



## Submittal Review Response

Project Name: **Hilo WWTP Rehabilitation and Replacement Project Phase 1**  
Submittal No.: **11395D-001.0**  
Date: **[Publish Date]**

Client: County of Hawai'i Carollo Project No.: 203975  
Contractor: Nan, Inc.  
Submittal Name: Daniel Company - BTF and Accessories  
Reviewed By: Khalil Kairouz

### SUBMITTAL REVIEW

Review is for general compliance with contract documents. No responsibility is assumed by Carollo for correctness of quantities, dimensions, and details. No deviation or variation is approved unless specifically addressed in these review comments. Refer to Section 01330 for additional requirements. The Contractor shall assume full responsibility for coordination with all other trades and deviations from contract requirements.

Approved	<input type="checkbox"/> No Exceptions
	<input type="checkbox"/> Make Corrections Noted - See Comments
	<input checked="" type="checkbox"/> Make Corrections Noted - Confirm
Not Approved	<input type="checkbox"/> Correct and Resubmit
	<input type="checkbox"/> Rejected - See Remarks
Receipt Acknowledged	<input type="checkbox"/> Filed for Record
	<input type="checkbox"/> With Comments - Resubmit

### Review Comments:

1. Acknowledged, under separate cover, submit per section 1.04 C.2 complete design calculations for the FRP vessels, ladders, and media supports. Structural calculations and drawings for the Bioscrubber vessel shall include wind and seismic load calculations and anchor bolt sizing. The design of structural and wind calculations shall be according to the current Hawaii Building code, Section 01850 - Design Criteria of the specifications and shall be sealed by applicable registered Professional Engineer in the state of Hawaii.
2. Acknowledged, submit under separate cover process control narratives and system operation as per sections 1.04 C.5 &6.
3. Acknowledged, submit under separate cover information on hazards associated with the system as per section 1.04.C.9.
4. Acknowledged, submit under separate cover and per section 1.04 C 15, complete instrumentation, control, logic, and power wiring diagrams, electrical schematics in sufficient details to allow installation of the instrumentation, controls, and electrical components.
5. Acknowledged, submit under separate cover and per section 1.04C.16 information on the VWCP, VLCPs and VMCP including external layouts, internal layouts, bill of materials, logic diagrams, HMIs, power and control wirings, PLC I/O, network connections, calculations, thermal management including air conditioners and heaters.
6. Acknowledged, submit under separate cover field testing plan per section 1.04 C18.

7. Acknowledged, submit under separate cover quality controls details per sections 1.04 D and E.
8. Acknowledged, submit under separate cover O&M manuals per section 1.04 F.
9. Acknowledged, submit under separate cover performing testing procedures and results per section 1.04 H.
10. Acknowledged, submit under separate cover and per section 2.03 I information on the ductwork and flex connectors. Provide flex connectors when ductwork connects to the inlet connection of the scrubber at no cost.
11. Contractor and odor control supplier system shall coordinate to make sure the installation of the field components whether internal or external to the vessels are installed properly. Certification by the odor control supplier shall be provided to confirm the proper and complete installation.
12. Acknowledged, submit under separate cover information on thermal mass air flowmeter per section 2.03 S.
13. Acknowledged, Piping, valves, etc. external of the water control panel shall be provided by the contractor.
14. Acknowledged, submit under separate cover information on the control system per section 2.04.
15. Acknowledged, submit under separate cover information on training section 3.06.
16. Although the vessels and associated nozzles connections look ok to the engineer and as per design documents, contractor and odor control supplier shall coordinate to make sure the vessels and their orientations are provided and installed according to the configuration layout in the design drawings.
17. Confirm the media and vessel warranty are provided per section 1.05 B and C. The submittal mentions a 5 year and 10-year extendable warranty; however, the specs call for 10-year media warranty non-prorated full replacement warranty.
18. Verify the OSHA approved handrail and self-latching swing gates, the FRP ladder SAF-T-Climb, fall prevention system and all safety components are provided per section 2.03V.
19. Verify if check valves are required on the discharge of the chemical nutrient pump.
20. Submit the external components and piping leading to the vendor water control panels such as pressure regulators, basket strainers, instruments and valves as shown on the drawings and specified.
21. Per spec section 2.03T, it calls for magnetic flow meters in the VWCP, however rotor –paddlewheel flow sensors are submitted. Verify that these flow meters are equivalent and will perform as the magnetic flow meters without an excess maintenance required.



## CONTRACTOR SUBMITTAL TRANSMITTAL FORM REV. A

**Owner:** County of Hawaii  
**Contractor:** Nan, Inc.  
**Project Name:** Hilo WWTP Phase 1  
**Submittal Title:** BTF and Accessories  
**TO:** County  
**From:** Nan Inc.

**Project No.:** WW-4705R      **Submittal Number:** 11395D - 001.0

<b>Specification No. and Subject of Submittal / Equipment Supplier</b>	
<b>Spec:</b> 11395D	<b>Paragraph:</b> 1.04, 2.01, 2.02, 2.03
<b>Authored By:</b> Daniel Company	<b>Date Submitted:</b> 06/09/2025

<b>Submittal Certification</b>	
<b>Check Either (A) or (B):</b> <p> <input checked="" type="checkbox"/> (A) We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings with no exceptions.         </p> <p> <input type="checkbox"/> (B) We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings except for the deviations listed.         </p>	
Certification Statement: By this submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and I have checked and coordinated each item with other applicable approved shop drawings and all Contract requirements.	
<b>General Contractor's Reviewer's Signature:</b> Jyun-Cheng Jhuo	
<b>Printed Name and Title:</b> Jyun-Cheng Jhuo, Project Engineer	
In the event, Contractor believes the Submittal response does or will cause a change to the requirements of the Contract, Contractor shall immediately give written notice stating that Contractor considers the response to be a Change Order.	
<b>Firm:</b>	<b>Signature:</b>
	<b>Date Returned:</b>

<b>PM/CM Office Use</b>	
Date Received GC to PM/CM: Date Received PM/CM to Reviewer: Date Received Reviewer to PM/CM: Date Sent PM/CM to GC:	

Nan, Inc

PROJECT: HILO WWTP REHABILITATION  
AND REPLACEMENT PROJECT - PHASE 1

JOB NO. WW-4705R

THIS SUBMITTAL HAS BEEN CHECKED BY  
THIS CONTRACTOR. IT IS CERTIFIED  
CORRECT, COMPLETE, AND IN  
COMPLIANCE WITH CONTRACT  
DRAWINGS AND SPECIFICATIONS. ALL  
AFFECTED CONTRACTORS AND  
SUPPLIERS ARE AWARE OF, AND WILL  
INTEGRATE THIS SUBMITTAL (UPON  
APPROVAL) INTO THEIR OWN WORK.

DATE RECEIVED 6/17/2025  
SPECIFICATION SECTION # 11395D  
SPECIFICATION Headworks Odor Control   
PARAGRAPH 1.04, 2.01, 2.02, 2.03  
DRAWING n/a  
SUBCONTRACTOR n/a  
SUPPLIER n/a  
MANUFACTURER Daniel Company

CERTIFIED BY CQCM or Designee :  Matthew Chiu



HILO, HI  
HILO WWTP REHABILITATION AND REPLACEMENT  
PROJECT PHASE 1 – JOB NO.: WW-4705R

## PRODUCT SUBMITTAL

### BIOTRICKLING FILTER AND ACCESSORIES (SECTION 11395D)

Revision 0

BY  
Daniel Company  
1939 W. 11<sup>th</sup> Street, Suite E  
Upland, CA 91786

FOR  
Nan, Inc.

MAY 2025

## **TABLE OF CONTENTS**

### **Daniel Company Information.....Section 1**

Daniel Company Brochure

Job Reference List

### **Compliance Checklist for Specification Section 11395D .....Section 2**

Letter of Compliance

Specification Section 11395D

### **FRP Materials List and Technical Data Sheets .....Section 3**

FRP Materials List

Resin: Interplastic CoRezyn CORVE 8401

Corrosion Liner Veil: C-Veil (Viledon T1777)

Spray-up Roving: Owens Corning OptiSpray F

Filament Winding Roving: Owens Corning 366 Roving

Chopped Strand Mat: CTG

Woven Roving: CTG (EWR800)

Unidirectional: Vectorply

Catalyst: NOROX MEKP-925H

UV Inhibitor: Cyasorb UV-9

Gel Coat / Color: Lilly-Ram WHITE W-1 (unless otherwise specified)

### **FRP Method of Construction and Design Calculations .....Section 4**

Method of Construction – Biotrickling Filters

Design Calculations – Biotrickling Filters

### **Quality Control Procedures and Warranty .....Section 5**

Quality Control Procedure

Quality Assurance Summary Reports Form

Barcol Testing Form

Resin Sheet Form

Handling, Storage, & Packaging

Procedures for Shipping and Installation of Fiberglass Reinforced Plastic Vessels

Manufacturer's Letter of Warranty

### **Biotrickling Filter Vessel Drawings and Performance Data .....Section 6**

Biotrickling Filter Vessel Fabrication Drawings

System Utility and Nutrient Usage

H2S Elimination Capacity Chart

System Pressure Drop Calculations

**Biotrickling Filter Vessel Accessories .....****Section 7**

Biotrickling Filter Media  
FRP Grating for Media Support  
Spray Nozzles  
Stack Mist Eliminator  
Ladder and Railing System

**Recirculation Pumps & Accessories.....****Section 8**

Recirculation Pump Curve  
Recirculation Pump Data Sheets and Drawings  
Recirculation Pump Baseplate Data Sheets and Drawings

**Water Control Panels & Accessories.....****Section 9**

Water Panel Drawings  
Water Panel Enclosures  
Ball Valves  
Motorized Ball Valves  
3-Way Ball Valves  
Diaphragm Valves  
Rotameters  
Flow Meter Sensors  
pH Sensors  
Flow Meter and pH Transmitters  
Nutrient Pumps  
Nutrient Tanks

\* \* \* \*

## **SECTION 1**

### **DANIEL COMPANY INFORMATION**

# DANIEL COMPANY

Fiberglass Air Pollution Control Systems



Specializing in the design, manufacturing, installation, and service of  
air pollution control and corrosion resistant air conveyance systems



At **DANIEL COMPANY** we are uniquely equipped to offer our customers a “turnkey” product, utilizing over 20 years of experience as a manufacturer of air pollution control systems built from corrosion-resistant materials. Our wealth of engineering strengths is applied primarily to solving odor control and fume exhaust problems that exist in the private and municipal markets. Focus is on building system components made of fiberglass reinforced plastic products with high structural integrity, durable corrosion resistance, and increased fire safety. In addition to striving for the highest level of excellence in performance, **DANIEL COMPANY** maintains premium quality manufacturing standards along with an ardent commitment to design innovation.

**DANIEL COMPANY** serves:

- Wastewater Treatment Plants
- Power Generation Plants
- Military Installations
- University Laboratories
- Pharmaceuticals
- Pulp and Paper Mills
- Printed Circuit Board Industries
- Semi Conductor Industries
- Metal Plating Industries

# Product Line

## AIR SCRUBBERS – DANIEL COMPANY

provides three types of air scrubbing systems:

- Wet Packed Towers with chemical recirculation systems designed for higher hydrogen sulfide removal efficiency.
- Dry Carbon Absorbers used as stand-alone, primary scrubbers or as secondary polishers.
- Bioreactor Towers utilized as a lower chemical consumption odor control scrubber.

All of the scrubber vessels are custom-constructed at Daniel Company's state-of-the-art specialty fiberglass reinforced plastic manufacturing plant. The interior linings are made of premium grade vinyl-ester corrosion layers. Each scrubber is provided as a monolithic unit with all appurtenances attached and/or included. Multi-stage, skid mounted systems are also provided to facilitate quick and simple installation. Flanged inlets, stacks, mist eliminators, access ports, lifting and tie-down lugs, packing, recirculation pumps, nozzles, PVC piping, pressure gauges, flow meters, pH/ORP sensors and analyzers, and chemical metering pumps are but a few of the specialty components included. A one year manufacturer's warranty accompanies Daniel Company's scrubber systems.



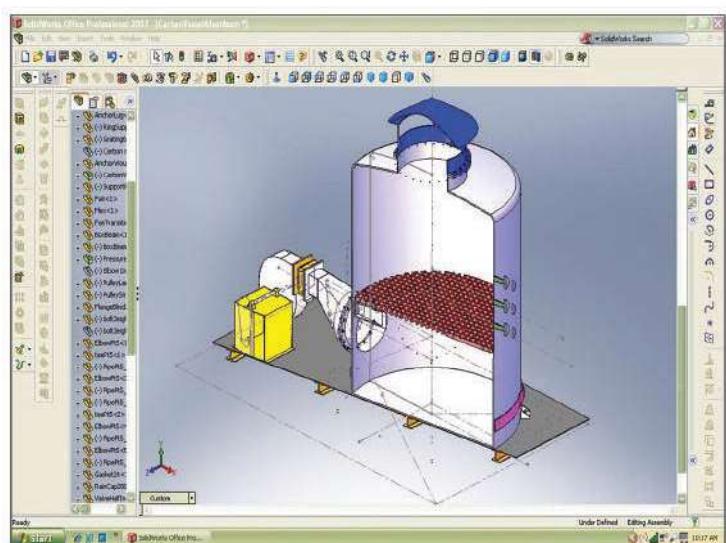
Northwest Water Reclamation Plant - Mesa, Arizona

## ENGINEERING AND DESIGN –

DANIEL COMPANY has over 150 years of combined in-house experience in designing odor control systems. Our professional engineering staff is expert at:

- Determining the conditions and needs at the user's facility by identifying the sources of fugitive emissions and performing fence line measurements along with laboratory analysis of sample contaminants.
- Engineering complete air scrubber systems that are most suitable for the application at hand.
- Providing ongoing technical support throughout critical stages of construction and manufacturing of air pollution conveyance and scrubber systems.
- Providing experienced startup and training services to facility managers and plant operators complemented by comprehensive, user-friendly operation and maintenance manuals.

Daniel Company's extensive engineering team has been involved in the successful design of hundred's of air scrubbing systems currently in operation.



Engineering and Design

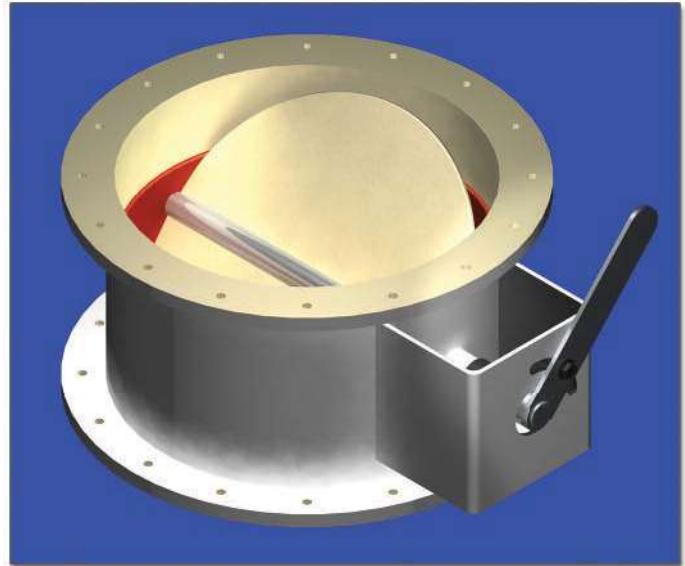
**DUCTWORK – DANIEL COMPANY** offers process air ductwork and liquid conveyance pipe fabricated from flame retardant and corrosion-resistant fiberglass reinforced plastic, using contact-molded hand lay-up and filament wound methods. Applications range from above grade low pressure ductwork to filament wound buried pipe designed to H-20 live load calculations. Round sizes range from 4" to 168" in diameter. Custom-sized rectangular duct and related fittings may be manufactured using core materials and composite stiffeners to achieve required structural integrity.

Fittings include round and rectangular elbows with long and short radii, transitions, flanges, end caps, tees, wyes, and laterals. Strict adherence to the accepted ASTM, RTP-I, NBS PS 15-69 dimensional and quality control standards guarantee the end user a superior product.

Also, as a licensed mechanical contractor, **DANIEL COMPANY** is uniquely equipped to install, balance, and test the performance of complete exhaust and supply air systems. Certified technicians are proficient in training installation crews on the jobsite in FRP field joining and installing techniques.



Nashville Central Wastewater Treatment Plant - Nashville, Tennessee



Dampers

**DAMPERS – DANIEL COMPANY** offers precision engineered FRP butterfly and multi-blade dampers utilizing only highly corrosion-resistant parts. Stainless steel or FRP blade shafts with seals made up of Viton, Hypalon or EPDM are incorporated for less leakage. Leakage rates are tested using AMCA 500-D procedures. Worm gear operators of the pneumatic, electric or hand operated types are offered, depending on the application. Opposed blade and Backdraft Dampers are available in round and rectangular shapes. A complete line of Zero-Leakage DanELAST isolation dampers are also available for greater isolation of process air during shutdown, and particularly for confined space entry conditions. Long-life non-metallic bearings and custom designed bushings require minimal maintenance and ensure continued free movement of the blade. Zero-leakage DanELAST isolation dampers require far less maintenance, are more durable, and outperform conventional butterfly dampers. Dampers range from sizes 4" diameter to 120" diameter.

## CHEMICAL STORAGE TANKS –

**DANIEL COMPANY** provides filament-wound fiberglass reinforced plastic corrosion-resistant tanks typically used for NaOCl and NaOH solution storage. All tanks are designed to be installed either above or below grade, and are built per RTP-I and ASTM D 3299 industry-accepted standards. Access ports and fill/drain nozzles are standard features included in our tanks.



Hoods

## ADDITIONAL APPLICATIONS –

**DANIEL COMPANY** also manufactures other equipment and components used in corrosive environments typically found at water and wastewater treatment facilities. These include Decarbonators, Hoods, Launder Covers, Weirs and Baffles, Ladders, Platforms, Fan Inlet Boxes, and a myriad of other customized products requested by our most valued clients.



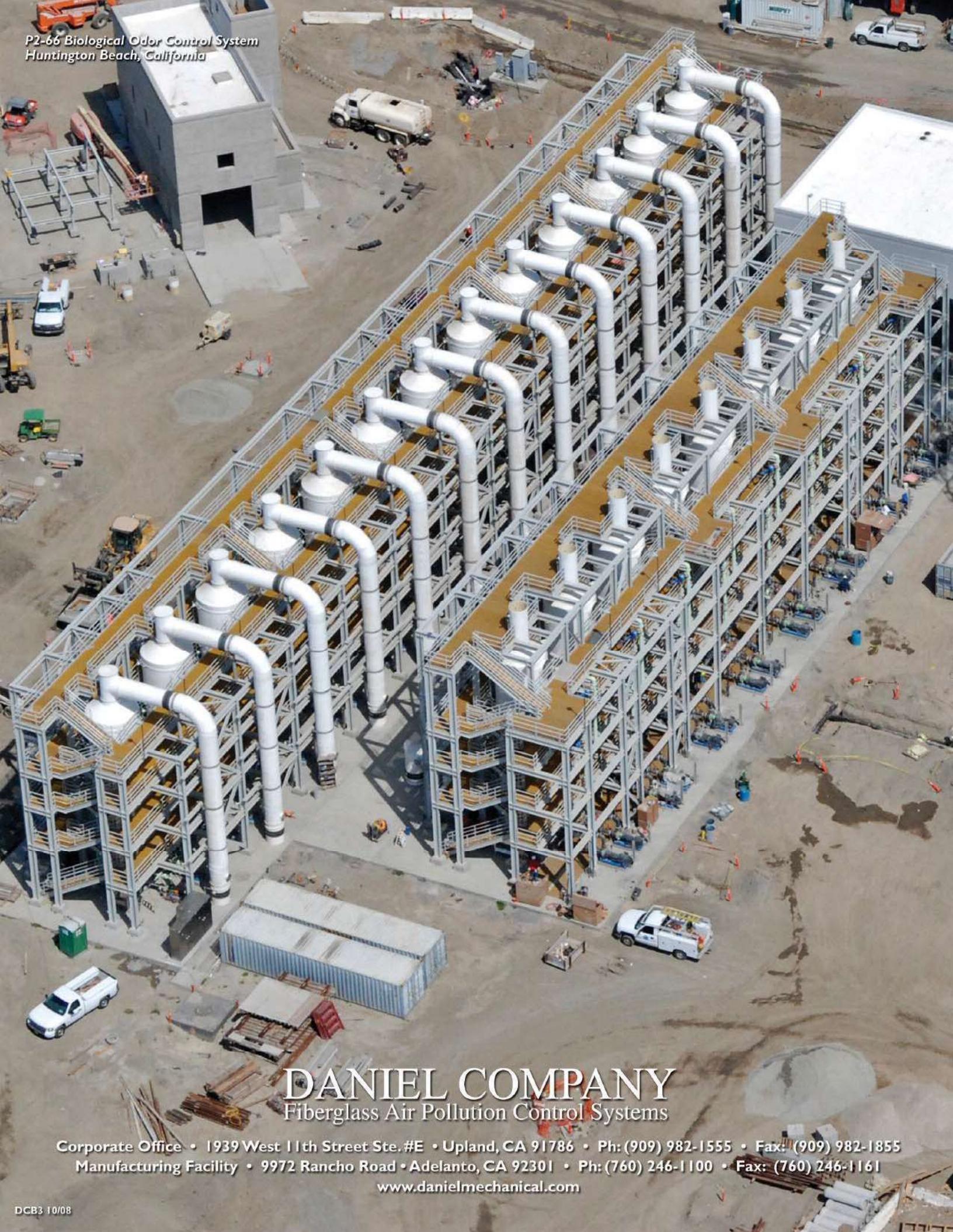
Advanced Water Treatment Facility – Fountain Valley, California



FLEXIBLE  
CONNECTORS –  
**DANIEL COMPANY**

features heavy-duty flexible connectors featuring polyester tire cord reinforced EPDM, neoprene, or Hypalon materials with 316 stainless steel retaining bands. The flexible connectors are seamless and constructed of one continuous piece of elastomer, having an integrally molded hollow-arched volute permitting contraction and expansion movements. These are designed for minimal maintenance and easy removal, and are ideally suited for isolating vibrations of moving components such as fans from the duct system. Heavy duty "U"Type expansion joints with extruded flanges and mating steel retaining rings are also provided for piping applications.

