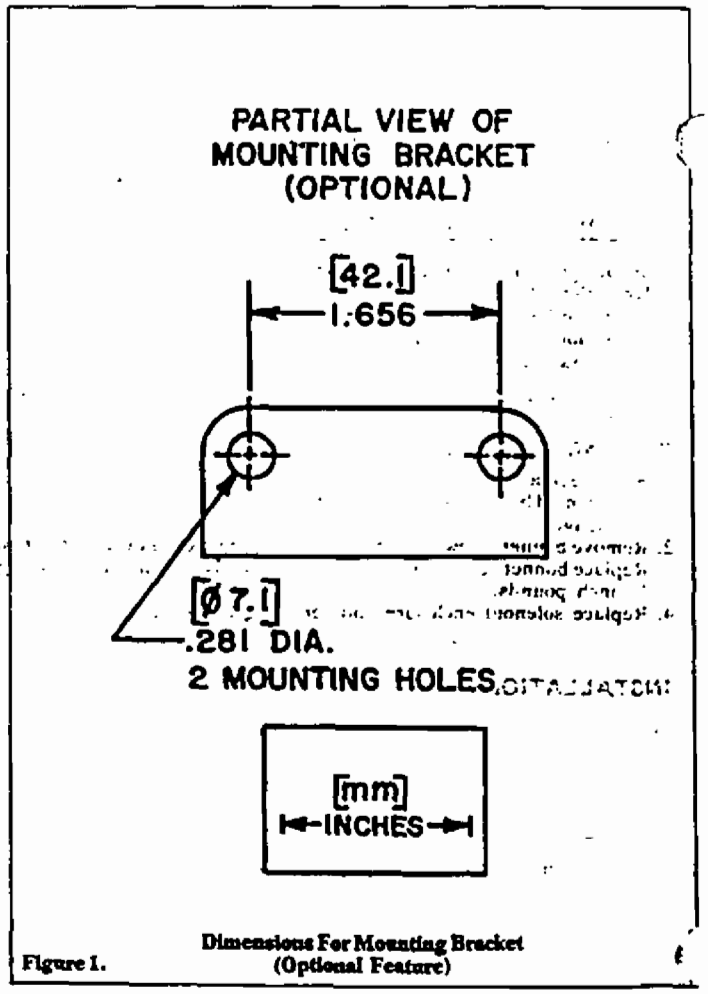
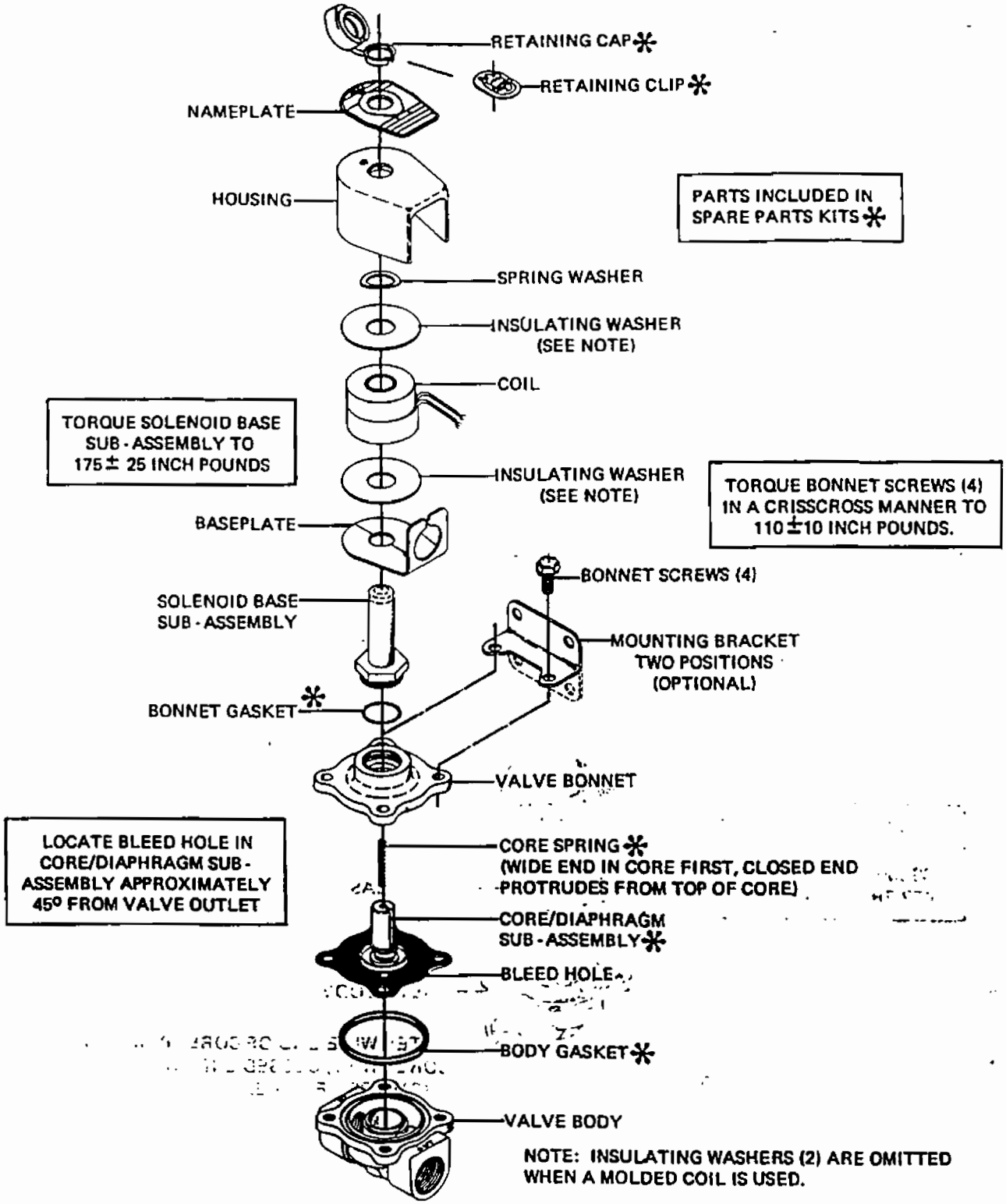
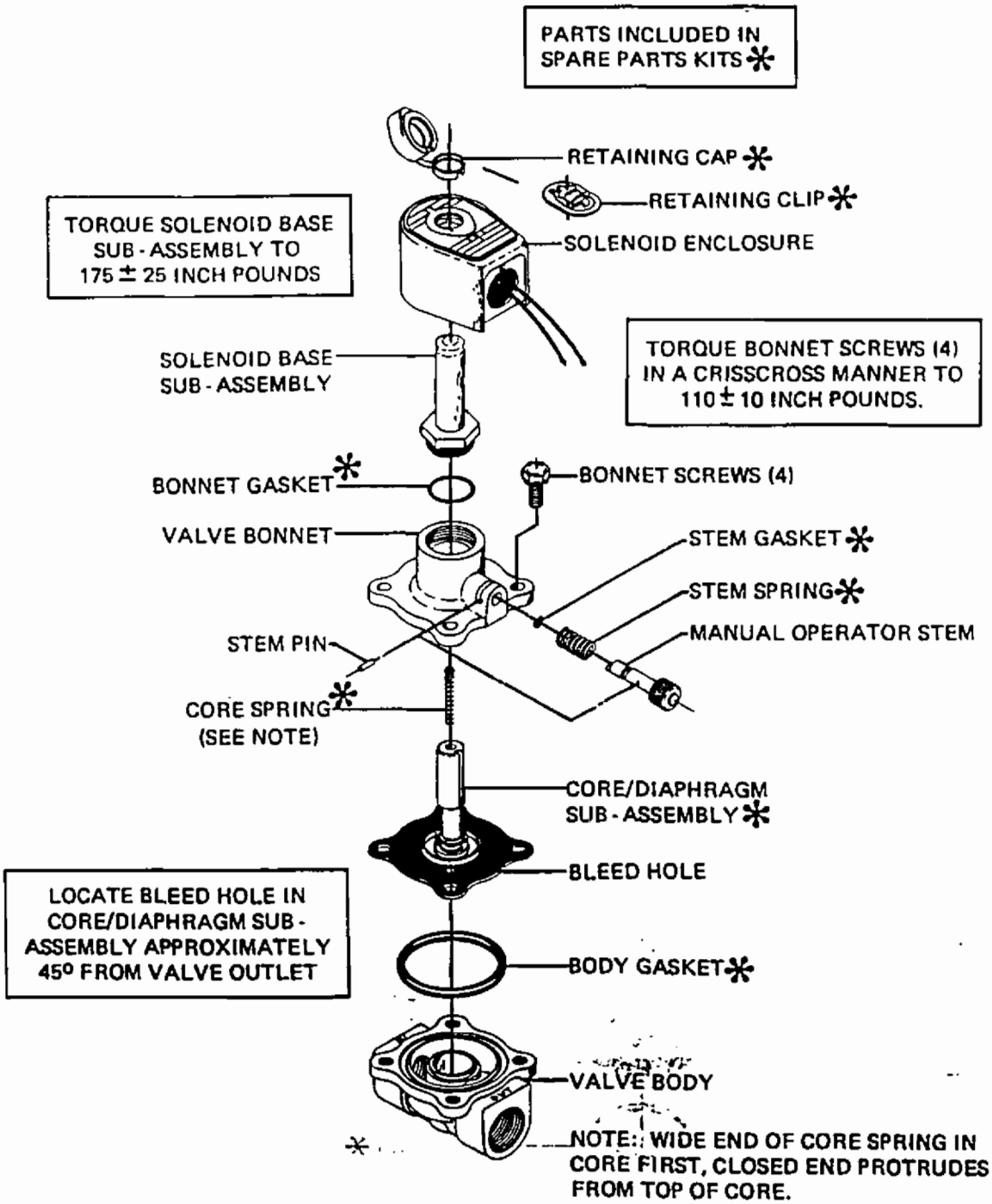