P2-66 Biological Odor Control System  
Huntington Beach, California



## DANIEL COMPANY

Fiberglass Air Pollution Control Systems

Corporate Office • 1939 West 11th Street Ste. #E • Upland, CA 91786 • Ph: (909) 982-1555 • Fax: (909) 982-1855  
Manufacturing Facility • 9972 Rancho Road • Adelanto, CA 92301 • Ph: (760) 246-1100 • Fax: (760) 246-1161

[www.danielmechanical.com](http://www.danielmechanical.com)

Project Name	End User	A & E	Contractor
City of Benicia Wastewater Treatment Plant Development <u>Desc:</u> O.C. Multiple Stage FRP Scrubbing System @ 18,400 CFM	City of Benicia Public Works Dept. Wastewater Division <b>Contact:</b> John Bailey - Plant Superintendent <b>Phone:</b> (707) 746-4294	Carollo Engineers <b>Contact:</b> Khalil Kairouz <b>Phone:</b> (714) 540-4300	Overaa Construction <b>Contact:</b> Marvin Korsmo <b>Phone:</b> (510) 234-0926
Elk Grove WRF Gravity Belt Thickening Project <u>Desc:</u> Odor Control & HVAC FRP Ducting System	County of Sacramento Public Works Agency <b>Contact:</b> Cliff Watson - Engineer <b>Phone:</b> (916) 395-5390	Taylor Systems Engineering, Inc. <b>Contact:</b> John Taylor - Engineer <b>Phone:</b> (916) 961-3400	Kaweah Construction <b>Contact:</b> Scott Reynolds - V.P. <b>Phone:</b> (559) 252-9492
South Bay Reclamations Sewer & Pump Station Grove Avenue Pump Station <u>Desc:</u> 2 FRP Odor Control Scrubbing Systems @ 13,000 CFM	City of San Diego Metropolitan Wastewater Dept. <b>Contact:</b> Gary Webb	Robert Bein, William Frost & Associates <b>Contact:</b> Paul Klein <b>Phone:</b> (858) 814-5200	PCL Civil Constructors, Inc. <b>Contact:</b> Mike McKinney <b>Phone:</b> (619) 229-9540
Hyperion Treatment Plant Secondary Facilities Phase 2 Contract C117 <u>Desc:</u> 4 Odor Control & Vent Gas Multiple Stage Scrubbing Systems @ 32,000 CFM	City of Los Angeles, Hyperion Treatment Plant <b>Contact:</b> Patty Jacobs - P.M. Greg Campbell - Engineer <b>Phone:</b> (310) 648-5263	Black & Veatch / DMJM Joint Venture <b>Contact:</b> Sam Abi Samra (Currently w/ CDM) <b>Phone:</b> (213) 312-3300	Tutor-Saliba, Perrini, Scott J.V. <b>Contact:</b> Dale Denny Currently w/ Olsson Construction <b>Phone:</b> (619) 229-9540
Phillipsburg N-Viro Facility Scrubber #2 <u>Desc:</u> 2 Odor Control Scrubbing Systems @ 50,000 CFM each.	Hydropress Environmental Services <b>Contact:</b> Phil Will <b>Phone:</b> (908) 859-5200	Webster Environmental Associates, Inc. <b>Contact:</b> Neil Webster - Engineer <b>Phone:</b> (502) 253-3443	Webster Environmental Associates, Inc. <b>Contact:</b> Neil Webster - Engineer <b>Phone:</b> (502) 253-3443

Project Name	End User	A & E	Contractor
Pt. Loma H.O.C.G <u>Desc:</u> 2 FRP Odor Control Scrubbing Systems @ 42,000 CFM each.	City of San Diego, CA. Metropolitan Wastewater Dept. <b>Contact:</b> Stuart Seymore - P.M. <b>Phone:</b> (619) 221-8320	Black & Veatch <b>Contact:</b> John Hay <b>Phone:</b> (949) 753-0500	Camp Dresser McKee <b>Contact:</b> Ed Mitiguy - P.M. <b>Phone:</b> (562) 432-7996
91st Avenue WWTP Plant Improvement Projects <u>Desc:</u> 2 Multiple Stage Scrubbing Systems @ 60,000 CFM Each. / 1 Multiple Stage Scrubbing Systems @ 7,000 CFM	City of Phoenix Environmental Engineering Dept. <b>Contact:</b> Jerry Green - Director <b>Phone:</b> (602) 262-1827	Malcolm Pirnie <b>Contact:</b> Dave DeShant - Engineer <b>Phone:</b> (602) 241-1770	<b>Contact:</b> Willy Nowotny formerly of McCarthy Construction, currently with Filanc <b>Phone:</b> (909) 595-4397
City of Surprise WWTP Facility Expansion <u>Desc:</u> Odor Control Scrubber & Biofilter bed Systems @ 8,600 CFM Each.	<b>Contact:</b> Rick Williams, Plant Manager <b>Phone:</b> (602) 546-5517	HDR Engineers <b>Contact:</b> Dave Noel - Engineer <b>Phone:</b> (602) 508-6600	MGC <b>Contact:</b> Randy Gates - P.M.
Chesapeake Elizabeth Wastewater Treatment Plant Odor Control Facilities <u>Desc:</u> 4 Odor Control Scrubbing Systems @ 27,000 CFM Each.	Hampton Road Sanitation District <b>Contact:</b> Bruce Husselby - P.M. <b>Phone:</b> (757) 460-2261	Parsons, Brinkerhoff, Gore & Storric, Inc. <b>Contact:</b> Scott Armstrong - Engineer <b>Phone:</b> (803) 227-3425	Pizzagalli Construction <b>Contact:</b> Dave Kress - Area Manager <b>Phone:</b> (404) 351-0401 or (678) 358-5548
Army Base Treatment Plant Odor Control Facilities <u>Desc:</u> 4 Odor Control Scrubber Systems @ 29,000 CFM Each.	Hampton Road Sanitation District <b>Contact:</b> Bruce Husselby - P.M. <b>Phone:</b> (757) 460-2261	Parsons, Brinkerhoff, Gore & Storric, Inc. <b>Contact:</b> Scott Armstrong - Engineer <b>Phone:</b> (803) 227-3425	Pizzagalli Construction <b>Contact:</b> Dave Kress - Area Manager <b>Phone:</b> (404) 351-0401 or (678) 358-5548

Project Name	End User	A & E	Contractor
Baltimore, MD. Back River WWTP <u>Desc:</u> 3 Multistage FRP Odor Control Scrubbers @ 12,000 CFM Each.	City of Baltimore, D.P.W. <b>Contact:</b> Jack Natali <b>Phone:</b> (410) 396-1663	Arrow Engineering <b>Contact:</b> Donald Aukamp - Engineer (Currently with Earthtek) <b>Phone:</b> (202) 787-2570 x 255	Norair Engineering, Co. <b>Contact:</b> Dragan Stojanovic <b>Phone:</b> (301) 499-2202
Seattle, WA South Treatment Plant Odor Control Improvements <u>Desc:</u> Secondary Odor Control FRP System @ 41,000 CFM	King County <b>Contact:</b> Dirk Apgar <b>Phone:</b> (206) 684-1769	Brown and Caldwell <b>Contact:</b> Philip Wolstenholme <b>Phone:</b> (206) 624-0100	Prospect Construction <b>Contact:</b> Mike Peterson <b>Phone:</b> (253) 446-1600
Seattle, WA Brightwater Conveyance System North Creek Facilities <u>Desc:</u> FRP Ductwork, FRP Dampers and Flexible Connectors.	King County <b>Contact:</b> Rick Andrews <b>Phone:</b> (206) 296-1432	MWH Jacobs Engineering <b>Contact:</b> Anthony Pooley <b>Phone:</b> (206) 296-1739	Miller Sheetmetal <b>Contact:</b> Fred Price <b>Phone:</b> (360) 479-1737
Plant #2 Headworks Replacement <u>Desc:</u> Multistage Odor Control FRP System @ 188,300 CFM	OCSD <b>Contact:</b> <b>Phone:</b> (714) 593-5101	Carollo Engineers <b>Contact:</b> Khalil Kairouz <b>Phone:</b> (714) 540-4300	J F Shea Construction <b>Contact:</b> Kurt McKean <b>Phone:</b> (909) 444-4253

## **SECTION 2**

# **COMPLIANCE CHECKLIST FOR SPECIFICATION SECTION 11395D**

# **DANIEL COMPANY**

Air & Water Pollution Control Systems



May 20, 2025

Nan, Inc.  
161 Silva St., Hilo, HI 96720  
Attn: Jyun-Cheng Jhuo

**RE: Hilo WWTP Rehabilitation and Replacement Project Phase 1**

**Subject: Compliance Checklist for Specification Section 11395D**

---

To Whom It May Concern:

The following attachment is a compliance checklist that Daniel Company uses to mark off what is being fulfilled and complied with under specification Section 11395D. A “√” means that Daniel Company acknowledges and fully adheres with the denoted paragraph of the specification. An “\*” means that there is a deviation with attached explanation. A “C” means that, while Daniel Company intends to fully comply with the specification, this particular item is to be supplied by the Contractor and/or others. An “N/A” indicates that this item is not applicable.

Please reach out if you have any questions regarding our compliance checklist.

Sincerely,

*Shawn Garey*

Shawn Garey  
Project Manager

**SECTION 11395D**  
**HEADWORKS ODOR CONTROL SYSTEM**

**PART 1 GENERAL**

**1.01 SUMMARY**

- A. The work specified shall include furnishing all labor, design, materials, equipment, incidentals and testing of all equipment and materials necessary to provide the Owner with completely operational biological Headworks Odor Control System for removal of hydrogen sulfide ( $H_2S$ ) from the wastewater process facilities as specified herein and indicated on the plans.
- B. The biological Odor Control Systems shall consist of bioscrubber vessels, internal structural members, media with support gratings, mist eliminators, internal piping, liquid distributors, nutrient feed and storage systems, irrigation valves, recirculation pumps and piping, air exhaust, fans, VFDs, process control system control panels, ducting, and any other equipment or accessories required to provide a complete and functioning odor control system. All major system components and controls as specified shall be provided by the Odor Control System Supplier for single source responsibility.
- C. All materials, products, or devices shall be new and unused.
- D. Unit responsibility - The contractor shall assign the scope of the odor control systems to an Odor Control Supplier (OCS) who shall have the single source responsibilities for providing the components described herein including design, fabrication, assembly, delivery, supervision of installation, startup and testing of the system and related accessories and appurtenances. However, the contractor shall have overall responsibilities of the odor control system and shall provide any other components and services that are not provided by the OCS but required for a complete operable system as specified and indicated on the drawings.
- E. The OCS scope responsibilities shall include but no limited to the following components:
  - 1. Bioscrubber vessels with associated internal and external appurtenances.
  - 2. Media.
  - 3. Irrigation spray nozzles and associated system assemblies.
  - 4. Headworks' odor control FRP fans and associated VFDs.
  - 5. Thermal mass air flow meter for measuring air flow to the odor control system.
  - 6. Independent nutrient feed systems (one per bioscrubber vessel). Each nutrient feed system shall be provided with a diaphragm metering pump, a 100 gallons FRP nutrient tank, piping appurtenances & controls.
  - 7. Recirculation pumps system (one per bioscrubber unit) with associated piping, valves, and controls.
  - 8. Instruments, including pressure gauges, transmitters, pH, and flowmeters (recirculation pump and air flow) associated with the bioscrubbers and the odor control fans.

- 9. Interconnecting FRP ductwork, dampers, flexible connections, and other components from the inlet box and dampers at the odor control Fans up to and including the final exhaust stacks.
  - 10. All interconnecting piping external to the bioscrubbers vessels including the piping, valves, supports, and instruments associated with the recirculation pumps, irrigation, and nutrient systems.
    - a. All PVC piping within the OCS Scope of Supply shall be minimum Schedule 80 PVC piping.
  - 11. One local Vendor Water Control Panel (VWCP) with minimum size as shown on the plans or specified (1 each per bioscrubber vessel) that house all components necessary for the controls and monitoring of the media irrigation and recirculation systems for each bioscrubber vessel. The VWCP shall include instruments, piping and equipment components that will provide as a minimum, an irrigation system capable of on/off timing of intermittent once through water system, and for recirculation with makeup water while in recirculation mode.
  - 12. One Vendor Master Control Panel (VMCP) that houses the PLC, LOI, and the controls related to the processes including but not limited to the fans, bioscrubbers, nutrient and recirculation pumping systems and as applicable, for each process area bioscrubber vessel and associated systems.
  - 13. One Vendor Local Control Panel (VLCP1) that houses the local operators, selectors, and indicator lamps for the headworks odor control fans and associated equipment controls.
  - 14. Two Vendor Local Control Panels (VLCP2 & VLCP3) that house the local operators, selectors, and indicator lamps for each of the individual headworks bioscrubber and associated equipment and controls.
  - 15. All other associated and required accessories as specified herein and elsewhere in these Specifications.
- F. Electrical requirements - See Section 16050 - Common Work Results for Electrical and Division 16 - Electrical, which contain information and requirements that apply to the work specified herein and are mandatory for this project.
- G. Building permit:
1. Contractor shall assist the County in securing the building permit for the Headworks Odor Control System. The permit application requires detailed design drawings and information prepared and stamped by a licensed engineer in the State of Hawaii. Time is of the essence. Submit complete shop drawings (including calculations) stamped by licensed engineer in the State of Hawaii for the Headworks Odor Control System at the earliest possible date after Notice to Proceed. The licensed engineer shall have past experience designing and stamping bioscrubber odor control systems of similar size in Hawaii.
  2. All shop drawing submittals and resubmissions shall be expedited to secure the permit and prevent delays in the Project schedule.

## 1.02 PROCESS DESCRIPTION

- A. The system shall perform in accordance with the design basis. It shall be designed for continuous operation in a highly corrosive environment.

- B. The biological or bioscrubber odor control system shall utilize a high surface synthetic/inert media to provide an optimal site for growth of microorganisms (aka - biomass). Microorganisms that attach to the media are capable of removing H<sub>2</sub>S and other odorous VOC's when they are contacted by these compounds in the odorous air stream. A fan conveys the odorous air from the odor source to the media at the bottom of the vessel where the air passes upward through the vessel and media. As the odorous air travels upward, it comes in contact with the biomass where non-pathogenic sulfur oxidizing bacteria immobilized on the synthetic media remove H<sub>2</sub>S and other odorous compounds. A solution containing water and nutrients is conveyed from the sump onto the media via a recycle pump to maintain a healthy biological population.

## 1.03 REFERENCES

- A. ASTM International (ASTM):
  - 1. ASTM D883 - Definition of Terms Relating to Plastics.
  - 2. ASTM D2583 - Test for Indentation Hardness of Rigid Plastics by Means of Barcol Impressor.
  - 3. ASTM D2563 - Recommended Practice for Classifying Visual Defects in Glass Reinforced Plastic Laminate Parts.
  - 4. ASTM D4097-01 - Standard Specifications for Contact Molded Glass Fiber Reinforced Thermoset Resin Chemical Resistant Tanks.
  - 5. ASTM E679 - Standard Practice of Odor and Taste Thresholds By a Forced-Choice Ascending Concentration Series Method of Limits.
  - 6. ASTM C582 - Revision of C582-02 Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
  - 7. ASTM D3299 - Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.
  - 8. ASTM D3982 - Standard Specification for Contact Molded Fiberglass Ducts.
- B. National Fire Protection Association (NFPA):
  - 1. The system and its components shall meet the requirements of NFPA 820 and other relevant codes and standards.

## 1.04 SUBMITTALS

- A. Submit shop drawings and literature describing the equipment and associated components for evaluation and approval. Fabrication of odor control system shall not begin until a written approval and notice to proceed is provided. If the selected manufacturer's equipment layout, configuration, and/or piping requires changes from the bid documents, it is the responsibility of the manufacturer to clearly submit all proposed changes in the submittals at no additional cost to Owner or Engineer. All exceptions and/or deviations shall be fully identified and described.
- B. General - Provide Shop Drawings, samples, administrative, quality control, and contract closeout submittals in accordance with the requirements of Section 01330 - Submittal Procedures, and as listed below.
- C. Provide shop drawings and items as specified herein for review prior to approval:

- 1. Detailed structural and mechanical layout drawings showing system fabrication, dimensions, size, and locations of connections to other work.
- \* 2. Complete basis of design calculations for the FRP vessels, ladders, and media supports. Structural calculations and drawings for the Bioscrubber vessel, shall include wind and seismic load calculations and anchor bolt sizing. The design of structural and wind calculations shall be according to the current Hawaii Building code, Section 01850 - Design Criteria of the specifications and shall be sealed by applicable registered Professional Engineer in the state of Hawaii.
- 3. Description of the laminate and the type of reinforcing to be used and a letter from the manufacturer stating the laminate reinforcing material used will provide chemical resistance at least equal to the published chemical resistance for the resin for the intended application, and the resin will meet the performance requirements stated and is suitable for the service conditions specified herein and the fabrication technique proposed. Manufacturer shall also submit certification of applicable wind load design in accordance with current edition of the Hawaii Building Code and applicable specifications.
- 4. Furnish a list of recommended spare parts for each piece of equipment in the scope of supply.
- \* 5. Process control narrative. Include irrigation system summary of the two featured modes of irrigation and how to change from recirculation mode quickly and easily to once-through, and vice-versa.
- \* 6. Description of control system operation to demonstrate compliance with the Specifications.
- 7. Equipment offloading and installation instructions with enough detail to allow the Contractor to complete the mechanical and electrical installation of all System components.
- 8. Annual utility and nutrient usage calculations.
- \* 9. Information on hazards associated with the System and appropriate safety precautions, including applicable Material Safety Data Sheets (MSDS).
- 10. Installation guidelines for the Contractor.
- 11. Manufacturer's catalog information, descriptive literature, specifications, and identification of materials of construction. Provide a detailed bill of materials.
- 12. Manufacturer's Information on the Bioscrubber media, such as:
  - a. Pressure drop data through media.
  - b. Media physical characteristics, including:
    - 1) Media volume.
    - 2) Media depth for each bed/layer.
    - 3) Specific surface area.
    - 4) Void ratio.
    - 5) Media sieve analysis (if applicable).
    - 6) Weight per cubic foot.
  - c. Information on expected settling rates of the media per year (if applicable).
  - d. Odor control system pressure drop calculations to include from suction ductwork connection at fan to the final discharge of the biotrickling filter.
  - e. Operating data from previous installations to substantiate media performance claims.
- 13. Manufacturer's information on the recirculation pump, spray nozzle, mist eliminator and all other mechanical components as applicable.
- 14. External utility requirements.

\* Anchor bolt calculations provided by others.

\* To be submitted under a separate cover.

\* To be submitted under a separate cover.

\* To be submitted under a separate cover.

\* NOTE #1: Fiberglass reinforced plastic vessels and surfaces are proposed to be coated with a factory applied, paraffinized gel coat finish in accordance with industry standards. Gel coat is made of the same resin base as the FRP vessel itself, providing superior surface adhesion and UV protection. See Section 3 for datasheet. This is in lieu of the coating listed in Section 09\_96\_01 Appendix B – Coating Detail Sheet for system EPU-FRP-1, which calls for a one coat epoxy with polyurethane finish coat.

\* To be submitted under a separate cover.

- \* 15. Complete instrumentation, control, logic, and power wiring diagrams, electrical schematics in sufficient details to allow installation of the instrumentation, controls, and electrical components.

\* To be submitted under a separate cover.

- \* 16. VWCP, VLCPs and VMCP external layouts, internal layouts, bill of materials, logic diagrams, HMIs, power and control wirings, PLC I/O, network connections, calculations, thermal management including air conditioners and heaters.

\* See NOTE #1 above.

- \* 17. Coating systems - Including manufacturer's descriptive technical catalog literature and specifications per Section 09960 - High-Performance Coatings.

\* To be submitted under a separate cover.

- \* 18. Field-testing plan for meeting system performance requirements.

\* To be submitted \* under a separate cover.

- D. Provide quality control submittals per Section 01330 - Submittal Procedures and Section 01756 - Commissioning, and as follows:
  1. Manufacturer's Certification of Compliance that the factory finish system is identical to the requirements specified herein.
  2. Manufacturer's Certificate of Installation and Functionality Compliance.
  3. Manufacturer's training program.
  4. Equipment Testing and Field Start-Up Report.

\* To be submitted under a separate cover.

\* To be submitted \* under a separate cover.

- \* E. Submit certification indicating the quality control, testing, and inspection has been completed and standards specified herein have been met prior to shipment to the jobsite.

- F. Furnish 3 bound copies and two (2) electronic copies of the Operation and Maintenance instructions for each odor control unit. The information shall be sufficient to instruct personnel who are unfamiliar with such equipment in the operation and maintenance of the system. It shall include diagnostic procedures to be used in the event of system shutdown or malfunction. Comply also with Section 01782 - Operation and Maintenance Manuals.

- G. Submit the performance guarantee and warranty for the system.

- H. Submit results of all performance testing procedures and results.

## 1.05 WARRANTY AND PERFORMANCE GUARANTEE

- A. As specified in Section 01783 - Warranties and Bonds.
- B. Special Warranty - Each biological odor control system and all associated components shall carry a 3-year "Full Replacement Warranty" that shall begin once the unit has been started, accepted by Owner, and is meeting all performance requirements. The synthetic/inert biological media, vessels, and support gratings shall carry a 10-year non-pro-rated full replacement warranty. Cost of removal and replacement of media shall be by Owner.
- C. Performance guarantee - The contractor and OCS shall guarantee the performance of each biological odor control system for 2 years from the final acceptance by the owner. If, within the 2-year guarantee period, the system fails to meet the performance requirements specified herein, the contractor and OCS shall make all corrective actions necessary to improve system performance at no additional cost to the Owner. The corrective actions may include replacing equipment or parts,

making operational adjustments, or replacing the entire system and all associated components.

## **1.06 SHIPPING, DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.

## **PART 2 PRODUCTS**

### **2.01 APPROVED MANUFACTURERS**

- A. The odor control systems manufacturer referred herein as the Odor Control Supplier (OCS) shall be experienced in the design, fabrication, construction, and successful operation of biological odor control systems for the removal of hydrogen sulfide gas and other odor producing compounds from air ventilated from wastewater treatment systems. All equipment shall be furnished by a single manufacturer/OCS with single-source responsibility.
- B. Systems utilizing organic, lava rock, stone, or proprietary media shall not be accepted.
- C. Manufacturers - The following or approved equal.
  1. Daniel Mechanical Company, Upland, California. (Basis of Design)
  2. Evoqua Water Technologies, LLC, San Diego, California.
- D. If an odor control system manufacturer/OCS is not a listed manufacturer and would like to be included in the above list, at a minimum the manufacturer shall:
  1. Provide manufacturer literature on bioscrubber equipment, components, and materials. A specification on the material and structural integrity of the vessel must be provided.
  2. Provide a letter documenting compliance with this specification, and if necessary, state any exceptions.
  3. Provide at least five (5) examples of satisfactory installations using proposed media treating an average influent hydrogen sulfide concentration of greater than 200 ppm and a peak concentration greater than > 400 ppm.
  4. Provide design criteria for each of the examples, including but not limited to - air flow (cfm), hydrogen sulfide inlet design concentration (ppm), hydrogen sulfide removal (%), water usage (gpd), vessel diameter and height (feet), and media used.
  5. Provide a list of references for each of the example installations with contact information including but not limited to - accurate contact information of owner (name, job title, location, phone number, email address), placed in service date, design conditions including air flow rate and hydrogen sulfide loading.
  6. Owner reserves the right to request additional information.
- E. The design of the odor control equipment is based on Daniel Mechanical Company. Any design modifications to the specified requirements and the design drawings shall be submitted for approval, and any costs associated to accommodate modified design to the system shown on the drawings and associated equipment shall be borne by Contractor. This shall include all design, procurement, and installation

costs for any necessary structural, mechanical, electrical, instrumentation and controls, and any other changes required for a complete and satisfactory installation, including Engineer's cost for redesign if any. Submitted systems not meeting the intent and configuration of the odor control systems as specified and shown on the drawings will not be accepted and will be rejected with no further review.

## 2.02 DESIGN CRITERIA

- A. Each facility odor control system shall be designed to meet the following criteria and shall meet or exceed the minimum performance requirements listed. Systems not meeting minimum EBRT (Empty Bed Residence Time) will not be accepted.

<b>Headworks Facility Odor Control System</b>	
Number of Bioscrubber vessels	2
Tags	07-BIS-1100, 07-BIS-1200
Vessel configuration	Vertical round
Diameter	14.0 ft
Minimum Height (not including stack)	37 ft
Number of local bioscrubbers water control panels, also referred to as Vendor Water Control Panel (VWCP)	2 Tag – 07-VCP-1150 Tag – 07-VCP-1250
Number of Local odor fan control panels, also referred to as Vendor Local Control Panel (VLCP1)	1 Tag – 07-VCP-1010
Number of Local Bioscrubber control panels, also referred to as Vendor Local Control Panel (VLCP2 for bioscrubber 1 and VLCP 3 for bioscrubber 2))	2 Tag – 07-VCP2-1100 Tag – 07-VCP3-1100
Number of master electrical control panels, also referred to as Vendor Master Control Panel (VMCP)	1 Tag – 07-VCP-1100
Total design air flow rate	23,000 cfm
Design air flow rate per vessel	11,500 cfm
Maximum pressure loss per vessel including mist eliminator	4.5-inch w.c.
Total number of media beds per vessel	3
Maximum Media depth/bed	7.25 ft
Minimum EBRT per vessel	17.47 seconds
Total number of recirculation pumps	2 (1 pump per vessel) 07-PMP-1140 07-PMP-1240
Inlet hydrogen sulfide	
Average	70 PPM
Peak	140 PPM

<b>Headworks Facility Odor Control System</b>	
Minimum H <sub>2</sub> S removal efficiency/24 hrs Average	99% or 0.5 ppm whichever is greater

## 2.03 SYSTEM COMPONENTS

- A. The Bioscrubber vessel shall be made of fiberglass reinforced plastic (FRP) material. The FRP shall be premium vinyl ester fiberglass resin. Vessels shall be resistant to chemical attack compounds present in the application. Each vessel shall contain, as a minimum, a 100-mil vinyl ester resin corrosion barrier. Resin shall be Derakane™ 510-B-400 by Dow Chemical or equal throughout the entire vessel and shall meet Class 1 fire spread per ASTM E84 without additives. Exterior fiberglass layer shall be UV resistant with UV resistant gel coat. Vessel fabrication shall be in accordance with Section 06608 - Fiberglass Reinforced Plastic, ASTM D3299, and ASTM D4097, whichever more stringent requirements shall apply. Vessel wall shall be filament wound to the thickness as required by design but no thinner than a minimum of 3/8-inch wall thickness excluding the 100-mil corrosion barrier. Submit structural calculations of the vessels signed and stamped by a Hawaii professional engineer.
- B. Vessel components shall be preassembled at the point of fabrication. Preassembly will not require all joints to be factory assembled, but all joints shall be prepared for field fabrication and square.
- C. Owner reserves the right to select the Bioscrubber vessel and ductwork exterior color.
- D. At a minimum, manways at sump, top and bottom of each packing bed, and top of mist eliminator shall be provided. Manways shall be at least 30 inches in diameter for access to facilitate both removal and replacement of the media. They should be located away from any obstructions such as piping and ductwork. All manways, except for those mounted at the vessel top, shall be provided with 1/2-inch-thick clear LEXAN covers.
- E. The bottom or reservoir section shall include at a minimum air inlet connection, makeup water connection, nutrient feed connection (if needed), inoculant injection connection, recirculation pump suction connection, drain, overflow, and any other required connections.
- \* F. Equipment shall be furnished with concrete anchors and hold down lugs, complete with Type 316 stainless steel plates, bolts, nuts, and washers for proper anchoring of the tank as required by the manufacturer/OCS.
- G. The structure shall comply with the specifications and current edition of the Hawaii Building Code including design for applicable wind loads, whichever is stricter and more stringent. If necessary, hurricane straps and accessories shall be provided to securely anchor the unit to the slab.

\* Anchor calculations and hardware by others. Hold down lugs will be attached to the vessels and provided by Daniel Company.

- H. Bioscrubber shall have air inlet and outlet flanges. Flanges shall be 3/4-inch thick, and widths will be commensurate with the scrubber dimensions. Maximum flange width will be 3 inches, otherwise flange dimensions shall be per ASTM 3982.

\* Ductwork and flex connectors will be submitted under a separate cover. Flex connectors will be provided on the fan outlets as shown in the plans. There are no flex connectors shown on the vessel inlet connections. "Loose" FRP sums and wrap kits will be provided by Daniel Company. Field location and installation of the sums shall be completed by others.

I. Provide flanged EPDM flexible connectors at vessel inlet air for connection of ductwork from fan discharge. Air inlet duct between the blower and vessel shall have a 1-inch diameter tap and 1-inch ball valve for inlet air sampling. Also provide a 12-inch diameter by 6-inch deep FRP sump in the ductwork at low points, connect 1-inch diameter tap and 1-inch PVC ball valve in the bottom of the duct to remove condensate in air duct at low point elevations including before the blower and between the blower and vessel, whether indicated or not indicated on the drawings.

- J. Vessel shall be furnished with a vertical exhaust stack with a bolted flanged connection to the outlet. Vertical exhaust stack shall be provided with a down turned 2-inch diameter internal outlet air collection, transitioning to 1-inch diameter outside the vessel, routed down to approximately 4 feet above the finished grade with a 1-inch ball valve for outlet air sampling. Outlet sample can either have a 1/2-inch hole in the pipe downstream of the sample location to facilitate airflow or can be routed to the suction side of the blower to allow for positive flow to the sample location.

- K. The chemically resistant synthetic/inert media shall have a high specific surface area of a minimum  $550 \text{ m}^2/\text{m}^3$  to provide an optimal site for growth of microorganisms while allowing for even airflow and water recirculation without possibility of media compaction. The media shall be made from chemically resistant material. Proprietary media is not allowed. The system must be constructed in a manner to minimize the potential for short circuiting of the air being treated.
- L. Media shall be supported by media support plates, packing support plates and mid span supports. Supports shall be suitable to support the weight of the packing specified plus entrained water/solution and any deposits on the media. Opening size shall not allow for passage of packing media in any random orientation. Manufacturer/OCS shall provide instructions for placement and removal of packing support in and out of the vessel.
- M. The vessel shall be configured with multiple fluid injection spray nozzle per spray array designed to be clog resistant. The spray nozzles shall be located to disburse the fluid evenly over the entire media surface area. Internal spray piping shall have flanged connection for easy removal without entering the vessel.
- N. The operation of the spray nozzles shall be via a recirculation pump (recirculation mode) or a motor-controlled actuator valve (fresh water intermittent mode) and shall be capable of continuous, intermittent, and dual mode operation with either recirculated sump water or fresh water.
- O. Mist eliminator shall be sized and provided to prevent excess mist from being discharged from each Bioscrubber vessel tower exhaust. Mist eliminator shall be sized for maximum face velocity of 750 ft/min and designed to remove 99 percent of all mist particles 40 microns and larger and 90 percent of all mist particles 10 microns and larger.

- P. Recirculation pumps shall be sized and selected by manufacturer/OCS supplier and shall be magnetic drive pump, dynamically balanced and be capable of mounting directly to standard NEMA motors. The pump shall be totally enclosed and suitable for exposure to the elements. Motors shall be TEFC. All pump components that are in contact with recirculation fluid shall be constructed of corrosion resistant materials such as ETFE or carbon fiber filled ETFE or approved equal materials. Vertically mounted motors shall include rain guard for protection. If necessary, the recycle line shall include motorized ball valves to alternate between multiple spray headers.
- Q. Provide supplemental nutrients to be periodically added to the injection fluid on and automatic or continuous basis to meet the performance requirements, they shall be supplied from an external tank as indicated on the drawings.
1. To maintain a fresh nutrient supply, nutrient storage tanks shall be sized for a minimum of 100 gallons. OCS shall provide the calculations to show the 100 gallons nutrient tank is sufficient for the design criteria, otherwise a larger tank shall be provided as required at no additional cost to Owner or Engineer.
  2. Liquid nutrients shall be available locally, non-hazardous, and non-proprietary. Manufacturer/OCS is responsible for providing chemical composition of recommended nutrients along with non-proprietary supplier information.
  3. When available, secondary plant effluent meeting supplier's standards shall be used in lieu of a nutrient feed system.
  4. The nutrient dosing system shall be provided by a dedicated metering pump for the delivery of nutrient to the media bed compartment. The metering pump shall be manually adjusted for output by the operator and located in the VWCP. Nutrient system tank shall include fill, outlet, low level switch and indicator and vent.

\* R.

pH probe and controller:

1. Manufacturers - Hach, Rosemount; or equal.
2. Probe - Glass pH sensor housed in a molded reinforced polypropylene body threaded for insertion, submersion, or flow-through installation as indicated on the Drawings. The probe will be mounted in the recirculation piping system in the VWCP (07-VCP-1150/1250 for each Bioscrubber as indicated on the plans).
3. pH analyzer/controller - NEMA 4X enclosure mounted on the face of each Vendor Local Control panel (VLCP). The controller shall be capable of receiving and sending pH 4-20 ma signals and receive signals from instruments as shown on the plans and P&IDs.
4. Transmitter - Power supply - 120 VAC. Outputs - Two isolated 4 to 20 milliamperes DC. The pH probe/analyzer controller will be powered from the VMCP.

\*

- S. Provide thermal mass airflow meter/transmitters and appurtenances to be installed in the air ductwork upstream of the odor control fans as shown on the plans and specified herein:
1. Manufacturers - One of the following or equal:
    - a. Kurz Instruments, Inc., Wet gas model.
  2. Performance requirements:
    - a. Accuracy:
      - 1) 1.5 percent of full scale for velocities over 2 feet per second.

- b. Repeatability:
  - 1) 0.5 percent of full scale.
- 3. Element:
  - a. Sensor with terminal enclosure.
  - b. Area Classification: Class I, Div 2 rated.
  - c. Construction suitable for area classification.
  - d. Utilize a sensor with 3/4-inch male NPT process connection.
  - e. No overheat at zero flow.
- 4. Transmitter:
  - a. Microprocessor-based.
  - b. Enclosure – suitable for Class I, Div 2 area
  - c. Power supply:
    - 1) 120 VAC.
    - 2) Power consumption - 50 VA maximum.
  - d. Outputs:
    - 1) Isolated 4 to 20 mA DC with HART communication protocol.
    - e. Alphanumeric display for flow rate.
    - f. Ambient operating temperature limits - 0 to 150 degrees Fahrenheit.
    - g. Because transmitter will be located in an operator inaccessible area, provide panel meter in local fan VCP to display incoming flow. for air flow readings and for operator use of manual fan speed adjustment and air balancing.
- 5. Components:
  - a. Signal cable between insertion probe and transmitter:
    - 1) Abrasive-resistant, polyurethane jacket.
    - 2) Sensor cable permanently bonded to sensor.
    - 3) Provide enough length of cable to allow removal and inspection of insertion element.
  - b. Flowmeters and instrumentation shall be furnished by the OCS, who shall be responsible for the entire system performance and compatibility.

T. Vendor Water Control Panel (VWCP):

- 1. OCS shall provide each odor control Bioscrubber vessel with one (1) Vendor Water Control Panel (VWCP) to supply and control the irrigation and nutrient supply systems as specified and indicated on the plans.
- 2. Constructed of NEMA 4X, 316 stainless-steel with integral sun shield.
- 3. Mounted free standing with 316 stainless steel supports, anchors, and hardware. The panels shall be designed and mounted outside adjacent to the vessel areas as shown on the plans and anchored to the concrete pad with 316 Stainless Steel anchors. The structural design of the VWCPs shall be the responsibility of the OCS.
- \* 4. Contains piping, manual valves, motorized ball valves, instruments, nutrient pump and controls for the nutrient and recirculation systems and related appurtenances. Operate using control signals from the VMCP and as shown on the plans. All components shall be preassembled piped and supported. These components shall be sized and selected by the manufacturer/OCS supplier and include but not limited to:
  - a. Motorized valves.
  - b. Isolation valves and check valves.
  - c. Pressure gauges, switches, and transmitters.
  - d. Magnetic flowmeters and indicators.

\* Anchors, anchor calculations and anchor design by others.

\* See proposed panel layout in Section 6 of the submittal herein.

- e. Rotameters.
- f. PH sensors and analyzer/indicators.
- g. Throttling needle, diaphragm, and globe valves.
- h. Nutrient metering pumps.
- i. Supports.
- j. Junction boxes for control and power wirings.

- \* Piping, valves, etc. external of the water control panel shall be provided by others.
- \* 5. Inlet water piping to the VWCP shall include pressure reducing valve, Basket strainer, and isolation valves as indicated on the plans and shall be provided by OCS.
    - a. Basket strainer shall be suitable for 150 psi working pressure minimum.
  - 6. Allow for a single connection to a potable or secondary effluent plant water source. However, Contractor is responsible for adding dichlorination filter if recommended by the odor control supplier.
  - 7. Power and control wiring and conduits from VMCP to the VLCP, and VWCP and to the field instruments and vice versa shall be installed by Contractor.

\* U. Headworks Odor control fans and associated VFDs:

- 1. Provide fans as specified in Section 15832 - Centrifugal Fans for Odor Scrubbing Service.
- 2. The fans shall be driven by Variable Frequency Drives (VFDs). The VFDs shall be located in the Primary Facilities Building as indicated on the plan drawings and be provided by the OCS.
  - a. All variable frequency drives shall comply with 16265 – Reduced Harmonic Variable Frequency Drives.
- 3. OCS to furnish VFDs which will be installed in the Primary Facilities building.
- 4. Provide vibration switch for each fan to shut down the fan in high vibration. The vibration switch shall be monitored from both the fan VLCP and the VMCP and shall provide high vibration alarm upon shutdown. Explosion proof vibration switch to be mounted on the fan and wired to alarm and shutdown fan in the event of excess fan vibration. The switch shall be made by Robertshaw, Murphy; or approved equal. The switch shall have a base mounted case, explosion-proof aluminum alloy housing; meets NEMA 7/IP50 specifications; Class I, Division I, Groups C and D; UL and CSA listed with 120 VAC rating, SPDT switch operation.
- 5. Provide an indication of fan belt failure and Zero speed. Alarm on both. These alarms will also be transmitted to the plant area PLC via network communications.

V. Safety devices:

- 1. Manufacturer/OCS supplier shall design and provide each vessel with access platforms, handrails and ladders designed to meet the OSHA and Hawaii codes for safety, wind and seismic loadings and as specified herein and indicated on the plans.
  - a. Hawaii and US OSHA approved FRP handrails and self-latching safety swing gates around the top perimeter of each vessel.
  - b. FRP platform for access to the spray nozzles. The platform shall be supported from the vessel and have inlet safety gate.
  - c. FRP ladder with fall protection system Model SAF-T-CLIMB for access to both top of vessel and nozzles platform. Do not include a safety cage.
    - 1) Comply with local, State, and OSHA standards, as a minimum.

- 2) Be extra-duty, ladder and each rung rated for minimum 350-pound load.
- 3) For fall prevention system, include railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying OSHA safe climbing requirements.
- d. Where possible, the manufacturer/OCS shall pre-fit and assemble all portions of the platforms, handrails, swing gates, and ladders to the vessel to the extent possible prior to shipping. The contractor shall field install any required loose components associated with the safety components.

- \* W. Vessel shall be provided with a permanently attached, stainless steel equipment identification plate. The label shall state the following in die-stamped lettering for the plate:

1. Equipment identification (tag) number shown on submittals and vessel name.
2. Manufacturers' name and address.
3. Model number and serial number.
4. Date of manufacture.
5. Material of construction.
6. Design pressure (vacuum).
7. Operating weight.
8. Vessel dimensions.

- \* X. All PVC piping associated with the Headworks Odor Control System including, but not limited to, recirculation, irrigation, nutrient feed, sampling, and drains shall be minimum Schedule 80 PVC piping.
- \* PVC piping inside of the BTF vessels shall be provided by Daniel Company. External PVC piping by others.

## \* 2.04 CONTROL SYSTEM

- \* To be submitted under a separate cover. A. General:
  1. Refer to the electrical and P&IDs drawings for additional information as well as specified herein.
  2. Vendor Water Control Panels:
    - a. The OCS shall provide the following control panels:
      - 1) Main Control Panel VMCP tagged 07-VCP-1100.
      - 2) Scrubber Fan Control Panel VLCP1 tagged 07-VCP-1010.
      - 3) Two Local Control Panels VLCP2/3 tagged 07-VCP2-1100 and 07-VCP3-1100.
      - 4) Two Water Control Panels VWCP tagged 07-VCP-1150 and 07-VCP-1250.
    3. Control system components include but are not limited to a local operator interface, Rockwell Compact or ControlLogix PLC, Motorized Valves, Timers, Relays, Nutrient Feed Pump Controls, Recirculation Pump Controls, Odor Control Fan Controls, Pressure, pH and Flow Instrument monitoring/feedback, associated level control interlocks in the Nutrient Tank and Bioscrubber, and gauges, as specified to meet the requirements and operational functionality of the system.
    4. Contractor shall provide all conduit and wire between each of the panels and the owners control system.
    5. The VMCP shall be manufactured of powder coated steel with all stainless steel mounting hardware and have a NEMA 12 enclosure rating. Each VMCP shall include PLC components and an LOI and shall be located in the Primary Facilities building as shown on the plans.

6. Each VLCP shall be manufactured of 304 stainless steel with all stainless-steel mounting hardware and have a NEMA 4X enclosure rating. Each VLCP shall include Panic-stop, pH display meter, flow pacing display meter, and operators and indicators and alarms for fans, pumps, and valves, level switches and other components as specified and shown on the plans. Each VLCP shall be located adjacent to its respective Bioscrubber unit and fans as shown on the plans.
7. Provide pressure gauge(s) on suction and discharge of each fan.
8. Labels shall be fixed to the face of the panel in such a manner that the function of each component shall be easily ascertained. Label terminal strips shall be provided to facilitate wiring of external devices such as switches, sensors, meters, and controllers. No more than two conductors shall be located in each termination point.
9. All conductors shall be labeled with wire numbers and those numbers shall correspond with those provided in a wiring and panel layout diagram. All components shall be labeled with the same symbol reference shown in the electrical wiring and instrument list.
10. Equipment metal framework shall include a ground wire (#2 tinned copper) bonded to the grounding grid. It shall be exothermically welded to the grounding grid and mechanically attached to the frame with a compression terminal on the wire and bolted to the frame.
11. Motor accessories and winding heaters:
  - a. Provide all 3 phase motors with belted or cartridge space heaters mounted within the motor enclosure.
  - b. Space heater rating shall be 120 volts, single-phase, unless otherwise indicated on the Drawings.
  - c. Power leads for heaters wired into conduit box.
  - d. Installed within motor enclosure adjacent to core iron.
  - e. Thermal Protection - provide automatic reset motor stator temperature detectors/switches, one switch in each phase. If any detector is activated, the sensor shall activate when the stator temperature exceeds 125 degrees C.
  - f. Provide current monitoring for all 3-phase motors.
12. VMCP and VLCPs shall be as specified herein and meet sections:
  - a. 16050 - Common Work Results for Electrical.
  - b. 17050 - Common Work Results for Process Control and Instrumentation Systems.
  - c. 17100 - Control Strategies.
  - d. 17101E - Specific Control Strategies- Headworks Odor Control.
  - e. 17710 - Control Systems: Panels, Enclosures, and Panel Components.
  - f. 17712 - Control Systems: Uninterruptible Power Supplies 10kVA and Below.
  - g. 17720 - Control Systems: Programmable Logic Controllers.
  - h. 17721 - Control Systems: Local Operator Interface (LOI).
  - i. 17733 - Control Systems: Network Materials and Equipment.
  - j. 17765 - Control Systems: Programming Requirements.
  - k. 17950 - Commissioning for Instrumentation and Controls.