Figure 1. Dimensions For Mounting Bracket (Optional Feature)



Bulletin 8210 — 3/8, 1/2 & 3/4 N.P.T. — A-C Construction
General purpose solenoid enclosure shown.
For explosion-proof/watertight solenoid enclosure used on Bulletin 8211, see Form No. V-5380.

Figure 2.



Bulletin 8210 — Manual Operator
General purpose solenoid enclosure shown.
For explosion-proof/watertight solenoid enclosure used on Bulletin 8211, see Form No. V-5380.

Figure 3.

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Attachment C

Pump Testing and Modeling

C.1 INTRODUCTION

One of the remedial alternatives to be investigated during the treatability study is the extraction and re-injection of groundwater. Data required for such an effort include appropriate spacing and sizing of the extraction and re-injection system, including wells, piping, pumps, etc. Typically this data is provided by a knowledge of site conditions (contamination distribution, hydrogeology, etc.) and a simulation of the remedial system operating within these conditions. Simulating such a system requires development of a conceptual model of the hydrogeology and a quantification of input parameters such as storativity and hydraulic conductivity. In order to provide data for conceptual model development, first estimates of aquifer characteristics for the simulation, and to preliminarily gauge aquifer response to pumping stresses, an aquifer characterization test was performed specific to SWMU 166. The characterization test was designed in several phases, each with a specific purpose, as listed below:

- Phase 1: Ambient condition monitoring – intended to identify and quantify ambient trends and/or effects in the aquifer system;

- Phase 2: Step drawdown testing – intended to provide a first measure of well performance and aquifer response for subsequent constant-rate pumping testing. The ultimate goal of this phase is to determine the maximum withdrawal rate that the pumping test system can sustain for a significant period of time.

- Phase 3: Constant-rate pumping test – intended to quantify initial aquifer response curves during pumping, and to monitor the aquifer once stabilization occurs. Analyses of the data yields estimates of storativity and hydraulic conductivity.

- Phase 4: Recovery monitoring – intended to quantify the aquifer response following pump shut-down. Analyses of the data yields estimates of storativity and hydraulic conductivity.

The following sections outline the methodologies and results of the aquifer characterization test.

C.2 AQUIFER CHARACTERIZATION TEST

After an initial round of water levels were collected, the pump, transducers, data loggers, rain gauge, and any other necessary equipment were installed and set up. Next, operation of the pump and data loggers was tested, the data loggers were programmed, and transducers and water level indicators were calibrated.

C.2.1 Monitoring Equipment and Observation Wells

To improve measurement accuracy and reduce manpower requirements, water levels in the pumping well and six nearby observation wells were measured using pressure transducers and automatic data loggers. Clocks on the data loggers were synchronized with each other before testing began. Water levels in most of the other site wells were monitored intermittently by hand.

Observation wells monitored with data loggers:

PW-1 (pumping well)		P-01	P-02
09D	10D	14D	16D

The effects of barometric pressure change on the aquifer were investigated during each phase of the test. Pressure changes were monitored with a barometric pressure transducer connected to a data logger.

C.2.2 Phase 1, Ambient Condition Monitoring

Ambient monitoring parameters including barometric pressure and static water level changes were monitored for 43 hours prior to the first test and during each phase of testing. Ambient monitoring was conducted to identify rising or falling water level trends in the aquifer and the influence of any nearby pumping wells. Barometric pressure was also monitored continuously during the ambient phases of the test to identify any potential relationships between it and water levels.

Because of their distance from the pumping well, outlying hand-monitored wells were considered ambient monitoring points. Therefore, the ambient behavior of the aquifer was monitored

throughout the entire testing period. Ambient monitoring did not reveal any operating production wells near the site. The monitoring did indicate a subtle but steady drop in water levels throughout most of the testing period that reversed after heavy rains came during the second constant rate test. Water levels dropped an average of 0.07 feet until infiltrating water from the 2.93-inch rain caused an average 1.13-foot water level rise in the distant deep wells.