B. Vendor Master Control Panel (VMCP 07-VCP-1100):

1. Construction and components as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

2. Enclosure:
  - a. Type NEMA 12 powder coated steel and as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.
  - b. Located in the Primary Facilities Building. Free standing, designed for seismic loading conditions, and anchored to a concrete pad as shown on the plans.
3. Electrical components:
  - a. Power Supply to Panel: 480-volt, 3-phase.
    - 1) Provide an internal breaker with the line side terminals covered by a barrier.
    - 2) Provide internal control power transformer for 120VAC to supplementary panels.
  - b. Circuit Breakers: As specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
    - 1) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
  - c. Motor starters for Recirculation pumps to be located in VMCP 07-VCP-1100 and wired to provide control and status at the panel.
  - d. Standalone VFDs for fans to be type, provided by OCS and located in Primary Facilities near VMCP. Provide terminals to interface to both VMCP 07-VCP-1100 and the local field panel 07-VCP-1010. Contractor to provide the necessary wiring and conduits between 07-VCP-1010 and 07-VCP-1100 the VMCP to VLCP and VWCP and vice versa for proper operation of the systems.
  - e. Power systems:
    - 1) Provide a surge protection device for incoming power. Provide surge protection for all power and control signals that are connected to devices outside a building.
    - 2) Provide duplex GFCI protected, 120-volt, 60-Hertz, 1-phase receptacle.
    - 3) Provide redundant 24 VDC regulated power supply.
    - 4) Provide a dedicated circuit breaker for each 120VAC load. Provide a dedicated fuse for each 24 VDC load. Combining breakers or fuses for multiple loads is not acceptable.
    - 5) Provide terminal strips for landing all field wiring.
4. Control components:
  - a. General:
    - 1) Control panel shall carry a UL label certifying the assembled industrial control panel complies with UL 508A.
    - 2) Provide thermal management for safe operation of all devices within the cabinet as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.
    - 3) Control panel shall be completely prewired, preprogrammed, and factory tested for proper operation prior to shipment as specified in Section 17950 - Commissioning for Instrumentation and Controls.
    - 4) Relays, timers, and other components as required providing the specified functionality and remote monitoring connections.
    - 5) Communicate with the plant control system over EtherNet/IP.

- 6) VMCP will send a single common general alarm to the plant control system via network connection.
    - 7) Provide necessary interlocks and time delays (operator adjustable) for system control.
  - b. Control panel shall consist of, but not be limited to, the following to provide a complete and operable system:
    - 1) A preprogrammed Rockwell CompactLogix or ControlLogix PLC to monitor and control operation of the system as specified in Section 17720 - Control Systems: Programmable Logic Controllers.
      - a) All PLC communication shall use Ethernet/IP.
      - b) Segregate ethernet communication so the owners control system can only see main PLC. All other ethernet traffic must be sub netted.
    - 2) Provide A local operator interface (LOI) as specified in Section 17721 - Control Systems: Local Operator Interface (LOI) on the front face of the VMCP for system monitoring, controlling, and adjustment of set points, timers, and alarms.
  - c. Provide network equipment such as managed ethernet switches, copper patch panels, as specified in Section 17733 - Control Systems: Network Materials and Equipment.
- C. Fan Vendor Local Control Panel VLCP (07-VCP-1010):
1. Provide field mounted panel for both odor control fans that allow for local control with indication as described here in.
  2. Contractor to provide wire and conduit between Fan Vendor Local Control Panel (07-VCP-1010) and Master Bioscrubber panel 07-VCP-1100 and the associated VFDs:
- D. Water Control Panels:
1. All devices requiring power shall be powered and controlled from the main vendor control panel 07-VCP-1100.
  2. panels per Bioscrubber unit (07-VCP2-1100 and 07-VCP3-1100). In systems with more than one Bioscrubber unit, control is maintained over all units by the VMCP.
  3. Construction and components as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.
  4. Refer to the P&IDs drawings for additional information on controls.
  5. Enclosure:
    - a. Type NEMA 4X 304 stainless steel and as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.
    - b. Free standing, designed for seismic loading conditions, and anchored to a concrete pad as shown on the plans.
  6. Electrical Components:
    - a. Power Supply to Panel - 480-volt, 60-Hz, 3-phase, from VMCP.
  7. Control Components:
    - a. General:
      - 1) Control panel shall carry a UL label certifying the assembled industrial control panel complies with UL 508A.
      - 2) Provide thermal management for safe operation of all devices within the cabinet as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

- 3) Control panel shall be completely prewired, preprogrammed, and factory tested for proper operation prior to shipment as specified in Section 17950 - Commissioning for Instrumentation and Controls.
    - 4) Relays, timers, and other components as required providing the specified functionality and remote monitoring connections.
  - b. Control panel shall consist of, but not be limited to, the following to provide a complete and operable system:
    - 1) Pushbuttons.
    - 2) Push-to-test Indicator Lamps.
    - 3) Selector Switches.
    - 4) Digital Panel Meters for analog instrument readouts.
    - 5) And as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.
8. Fan Vendor Local Control Panel 07-VCP-1010 Operation:
    - a. General:
      - 1) As indicated on the contract drawings and as specified in this section.
    - b. Control devices (Each fan):
      - 1) PANIC-STOP pushbutton.
      - 2) Odor Control Fan HAND-OFF-REMOTE selector switch (in HAND fan will start automatically).
      - 3) Odor Control Fan RESET Pushbutton.
      - 4) Odor control Fan Speed potentiometer.
      - 5) Odor Control Fan RUNNING lamp.
      - 6) Odor Control Fan FAILED lamp.
      - 7) Odor Control Fan speed indication.
      - 8) Foul air flow indication (from air flow meter) (4-20mA signal from 07-VCP-1100 to panel meter) as shown on the Drawings.
  9. 07-VCP2-1100 and 07-VCP3-1100 Operation:
    - a. General:
      - 1) As indicated on the contract drawings and as specified in this section.
    - b. Control devices (Each Bioscrubber VCP 07-VCP2-1100 and 07-VCP3-1100):
      - 1) Recirculation/Once-Through selector switch.
      - 2) Recirculation Pump HAND-OFF-REMOTE selector switch (in HAND pump starts automatically).
      - 3) Nutrient Dosing Pump HAND-OFF-REMOTE selector switch.
      - 4) 2-way motorized Once-Through & makeup water flush valve HAND-OFF-REMOTE selector switch.
      - 5) 2-way motorized Once-Through & makeup water flush valve OPEN-STOP-CLOSE selector switch.
    - c. Indication/Alarms (Each Bioscrubber VLCP):
      - 1) Bioscrubber Level Float switches LEVEL LOW-LOW lamp.
      - 2) Bioscrubber Level Float switches LEVEL LOW lamp.
      - 3) Bioscrubber Level Float switches LEVEL HIGH lamp.
      - 4) Nutrient Tank LEVEL LOW lamp.
      - 5) Recirculation Pump RUNNING lamp.
      - 6) Recirculation Pump FAULT lamp.
      - 7) 2-way motorized Once-Through & makeup water flush valve OPEN lamp.

- 8) 2-way motorized Once-Through & makeup water flush valve CLOSE lamp.
- 9) Nutrient Dosing Pump RUNNING lamp.
- 10) Nutrient Dosing Pump FAULT lamp.
- 11) Digital Panel Meter for local pH readout.
- 12) Low pH alarm lamp.
- 13) Recirculation Flow Meter FLOW LOW lamp.
- 14) Digital Panel Meter for recirculation Flow readout.

**E. System Control Philosophy:**

1. General:
  - a. Hardwired interlocks to shut down the equipment in all modes of operation and activates Fail Alarms. Refer also to the P&IDs and electrical drawings for additional information.
2. Operating Modes:
  - a. Headworks Odor Control fans:
    - 1) One fan operates at a time. The second fan would be in standby. In the event the service fan is out of service, the standby fan would be put online manually. There is no automatic switching to the standby fan in case of the failure of the online fan.
    - 2) If the fan HAND-OFF-REMOTE at the VLCP1 is in HAND, the fan can be started manually at the VLCP1 by pressing the START button.
    - 3) If the fan HAND-OFF-REMOTE at the VLCP1 is in REMOTE, the fan can be started manually at the VMCP via the local operator interface screen.
    - 4) The speed of the fan will be manually adjusted via the speed potentiometer at the VLCP1.
    - 5) There is no automatic speed adjustment for the fans at either the VLCP1 or at the VMCP.
    - 6) The speed of the fan would be adjusted manually as required to meet the air flow requirement for the odor control system (23,000 cfm) as monitored by the thermal air flow meter located in the ductwork upstream of the odor control fans. A panel meter display will be provided for the air flow meter value and is mounted in the VLCP1 for monitoring during manual fan speed adjustment.
  - b. Bioscrubber Recirculation mode system operation (VLCP2 and VLCP3):
    - 1) This mode of operation operates the recirculation pump during acclimation period of the media and continues after the bioscrubber acclimation period.
    - 2) The Recirculation/Once-Through mode selector switch (hereon known as the Rec/OT switch) is set to Recirculation position.
    - 3) The 3-way manual valves shall be manually adjusted to the appropriate positions to allow makeup water supply to the sump.
    - 4) The makeup water supply valve HAND -OFF-REMOTE (HOR) selector switch is set to Remote position. The controls will close the valve if open and open the valve when low-level or low pH demands more water.
    - 5) If the recirculation pump HAND/OFF/REMOTE selector switch is set to the Remote position, the controls will start the recirculation pump.

- 6) If the nutrient pump HOR selector switch is set to Remote position, the controls will turn the pump on and feed nutrient at constant rate into the irrigation piping.
  - 7) With the makeup water flush valve HOR selector switch set to Remote position, the pH of the water is continuously monitored. The makeup water flush valve will be interlocked with pH and level in the sump. This will allow additional supply water to the sump to correct the pH in case the pH reaches a Low value (<1.5). It will also allow additional makeup supply water to the sump in case the water level in the sump reaches a low level.
  - 8) A sump Low-Low level switch shuts off the recirculation pump.
- c. Bioscrubber Once-Through intermittent irrigation mode system operation:
- 1) In this mode, the media should have been first acclimated using the recirculation mode above. Once acclimated, the system may then run as a once-through intermittent operation.
  - 2) The recirculation pump HAND/OFF/REMOTE selector switch is set to the Off position.
  - 3) The 3-way manual valves shall be manually adjusted to the appropriate positions to allow makeup water supply to allow plant water to pass directly to the spray nozzle system.
  - 4) The makeup/flush water supply valve HOR selector switch is set to Remote position. The controls will open and close the valve intermittently based on adjustable time cycle to irrigate the media periodically.
  - 5) Irrigation timing of once-through makeup/flush water supply valves shall be staggered within the PLC logic so that total demand of water from the plant water system is not excessive.
  - 6) If the nutrient pump HOR selector switch is set to Remote position, the controls will interlock the nutrient feed pump with the water supply valve to feed nutrient into the irrigation pipe when the makeup/flush water supply valve opens.
  - 7) With the Rec/OT switch set to Once Through (OT) position the pH of the water in the recirculation piping is not continuously measured. When operating in once-through mode it is advisable to allow no lower than 1.8 pH in the sump overflow. To achieve change in sump effluent pH, operations personnel must manually adjust timing settings for the irrigation schedule and allow the system to stabilize.
3. LOI Indicators and Alarms:
- a. General:
- 1) For Odor Control Systems that have more than one Bioscrubber Unit, provide status indicators and alarms for each fan and Bioscrubber system accessible from the area VLCPs and VMCP.
- b. Alarms:
- 1) pH LOW Alarm.
  - 2) pH HIGH Alarm.
  - 3) Recirculation FLOW LOW Alarm.
  - 4) Nutrient Tank LEVEL LOW Alarm.
  - 5) Nutrient Dosing pump FAIL Alarm.
  - 6) Recirculation pump Temperature HIGH Alarm.
  - 7) Recirculation pump motor starter OVERLOAD Alarm.
  - 8) Odor Control Fan Vibration HIGH Alarm.

- 9) Odor Control Fan Temperature HIGH Alarm.
  - 10) Odor Control VFD Fan Belt FAULT Alarm.
  - 11) Odor Control VFD general FAULT Alarm.
  - 12) Bioscrubber Sump LEVEL LOW-LOW Alarm.
  - 13) Bioscrubber Sump LEVEL LOW Alarm.
  - 14) Bioscrubber Sump LEVEL HIGH Alarm.
  - 15) Foul air system air low flow alarm.
  - 16) System Panic-STOP Alarm.
- c. Status Indicators:
- 1) Panel Power indication.
  - 2) pH indication.
  - 3) Recirculation/Once-Through Operation Mode indication.
  - 4) Recirculation flow indication.
  - 5) Nutrient Dosing pump RUNNING indication.
  - 6) Nutrient Dosing pump IN-REMOTE indication.
  - 7) Once Through & Makeup water flush valve OPEN indication.
  - 8) Once Through & Makeup water flush valve CLOSED indication.
  - 9) Once Through & Makeup water flush valve IN-REMOTE indication.
  - 10) Recirculation pump RUNNING indication.
  - 11) Recirculation pump STOP indication.
  - 12) Recirculation pump IN-REMOTE indication.
  - 13) Odor Control Fan RUNNING indication.
  - 14) Odor Control Fan STOP indication.
  - 15) Odor Control Fan IN-REMOTE indication.
  - 16) Odor Control Fan VFD READY indication.
  - 17) Odor Control Fan VFD SPEED feedback indication.
  - 18) Foul air flow indication.
- d. Operators:
- 1) Recirculation/Once-Through selection operator.
  - 2) Nutrient Dosing Pump HAND/OFF/REMOTE operator.
  - 3) Nutrient Dosing Pump START/STOP operator.
  - 4) Recirculation pump START/STOP operator.
  - 5) Recirculation pump HAND/OFF/REMOTE operator.
  - 6) Recirculation pump RESET operator.
  - 7) Odor Control Fan START/STOP operator.
  - 8) Odor Control Fan HAND/OFF/REMOTE operator.
  - 9) Odor Control Fan RESET operator.
  - 10) Odor Control Fan VFD SPEED Command operator.
  - 11) Once Through & Makeup water flush valve OPEN-STOP-CLOSE operator.
  - 12) Once Through & Makeup water flush valve HAND-OFF-REMOTE operator.

## 2. Hardwired I/O:

- a. Provide a list of all hardwired I/O between vendor's equipment and vendor's panels with each Vendor Package Submittal. At a minimum, hardwired I/O between vendor's equipment and vendor's panels shall include:
- 1) thermal air flow signal to Master Vendor Control Panel and Fan Local Vendor Control Panel meter display.
  - 2) Fan zero speed to Master Vendor Control Panel.
  - 3) Fan High amps to Master Vendor Control Panel.

- 4) Fan High vibration alarm to Master Vendor Control Panel.
  - 5) Fan belt failure alarm to Master Vendor Control Panel.
3. Network Communications and Owner Control:
  - a. General:
    - 1) Communications from Master Vendor Control Panel to Owner area PLC to be Ethernet/IP.
    - 2) An Ethernet Switch shall be provided in accordance with Section 17733 - Control Systems: Network Materials and Equipment. A fiber patch panel shall be provided and accept the incoming 12 strand multimode fiber optic cable, for communicating back to the Plant PLC/SCADA system.
    - 3) Owner area plant PLC/ SCADA system shall be capable of maintaining full system monitoring, control, and ability to adjust set points, timers, and alarms.
      - a) Provide a list of all soft I/O points to be shared with Owner area PLC/SCADA with each Vendor Package Submittal.
    - 4) Others as specified in Section 17100 - Control Strategies and Section 17101E - Specific Control Strategies - Headwords Odor Control.
    - 5) At a minimum provide the following soft I/O points:
      - a) RECIRC PUMP NO. 1 RUNNING.
      - b) RECIRC PUMP NO. 1 STOPPED.
      - c) RECIRC PUMP NO. 1 FAULT.
      - d) RECIRC PUMP NO. 1 FAIL TO START.
      - e) RECIRC PUMP NO. 1 FAIL TO STOP.
      - f) RECIRC PUMP NO. 2 RUNNING.
      - g) RECIRC PUMP NO. 2 STOPPED.
      - h) RECIRC PUMP NO. 2 FAULT.
      - i) RECIRC PUMP NO. 2 FAIL TO START.
      - j) RECIRC PUMP NO. 2 FAIL TO STOP.
      - k) NUTRIENT FEED PUMP RUNNING.
      - l) NUTRIENT FEED PUMP STOPPED.
      - m) NUTRIENT pH.
      - n) NUTRIENT FLOW.
      - o) NUTRIENT TO SPRAY VALVE OPEN.
      - p) NUTRIENT TO SPRAY VALVE CLOSED.
      - q) NUTRIENT TO SUMP VALVE OPEN.
      - r) NUTRIENT TO SUMP VALVE CLOSED.
      - s) MEDIA BED RECIRC SUMP LOW LEVEL.
      - t) MEDIA BED RECIRC SUMP LOW LOW LEVEL.
      - u) MEDIA BED NO. 1 DIFF PRESS.
      - v) MEDIA BED NO. 2 DIFF PRESS.
      - w) CARBON BED NO. 1 DIFFL PRESS.
      - x) CARBON BED NO. 2 DIFF PRESS.
      - y) READY.
      - z) NETWORK TIME SYNCH.
      - aa) NETWORK LINK STATUS.
      - bb) FAN NO. 1 RUNNING.
      - cc) FAN NO. 1 STOPPED.
      - dd) FAN NO. 1 FAULT.
      - ee) FAN NO. 1 FAIL TO START.

- ff) FAN NO. 1 FAIL TO STOP.
- gg) NUTRIENT FEED PUMP RUNNING.
- hh) NUTRIENT FEED PUMP STOPPED.
- ii) NUTRIENT TO SPRAY VALVE OPEN.
- jj) NUTRIENT TO SUMP VALVE CLOSED.
- kk) FAN NO. 1 LOW DIFFERENTIAL PRESSURE.
- ll) READY.
- mm) NETWORK TIME SYNCH.
- nn) NETWORK LINK STATUS.
- oo) FAN ZERO SPEED.
- pp) FAN HIGH AMPS.
- qq) THERMAL AIR FLOW.
- rr) FAN HIGH VIBRATION.
- ss) FAN BELT FAIL.

**F. Vendor Control System Commissioning:**

1. Equipment programming meetings - Attend a meeting with the Programmer to coordinate with the Owners control system. The meeting discussion point will include the following at a minimum:
  - a. Tag Naming Conventions.
  - b. PLC to PLC global data mapping.
  - c. All PLCs to SCADA tags for future mapping.
  - d. LOI screen colors and navigation.
  - e. Interlock and Permissive definitions.
  - f. Communication Methods.
  - g. Standard code blocks for common control functionality.
  - h. Alarms - clearing, formats, colors, and status.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Refer to Section 15050 - Common Work Results for Mechanical Equipment.

### 3.02 FIELD FINISHING (AND/OR CORROSION PROTECTION)

\* See NOTE #1 on

the previous spec

paragraph 11395D-1.04-C-17.

- \* A. Coat equipment and piping per Section 09960 - High-Performance Coatings.
- \* B. Field touch up in accordance with Section 09960 - High-Performance Coatings.
- C. Damage to pigmented gel coat and/or exterior laminate on any FRP component shall be repaired in accordance with equipment fabricator's recommendations. Exposed surfaces will be restored to a uniform texture and color-matched appearance. Color selection shall be subject to the Owner's approval.

### 3.03 INSTALLATION

- A. General - Follow manufacturer's written instructions for installation and adjustment of components.

- B. FRP fans and duct - Airflow to each biological odor control system shall be dynamically tested and balanced in accordance with ASTM D-4167. Field balancing shall be done by the Contractor by qualified and certified air balancing contractor and in accordance with the air testing and balancing specifications.
- C. As far as is reasonably possible, all equipment should be pre-assembled prior to shipment, to minimize the need for on-site assembly. Media can be pre-installed by the Manufacturer and certified to meet the specified performance requirements.
- D. Installation of all equipment will be performed by the Contractor and must be in accordance with OCS/Manufacturer's written installation and startup instructions and by workers experienced in the handling of fiberglass vessels, electrical work, plumbing, and instrumentation. The final installation must be certified by the Manufacturer/OCS as complete and correct.
- E. The Manufacturer/OCS shall provide the Contractor with required clearances, tolerances, and limitations, such as smoothness/flatness of concrete pad and shall be available to answer questions prior to and during the installation of the equipment.

### **3.04 FACTORY ACCEPTANCE TEST**

- A. Bioscrubber vessel:
  - 1. Each FRP vessel shall be inspected prior to shipping for conformance to the following:
    - a. Dimensions matching those shown on submittal drawings and are within Manufacturer's specified tolerances.
    - b. Flanges and connections between vessel parts fit securely without improper bending or stressing of parts.
    - c. Damage or imperfections to paint or fiberglass work, including cracking/crazing are minimal and in accordance with FRP specifications.
    - d. Manufacturer shall keep a record of the quality control document for each vessel(s) that is available to the Engineer upon request.
- B. VMCP:
  - 1. Each VMCP shall be inspected prior to shipping for conformance to the following:
    - a. NEMA rating and UL508A label.
    - b. PLC program and HMI shall be tested for proper communication and functionality.
    - c. PLC digital and analog inputs shall be electrically tested to ensure input recognition in the proper area of the PLC program.
    - d. All wiring between panel components and terminal strips shall be checked for proper labeling and connection.
- C. VLCPs:
  - 1. Each VLCP shall be inspected prior to shipping for conformance to the following:
    - a. NEMA rating and UL508A label.
    - b. Each VLCP to be interconnected to the VMCP and shall be tested for proper communication and functionality.

- c. All wiring between panel components and terminal strips shall be checked for proper labeling and connection.
- D. VWCP:
  - 1. Each VWCP piping and/or other pre-installed piping shall be tested prior to shipping for conformance to the following:
    - a. System shall have no leaks when subjected to a pressure test at 100 psi for a minimum of 2 hours.
    - b. All installed instruments, sensors, pumps, actuated valves, and other electrical components shall be tested for proper operation.
    - c. All wiring from terminal strips to all electrical components shall be tested to ensure proper wiring.
- E. Spray nozzles:
  - 1. Spray nozzles shall be factory tested to ensure compliance with Manufacturer standards for uniform distribution.

### **3.05 FIELD TEST AND START-UP**

- A. OCS System's services:
  - 1. The OCS system's representative for the equipment specified shall be present at the jobsite and/or classroom designated by the Owner for the minimum man-days listed for the following services, travel time excluded:
    - a. Provide 2 man-days for installation assistance, inspection, and certification of the installation.
    - b. Provide 1 man-day for pre-start-up classroom and jobsite training and start-up assistance training of the Owner's personnel. During this trip the field training shall include startup, operation, monitoring of the parameters, electrical and controls of the entire odor control system. The O&M staff and any other staff at the discretion of the owner would be present in the field training. Allow for minimum 2 hours for classroom and 4-6 hours for field training.
    - c. Start-up services and training of Owner's personnel shall be at such times as requested by the Owner. The contractor and the OCS representative shall coordinate with the owner for the training and shall advise the owner the training subjects that will be done during each trip.
  - 2. Once the installation of each odor control system has been certified by the OCS, the Contractor, with assistance from the OCS, shall start the System to begin the biological acclimation period. This startup period shall take no longer than six weeks but at any point during this startup period, at the discretion and direction of the Manufacturer/OCS, the Contractor shall switch the system over to normal operation. Any re-piping, plumbing, or FRP work required will be clearly detailed in the installation and startup manual and will be performed by the Contractor at no additional cost to the Owner.
  - 3. The air balancing contractor shall be present on site and shall have been air balanced the foul air conveyance systems according to this Section and Section 15954 - Testing, Adjusting, and Balancing for HVAC prior to start of acclimation of the media.
  - 4. Any special tools or materials required for this start-up/acclimation period shall be provided by the OCS.

5. After satisfactory acclimation, start-up and the corresponding switch over to normal operation, the Contractor shall, in the presence of the Engineer, conduct the performance test as detailed below.
- B. Functional testing:
1. Test all system components for proper adjustment and operation in both the manual and automatic operating modes. Also, the air balancing contractor shall be present on site and shall have make any necessary corrections for proper air flow rates and pumping flows.
  2. Allow the bioscrubber irrigation system to operate for a 48-hour period with the moisture control system in AUTO mode and adjust as necessary for proper irrigation moisture system operation.
  3. All testing, adjusting, and balancing of the fans, pumps and VFDs shall have been completed and approved.

- \* To be submitted under a separate cover.
- C. Performance testing:
1. Each facility or area odor control system shall be performance tested.
  2. Performance testing shall not commence until the entire air conveyance system has been properly tested and balanced and the air flow rate to the vessel is confirmed. Also, the odor control system has been satisfactorily started up and enough time has been allowed for the acclimation of the bacteria. Performance test shall be conducted using the naturally occurring H<sub>2</sub>S provided by the plant processes.
  3. After the odor control system has been satisfactorily started-up and switched to normal operation, the Odor Control Supplier shall conduct a performance test to verify that the system meets or exceeds the performance criteria listed previously. The testing shall be witnessed by the Owner and Engineer.
  4. The Contractor shall provide the Owner with a written test protocol for review by the Owner and Engineer.
  5. The Contractor shall supply, install, and operate all equipment, sensors, and instrumentation required to complete the performance test.
  6. H<sub>2</sub>S Testing procedure:
    - a. Measure airflow into each bioscrubber unit and, if necessary, adjust dampers and fans speeds to obtain the specified design airflow in each scrubber vessel (+/- 10 percent). Airflow shall be measured at the beginning of the test period. The set position on the damper(s) will be marked or noted. Airflow should not change if damper(s) remain in position.
    - b. Measure pressures drop across each bioscrubber at beginning of test period.
    - c. Measure temperature and humidity of the inlet, outlet, and ambient air.
    - d. Performance test period to begin at a noted time and last for 24 hours. H<sub>2</sub>S data from the common inlet location or inlet location of each unit and from the outlet of each bioscrubber will be measured and logged once every 10 minutes to demonstrate performance during test period.
    - e. The inlet H<sub>2</sub>S data will be logged with a pre-calibrated OdaLog or acrulog gas data logger with appropriate range and accuracy for the inlet air stream (0 to 1,000 ppmv, 1 ppm display resolution or 0.0 to 200.0 ppmv range, 0.1 ppmv display resolution).
    - f. The outlet H<sub>2</sub>S data will be measured with a recently calibrated Acrulog PPB H<sub>2</sub>S Low-range monitor/ Analyzer with appropriate range and

- accuracy for the outlet air stream. Outlet readings shall be measured at 10-minute intervals.
- g. Include in the bid for each bioscrubber unit a minimum of 6 Tedlar bag tests where 3 bags tests shall be collected at the inlet and 3 Tedlar bag samples shall be collected at the outlet of each odor control vessel. The Tedlar bag samples shall be sent to approved independent test lab for the analysis of 20 reduced sulfur compounds. The Tedlar bags samples shall be taken at 3 different time intervals during the 24 -hour testing period as directed by Engineer and Owner.
- D. Odorous compounds removal Acceptance criteria:
1. The odor control system's removal efficiency shall be determined by calculating the average inlet concentration and the average outlet concentration using the following formula - Removal efficiency (percent) =  $(1 - \text{average outlet concentration}/\text{average inlet concentration}) \times 100$ . The system shall have passed the odorous compounds performance test if the removal efficiency is meets or exceeds the specified removal criteria listed in Article 2.02.

### 3.06 TRAINING

\*

\* To be submitted  
under a separate  
cover.

- A. Require manufacturer's representative to perform the following services in a minimum of two separate trips as described below and as specified in Section 01756 - Commissioning. Specified durations are the minimum required time on the job site. Additional services and/or longer durations shall be provided as needed at no cost to Owner to meet the required quality of work. Work to be done in a minimum of five trips.
1. Installation assistance: As required.
    - a. Advise/observe the Contractor on the installation of the equipment.
    - b. Provide additional assistance as required.
  2. Installation inspection: 1 trip; 2 workday.
  3. Start-up/performance testing assistance: 2 trips; 2 workdays each trip:
    - a. Prior to start-up, the equipment shall be inspected for proper alignment, operation, and satisfactory performance.
    - b. Provide additional start-up/testing assistance as required.
    - c. Provide Certificate of Installation and Functionality Compliance per Section 01756 - Commissioning.
  4. Training - As defined in Section 01756 - Commissioning. Provide training as follows for each facility odor control system:
    - a. Operations Training - 2-hour class, 2 sessions.
    - b. Mechanical Maintenance Training - 4-hour class, 1 session.
    - c. Electrical and Controls Maintenance Training - 4-hour class, 1 session.
  5. Specified durations are the minimum required time on job site and do not include travel time.

END OF SECTION

## **SECTION 3**

### **FRP MATERIAL LIST AND TECHNICAL DATA SHEETS**

# **DANIEL COMPANY**

Air & Water Pollution Control Systems



**Project:** 5013 Hilo

**Date:** 5/27/2025

**Revision:** 0

## **Fiberglass Reinforced Plastic Materials List**

**Resin:** Interplastic CoRezyn CORVE 8401

**Corrosion Liner Veil:** C-Veil (Viledon T1777)

**Spray-up Roving:** Owens Corning OptiSpray F

**Filament Winding Roving:** Owens Corning 366 Roving

**Chopped Strand Mat:** CTG

**Woven Roving:** CTG (EWR800)

**Unidirectional:** Vectorply

**Catalyst:** NOROX MEKP-925H

**UV Inhibitor:** Cyasorb UV-9

**Gel Coat / Color:** Lilly-Ram WHITE W-1 (unless otherwise specified)

\*All materials shall be as specified above or equal.



# CORVE8401

## Fire Retardant Vinyl Ester Resin

### Technical Data Sheet

CORVE8401 is a promoted, fire retardant, vinyl ester resin. This resin has a flame spread rating of  $\leq 25$  (Class 1) per ASTM E84 Tunnel Test without additives. Contact your Interplastic Corporation representative for specific corrosion recommendations.

FEATURES	BENEFITS
• Flame Spread Rating 25 per ASTM E84	• No additives to cloud laminates; easy inspections
• Highly Corrosion Resistant	• Resists acid, alkali, and oxidizing chemical environments
• Excellent Physical Properties	• Suitable for tanks, pipe, and process equipment

LIQUID PROPERTIES	RESULTS
Viscosity, Brookfield Model LV #3 Spindle @ 60 rpm, 77°F (25°C), cps	400-600
100 grams resin @ 77°F (25°C), initiated with 1.2% Hi-Point 90 by volume *	
Gel Time, min:sec	16:00-19:00
Gel to Peak Exotherm Time, min:sec	9:00-16:00
Peak Exotherm	300-350°F (149-177°C)
HAP Content, %	37.0-42.0
Specific Gravity	1.15-1.17

TYPICAL PROPERTIES								
Thickness	1/8 inch (3.2 mm) Casting		1/8 inch (3.2 mm) Laminate					
Construction	Not Applicable		4 Plies 1.5 oz/ft <sup>2</sup> , 33% Glass Mat					
Flexural Strength, ASTM D790	22,000	psi	150	MPa	25,400	psi	175	MPa
Flexural Modulus, ASTM D790	$5.6 \times 10^5$	psi	3,800	MPa	$11.0 \times 10^5$	psi	7,586	MPa
Tensile Strength, ASTM D638	13,000	psi	89	MPa	13,900	psi	85.8	MPa
Tensile Modulus, ASTM D638	$5.1 \times 10^5$	psi	3,500	MPa	$12.8 \times 10^5$	psi	8,828	MPa
Tensile Elongation, ASTM D638	6.4	%	6.4	%	1.4	%	1.4	%
Barcol Hardness, 934-1 gauge, ASTM D2583	34		34		44-48		44-48	
Heat Distortion Temperature, ASTM D648	220	°F	104	°C	--	°F	--	°C

\* The gel time and reactivity will vary due to the type and concentration of Free Radical Initiator (catalyst), shop temperature, humidity, and type of fillers used. In order to meet your individual needs consult our technical sales representative for assistance. If using methyl ethyl ketone peroxide (MEKP) to gel and cure CoREZYN vinyl esters, we recommend only these four brands: Cadox® L-50a (Akzo Nobel); Luperox® DHD-9 (Arkema); Hi-Point® 90 (Pergan); or Norox® MEKP-925 (United Initiators). These must be used at the appropriate percentage and suitable temperature. Contact your Interplastic Corporation representative for assistance.

FLAME TEST PROPERTIES	
Thickness	1/8 inch (3.2 mm) Laminate
Construction	4 Plies 1.5 oz/ft <sup>2</sup> , 33% Glass Mat
ASTM D635, Horizontal Burn Rate	< 1"
ASTM E84, Flame Spread	25
UL 94 **This is not to imply UL warranty	(V-O) (HB < 1") (5V Pass)
HLT 15	100

All specifications and properties specified above are approximate. Specifications and properties of material delivered may vary slightly from those given above. Interplastic Corporation makes no representations of fact regarding the material except those specified above. No person has any authority to bind Interplastic Corporation to any representation except those specified above. Final determination of the suitability of the material for the use contemplated is the sole responsibility of the Buyer. The Thermoset Resins Division's technical sales representatives will assist in developing procedures to fit individual requirements.

INTERPLASTIC CORPORATION  
2015 Northeast Broadway Street  
Minneapolis, Minnesota 55413-1775  
651.481.6860 Fax 612.331.4235  
[www.interplastic.com](http://www.interplastic.com)

# Nonwovens for Fiber Reinforced Plastics

## Vliesstoffe für faserverstärkte Kunststoffe

**T 1777 C**

**viledon®**

Technical data / Technische Daten			
Fibre Faser		C-Glass C-Glas	
Binder system Bindesystem		chemical (soluble in styrene) chemisch (styrollöslich)	
Nonwoven structure Vliesstruktur		random wirr	
Weight Gewicht	ISO 9073-1	26 g/m <sup>2</sup>	
Thickness Dicke	ISO 9073-2	0.30 mm	
Max. tensile strength Höchstzugkraft	ISO 9073-3	25 N/50mm	machine direction längs
		18 N/50mm	cross direction quer
Elongation at max. tensile strength Höchzugkraftdehnung	ISO 9073-3	1 %	machine direction längs
		1 %	cross direction quer

Supply form / Lieferform	
Roll width (max.) Rollenbreite (max.)	2.000 mm
Roll length (standard) Rollenlänge (Standard)	250 m / 500 m / 1.000 m
Core diameter (standard) Kerndurchmesser (Standard)	70 mm / 76 mm

Application / Anwendung
Hand lay-up and fiber spray-up / Filament winding dry Handlaminier- und Faserspritzverfahren / Wickelverfahren trocken

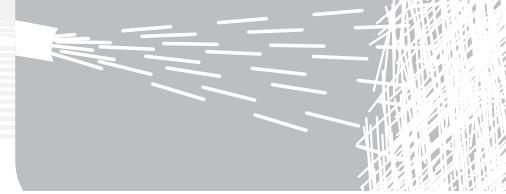
Average values, subject to normal production tolerances.  
Mittelwerte, die den üblichen Produktionsschwankungen unterliegen.



INNOVATIONS FOR LIVING™

## PRODUCT INFORMATION

# OptiSpray™ Solutions



# OptiSpray™ F Roving For Fast Wet out Spray-up in Complex Molds

## PRODUCT DESCRIPTION

OptiSpray™F reinforcement is a multi end roving using Advantex® glass fiber. Advantex® glass fiber combines the electrical and mechanical properties of traditional E-glass with the acid corrosion resistance of E-CR glass.

This Advantex® glass roving has a sizing system with a silane coupling agent. It has been designed to provide best in class performance for spray-up applications where fast wet out speed is preferred.

## PRODUCT APPLICATIONS

Variety of applications including boats, tub & shower, truck caps, vehicle body parts, bath tubs, tanks and applications with complex molds or sharp curvatures.



## FEATURES AND PRODUCT BENEFITS

- |                                      |  |
|--------------------------------------|--|
| • Easy chopping                      | • Good mechanical properties               |
| • Low fuzz                           | • Flat lay down and uniform dispersion     |
| • Great surface quality              | • Excellent conformability, no spring back |
| • Best performance on vertical parts | • Optimal resin consumption                |
- 

Linear weight of roving (tex)*	Yield (Yds/Lb)	Loss on Ignition (%)	
		ISO 1887: 1995	
2400	207	1.25	
3000	165	1.25	

\*Other tex may be available upon request

## PRODUCT AVAILABILITY (STANDARD REF.)

Product	Doff characteristics			
	Diameter (mm)		Height (mm)	Net weight (kg)
	Internal	External		
OptiSpray™ F	75	303	265	23

# OptiSpray™ F Roving

## For Fast Wet out Spray-up in Complex Molds

### PACKAGING (standard ref.)

- Each OptiSpray™ F doff is protected by a tack-wrap polythene film and identified by an individual label. Please do not remove film during use.
- Creel pack packaging is available upon request.
- Customer specific packaging requirements may be available upon request.

Product	Doff Ø (mm)	Pallet dimensions L x W (cm)	Layers per pallet	Doffs per layer	Total number of doffs	Creel Pack	Pallets	
						Number of ends	Approx. height (cm)	Net weight* (kg)
OptiSpray™ F Creel Pack 4E™ 2400	303	129.5x96.5	4	12	48	4	13.9	1120
OptiSpray™ F Creel Pack 2E™ 2400	303	129.5x96.5	4	12	48	2	13.9	1120
OptiSpray™ F Close Top™ 2400	303	129.5x96.5	4	12	48	Individual Boxes	13.9	1120

(\* ) Add 35 to 45 kg to obtain gross weight.

### LABELING

- Each doff has a self-adhesive identification label, showing the product reference and the production date.
- Each pallet has two identification labels detailing the product reference, pallet net and gross weights, production date and pallet production code.

### STORAGE

The OptiSpray™ F product should be stored in its original packaging in a dry and cool place. Best conditions are at temperature from 10 to 35°C (50 to 95°F) and humidity between 35 and 85%. If you store the product at lower temperatures, please move the soon-to-be-processed pallets to the production area 24 hours ahead of time. You can stock pallets one on one with a plywood plank between the two.

#### Contact

MultiEndRovings@owenscorning.com



INNOVATIONS FOR LIVING™

**OWENS CORNING  
COMPOSITE MATERIALS, LLC**  
ONE OWENS CORNING PARKWAY  
TOLEDO, OHIO 43659  
1.800.GET.PINK™  
[www.owenscorning.com](http://www.owenscorning.com)  
[www.composites.owenscorning.com](http://www.composites.owenscorning.com)

**EUROPEAN OWENS CORNING  
FIBERGLAS, SPRL.**  
166, CHAUSSÉE DE LA HULPE  
B-1170 BRUSSELS  
BELGIUM  
+32.2.674.82.11

**OWENS CORNING  
COMPOSITE SOLUTIONS BUSINESS  
ASIA PACIFIC REGIONAL HEADQUARTERS**  
UNIT 01,02,05,39/F, PUDONG KERRY PARKSIDE,  
1155 FANG DIAN ROAD, PUDONG, SHANGHAI  
201204, CHINA  
+86-21-6101 9666



This information and data contained herein is offered solely as a guide in the selection of a reinforcement. The information contained in this publication is based on actual laboratory data and field test experience. We believe this information to be reliable, but do not guarantee its applicability to the user's process or assume any responsibility or liability arising out of its use or performance. The user agrees to be responsible for thoroughly testing any application to determine its suitability before committing to production. It is important for the user to determine the properties of its own commercial compounds when using this or any other reinforcement. Because of numerous factors affecting results, we make no warranty of any kind, express or implied, including those of merchantability and fitness for a particular purpose. Statements in this publication shall not be construed as representations or warranties or as inducements to infringe any patent or violate any law, safety code or insurance regulation..

# 366 Roving

## Single End Roving for Pultrusion and filament Winding Processes

### PRODUCT DESCRIPTION

Single-End Rovings are produced by pulling individual fibers directly from the bushing and winding them onto a roving package ready for shipment. The uniform distribution of a proprietary sizing system ensures an excellent resin-to-glass binding through uniform distribution of the binding agent. This results in maximum strand integrity. Single-End Rovings are manufactured using the T30® Roving state-of-the-art technology of Owens Corning, in conjunction with statistical process control in manufacturing facilities certified to ISO 9001.



© JL Sponga

### PRODUCT APPLICATION

366 roving is specifically designed for use in pultrusion and filament winding applications in polyester, vinyl ester and epoxy resin systems.

366 roving has also been successfully used in acrylic resin and polyurethane resin systems. 366 roving can be used in a variety of processes to manufacture pipes, tanks, ladder rails, pultruded structural shapes and grating systems.

Advantex® Glass is an Owens Corning patented glass formulation, which meets ASTM D 578 and ISO 2078, as a boron-free corrosion resistant E-CR glass fiber. Advantex® Glass has been providing superior corrosion resistance vs. standard E-glass, since 1996, leading to longer part life and greater service life strength in applications facing corrosion, opening new markets for composites and our customers. Advantex® glass fiber reinforcements combine the electrical and mechanical properties of traditional E-glass with the acid corrosion resistance of E-CR glass. For additional information on Advantex® use the link below.

<http://composites.owenscorning.com/aboutAdvantex.aspx>



©Paulo Manuel Furtado Pires/shutterstock.com

### FEATURES AND PRODUCT BENEFITS

- Excellent Processing
  - 366 roving has no catenary, which means it will run out smoothly throughout the package under a variety of conditions and speeds.
  - 366 roving has low fuzz properties that will result in smoother parts, less cleanup and improved machine efficiencies.
  - The Tack-Pak® packaging allows virtually 100 percent transfer efficiency.
- Multi -Resin Compatible
  - The silane-based sizing of 366 roving is designed for excellent adhesion with polyester, vinyl ester and epoxy resin systems. Multi-compatibility allows a change in resin systems without the need for the time consuming effort of changing glass in the creel. In addition, 366 roving has had great success in acrylic and polyurethane resin systems.
- Excellent strand opening and spreading
  - 366 roving allows fast, uniform wet out of the strand in all resin systems. Fast wet out should allow for optimized part fabrication time, increased productivity and improved competitive position in the market.
- Available globally
  - 366 roving product line is available globally in a wide variety of yields and TEX. Global availability allows for one product qualification rather than designing or modifying product or processes by region. Global availability results in lower design and qualification costs.
- Superior corrosion resistance with Advantex® Glass compared to standard E-glass
  - Advantex® Glass provides superior corrosion resistance vs. standard E-glass, leading to longer part life and greater service life strength in applications facing corrosion.