C.2.3 Phase 2, Step Drawdown Testing

Step drawdown testing involves pumping a well at increasingly greater discharge rates (steps) while monitoring drawdown in the well. By comparing each discharge rate with the corresponding drawdown, the optimum pumping rate for the tested well can be estimated.

A step drawdown test on PW-1 was started at 1445 on January 20, 1999 with a flow rate of approximately 0.5 gallons per minute (gpm). Drawdown in the pumping well was monitored during the test to determine when the next step could begin. After 60 minutes the drawdown stabilized at 3.19 feet and the flow rate was stepped up. The rate for the second step was 0.65 gpm and the water level stabilized after 30 minutes with 4.68 feet of drawdown.

Additionally, during development, PW-1 was pumped at approximately 1.75 gpm for 30 minutes and the drawdown was 13.79 feet. Before the second constant rate test was conducted, a single step test was conducted on the well to determine it's response to a higher pumping rate of 2 gpm. At 60 minutes, the water level stabilized with 14.7 feet of drawdown.

Groundwater from the pumping well was routed through two 5-foot long, 12-inch diameter activated carbon tanks and then to the sanitary sewer. Influent and effluent samples were collected and analyzed for VOC concentrations on approximately 24 hour intervals during pumping periods.

C.2.4 Phase 3, Constant-Rate Aquifer Test

As the name implies, a constant-rate pumping test involves pumping a well at a constant discharge rate while simultaneously recording water levels in pumping and observation wells and the time

elapsed from the start of pumping. The water level/elapsed-time measurements are used to estimate aquifer characteristics (hydraulic conductivity, storativity, etc.)

Two constant-rate pumping tests were conducted on PW-1 at different pumping rates. Test 1 started at 1200 on January 21, 1999 and ran for 18.57 hours until the pump overheated and stopped. The pumping rate for this test was 1 gpm.

Because Test 1 was prematurely terminated and greater stressing of the aquifer was desired, a second constant-rate test was conducted. Test 2 started at 0900 on January 23 at a pumping rate of 1.71 gpm. This test lasted for 51.67 hours, however; the heavy rains masked and eliminated the drawdown in most of the observation wells approximately 10 hours into the test and throughout the rest of the test.

C.2.5 Phase 4, Recovery Monitoring

Recovery tests involve monitoring the rise of water levels back to static conditions after pumping has stopped. Recovering water levels are recorded with the time elapsed after pump shutoff and the relationships between pumping rate, pumping duration, and recovery time are used to estimate aquifer characteristics. Generally, recovery data provide a means to double-check the results obtained during the constant-rate test.

Because Test 1 was prematurely terminated, little early-time recovery data could be collected. The rain event during Test 2 adversely altered the recovery rate of wells still showing drawdown. Therefore, the recovery data from both tests were deemed unusable and no recovery analysis was conducted.

After testing, the transducers were removed and decontaminated. The data loggers were taken to the office and the data was downloaded to a PC.

C.2.6 Equipment Decontamination

To prevent cross-contamination, water level indicators, pressure transducers, and other equipment that came in contact with contaminated groundwater was decontaminated before and after each use.

Decontamination Steps:

1. Equipment was rinsed with deionized water.
2. Equipment was rinsed with isopropyl alcohol.
3. Equipment was rinsed with deionized water.

C.3 DATA MANAGEMENT AND MANIPULATION

Once in the computer, data were loaded into a spreadsheet program for manipulation and graphing. Before the data can be analyzed, drawdown corrections must be evaluated.

C.3.1 Drawdown Corrections

A rainfall event occurred about 24 hours into the test, but drawdown data collected after the rain event was not needed to estimate transmissivity and conductivity. Drawdown data prior to the rain event were evaluated for correlation with barometric pressure and ambient water level trends. Both these parameters were determined to have a negligible effect on water levels. Therefore, drawdown corrections for barometric pressure changes or ambient water level trends were not required or conducted.

C.3.2 Data Reduction and Compilation

Data from the pumping tests were compiled using the computer program Aquifer Test Solver (AQTESOLV) for Windows by HydroSOLVE, Inc. (1998). AQTESOLV has several widely published and accepted analytical solutions for many different kinds of aquifer tests. Specifically, a drawdown model associated with leaky confined aquifers was used to estimate aquifer characteristics. A localized clay unit in the study area acted as a semi-confining unit during the pumping test.

Pumping Test Results

Data from the constant-rate tests were entered in AQTESOLV and plotted using a leaky confined solution developed by Hantush and Jacob (1955). This method uses time (elapsed) plotted against displacement (drawdown) on logarithmic graph paper to calculate aquifer transmissivity (T) and storativity (S).

Table C-1 presents the transmissivity (T), hydraulic conductivity (K) and storativity (S) results of both constant-rate tests.

Table C-1
Constant-Rate Test Results

Observation Well	Test 1			Test 2		
	T (ft^2/min)	K (ft/day)	S (unitless)	T (ft^2/min)	K (ft/day)	S (unitless)
P-01	0.008	1.44	0.0021	0.0052	0.936	0.0019
P-02	0.012	2.16	0.0008	0.0092	1.656	0.0008
14D	0.32	57.6	0.001	0.17	30.6	0.001
09D	0.12	21.6	0.0002	0.1	18	0.0003
16D	0.23	41.4	0.0014	0.15	27	0.0011
Geometric Mean	Both tests combined: T = 0.05 ft^2/min		K = 9.05 ft/day		S = 0.0009	

Notes:

T = K*b; where b = 8 feet at this site.

Because these aquifer parameters are lognormally distributed, the geometric mean is the best measure of central tendency. Therefore, the average for the site is presented as the geometric mean of all five wells and the two tests combined.

During both constant-rate tests, only the five transducer-monitored observation wells of Table C-1 exhibited drawdown levels sufficient for analysis. However, all the transducer-monitored wells and hand-monitored wells 06D and 07D were influenced by pumping. This indicates a radius of influence of at least 246 feet; the distance between PW-1 and 06D.

C.4 GROUNDWATER MODELING OF TREATABILITY TEST AREA

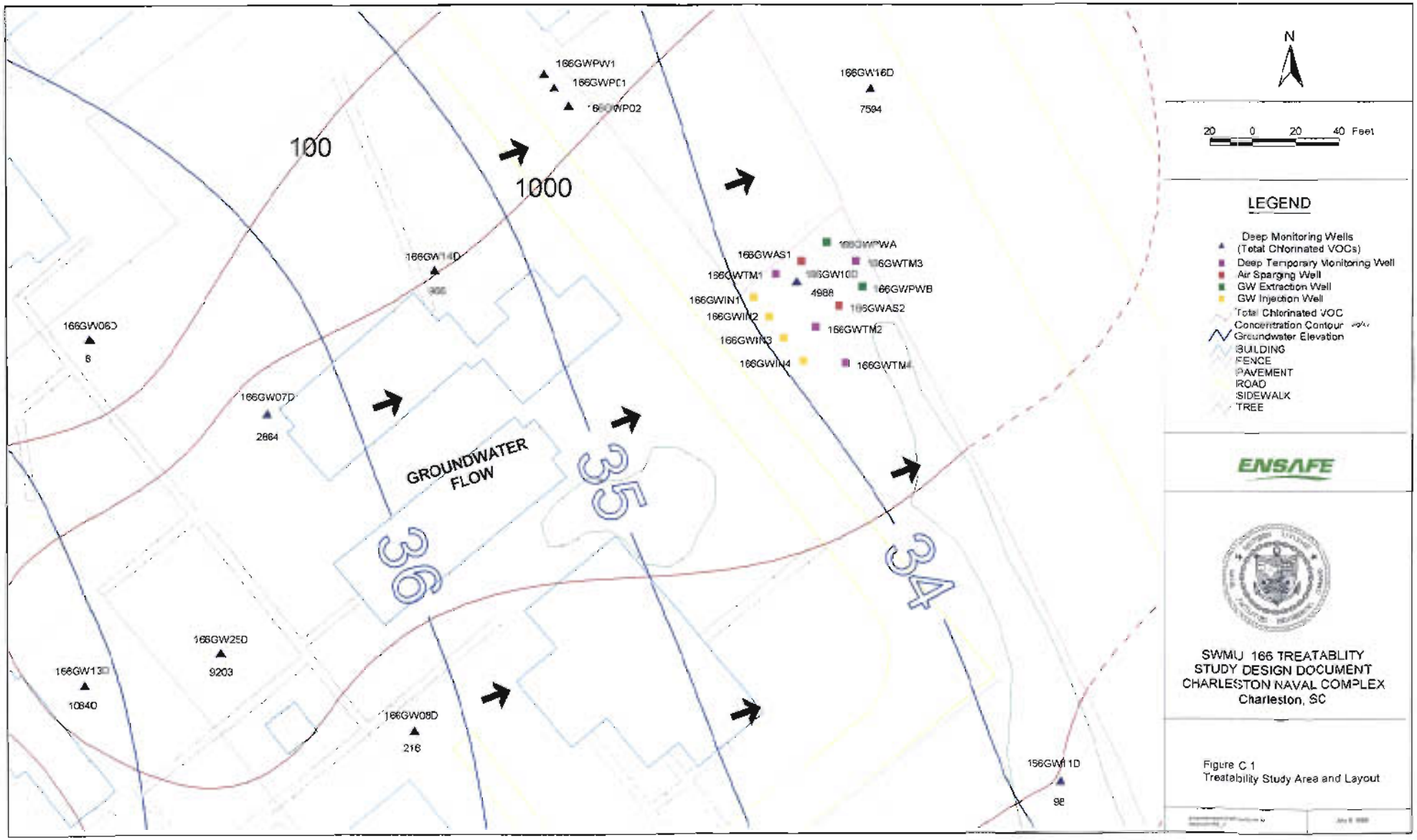
A groundwater modeling effort was conducted to support the execution of a treatability study at SWMU 166. The study is addressing enhanced bioremediation, and requires that affected groundwater be extracted from the vicinity of the bordering sewer line and re-injected in the surficial aquifer upgradient of the extraction points. Siting of the extraction and injection points, as well as determining predicted extraction and recharge rates, were the goal of this modeling effort. A time frame of six months was specified as the treatability study performance period. Due to the simplistic nature of the aquifer and the anticipated remedial actions, an analytical solution was used for the modeling. Figures C-1 and C-2 display the study area layout relative to significant site features.