# 366 Roving

## Single End Roving for Pultrusion and filament Winding Processes

### PRODUCT AVAILABILITY

Yield	Tex
675, 450, 330, 250, 207, 113	735, 1100, 1500, 2000, 2400, 4400

### MECHANICAL PROPERTIES

The following data was generated using production material 366 roving – 113 Yield (4400 tex)

Strand Tensiles : ASTM D 2343	Strength (MPa)	Strength (Ksi)
DER 331 Epoxy resin	2360	340
Polyester F701 Resin	2300	335

Interlaminar Shear Strength NOL ring : ASTM D 2344	Dry shear strength (MPa)	Dry shear strength (psi)	shear strength Retention 72 hr boil (%)
DER 331 Epoxy resin	61.6	8940	98%
Polyester F701 Resin	72.5	10520	86%

### PACKAGING

Rovings are available in a single-end internal-pull package. Each pallet weighed about 1 ton. Pallets are stretch wrapped for load stability. All doffs are wrapped with Tack-Pak® or shrinkable film for protection during transport. Full doffs are available in weights between 20 kg (45 lb.) and 35 kg (77 lb.) and they can be packaged in bulk or Creel-Pak® format. More information is available in the Customer Acceptance Standards.

### STORAGE

It is recommended to store glass fiber products in a cool, dry area. The glass fiber products must remain in their original packaging material until the point of usage; the product should be stored in the workshop, within its original packaging, 48 hours prior to its utilization, to allow it to reach the workshop temperature condition and prevent condensation, especially during cold season. The packaging is not waterproof. Be sure to protect the product from the weather and other sources of water.

When stored properly, there is no known shelf life to the product, but retesting is advised after three years from the initial production date to insure optimum performance.



INNOVATIONS FOR LIVING™

OWENS CORNING  
COMPOSITE MATERIALS, LLC  
ONE OWENS CORNING PARKWAY  
TOLEDO, OHIO 43659  
1.800.GET.PINK™  
[www.ovenscorning.com](http://www.ovenscorning.com)  
[www.composites.ovenscorning.com](http://www.composites.ovenscorning.com)  
Contact:  
[SingleEndRovings.ocamerica@owenscorning.com](mailto:SingleEndRovings.ocamerica@owenscorning.com)

EUROPEAN OWENS CORNING  
FIBERGLAS, SPRL.  
166, CHAUSSÉE DE LA HULPE  
B-1170 BRUSSELS  
BELGIUM  
+32 2 674 8211

OWENS CORNING COMPOSITES SOLUTIONS BUSINESS  
ASIA PACIFIC REGIONAL HEADQUARTERS  
UNIT 01, 02, 05, 39/F, PUDONG KERRY PARKSIDE  
1155 FANG DIAN ROAD, PUDONG, SHANGHAI  
201204, CHINA  
+86-21-6101 9666

Contact:  
[SingleEndRovings.ocap@owenscorning.com](mailto:SingleEndRovings.ocap@owenscorning.com)

This information and data contained herein is offered solely as a guide in the selection of a reinforcement. The information contained in this publication is based on actual laboratory data and field test experience. We believe this information to be reliable, but do not guarantee its applicability to the user's process or assume any responsibility or liability arising out of its use or performance. The user agrees to be responsible for thoroughly testing any application to determine its suitability before committing to production. It is important for the user to determine the properties of its own commercial compounds when using this or any other reinforcement. Because of numerous factors affecting results, we make no warranty of any kind, express or implied, including those of merchantability and fitness for a particular purpose. Statements in this publication shall not be construed as representations or warranties or as inducements to infringe any patent or violate any law safety code or insurance regulation.



## 【Product Description】 (CHOPPED STRAND MAT)

Composed of E-glass chopped strands bounded with unsaturated polyester binder.

Application for hand lay-up.

Compatible with unsaturated polyester resins and vinyl resins for manufacture of panel, boat hulls and other FRP parts.

## 【Characteristics】

Thickness steady and optimum stiffness.

Excellent strands dispersion and outstanding bonding on double sides.

Easy impregnation, good air-releasing performance and less resins consumption.

Optimum wet out, excellent processibility, high abrasion and corrosion resistance

Good mechanical properties

## 【Technical data】

Specification	Width (mm)	Wet out(S)	Styrene solubility (S)	Moisture (%)	Process
EMC450	100-3000	≤100	≤40	≤0.20	Hand lay-up

Notes:1. Individualized specification is available as per customer's request.

2. this data sheet herein above is provided for information purposes only and CTG reserves the right to modify it without prior notice.

## 【Packaging】

E-glass powder mat is packed in PE bags and put into cartons, stacked on pallets or separately put in cartons. Pallets should not be stacked over 2 layers and cartons not over 5 layers.

Roll width(mm)	roll weight(kg)	rolls/pallet	pallet size(mm)	weight per pallet(kg)
1270	48	6/9/12	1280*960	288/432/576

## 【Storage】

This product should be stored in a dry, cool and rainproof place, with temperature from 5 °C to 35 °C and humidity between 35% and 65%. It is recommended to be used at room temperature, and finished within 12 months after receipt by customer and kept in intact package when not used to avoid damp.



### 【Product description】 (WOVEN ROVING)

EWR800 woven roving from E-glass direct roving by weaving machines.

Applicable for hand lay-up process, mould pressing, machinery formation.

Compatible with unsaturated polyester resin and vinyl resin.

### 【Characteristics】

Thickness steady  
Free of contamination  
Fast wet out  
High laminate strength  
Good mechanical properties

### 【Product code】

EWR800  
E      E-glass  
WR      Woven roving  
800      Unit weight (g/m<sup>2</sup>)  
Width      Net width of fabrics (mm)

### 【Technical data】

Unit weight (g/m <sup>2</sup> )	Warp		Weft		Moisture (%)	Loss on ignition (%)	Tensile strength on warp(N)	Tensile strength on weft(N)
	tex	Density (roving/10cm)	tex	Density (roving/10cm)				
800±8%	2400±5%	18.1±10%	2400±5%	15.5±10%	≤0.2	0.4~0.8	≥4600	≥4400
According to the standard GB/T 18370-2001								

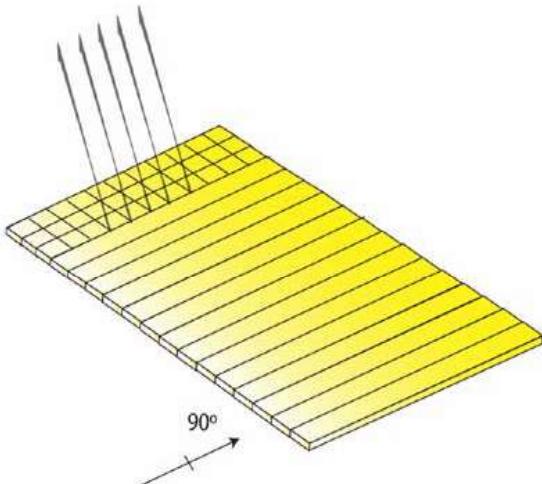
### 【Package】

E-glass woven roving is packed and sealed in PE bags by roll, put into cartons or wrapped with craft paper, and put flat on pallets or in bulk package. And pallets should not be stacked more than 2 layers.

Roll width(mm)	roll weight(kg)	rolls/pallet	pallet size(mm)	weight per pallet(kg)
1270	50	16	1350*1120	800

### 【Storage】

This product should be stored in a dry, cool and rainproof place, with temperature from 5°C to 35°C and humidity between 35% and 65%. It is recommended to be put under room temperature for over 24 hours prior to use and kept in intact package when it is not used to avoid damp.



## E-T 1600

Fiber Type: E-Glass  
 Architecture: 90° Unidirectional  
 Dry Thickness 0.031 in. / 0.79 mm  
 Total Weight: 15.07 oz/sq.yd / 511 g/sq.m

### Roll Specifications

Roll Width: 50 in / 1270 mm Roll Weight: 187 lb / 85 kg Roll Length: 138 yd / 126 m

### Fiber Architecture Data

0 ° :	n/a
45 ° :	n/a
90 ° :	15.07 oz/sq.yd / 511 g/sq.m
- 45 ° :	n/a
Chopped Mat :	n/a

1: Packaging: box or bag.

2: Weights do not include polyester stitching.

### Laminated Properties

0 °

0 °

#### Laminate Weight

(lb/sq.ft)	E-T 1600 Resin Infused	E-T 1600 Open Mold
Fiber	0.10	0.10
Resin	0.05	0.09
Total	0.15	0.19

#### Physical Properties

	E-T 1600 Resin Infused	E-T 1600 Open Mold
Density (g/cc)	1.90	1.69
Fiber Content (% by Wt.)	70%	55%
Thickness (in)	0.015	0.022

Laminate Modulii (MSI)	E-T 1600 Resin Infused	E-T 1600 Open Mold
Ex	2.07	1.45
Ey	5.68	4.17
Gxy	0.38	0.27
Ex,flex.	1.93	1.34
Ey,flex.	5.28	3.87

Ultimate Stress (KSI)	E-T 1600 Resin Infused	E-T 1600 Open Mold
Long. Ten.	21	14
Long. Comp.	21	14
Trans. Ten.	108	79
Trans. Comp.	108	79
In-Plane Shear	8	5
Long. Flex.	21	14
Trans. Flex.	135	99

In-Plane Stiffness, "EA"	E-T 1600 Resin Infused	E-T 1600 Open Mold
10^3 lb/in		
(EA)x	31	31
(EA)y	86	90
(GA)xy	6	6

Ultimate In-Plane Load lb/in	E-T 1600 Resin Infused	E-T 1600 Open Mold
Long. Ten.	314	313
Long. Comp.	314	313
Trans. Ten.	1,631	1,708
Trans. Comp.	1,631	1,708
In-Plane Shear	115	115

**Notes:**

1: Resin infused laminate made with vinyl ester resin 200 cps viscosity @ 77° F.

2: Open mold laminate made with polyester resin.

3: All standard reinforcements should be infused with a flow aid or Vectorfusion® reinforcements.



3500 Lakewood Dr. Phenix City, AL 36867 tel. 334 291 7704 fax. 334 291 7743

Disclaimer:

As a service to customers, Vectorply Corporation ("VP") may provide computer-generated predictions of the physical performance of a product using a reinforcement fabric produced by VP in combination with other materials or systems.

VP makes no warranty whatsoever as to the accuracy of any such predicted physical performance, and customer acknowledges that customer is solely responsible for determining the performance and fitness for a particular use of any product produced by customer utilising a fabric or material produced or manufactured by VP. Specifications of reinforcements may change without notice.

# Technical Data Sheet



## NOROX® MEKP-925H

Methyl ethyl ketone peroxide  
CAS#1338-23-4  
Liquid mixture

### Description

Norox® MEKP-925H is specifically formulated to reduce gas generation in critical corrosion applications for vinyl ester resins in gel coats, barrier coatings, and corrosion resistant structures. The low hydrogen peroxide level in Norox® MEKP-925H often requires that the resin promotion system be modified for some resins to obtain reasonable gel times.

### Technical Data

Active Oxygen:	9.0% max.
Form:	Liquid
Color:	Water White
Specific Gravity @ 25°C:	1.10
Flash point (C.O.C.):	200°F, min.
Flash point (SETA C.C.):	170°F, min.
Soluble in:	Oxygenated organic solvents
Slightly soluble in:	Water
SADT	<140°F (60°C)
Storage temp:	<80°F(27°C)
Max Transport Temp:	<80°F(27°C)

### Application

Norox® MEKP-925H is a methyl ethyl ketone peroxide composition formulated to be an excellent cure initiator for both unsaturated polyester resins and vinyl ester resins. With most unsaturated polyesters it gives longer gel and gel to cure times but with a higher peak exotherm than Norox® MEKP-9, particularly in thick sections. With most vinyl esters Norox® MEKP-925H gives the most complete cure of any currently available MEK peroxide.

# Technical Data Sheet



## PACKAGING, SHIPPING & AVAILABILITY

- The standard package sizes of Norox® MEKP-925H are cases of 4x8 lb. polyethylene bottles; and 40 lb. or 20 kg Hedpacks. For custom package sizes, please contact your local distributor or United Initiators, Inc.
- Classification – Please refer to the specific Norox® MEKP-925H Safety Data Sheet under section 14, Shipping Description.
- Norox® MEKP-925H is available through a nation-wide distributor network. Call United Initiators, Inc. for the name of the distributor in your area.

This information and our application-technical advice – whether verbal, in writing or by way of trials – reflect our present state of knowledge based on internal tests with local raw materials. Their purpose is to inform interested parties about our products and their possible application. They should not be construed as guaranteeing specific product properties or their suitability for a particular application. Furthermore, the information does not contain complete instructions for use. Nor does it constitute a guarantee as to quality and durability. Changes due to technical progress and corporate advancement reserved. Any existing third-party copyrights are to be taken into account.

Application and use of our products based on our application-specific advice is beyond our control and sole responsibility of the user. The user is not released from the obligation of verifying the suitability and applicability as to the intended purpose.

T: +49 89 74422 237  
F: +49 89 74422 6237  
cs-initiators.eu@united-in.com

T: +1 800 231 2702  
F: +1 440 323 0898  
cs-initiators.nafta@united-in.com

T: +86 20 6131 1370  
F: +86 139 2503 8952  
cs-initiators.cn@united-in.com

T: +61 2 9316 0046  
F: +61 2 9316 0034  
cs-initiators.au@united-in.com

**[www.united-initiators.com](http://www.united-initiators.com)**

Revision number: 1.0. Date: 03.03.14. Device M: TDS.

# CYASORB<sup>®</sup>UV-9 light absorber

## TYPICAL PROPERTIES

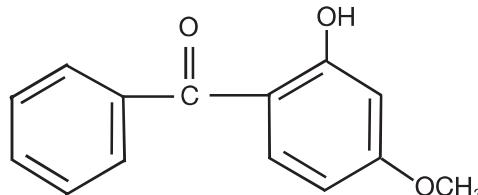
Chemical Formula	C <sub>14</sub> H <sub>12</sub> O <sub>3</sub>
Molecular Weight	228.2
Specific Gravity (25°C)	1.32
Melting Point, °C	62.0

## SPECIFICATIONS

Description	Pale cream to white powder with friable lumps
Congeal Point, °C	62.0 min
Insolubles in Toluene, %	0.05 max
Color in 10% Solution	4 max
Purity from congeal pt., %	98.0 min
Moisture, %	0.1 max

## PERFORMANCE BENEFITS

- Minimal color contribution
- Excellent light stability
- Superb compatibility with polymers and other additives



2-Hydroxy-4-methoxybenzophenone

CAS NUMBER 000131-57-7

## HEALTH AND SAFETY

### EFFECTS OF OVEREXPOSURE:

Acute oral (rat) and dermal (rabbit) values are estimated to be greater than 5.0 g/kg and 2.0 g/kg, respectively. The 4-hour LC<sub>50</sub> (rat) value is estimated to be greater than 20 mg/L.

Direct contact with this material may cause minimal eye and skin irritation.

Before handling this material, read the corresponding Cytec Industries Inc. Material Safety Data Sheet (MSDS) for safety, health, and environmental data.

## FDA STATUS

CYASORB UV-9 light stabilizer is sanctioned by Section 177.1010 of the Food Additives Regulations as a stabilizer in semirigid, rigid, and modified acrylic plastics intended for use in contact with food.

### Shipping Classification:

Chemical NOI

### Shipping Container:

32-gallon fiber drum, 100 lb net



Lilly-Ram Chemical Company  
P.O. Box 3337  
Ontario, CA. 91761-9998

## Lilly-Ram Gel Coat Technical Data Sheet

Lilly-Ram Gel Coat is a general purpose conventional type gel coat with a specially formulated resin system designed specifically for exterior applications.

FEATURES	BENEFITS
• High performance polymer	• Provides improved gloss retention, weather and chalk resistance
• Light stabilized	• Long-term UV resistance and color retention
• Ease of sanding/buffing	• Excellent patching and gloss restoration
• HAP content is a maximum of 36%	• Excellent application characteristics

LIQUID PROPERTIES	RESULTS	TEST METHOD
Viscosity, Brookfield Model LV #4 Spindle @ 6 rpm, 77°F (25°C), cps	16000 – 20000	CRSTP-301
Thixotropic Index	5.00 – 8.00	CRSTP-301
100 grams gel coat @ 77°F (25°C), catalyzed with 2.0% L-50A by volume		
Gel Time, min:sec	18:00 – 22:00	CRSTP-340
Color Tolerance, DE CIELAB (D65/10)	≤ 1.0	CRSTP-323
HAPs (Styrene + Methyl Methacrylate), %	≤ 36.0	CRSTP-329
HAPs content, lbs/gal	≤ 3.96	CRSTP-329
Non-Volatile Matter, %	64.0 – 66.0	CRSTP-329
Weight per gallon @ 77°F (25°C), lbs/gal	10.5 – 11.0	CRSTP-308
Specific gravity @ 77°F (25°C)	1.25 – 1.32	CRSTP-308

\* Gel time and reactivity will vary due to the type and concentration of a free radical initiator (peroxide), shop temperature and humidity

TYPICAL PERFORMANCE PROPERTIES	RESULTS	TEST METHOD
UV resistance, Delta E (D65) CIELAB, after 1500 hrs QUV-A exposure	≤ 5.00	ASTM G-154
60° Gloss retention after 1500 hrs QUV-A exposure, %	≥ 50.0	ASTM D-523
Sag resistance @ 77°F (25°C), mil of a wet film thickness	no less than 20	CRSTP-315
Opacity, mils of wet thickness	15	CRSTP-303
Material coverage (assuming no loss) @ 20 mils of a wet film thickness, ft <sup>2</sup> /Gal	80.0	Calculated

**Application:** LR Gel Coat is formulated for spraying as supplied. It is strongly recommended that the material be mixed before use. Optimum application temperature is 65°F - 90°F (18°C - 32°C). Apply in several thin, overlapping passes rather than a single heavier coat; this will help avoid porosity, solvent entrapment, and sagging. The suggested wet film thickness is 15 - 20 mils (0.38 - 0.51mm). Brushing is not recommended.

**Storage and Handling:** LR Gel Coat should be stored in closed, opaque containers at temperatures not exceeding 77°F (25°C). Do not keep gel coat near catalyst storage areas. To avoid decomposition keep away from direct sunlight and excess heat. Refer to the Material Safety Data Sheet for further details on safety and storage.

All specifications and properties specified above are approximate. Specifications and properties of material delivered may vary slightly from those given above. Lilly-Ram Chemical Company reserves the right to update sales specifications information without prior notice. Lilly-Ram Chemical Co makes no representations of fact regarding the material except those specified above. No person has any authority to bind Lilly Ram Chemical Co to any representation except those specified above. Final determination of the suitability of the material for the use contemplated is the sole responsibility of the Buyer.

## Our colors match the spectrum of your creativity.

**Filly-RAM®**

* WHITE W-1	YO WHITE W-33	50 WHITE W-52	LIGHT GRAY E-6	PLATINUM E-48	MEDIUM GRAY E-7	CAFE L-49	CHARCOAL E-8
* ANTIQUE WHITE W-41	IVORY W-5	TAN W-47	FAWSKIN L-11	PALE YELLOW L-45	* SPANISH GOLD L-10	* OXIDE R-32	BUBBLE GUM R-24
* CANARY YELLOW L-27	YELLOW L-55	TANGERINE N-50	BURNT ORANGE N-23	* ORANGE N-12	VIPER RED R-54	* RED R-14	MAROON R-15
LIME GREEN G-28	DEEP LIME GREEN G-43	TEAL G-19	GREEN G-20	FOREST GREEN G-51	* DARK GREEN G-35	PURPLE R-44	* BURGUNDY R-31
AQUA A-18	LIGHT BLUE A-46	BLUE A-16	DARK BLUE A-17	* MIDWATCH BLUE A-34	BOYSENBERRY R-26	DEEP PURPLE R-42	DARK PURPLE R-29

All colors are lead, chromium and cadmium free.  
★ Represents colors available in pigment dispersions.

These color swatches are only representations and can be affected by the type of light in which they are viewed, exposure to heat, light rays, age of the printed sample, surface conditions, and method of application.

This color selection guide is only an introduction to our capability. Call us for immediate color match requests!

## **SECTION 4**

### **FRP METHOD OF CONSTRUCTION AND DESIGN CALCULATIONS**

# **DANIEL COMPANY**

Fiberglass Air Pollution Control Systems

**Project:** 5013 Hilo

**Date:** 05/27/2025

**Revision:** 0

## **Method of Construction – Biotrickling Filters**

<b>Corrosion Layer</b>	
<u>Corrosion Liner</u>	Consists of (1) layer (minimum thickness of 10-15 mils) of C-veil saturated with Interplastic CORVE 8401 Epoxy Vinyl Ester resin followed by random-chopped glass mat. This combination forms the “corrosion layer” having a total thickness of 100 mils and 20% +- 5% glass by weight. This applies to filament-wound and contact-molded methods of construction.
<b>Structural Layer</b>	
<u>Filament Wound</u>	Consists of a helical filament-winding technique per ASTM D2996 saturated with Interplastic CORVE 8401 Epoxy Vinyl Ester resin. This combination forms the “structural layer” having a total thickness never less than denoted in the structural calculations within our submittal. This method of construction is specific to straight-length cylindrical items only.
<u>Hand Lay-Up</u>	Consists of alternate layers of 1.5 oz/sq.ft. mat, random-chopped glass mat, and/or woven roving per the Hand Lay-Up Laminate Composition Table included in this submittal. Alternative structural layers shall be chopped, sprayed, and woven roving as described.
<u>Flanges</u>	Flanges shall be hand lay-up and undrilled with dimensions in accordance with ASTM D3982. Flange thickness shall be $\frac{3}{4}$ " minimum. Gaskets, nuts, bolts, washers shall be provided by others.