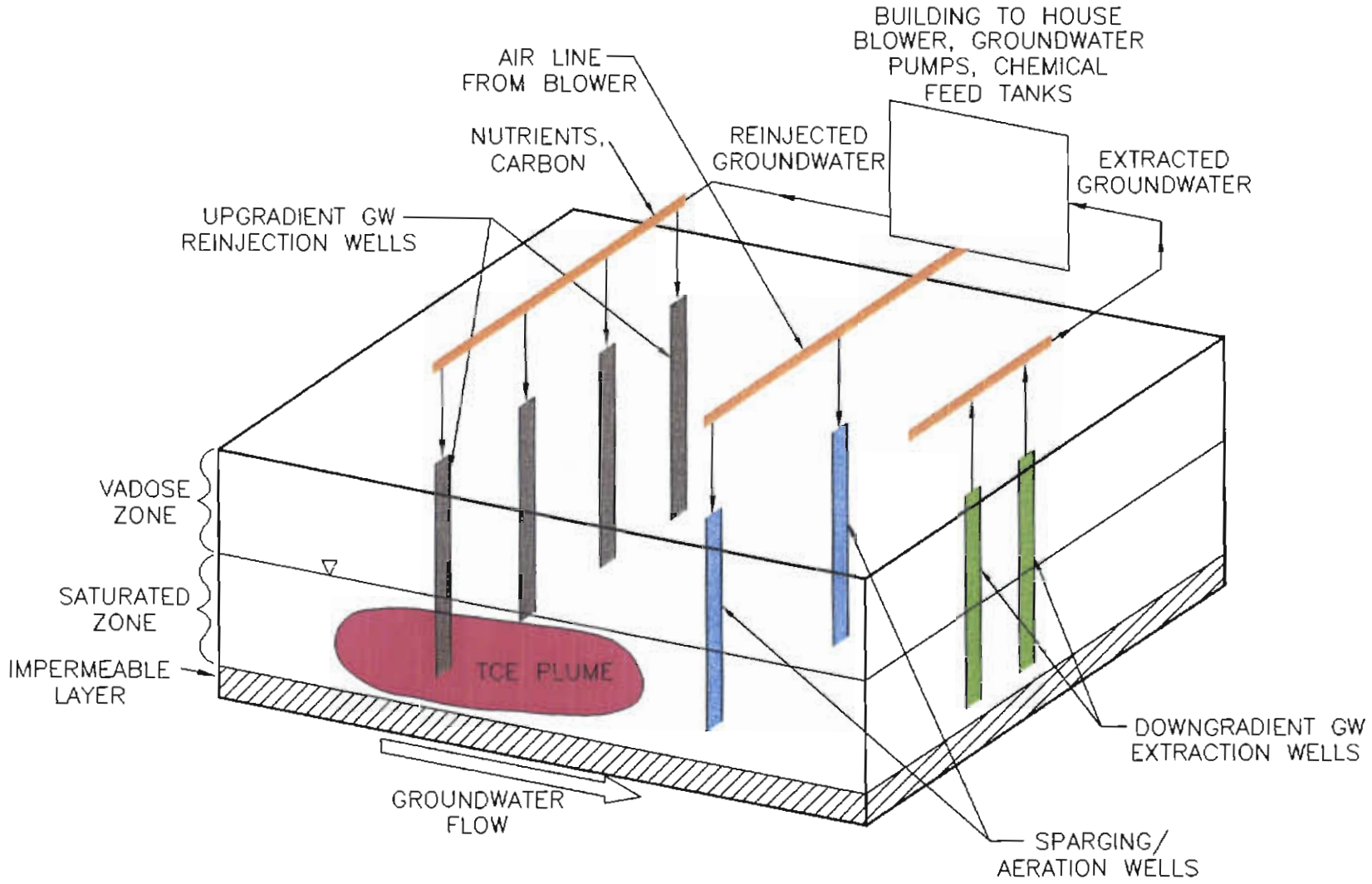
C.4.1 CONCEPTUAL MODEL

The surficial aquifer at SWMU 166 is comprised of a mosaic of fluvial and shallow marine deposits containing mostly sands with minimal amounts of clays and silts. The modeling effort treated the aquifer as a single isotropic and homogenous layer, within which the groundwater is unconfined. The analytical solution assumes steady state conditions, and is based on an established piezometric surface. Transient effects features such as recharge boundaries, drains, and no-flow boundaries were not considered in the conceptual model.

C.4.2 DATA COMPILATION

The analytical solution requires the input of transmissivity, storativity and aquifer thickness. A review of boring and well logs indicated that the saturated thickness of the aquifer in the proposed treatability study area is approximately 25 feet. Values of horizontal conductivities and storativity were estimated from pumping tests performed about 100 feet north of the treatability area where aquifer thickness was only about 8 feet. However, the aquifer test and treatability study water producing zones appears to contain similar soils. Table C-2 provides a compilation of the resultant values for T and S from Test 1 analyses (extraction at 1 gpm) and Table C-3 provides a compilation of Test 2 analyses (extraction at 1.7 gpm).


166GWPW1
166GWPC1
166GWP02
166GW16D
7594
100
1000
166GW14D
166GW06D
6
166GW07D
2864
GROUNDWATER FLOW
35
36
34
166GWAS1
166GWTM3
166GWTM1
166GW10D
4988
166GWPWB
166GWIN1
166GWAS2
166GWIN2
166GWTM2
166GWIN3
166GWIN4
166GWTM4
166GW25D
9203
166GW13D
10840
166GW08D
216
166GW11D
98
N
20 0 20 40 Feet
LEGEND
Deep Monitoring Wells (Total Chlorinated VOCs)
Deep Temporary Monitoring Well
Air Sparging Well
GW Extraction Well
GW Injection Well
Total Chlorinated VOC Concentration Contour
Groundwater Elevation
BUILDING
FENCE
PAVEMENT
ROAD
SIDEWALK
TREE
ENSAFE
SWMU 166 TREATABILITY STUDY DESIGN DOCUMENT
CHARLESTON NAVAL COMPLEX
Charleston, SC
Figure C 1
Treatability Study Area and Layout



NOT TO SCALE

SWMU 166 AA
SEQUENCING TREATABLITY
STUDY DESIGN
CHARLESTON
NAVAL COMPLEX

FIGURE C-2
CONCEPTUAL REMEDIAL TECHNOLOGY SCHEMATIC FOR ANAEROBIC-AEROBIC SEQUENTIAL GROUNDWATER TREATMENT
SWMU 166

DWG DATE: 06/22/99 | DWG NAME: 2911S001

Table C-2 – Test 1 Results

Well	Transmissivity (ft sq/m)	Storativity
PW-1	3.234E-3	.1343
PO-1	8.009E-3	.002052
PO-2	1.172E-2	.0008032
14D	3.199E-1	9.55E-4
16D	2.265E-1	1.408E-3
9D	1.218E-1	1.871E-4

Table C-3 – Test Results

Well	Transmissivity (ft sq/m)	Storativity
PW-1	3.128E-3	.1061
PO-1	5.187E-3	.001852
PO-2	9.214E-3	7.588E-4
14D	1.741E-1	9.936E-4
9D	1.031E-1	2.661E-4
16D	1.472E-1	1.144E-3

The data were geometrically averaged with no bias for initial model input. The geometric mean of T was 458 gpd/ft, and for storativity was 2.572E-3.

C.4.3 MODELING

The code used for hydraulic calculations was CAPZONE, a commercially available platform. Particle tracking and capture zone analysis was performed using GWPATH, a commercially available numerical tracking program. This combination of models was chosen specifically because of the ease of importing the site-specific piezometric configuration. By allowing importation of the static piezometric surface as the basis for the flow model, and then allowing drawdown stresses to be directly superimposed on this piezometric configuration, hydraulic interferences (such as those between extraction and injection wells) can be realistically portrayed. The resulting flow field can then be directly imported into the particle tracking program as a

hydraulic head file, and the tracking within the modeled flow regime inherently accounts for the hydraulic interferences. Modeling within CAPZONE entails the following sequence:

a) grid the static site piezometric surface (75 node limit);

b) calculate drawdown induced by pumping within a congruent grid configuration as a); (drawdowns were calculated using the Theis flow equation for the same time period as the pumping test Test 2);

c) superimpose calculated drawdowns on the site piezometric surface.

SURFER was used as the gridding code. Table C-4 provides the grid specifics used for the model domain.

Table C-4 - Grid Specifics

Origin (x,y)	2300090, 387767
Number of nodes (x,y)	54, 51
Spacing in feet (x,y)	20, 19.96

A semi-quantitative calibration procedure was employed in which T and S were altered within step b) to match actual drawdowns measured in PO-1 and PO-2 during Test 2. Final agreement with measured drawdowns (measured as a percentage discrepancy of predicted drawdown/measured drawdown) was within -9% for PO-1 and +8.5% for PO-2 using calibrated T and S values of 458 gpd/ft and .009 respectively. Additionally, using these values of T and S to predict drawdown and compare to measured drawdown, well efficiency for PW-1was determined to be about 60%.

GWPATH imported the superimposed drawdown file from CAPZONE. Forward particle tracking from the injection wells, and reverse tracking from the extraction wells, was run for a period of 6 months. Figure C-3 shows the GWPATH output.

Analysis:

Approximately 50% of injected groundwater will be re-captured within 6 months by the recovery wells. The remaining 50% will either skirt the anticipated six-month capture zone of the extraction wells or travel on the upgradient side of the upcone re-injection surface. This 50% can likely be captured using a longer time period of performance.

C.4 REFERENCES

Hantush, M.S. and C.E. Jacob, (1955). *Non-steady radial flow in an infinite leaky aquifer:* Am. Geophys. Union Trans., vol. 36, pp. 95-100.

HydroSOLVE, Inc. (1998). *AQTESOLV for Windows Version 2.12–Professional.*

Attachment D

Groundwater Effectiveness Sampling and Monitoring Plan

EFFECTIVENESS PLAN MONITORING AND SAMPLING

Treatability system monitoring and sampling will be performed to measure or estimate the effectiveness of the treatment technology and develop scale up factors for the design and cost of full-scale remediation. Monitoring will include analytical sampling and field monitoring.

D.1 Groundwater Analytical Sampling

D.1.1. Baseline Analytical Sampling

Groundwater samples will be collected before the treatability study begins to obtain baseline chemical and biochemical data in the study area. Samples will be analyzed for several parameters listed in Table D.1. Samples will be collected from the extraction wells, re-injection wells, treatability study monitoring wells, as well as existing monitoring wells located within the area of influence of the treatability study. In addition to measuring the contaminants of concern (chlorinated solvents) and biochemical parameters, the samples will also be tested for metals. Metals analysis is required to examine how geochemical changes in the groundwater resulting from the treatability study effects metal species distribution and precipitative effects, if any.

D.1.2 Periodic Groundwater Sampling

Groundwater samples will also be collected monthly during treatability study operation. This sampling will be used to track the decrease and changes in chlorinated solvent contamination and daughter product formation and destruction, and assist in calculating the nutrient supplementation required during the treatability study.

D.2 Groundwater Field Monitoring

D.2.1. Geochemical Monitoring

Groundwater wells in the vicinity of the test area will be monitored on a weekly basis for geochemical parameters. These geochemical parameters such as dissolved oxygen (DO) and oxidation-reduction (redox potential) will be used in the operation and optimization of the system, and to assess the geochemical response of the treatability study in the evaluation process. Field geochemical evaluation will supplement the analytical sampling data and will be used for full-scale design. Table D.2 lists the wells and the parameters analyzed for geochemical monitoring.

Table D.1
Baseline and Monthly Groundwater Sampling Protocol

Analyte	Analytical Method	Wells to be Sampled	Purpose/Remarks
Volatile Organic Compounds (VOCs)	SW 8260	Extraction wells (2) Re-injection Wells (4) TS Monitoring Wells (4) Monitoring Wells (4) MW10D, 11D, 14D, and 16D	The purpose of VOC sampling is to obtain starting concentrations and track decreases in contaminant concentrations during the TS.
Metals	Method 6010/7000	Extraction wells (2) Re-injection Wells (4) TS Monitoring Wells (4) Monitoring Wells (4) MW10D, 11D, 14D, and 16D	To examine clogging or solubilization effects on metals such as iron and manganese as a result of the created anaerobic-aerobic zone.
Biochemical Parameters Total Kjeldahl Nitrogen (TKN)	351.1 - 351.4	Extraction wells (2) TS Monitoring Wells (4) Monitoring Wells (4) MW10D, 11D, 14D, and 16D	Nitrogen, phosphorus and carbon measurements are required to estimate the amount and frequency of nutrient supplementation required to optimize microbial activity. Chlorides are a good indicator parameter used to estimate the quantity of chlorinated solvents that have been degraded during the TS.
Ammonia-nitrogen	350.1		
Total Phosphorus	365.4		
Orthophosphate	365.2 - 365.3		
Nitrate-nitrogen	352.1		
Total Organic Carbon (TOC)	415.1		
Chloride	325.3		
Total Heterotrophic Counts	SM 9215B		

Table D.2
Field Groundwater Geochemical Sampling Protocol

Analyte	Analytical Method	Wells to be Sampled	Sampling Frequency
Dissolved Oxygen (DO)	YSI 55 DO Meter calibrated prior to use as per manufacturer's instructions	Extraction wells (2) Re-injection Wells (4) TS Monitoring Wells (4) Monitoring Wells (4) MW10D, 11D, 14D, and 16D	Weekly
Carbon Dioxide (CO_2)	(CO_2) Meter calibrated prior to use as per manufacturer's instructions	Extraction wells (2) Re-injection Wells (4) TS Monitoring Wells (4) Monitoring Wells (4) MW10D, 11D, 14D, and 16D	Weekly

Table D.2
Field Groundwater Geochemical Sampling Protocol

Analyte	Analytical Method	Wells to be Sampled	Sampling Frequency
pH	Orion pH Meter or equivalent calibrated prior to use as per manufacturer's instructions	Extraction wells (2) Re-injection Wells (4) TS Monitoring Wells (4) Monitoring Wells (4) MW10D, 11D, 14D, and 16D	Weekly
Oxidation-reduction potential (ORP)	Orion 250A ORP meter or equivalent calibrated prior to use as per manufacturer's instructions	Extraction wells (2) Re-injection Wells (4) TS Monitoring Wells (4) Monitoring Wells (4) MW10D, 11D, 14D, and 16D	Weekly

D.2.2 Hydrogeological Monitoring

Water levels will be measured prior to, during, and after the treatability study to assess the hydrogeologic effects of extraction and re-injection of groundwater in the study area. Water levels will be measured in monitoring wells (MWs) 6D, 7D, 8D, 9D, 10D, 11D, 13D, 14D, 15D, 16D, 17D, 24D, and 25D and the 4 new treatability study wells.

D.2.3. Field Equipment Monitoring

Blower

Blower operating parameters - air flow, pressure, and temperature - will be measured and recorded on field data sheets on a weekly basis. Adjustments to system flow will be made by the engineer based on these measurements.

Chemical Feed System

The metering pumps at the chemical feed tanks will be monitored weekly and readings recorded on field data sheets. The pumps will be adjusted by the field engineer if larger or smaller amounts of chemicals (carbon and/or nutrients) or flow rates are required based on groundwater field and analytical sampling results. Monthly groundwater sampling and analysis for total organic carbon (TOC), nitrogen, and phosphorus will be used to determine the need for modification in chemical addition. Generally, the ideal ratio of organic carbon (TOC): nitrogen: phosphorus is 100:5:1. If groundwater sampling results show that there is significant departure from this recommended

optimal ratio, chemical feed amounts of carbon and nitrogen will be modified to maintain this ratio. Groundwater extraction and re-injection rates will also be measured or estimated and readings recorded.

D.3 Groundwater Analytical Sampling QA/QC

Groundwater samples will be collected from area wells and analyzed for chemical and microbial data (Tables D.1 and D.2). All sampling will be performed in accordance with the Quality Assurance Project Plan (QAPP) and the Sampling and Analysis Program (SAP) developed as part of the RFI for this site. Samples to be analyzed will be sent to the site-wide selected contracted laboratory. Analytical work on 10% of the samples submitted will be performed to CLP Level IV standards with the remainder at CLP Level III standards, all at standard turnaround times.