## ENGINEERING DESIGN REPORT FIBERGLASS REINFORCED PLASTIC TANK

Project: Hilo BTF

Customer: Daniel Company

Customer Project No.: 5013

Equipment Name: TBD

Dimension: 14'-0" Inside Diameter X 36'-0" Straight Shell Height

Configuration: Flat Bottom, Dish Top, Cylindrical Shell, Vertical

Head Config: Torispherical

Construction: Filament Wound & Hand Layup

Resin System: Vinyl Ester Resin with MEKP in Liner & Structure

Corrosion Barrier: 100 mil w/ 1 ply Veil

Design Pressure: +0.36 / -0 psig

Design Temperature: 120 deg. F max.

Liquid Content: 2'-6" max. depth

Liquid SG : 1.0

Wind Load: ASCE 7-16 @ 145 MPH, Cat. IV, Exp. C

Seismic Load: ASCE 7-16, Ss = 1.5 g, S1 = 0.6 g, Cat. IV, Site C, SDC D

Snow Load: 0 psf

Live Load: 40 psf

Design Ref. Code: ASTM D3299-18

Construction Code: ASTM D3299-18

Equipment Service Location: Hilo, HI

Designer: Joann(Juan) Du, P.E.

Revision: 0

Issue Date: 2/20/2025



*Juan Du*  
exp. 4/30/2026

## Table of Contents

**Chapter 1 Design Inputs**

**Chapter 2 Material Properties & Component Weight**

**Chapter 3 Dished Top Head & Joint Design**

**Chapter 4 Design of Cylindrical Shell**

**Chapter 5 Flat Bot. Head Design**

**Chapter 6 Wind Load Analysis**

**Chapter 7 Seismic Load Analysis**

**Chapter 8 Shell Combined Stress**

**Chapter 9 Opening Reinforcement**

**Chapter 10 Lifting Lug Design**

**Chapter 11 Anchor Lug Design**

**Chapter 12 Media Bed Support Design**

**Appendix A Design Summaries and Sketches**

**Appendix B FRP Lamination Analysis**



---

## Chapter 1 Design Inputs

Shell Inside Diameter  $D := 14 \cdot \text{ft} = 168 \text{ in}$

Shell Inside Radius  $R := \frac{D}{2} = 84 \cdot \text{in}$

Total Straight Shell Length  $H := 36 \cdot \text{ft} = 432 \text{ in}$

Design Liquid Level  $H_L := 30 \cdot \text{in}$

Applied Internal Pressure  $P_{\text{int}} := 0.36 \cdot \text{psi}$

Applied External Pressure  $P_{\text{ext}} := 0 \cdot \text{psi}$

Corrosion Barrier Thk.  $t_{\text{cb}} := 0.10 \cdot \text{in}$

Exterior Layer Thk.  $t_{\text{ex}} := 0 \cdot \text{in}$

Max. Design Temperature  $T_{\text{max}} := 120 \cdot \text{F}$

Content Specific Gravity  $SG_L := 1.0$

Water Density  $\rho_W := 0.0361 \cdot \frac{\text{lb}}{\text{in}^3}$

Content Density  $\rho_C := \rho_W \cdot SG_L = 0.036 \frac{\text{lb}}{\text{in}^3}$

FRPDensity  $\rho_{\text{frp}} := 0.065 \cdot \frac{\text{lb}}{\text{in}^3}$

## Wind Load Design Parameters

Design Reference Code: ASCE 7-16

Basic Wind Speed:  $V_b := 145 \text{ mph}$

Occupancy Category: oc := "IV"

Exposure: Exposure := "C"

## Seismic Load Design Parameters

Design Reference Code/Std ASCE 7-16

Soil Site Class siteclass := "C"

Occupancy Category oc = "IV"

Seismic Design Category sdc := "D"

Spectral Response Parameters  $S_s := 1.5$        $S_1 := 0.6$

Response Modification Factor rmf := 3.0

**Live Load**  $P_{\text{live}} := 40 \cdot \text{psf}$

## Safety Factors for Design

Design Safety Factor for Sustained Load  $F_s := 10$

Design Safety Factor for Transient Load,  
Vacuum, and Combined Loads  $F_t := 5$

Note : Corrosion barrier is included in structural analysis.

## Chapter 2 Material Properties & Component Weight

Top Head Configuration      $\Omega_R := 3$

(0:flat head/open top; 1:SE head; 2:Hemi head; 3:F&D head)

Top Head Structural Thickness:  $t_{th} := th \cdot in = 0.27in$

Top Head Total Thickness:  $t_{th\_tot} := t_{th} + t_{cb} + t_{ex} = 0.37in$

Top Head Tensile Modulus:  $E_{th} := 1500\text{ ksi}$

Top Head Tensile Strength:  $S_{th} := 15\text{ ksi}$

Top Head Flexural Modulus:  $E_{thf} := 1500\text{ ksi}$

Top Head Flexural Strength:  $S_{thf} := 19\text{ ksi}$

Bot. Head Configuration     $\Omega_B := 0$

Bot. Head Structural Thickness:  $t_{bh} := bh \cdot in = 0.275in$

Bot. Head Total Thickness:  $t_{bh\_tot} := t_{bh} + t_{cb} = 0.375in$

Bot. Head Tensile Modulus:  $E_{bh} := E_{th} = 1.5 \times 10^6\text{ psi}$

Bot. Head Tensile Strength:  $S_{bh} := S_{th} = 1.5 \times 10^4\text{ psi}$

Bot. Head Flexural Modulus:  $E_{bfh} := E_{thf} = 1.5 \times 10^6\text{ psi}$

Bot. Head Flexural Strength:  $S_{bfh} := S_{thf} = 1.9 \times 10^4\text{ psi}$

Poisson's Ratio of Type II Laminate:  $\nu \equiv 0.25$

Number of Shell Courses      $n \equiv 4$       $i \equiv 1..4$

Shell Structural Thk.

$$t_s := t_{su} \cdot in = \begin{pmatrix} 0.24 \\ 0.24 \\ 0.24 \\ 0.41 \end{pmatrix} \cdot in$$

Shell Total Thk

$$t_{stot} := t_s + t_{cb} + t_{ex} \quad t_{stot} = \begin{pmatrix} 0.34 \\ 0.34 \\ 0.34 \\ 0.51 \end{pmatrix} in$$

Shell Mean Radius

$$R_m := R + \frac{t_s}{2}$$

$$R_m = \begin{pmatrix} 84.12 \\ 84.12 \\ 84.12 \\ 84.205 \end{pmatrix} \text{in}$$

Shell Outside Diameter

$$D_o := D + 2 \cdot t_{\text{stot}}$$

Shell Length  
(from top to bot.)

$$L := \begin{pmatrix} 78 \\ 111 \\ 111 \\ 132 \end{pmatrix} \cdot \text{in}$$

$$\sum L = 432 \text{ in} \quad H = 432 \cdot \text{in}$$

Property Reduction Factor

$$\eta_p \equiv 0.98$$

Axial Tensile Modulus

$$E_a := \begin{pmatrix} 1684000 \\ 1684000 \\ 1684000 \\ 1745000 \end{pmatrix} \cdot \eta_p \cdot \text{psi} = \begin{pmatrix} 1.65 \times 10^6 \\ 1.65 \times 10^6 \\ 1.65 \times 10^6 \\ 1.71 \times 10^6 \end{pmatrix} \cdot \text{psi}$$

Hoop Tensile Modulus

$$E_h := \begin{pmatrix} 2763000 \\ 2763000 \\ 2763000 \\ 3740000 \end{pmatrix} \cdot \eta_p \cdot \text{psi} = \begin{pmatrix} 2.708 \times 10^6 \\ 2.708 \times 10^6 \\ 2.708 \times 10^6 \\ 3.665 \times 10^6 \end{pmatrix} \cdot \text{psi}$$

Axial Flexural Modulus

$$E_{af} := \begin{pmatrix} 1284000 \\ 1284000 \\ 1284000 \\ 1532000 \end{pmatrix} \cdot \eta_p \cdot \text{psi} = \begin{pmatrix} 1.258 \times 10^6 \\ 1.258 \times 10^6 \\ 1.258 \times 10^6 \\ 1.501 \times 10^6 \end{pmatrix} \cdot \text{psi}$$

Hoop Flexural Modulus

$$E_{hf} := \begin{pmatrix} 2232000 \\ 2232000 \\ 2232000 \\ 3044000 \end{pmatrix} \cdot \eta_p \cdot \text{psi} = \begin{pmatrix} 2.187 \times 10^6 \\ 2.187 \times 10^6 \\ 2.187 \times 10^6 \\ 2.983 \times 10^6 \end{pmatrix} \cdot \text{psi}$$

Axial Hoop Poisson's Ratio

$$v_{ah} := \begin{pmatrix} 0.19 \\ 0.19 \\ 0.19 \\ 0.12 \end{pmatrix}$$

Hoop Axial Poisson's Ratio

$$v_{ha} := \begin{pmatrix} 0.31 \\ 0.31 \\ 0.31 \\ 0.25 \end{pmatrix}$$

Shell Moment of Inertia:  $MOI_s := \frac{\pi}{64} \cdot \left[ (D + 2t_s)^4 - D^4 \right]$

Shell Section Modulus  $S := \frac{MOI_s}{\frac{D_o}{2}}$

Top Head Dish Radius  $idr := R_c \cdot in = 168 \text{ in}$

Knuckle Radius  $ikr := r_c \cdot in = 10 \text{ in}$

Top Head Total Weight  $w_R := \begin{cases} \pi \cdot R^2 \cdot t_{th\_tot} \cdot \rho_{frp} & \text{if } \Omega_R = 0 \\ 1.084 \cdot D^2 \cdot t_{th\_tot} \cdot \rho_{frp} & \text{if } \Omega_R = 1 \\ \frac{\pi \cdot D^2}{2} \cdot t_{th\_tot} \cdot \rho_{frp} & \text{if } \Omega_R = 2 \\ W_{torihead}(\rho_{frp}, ikr, R, idr, 0, t_{th\_tot}) & \text{if } \Omega_R = 3 \end{cases}$

$w_R = 635.025 \text{ lb}$

Top Head Depth  $h_d := \begin{cases} 0 & \text{if } \Omega_R = 0 \\ \frac{1}{4}D & \text{if } \Omega_R = 1 \\ \frac{1}{2}D & \text{if } \Omega_R = 2 \\ idr - \left[ (idr - ikd) \cdot \cos \left( \arcsin \left( \frac{\frac{D}{2} - ikd}{idr - ikd} \right) \right) \right] & \text{if } \Omega_R = 3 \end{cases}$

$h_d = 28.401 \text{ in}$

Total Weight of Flat Bot.

$$W_B := \begin{cases} \pi \cdot R^2 \cdot t_{bh\_tot} \cdot \rho_{frp} & \text{if } \Omega_B = 0 \\ 1.084 \cdot D^2 \cdot t_{bh\_tot} \cdot \rho_{frp} & \text{if } \Omega_B = 1 \\ \frac{\pi \cdot D^2}{2} \cdot t_{bh\_tot} \cdot \rho_{frp} & \text{if } \Omega_B = 2 \\ 0.9286 \cdot D^2 \cdot t_{bh\_tot} \cdot \rho_{frp} & \text{if } \Omega_B = 3 \end{cases}$$

$$W_B = 540.323 \text{ lb}$$

Total Weight of Shell

$$W_S := \rho_{frp} \cdot \pi \cdot \sum_{j=1}^n \left( 2 \cdot R_{m_j} \cdot t_{stot_j} \cdot L_j \right) = 5.819 \times 10^3 \text{ lb}$$

$$W_S = 5.819 \times 10^3 \text{ lb}$$

Top Head Volume

$$V_{L\_R} := f\_volts(ikr, R, idr, 0) = 1.658 \times 10^3 \text{ gal}$$

Tank Volume (Flooded):

$$V_{L\_fl} := \begin{cases} V_{L\_R} + \pi \cdot R^2 \cdot H_L & \text{if } \Omega_B = 0 \\ V_{L\_R} + \frac{\pi D^3}{24} + \pi \cdot R^2 \cdot H_L & \text{if } \Omega_B = 1 \\ V_{L\_R} + \frac{\pi D^3}{12} + \pi \cdot R^2 \cdot H_L & \text{if } \Omega_B = 2 \\ 2V_{L\_R} + \pi \cdot R^2 \cdot H_L & \text{if } \Omega_B = 3 \end{cases}$$

$$V_{L\_fl} = 4.537 \times 10^3 \text{ gal}$$

Tank Volume (Filled To Tangent Line)

$$V_{L\_op} := \pi \cdot R^2 \cdot H_L = 2.879 \times 10^3 \text{ gal}$$

Content Weight  $W_L := \rho_c \cdot V_{L\_op} = 2.401 \times 10^4 \text{ lb}$

Extra FRP Dead Weight  
(Head & shell joints,  
nozzles, repad, body flange  
and etc.)  $W_{ad1} := 800 \cdot \text{lb}$

Packing Weight  $W_{ad2} := w_{tbd} \cdot \text{lb} \cdot 3 = 4.017 \times 10^4 \text{ lb}$

Total Weight Multiplication Factor:  $\eta := 1.15$

Total FRP Weight:  $W_{FRP} := (W_S + W_B + W_R + W_{ad1}) \cdot \eta = 8.964 \times 10^3 \text{ lb}$

Total FRP + Content Weight:  $W_T := W_{FRP} + W_L + W_{ad2} = 7.314 \times 10^4 \text{ lb}$

## Chapter 3 Dished Top Head & Joint Design

Ref: ASTM D-3299 6.3.2.5

Top Head Type ASME Flanged & Dished

Top Head Dish Radius  $R_c \equiv 168$  idr = 168 in

Top Head Knuckle Radius  $r_c \equiv 10$  ikr = 10 in

Top Head Thickness  $t_{th} = 0.27$  in

Tensile Modulus  $E_{th} = 1.5 \times 10^3$  ksi

Tensile Strength  $S_{th} = 15$  ksi

Flexural Modulus  $E_{thf} = 1.5 \times 10^3$  ksi

Ultimate Flexural Strength  $S_{thf} = 19$  ksi

Poisson's Ratio  $\nu = 0.25$

Design Concentrated Load  $P_1 := 250$  lb

Radius of Concentrated Load  $r_0 := 2.257$  in

Dish Head Depth  $h_d = 28.401$  in

Top Head Design Factor For Pressure/  
Sustained Load:  $F_s = 10$

Top Head Design Factor For  
Vacuum/Transient Load:  $F_t = 5$

## Dish Head Design for Pressure

Top Head Construction: Hand Layup

Top of Overflow Above Top of  
Dish Head ("+" above, "-" below):  $h_{of} := 0 \cdot \text{in}$

Top Head Total Internal Pressure:  $P_{th\_ip} := P_{int} = 0.36 \cdot \text{psi}$

$$P_{th\_ip} = 0.36 \cdot \text{psi}$$

Minimum Required Thk. for Pressure

$$t_{th\_ip} := \frac{\frac{0.885P_{th\_ip} \cdot idr}{S_{th}}}{F_s} \quad t_{th\_ip} = 0.036 \text{ in}$$

$$t_{th\_ip} = 0.036 \text{ in}$$

Top Head Structural Thk.  $t_{th} \equiv 0.27$   $t_{th} = 0.27 \text{ in}$

Top Head Total Thk.  $t_{th\_tot} = 0.37 \text{ in}$

Top Head to Shell Joint Min. Thk.:  $t_{j\_th} := 0.36 \cdot \text{in}$

**See Appendix A for Head to Shell Joint Detail.**

**Design for 250 lb load on a 4 in x 4 in area on the top of a dish head**

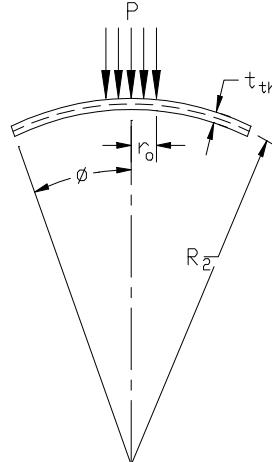
Mean Dish Radius:  $R_{dm} := idr + \frac{t_{th\_tot}}{2}$

Allowable Deflection  $\delta_{th} := \min(0.5 \cdot \text{in}, 0.005 \cdot D) = 0.5 \text{ in}$

$$\phi := \arcsin\left(\frac{R}{R_{dm}}\right) \quad \phi_{ref} := \arcsin\left(1.65 \cdot \sqrt{\frac{t_{th\_tot}}{R_{dm}}}\right)$$

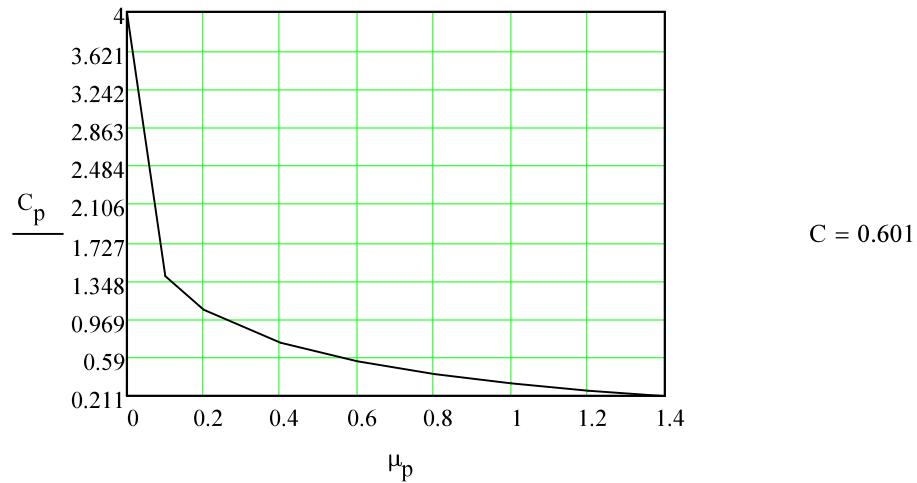
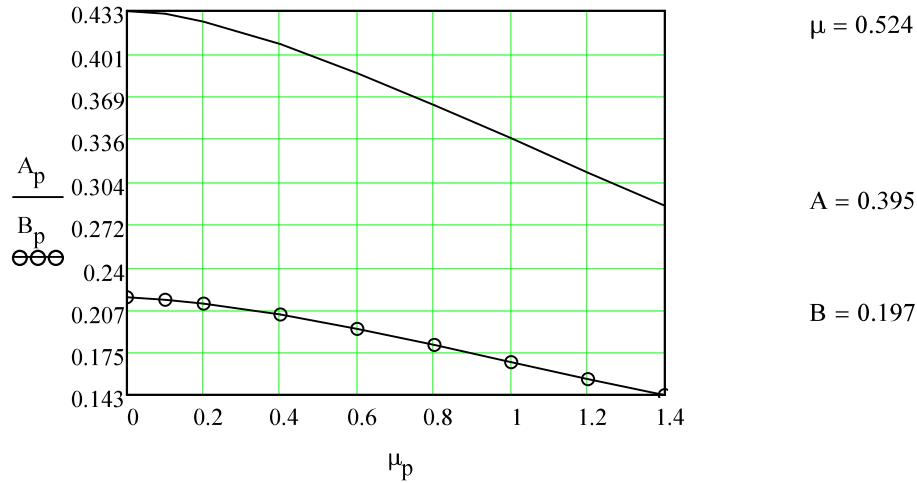
$\phi = 0.523$        $\phi_{ref} = 0.077$

$$\mu := r_0 \cdot \left[ \frac{12 \cdot (1 - v^2)}{R_{dm}^2 \cdot t_{th\_tot}^2} \right]^{.25} \quad \mu = 0.524 \quad \mu \equiv 0.524$$



Check := if( $\phi \geq \phi_{ref}$ , "Good", "See Roark's, Table 13.3, Case 2")

Check = "Good"



$$y_{\max} := -A \cdot \left( \frac{P_l \cdot R_{dm} \sqrt{1 - v^2}}{E_{th} \cdot t_{th\_tot}^2} \right)$$

$$y_{\max} = -0.078 \cdot \text{in}$$

checktopheaddeflection := if( $-y_{\max} \leq \delta_{th}$ , "OK", "Excessive Deflection") = "OK"

### Top Head Stresses Under Point Load

$$\sigma_m := -B \cdot \left( \frac{P_l \cdot \sqrt{1 - v^2}}{t_{th\_tot}^2} \right) \quad \text{membrane stress} \quad \sigma_m = -349 \cdot \text{psi}$$

$$\sigma_b := -C \cdot \left( P_l \cdot \frac{1 + v}{t_{th\_tot}^2} \right) \quad \text{bending stress} \quad \sigma_b = -1373 \cdot \text{psi}$$

$$\text{Combined Stress} \quad \sigma_{th\_p} := \sqrt{\sigma_m^2 + \sigma_b^2} = 1.417 \times 10^3 \cdot \text{psi}$$

$$\text{checktopheadstress}_p := \text{if} \left( \sigma_{th\_p} \leq \frac{S_{th}}{F_t}, \text{"OK"}, \text{"Excessive Stress Under Point Load"} \right) = \text{"OK"}$$

## Dish Head Design for Vacuum + Live Load

Ref: ASTM D-3299 6.2.2

Tank External Pressure       $P_{ext} = 0 \cdot \text{psi}$

Design Vacuum:       $P_{th\_ep} := P_{ext} + P_{live} + P_{we\_th} \cdot \text{psi} = 0.44 \cdot \text{psi}$