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY
CHARLESTON NAVAL COMPLEX
CHARLESTON, SOUTH CAROLINA
CTO-029

RESPONSE TO COMMENTS FOR

DRAFT ZONE K, SWMU 166
ANAEROBIC-AEROBIC SEQUENCING DESIGN
DOCUMENT (April 16, 1999)

Prepared for:

Department of the Navy
Southern Division
Naval Facilities Engineering Command
Charleston, South Carolina

SOUTHDIV Contract Number:
N62467-89-D-0318

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July 19, 1999
Revision: 0

Draft SWMU 166 Anaerobic-Aerobic Sequencing Design Document
Comments/ Responses to Comments

The following is a summary of SCDHEC's written and verbal comments and EnSafe's responses on the Draft SWMU 166 Treatability Study Design Document dated April 16, 1999.

Comments of Paul Bergstrand

Comment 1
Page A-14, Section 1.1 Pump Design
The third bullet in this section calls for pumps that are "Top-loading for total fluid recovery." It is not clear how top loading pumps will be an advantage when pumping water contaminated with a chlorinated solvent. Please address.

Response 1 (Page A-14, Section 1.1. Pump Design)
The sentence on top-loading pumps is not needed and deleted. We will use only a down-well located (submersible) air operated pump. The text will be revised accordingly.

Comment 2
Page A-14, Section 1.1 Pump Design
The seventh bullet in this section calls for the pumps to "Know when they are full or empty and therefore, automatically through on or off, using air only on demand during discharge cycle." This statement makes no sense. Please revise.

Response 2 ((Page A-14, Section 1.1. Pump Design, Bullet # 7)
This sentence is confusing. This sentence will be changed to read:
Pump control will be regulated using a liquid level controller located in the holding tank to turn the pump(s) on and off.

Comment 3
Page A-18, Groundwater well system
All proposed wells are 4 inch diameter. The well proposal dated 3 May 1999 had some of the wells as 2 inches in diameter. Please clarify.

Response 3

Injection and extraction wells will be 4 inch diameter to improve efficiency. Monitoring and sparging wells will be 2 inch diameter.

Comment 4

No Page Numbers, Tab B

Most of the diagrams represent wells and recovery systems for free product hydrocarbons. If portions of the systems are intended for use in this project the applicable sections should be highlighted in some manner or the non-applicable sections explained in a text outlining the plan. Please clarify.

Response 4 (Appendix A, Cut sheets).

The same diagrams that are applicable for free-product hydrocarbons are also applicable for recovery of soluble phase chlorinated solvent groundwater. The manufacturer's cut sheets do not come separately for dissolved or soluble phase recovery of contaminated groundwater. Therefore, we have presented all their cut sheets.

Comment 5

Page C-5, Drawdown Corrections. This section is not clear. Please explain.

Response 5

Section 2.2 of Appendix C notes a 1.13 foot average rise in deep well water levels following a 2.93 inch rain event. Section 3.1 later says that ambient water levels had negligible effect on drawdown data. These statements are contradictory as presented. However, the text has omitted the facts that the rainfall event occurred about 24 hours into the test and drawdown data collected after the rain event was not needed to estimate transmissivity and conductivity. The text in Section 3.1 will be revised to reflect this.

Comment 6

Page C-5, Data Reduction and Compilation

The drawdown model used was for a leaky confined aquifer. It appears this model does not represent conditions at SWMU 166. Please address.

Response 6

At the pumping well and nearby observation well there is a localized upper clay semi-confining unit. This local feature caused the aquifer to behave in leaky confined fashion. This clay feature is absent in the newly located treatability study area, however aquifer geology appears otherwise similar.

Comment 7

Page C-7, Conceptual Model

This paragraph is contradictory. The first sentence describes a "mosaic of fluvial and shallow marine deposits containing mostly sands with minimal amounts of clays and silts." Yet the model used "treated the aquifer as a single isotropic and homogeneous layer," Please address the following concerns

A. The flow of groundwater and contaminated groundwater is not uniform. The use of this model does not address the major and minor flow paths, which are presented in the second MNA Report.

B. The distribution of contamination is not uniform across the site. Drastic differences in contaminant levels exist from well to well over the space of 100 feet but have not been explained. The use of this model implies the distribution of contaminants is controlled only by groundwater flow.

C. This model does not address how small scale flow variability within the aquifer may exert significant control of contamination migration during the treatability study.

Response 7

A. Due to the small scale of this treatability study (about 60 feet from injection to extraction) and because all of the water bearing horizons within the unit are hydraulically connected, we do not expect major and minor flow pathways to significantly affect the process. Moreover, any full-scale remedial system would be designed to address the unit as a whole and would not likely be affected by minor variations in flow pathways.

B. The comment is correct in that the distribution of contaminants is not uniform across the site. The addition of extra monitoring wells in the treatability area will better define the

distribution of contaminants and groundwater flow in the study area, however the CAPZONE model will only address hydraulic, not chemical, distributions in the aquifer.

C. Small scale flow variability will occur, however recirculation mixing and chemical diffusion will dampen these effects. However, spatial distribution of test parameters (changes in water levels and contaminant concentrations) will be evaluated among the different monitoring wells to examine whether small scale flow variability had any effect.

Comment 8

Page C-7, Data Compilation. This paragraph indicates the saturated thickness of the aquifer to be 25 feet. The AQTESOLVE program for the drawdown tests used a saturated thickness of 8 feet. Please resolve the contradiction.

Response 8

The localized upper clay semi-confining unit restricted the aquifer thickness to 8 feet in the area of the pumping well. However, this clay unit is absent in the treatability study area where the aquifer is about 25 feet thick. The treatability study was originally planned in the area of the pumping test well. However, pump test results indicated a need to reduce the distance between the extraction and injection wells which would have caused access restrictions due to building and traffic flow in the area of the pumping test well. Therefore, the treatability study was relocated to south of the motor pool parking area.

HydroSOLVE, Inc. can be contacted at 703-264-9024 or www.netcom.com/~gmd.hsi

Comment 9

Page C-9, Analysis. This paragraph states "Approximately 50% of injected groundwater will be recaptured within 6-months by the recovery wells. The remaining 50% will either skirt the anticipated six-month capture zone of the extraction wells or travel on the upgradient side of the upcone re-injection surface. This 50% can likely be captured using a longer time period of performance." Only 50% capture appears to be a lack of hydraulic control. Please address.

Response 9

Modeling indicates that 50% of the reinjectate will reach the extraction wells and be recirculated through treatability study area. Because this is a no-net-loss recirculation

system, some of the reinjectate will not be recovered due to ambient flow. The model placed hydraulic stresses on the sloping configuration of the potentiometric surface, and naturally hydraulic interferences complicate the recovery. If the system were allowed to operate for a longer time frame (2 yrs or longer) then 100% capture would be likely.

Mounding due to the air sparging wells may occur during the study and will be assessed as part of groundwater monitoring at the site. However, air sparging will be done only to provide an oxygen source in this application and will be much less than that seen during typical sparging where the air is used to strip VOCs in-situ.

Comment 10

Page D-1, Baseline analytical Sampling. This section states "Samples will be collected from,,,,,,, treatability monitoring wells and existing monitoring wells located within the area of influence of the treatability study." Given the area of influence from the drawdown test, this study should include wells 14D, 11D and an additional treatability monitoring well. Please revise.

Response 10

Concur. Wells 14D, 11D, and an additional new treatability monitoring well will be included in monitoring and added to Tables D.2 and D.3. These wells will provide better coverage in assessing the spatial distribution of TS effects.

Comment 11

Page D-1, Baseline analytical Sampling. Because the distribution of metals may change and precipitation of metals may result from the treatability test, metals should be sampled at the same frequency as VOC and Biochemical parameters. Please revise.

Response 11

Concur. The drastic changes in redox potential expected in the TS area may result in changes in soluble metals concentrations.

Comment 12

Page D-4, Hydrogeological Monitoring. The treatability study monitoring wells should be included in this measurement effort. Please revise.

Response 12

Concur. Water levels from the TS wells will aid in assessing study area hydrology.

Comment 13

Page D-4, Chemical Feed System. Please describe how decisions to augment chemical feed or to modify flow rates will be made.

Response 13 (Chemical feed System)

The following paragraph can be added to make it more readable:

Monthly groundwater sampling and analysis for total organic carbon (TOC), nitrogen, and phosphorus will be used to determine the need for modification in chemical addition. Generally, the ideal ratio of organic carbon (TOC): nitrogen: phosphorus is 100:5:1. If groundwater sampling results show that there is significant departure form this recommended optimal ratio, chemical feed amounts of carbon and nitrogen will be modified to maintain this ratio.

Comment 14

The Underground Injection Control Application dated February 9, 1999 has not been approved and as of 17 May 1999 has not been updated or resubmitted. The reply letter dated 12 April 1999 clearly states "Air sparging wells are defined as injection wells....." and that "These wells (i.e., all injection wells) must receive a Permit to Construct and Operate from the UIC Program prior to their installation and operation." Please address.

Response 14

Robert Devlin (reinjection permitting) and Tim Eleazor (waste water treatment construction permitting) of SCDHEC have been contacted and concerns in the April 12, 1999, letter have been addressed. The revised injection control permit application was distributed the week of 5/24.

Comments of Mihir Mehta

Comment 1

The referenced document should have an introduction section describing the overall goals and objectives of the document. It should also reference previous documents leading to the development of the referenced document. This will help the reviewer to understand the issue at hand in an appropriate fashion. Please revise the document accordingly.

Response 1

An introduction has been added to the beginning of the document outlining the objectives of the study. Additional detail on goals and objectives can be found in the March 1999 TSWP.

Comment 2

From review of the referenced document, it appears that the area indicated for field implementation of the referenced treatability study has been changed from the review of the work plan dated December, 1998. The current field location for the treatability study is associated with the area of low contaminant concentration. Please provide rational, discussion, and the consequences as a result of this change.

Also note that the December work plan has not been revised consistent with the comment discussion during the conference call.

Response 2

The introduction will include the following explanation for why the study area was offset from the location outlined in the TSWP:

> **The study location was moved based on capture zone modeling which showed that a much smaller area would be required in order to achieve complete recirculation of extracted groundwater in the 4 to 6 month time frame planned for this study. If the test were not moved, it would have interfered with daily operations at the naval Annex through disrupting traffic flow and access to the motor pool area. The new test location lies near the centerline of the plume in an area with about 5,000 ug/L total chlorinated solvents in groundwater based on observations in well 10D. This should provide an even better indication of AA capabilities than the previous location.**

A revised TS work plan was completed in March 1999 to address SCDHEC comments on the December 1998 version. A copy can be obtained by contacting Ted Blahnik in the EnSafe Dallas office at (972)791-3222.

Comment 3

Section I, page A-18

The document has only two maps that are of poor quality and difficult for the reviewer to interpret and correlate them to the text and design. Please provide appropriate maps and figures that illustrate groundwater flow direction, current groundwater contamination, groundwater monitoring wells in the vicinity of the groundwater plume, groundwater aquifer system, and other physical features as deemed appropriate.

The maps need to show the locations of the proposed treatability study monitoring wells.

Response 3

A map (Figure C.1) showing the location of the existing and proposed wells will be added to the document at the end of Attachment C.

Comment 4

Please show the locations of the nearby monitoring wells on a map with respect to groundwater flow direction, contaminant plume and other well locations.

Response 4

Please refer to response 3.

Comment 5

Section 2 and 3 describe what tests have been conducted in order to determine the aquifer characteristics and presents the results respectively. The document fails to detail key points (such as default parameters, chemistry, etc) that are associated with these tests and the rational for their selection. Please provide appropriate figures to understand the results of the tests that are conducted as described in the text. For example, on page C-6 last line states that "this indicates a radius of influence of at least 246 feet; the distance between PW-1 and 06D." It is difficult to picture the radius of influence with respect to the location of the treatability study design wells.

Response 5

Section C.1 has been revised to address Comment 5. In general, aquifer testing and subsequent capture zone modeling was performed in order to adequately size and space the treatability recovery and injection systems. Additional data to be collected as part of the treatability study will further characterize the aquifer and allow for similar estimates of size and spacing required for a full-scale AA system. An additional map (Figure C-1) will be included in the revised design plan showing updated existing and proposed well locations so that the study can be better visualized.

Comment 6

Please provide necessary figure illustrating the conceptual model as described in the test.

Response 6

A lithologic cross section of the area is provided in the Zone K RFI report and March 1999 TS work plan. Boring logs are also available in the RFI report.

Comment 7

The introduction paragraph indicates that the modeling was performed to located the injection and extraction wells and extraction and recharge rates. The modeling failed to evaluate the interference of the extraction wells, injection wells, and air sparging wells, and hydraulic control of the groundwater plume.

The modeling also failed to predict modeled groundwater contaminant concentrations at various locations during the treatability study as quantitative goals to be achieved. This should be evaluated for both anaerobic and aerobic conditions

Response 7

Section C.4.3 has been revised to address the first part of Comment 7. Please note that groundwater table elevations will be monitored during the study to evaluate mounding effects caused by the injection and sparging wells and to assess the extent of hydraulic control of the plume in the study area.

In response to the second part of Comment 7, predictive chemical fate and transport modeling was not completed as part of this design. This study is being performed in part to

answer F&T questions raised in the comment, however there are no quantitative goals. The study aims to produce quantitative estimates for achievable degradation rates and end-point concentrations of TCE and its daughter products so that a site-wide system can be evaluated and designed. Additional details on study goals and objectives can be found in Section 3 of the March 1999 TSWP.

Comment 8

Table D-2. Periodic sampling protocol

Please include monitoring for daughter products as deemed appropriate.

Response 8

Per the request of Mr. Bergstrand, the monitoring suite has been expanded to include metals and VOCs for all analytical sampling well locations.

Comment 9

Please provide a map showing the TS monitoring wells.

Response 9

An additional map (Figure C-1) will be included in the revised design plan showing updated existing and proposed well locations so that the study can be better visualized.