Flexural Modulus:       $E_{thf} = 1.5 \times 10^6 \cdot \text{psi}$

Outside Dish Radius:       $R_{do} := idr + t_{th\_tot} = 168.37 \text{ in}$

Minimum Req'd Thk. For Vacuum:       $t_{th\_ep} := R_{do} \cdot \sqrt{\frac{F_t \cdot P_{th\_ep}}{0.36 \cdot E_{thf}}} = 0.34 \cdot \text{in}$

checktopheadthk := if( $t_{th\_tot} \geq t_{th\_ip} \wedge t_{th\_tot} \geq t_{th\_ep}$ , "Top Head OK", "Inadequate") = "Top Head OK"

## Chapter 4 Design of Cylindrical Shell

### Cylindrical Shell Stress Under Internal Pressure

Ref : ASTM D3299 6.1.3.1

Allowable Strain For Sustained Load       $\varepsilon \equiv 0.001$

Shell Design Internal Pressure       $P_{int} = 0.36 \cdot \text{psi}$

$n = 4$        $i \equiv 1..n$

Cumulative Shell Height       $\overrightarrow{\sum L_i} := \sum_{j=1}^i L_j$        $\sum L_i = \begin{pmatrix} 78 \\ 189 \\ 300 \\ 432 \end{pmatrix} \text{in}$

Additional Hydrostatic Head Height       $h_{ad} := 0 \cdot \text{in}$

Hydrostatic Pressure At the Bot. of Each Shell Course

$$P_{hy} := \rho_c \cdot \begin{pmatrix} 0 \\ 0 \\ 0 \\ 30 \end{pmatrix} \cdot \text{in} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1.083 \end{pmatrix} \cdot \text{psi}$$

Total Pressure At the Bot.  
of Each Shell Course       $P_i := P_{int} + P_{hy_i}$        $P = \begin{pmatrix} 0.36 \\ 0.36 \\ 0.36 \\ 1.44 \end{pmatrix} \cdot \text{psi}$

Min. Req'd Shell Thk. Due  
to Hoop Force

$$t_{s\_h} := \xrightarrow{\frac{P \cdot D}{2 \cdot \epsilon \cdot E_h}} t_{s\_h} = \begin{pmatrix} 0.011 \\ 0.011 \\ 0.011 \\ 0.033 \end{pmatrix} \text{in}$$

Min. Req'd Shell Thk. Due  
to Axial Force

$$t_{s\_a} := \xrightarrow{\frac{P_{int} \cdot D}{4 \cdot \epsilon \cdot E_a}} t_{s\_a} = \begin{pmatrix} 9.162 \times 10^{-3} \\ 9.162 \times 10^{-3} \\ 9.162 \times 10^{-3} \\ 8.842 \times 10^{-3} \end{pmatrix} \text{in}$$

Min. Req'd Shell Thk. Due  
to Pressure

$$t_{s\_ip_i} := \text{if}\left(t_{s\_h_i} \geq t_{s\_a_i}, t_{s\_h_i}, t_{s\_a_i}\right) \quad t_{s\_ip} = \begin{pmatrix} 0.011 \\ 0.011 \\ 0.011 \\ 0.033 \end{pmatrix} \text{in}$$

Design Shell Structural Thk.

$$t_{stot} = \begin{pmatrix} 0.34 \\ 0.34 \\ 0.34 \\ 0.51 \end{pmatrix} \text{in}$$

Check Shell Thk. For  
Pressure

$$\text{checkforpressure}_i := \text{if}\left(t_{stot_i} \geq t_{s\_ip_i}, "OK", "Inadequate"\right)$$

$$\text{checkforpressure} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Shell Hoop  
Strain Due  
to Pressure

$$\epsilon_{h\_s} := \xrightarrow{\frac{P \cdot D}{2 \cdot t_{stot} \cdot E_h}}$$

$$\varepsilon_{h\_s} = \begin{pmatrix} 3.285 \times 10^{-5} \\ 3.285 \times 10^{-5} \\ 3.285 \times 10^{-5} \\ 6.485 \times 10^{-5} \end{pmatrix}$$

Shell Axial  
 Strain Due  
 to Pressure

$$\varepsilon_{a\_s} := \frac{\overrightarrow{P_{int} \cdot D}}{4 \cdot t_{stot} \cdot E_a}$$

$$\varepsilon_{a\_s} = \begin{pmatrix} 2.695 \times 10^{-5} \\ 2.695 \times 10^{-5} \\ 2.695 \times 10^{-5} \\ 1.734 \times 10^{-5} \end{pmatrix}$$

$$t_{su} = \begin{pmatrix} 0.24 \\ 0.24 \\ 0.24 \\ 0.41 \end{pmatrix}$$

## Chapter 5 Flat Bottom Head Design

Ref : ASTM D3299 6.3.2

Bot. Head Combined  
Structure Thk.

$$bhu \equiv 0.275$$

$$t_{bh} = 0.275 \text{ in}$$

Flat Bot. Total Thk.

$$t_{bh\_tot} = 0.375 \text{ in}$$

$$t_{bh\_min} := \begin{cases} 0.1875 \cdot \text{in} & \text{if } D \leq 6 \cdot \text{ft} \\ 0.25 \cdot \text{in} & \text{if } 6 \cdot \text{ft} < D \leq 12 \cdot \text{ft} \\ 0.375 \cdot \text{in} & \text{if } 12 \cdot \text{ft} < D \end{cases}$$

$$\text{checkbotthk} := \text{if}(t_{bh\_tot} \geq t_{bh\_min}, \text{"OK"}, \text{"Inadequate"}) = \text{"OK"}$$

## Chapter 6 Wind Load Analysis - ASCE 7-16

Basic Wind Speed:  $V_b = 145 \cdot \text{mph}$

Occupancy Category:  $oc = \text{"IV"}$

Exposure Category:  $\text{Exposure} = \text{"C"}$

Diameter Addition:  $\Delta d := 2 \cdot \text{ft}$

Outside Diameter  
of Surface  $D_{ow_i} := D_{o_i} + \Delta d$

Normal to Wind:

$$\text{Cumulative Height for Wind Analysis: } h_{w_i} := \sum_{j=i}^n L_j \quad h_w = \begin{pmatrix} 432 \\ 354 \\ 243 \\ 132 \end{pmatrix} \cdot \text{in}$$

$$z_g := \begin{cases} (1200 \cdot \text{ft}) & \text{if Exposure = "B"} \\ (900 \cdot \text{ft}) & \text{if Exposure = "C"} \\ (700 \cdot \text{ft}) & \text{if Exposure = "D"} \end{cases}$$

$$\alpha := \begin{cases} 7.0 & \text{if Exposure = "B"} \\ 9.5 & \text{if Exposure = "C"} \\ 11.5 & \text{if Exposure = "D"} \end{cases}$$

$$\text{Velocity Pressure Exposure Coefficient} \quad K_{zh} := 2.01 \cdot \left( \frac{h_w}{z_g} \right)^{\frac{2}{\alpha}} \quad K_{zh} = \begin{pmatrix} 1.021 \\ 0.979 \\ 0.904 \\ 0.795 \end{pmatrix}$$

(ASCE 29.3.1)

Wind Directionality Factor:  $K_d := 0.95$  ASCE 26.6-1

Topographic Factor:  $K_{zt} := 1.0$  ASCE 26.8.2

Velocity Pressure:  $q_z := .00256 \cdot \frac{\text{lb}}{\text{ft}^2} \cdot K_{zh} \cdot K_{zt} \cdot K_d \cdot \left( \frac{V_b}{\text{mph}} \right)^2 = \begin{pmatrix} 0.362 \\ 0.348 \\ 0.321 \\ 0.282 \end{pmatrix} \cdot \text{psi}$  ASCE 29.3.2

Gust Effect Factor:  $\text{Gust}_{\max} := 0.85$  ASCE 26.9

$$z_{\min} := \begin{cases} 30 & \text{if Exposure = "B"} \cdot \text{ft} \\ 15 & \text{if Exposure = "C"} \\ 7 & \text{if Exposure = "D"} \end{cases} \quad c := \begin{cases} .3 & \text{if Exposure = "B"} \\ .2 & \text{if Exposure = "C"} \\ .15 & \text{if Exposure = "D"} \end{cases}$$

$$\varepsilon := \begin{cases} \frac{1}{3} & \text{if Exposure = "B"} \\ \frac{1}{5} & \text{if Exposure = "C"} \\ \frac{1}{8} & \text{if Exposure = "D"} \end{cases} \quad \gamma := \begin{cases} 320 & \text{if Exposure = "B"} \cdot \text{ft} \\ 500 & \text{if Exposure = "C"} \\ 650 & \text{if Exposure = "D"} \end{cases}$$

$$z_{\bar{b}} := \begin{cases} (.60 \cdot H) & \text{if } H \geq z_{\min} \\ z_{\min} & \text{otherwise} \end{cases}$$

$$g_Q := 3.4 \quad g_V := 3.4$$

$$I_{zb} := c \cdot \left( \frac{33 \cdot \text{ft}}{z_{\bar{b}}} \right)^{\frac{1}{6}} \quad L_{zb} := \frac{\gamma}{\text{ft}} \cdot \left( \frac{z_{\bar{b}}}{33 \cdot \text{ft}} \right)^{\varepsilon}$$

$$Q_w := \sqrt{\frac{1}{1 + 0.63 \cdot \left( \frac{D + H}{L_{zb} \cdot \text{ft}} \right)^{0.63}}} \quad \text{gust'} := 0.925 \cdot \frac{(1 + 1.7 \cdot g_Q \cdot I_{zb} \cdot Q_w)}{1 + 1.7 \cdot g_V \cdot I_{zb}} \quad \text{gust'} = 0.889$$

$$\text{Gust} := \min(\text{Gust}_{\max}, \text{gust}') = 0.85$$

$$hd := \frac{hw}{D} = \begin{pmatrix} 2.571 \\ 2.107 \\ 1.446 \\ 0.786 \end{pmatrix} \quad \frac{D}{ft} \cdot \left( \frac{q_z}{psf} \right)^{0.5} = \begin{pmatrix} 101.14 \\ 99.042 \\ 95.197 \\ 89.274 \end{pmatrix}$$

Force Coefficient: ASCE Figure 29.5-1, Other Structures - Method 2, Chimneys, Tanks, Rooftop Equipment

roughness := "moderately smooth"

$$Cf_{tab} := \begin{pmatrix} 1 & 7 & 25 \\ 0.5 & 0.6 & 0.7 \\ 0.7 & 0.8 & 0.9 \\ 0.8 & 1.0 & 1.2 \\ 0.7 & 0.8 & 1.2 \end{pmatrix} \quad ri' := \begin{cases} 2 & \text{if roughness = "moderately smooth"} \\ 3 & \text{if roughness = "rough"} \\ 4 & \text{if roughness = "very rough"} \end{cases}$$

$$ri_i := \begin{cases} ri' & \text{if } 2.5 < \frac{D}{ft} \cdot \sqrt{\frac{q_{zi}}{psf}} \\ 5 & \text{otherwise} \end{cases} \quad ri = \begin{pmatrix} 2 \\ 2 \\ 2 \\ 2 \end{pmatrix}$$

$$Cf_i := \begin{cases} Cf_{tab}(ri_i, 1) & \text{if } hd_i < Cf_{tab, 1, 1} \\ Cf_{tab}(ri_i, 3) & \text{if } hd_i > Cf_{tab, 1, 3} \\ \text{interp}\left[\left(Cf_{tab}^T\right)^{(1)}, \left(Cf_{tab}^T\right)^{(ri_i)}, hd_i\right] & \text{otherwise} \end{cases} \quad Cf = \begin{pmatrix} 0.526 \\ 0.518 \\ 0.507 \\ 0.5 \end{pmatrix}$$

Wind Pressure:  $P_{wd_i} := q_{zi} \cdot Cf_i \cdot Gust$

$$P_{wd} = \begin{pmatrix} 0.162 \\ 0.153 \\ 0.138 \\ 0.12 \end{pmatrix} \cdot \text{psi} \quad \text{ASCE eq. 29.5-1} \quad P_{we\_th} \equiv 0.162$$

Design Wind Pressure:  $P_w := P_{wd}$

$$P_w = \begin{pmatrix} 0.162 \\ 0.153 \\ 0.138 \\ 0.12 \end{pmatrix} \cdot \text{psi}$$

Wind Induced Lateral Force  
on Each Shell Course:

$$V_{w\_s_i} := P_{w_i} \cdot D_{ow_i} \cdot L_i$$

$$V_{w\_s} = \begin{pmatrix} 2.436 \times 10^3 \\ 3.276 \times 10^3 \\ 2.962 \times 10^3 \\ 3.058 \times 10^3 \end{pmatrix} \text{lb}$$

Combined Wind Induced  
Lateral Force at the Bot. of  
Each Shell Course:

$$V_{w_i} := \sum_{j=1}^i (V_{w\_s_j})$$

$$V_w = \begin{pmatrix} 2.436 \times 10^3 \\ 5.712 \times 10^3 \\ 8.674 \times 10^3 \\ 1.173 \times 10^4 \end{pmatrix} \text{lb}$$

Top Head Projected Area  
Subject to Wind Load:

$$A_{th} := D \cdot h_d = 4.771 \times 10^3 \text{ in}^2$$

Wind Load on Top Head:

$$V_{wth} := P_{w_1} \cdot A_{th} = 773.443 \text{ lb}$$

Top Head Wind Load Moment  
Arm:

$$L_{wth} := \frac{h_d}{3} = 9.467 \text{ in}$$

Wind Load Induced Overturning Moment at The Base of Each Course:

$$\Delta Lr_i := \sum_{j=1}^i L_j \quad \Delta Lr = \begin{pmatrix} 78 \\ 189 \\ 300 \\ 432 \end{pmatrix} \text{in}$$

Wind Load Induced Overturning Moment at The Base of Each Course:

$$M_{w_1} := V_{w\_s_1} \cdot \frac{L_1}{2} + P_{w_1} \cdot A_{th} \cdot (L_{wth} + \Delta Lr_1)$$

$$M_{W_2} := V_{W-s_1} \cdot \left( \frac{L_1}{2} + L_2 \right) + V_{W-s_2} \cdot \frac{L_2}{2} + P_{W_1} \cdot A_{th} \cdot (L_{wth} + \Delta Lr_2)$$

$$M_{W_3} := V_{W-s_1} \cdot \left( \frac{L_1}{2} + L_2 + L_3 \right) + V_{W-s_2} \cdot \left( \frac{L_2}{2} + L_3 \right) + V_{W-s_3} \cdot \frac{L_3}{2} + P_{W_1} \cdot A_{th} \cdot (L_{wth} + \Delta Lr_3)$$

$$M_{W_4} := V_{W-s_1} \cdot \left( \frac{L_1}{2} + L_2 + L_3 + L_4 \right) + V_{W-s_2} \cdot \left( \frac{L_2}{2} + L_3 + L_4 \right) + V_{W-s_3} \cdot \left( \frac{L_3}{2} + L_4 \right) + V_{W-s_4} \cdot \frac{L_4}{2} \dots \\ + P_{W_1} \cdot A_{th} \cdot (L_{wth} + \Delta Lr_4)$$

$$M_W = \begin{pmatrix} 1.627 \times 10^5 \\ 7.007 \times 10^5 \\ 1.585 \times 10^6 \\ 3.034 \times 10^6 \end{pmatrix} \text{ in-lb}$$

$$\text{Wind Base Shear: } V_{W_n} = 1.173 \times 10^4 \text{ lb}$$

$$\text{Wind Base Overturning Moment: } M_{W_n} = 3.034 \times 10^6 \text{ in-lb}$$

## Chapter 7 Seismic Load Analysis

Ref.: IBC 2018, ASCE 7-16 & API Standard 650, App. E

rmf = 3	= Response Modification Coefficient
siteclass = "C"	= Site Class
oc = "IV"	= Occupancy Category
H <sub>L</sub> = 30 in	= Design Liquid Level
W <sub>R</sub> = 635.025 lb	= Top Head Weight
W <sub>S</sub> = $5.819 \times 10^3$ lb	= Shell Weight
W <sub>L</sub> = $2.401 \times 10^4$ lb	= Liquid Weight
W <sub>1</sub>	= Wgt of Tank Contents That Moves With Tank Shell
W <sub>2</sub>	= Wgt of Contents That Moves in 1st Sloshing Mode
x <sub>s</sub>	= Tank Shell's Center of Gravity (C.G.)
x <sub>1</sub>	= C.G. of W <sub>1</sub> (Sec. E.3.2.2)
x <sub>2</sub>	= C.G. of W <sub>2</sub> (Sec. E.3.2.2)
T <sub>i</sub>	= Natural Period of First Sloshing Mode

Max. considered earthquake ground motion of 0.2 sec. spectral response acceleration with 5% of critical damping  $S_s = 1.5$

Max. considered earthquake ground motion of 1.0 sec. spectral response acceleration with 5% of critical damping  $S_i = 0.6$

Occupancy Category  
 (Table 1-1)

$$oc_s := \begin{cases} 1 & \text{if } oc = "I" \\ 2 & \text{if } oc = "II" \\ 3 & \text{if } oc = "III" \\ 4 & \text{otherwise} \end{cases} \quad oc_s = 4$$

Site Class Definition  
 (table 20.3-1)

$$\text{siteclass} = "C" \quad ic := \text{str2vec(siteclass)}_1 - 64$$

$$ic = 3$$

Site Coefficient (table 11.4-1)

$$Fa := \begin{pmatrix} 0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\ 0.9 & 0.9 & 0.9 & 0.9 & 0.9 & 0.9 \\ 1.3 & 1.3 & 1.2 & 1.2 & 1.2 & 1.2 \\ 1.6 & 1.4 & 1.2 & 1.1 & 1.0 & 1.0 \\ 2.4 & 1.7 & 1.3 & 1.1 & 1.0 & 1.0 \\ 2.4 & 1.7 & 1.3 & 1.1 & 1.0 & 1.0 \end{pmatrix} \quad Ss_{fa} := \begin{pmatrix} .25 \\ .5 \\ .75 \\ 1.0 \\ 1.25 \\ 1.5 \end{pmatrix}$$

Site Coefficient (table 11.4-2)

$$Fv := \begin{pmatrix} 0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\ 0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\ 1.5 & 1.5 & 1.5 & 1.5 & 1.5 & 1.4 \\ 2.4 & 2.2 & 2.0 & 1.9 & 1.8 & 1.7 \\ 4.2 & 2.2 & 2.0 & 1.9 & 1.8 & 1.7 \\ 4.2 & 2.2 & 2.0 & 1.9 & 1.8 & 1.7 \end{pmatrix} \quad S1_{fv} := \begin{pmatrix} 0.1 \\ 0.2 \\ 0.3 \\ 0.4 \\ 0.5 \\ 0.6 \end{pmatrix}$$

$$Fa := \begin{cases} Fa_{ic,1} & \text{if } S_s \leq Ss_{fa}_1 \\ \left[ \text{interp} \left[ Ss_{fa}, (Fa^T)^{\langle ic \rangle}, S_s \right] \right] & \text{if } Ss_{fa}_1 < S_s < Ss_{fa}_6 \\ Fa_{ic,6} & \text{if } S_s \geq Ss_{fa}_6 \end{cases} \quad Fa = 1.2$$

$$F_v := \begin{cases} F_{v_{ic,1}} & \text{if } S_1 \leq S_{1fv_1} \\ \left[ \text{interp} \left[ S_{1fv}, \left( F_v^T \right)^{\langle ic \rangle}, S_1 \right] \right] & \text{if } S_{1fv_1} < S_1 < S_{1fv_6} \\ F_{v_{ic,6}} & \text{if } S_1 \geq S_{1fv_6} \end{cases} \quad F_v = 1.4$$

$$S_{MS} := F_a \cdot S_s \quad S_{MS} = 1.8 \quad S_{DS} := \frac{2 \cdot (S_{MS})}{3} \quad S_{DS} = 1.2$$

$$S_{M1} := F_v \cdot S_1 \quad S_{M1} = 0.84 \quad S_{D1} := \frac{2}{3} \cdot (S_{M1}) \quad S_{D1} = 0.56$$

$$I_s := \begin{cases} 1.0 & \text{if } oc_s < 3 \\ 1.25 & \text{if } oc_s = 3 \\ 1.5 & \text{if } oc_s = 4 \end{cases} \quad I_s = 1.5$$

$$T_s := \frac{S_{D1}}{S_{DS}} \cdot s = 0.467 s$$

$$E_{eq} := \left[ \overline{(E_h \cdot E_a)} \right]^{0.5} = \begin{pmatrix} 2.114 \times 10^6 \\ 2.114 \times 10^6 \\ 2.114 \times 10^6 \\ 2.504 \times 10^6 \end{pmatrix} \cdot \text{psi}$$

$$E_{eqm} := \text{mean}(E_{eq}) = 2.211 \times 10^6 \cdot \text{psi}$$

$$t_m := \text{mean}(t_{stot}) = 0.383 \text{ in}$$

Fundamental Period:

$$T_i := \frac{1}{0.56} \cdot \left[ \frac{\frac{W_{FRP} \cdot (H)^4}{H}}{g \cdot E_{eqm} \cdot \frac{\pi \cdot (D)^3 \cdot t_m}{8}} \right]^{0.5} = 0.062 \text{ s}$$

Natural Period of The 1st Mode of Sloshing:

$$T_c := 2 \cdot \pi \cdot \left[ \frac{D}{\left( 3.68g \cdot \tanh \left( 3.68 \cdot \frac{H}{D} \right) \right)} \right]^{0.5} = 2.161 \text{ s}$$

$$T_L := 12 \cdot s$$

$$S_{ac} := \begin{cases} \frac{1.5 \cdot S_{D1} \cdot \left( \frac{T_L}{s} \right)}{\left( \frac{T_c}{s} \right)^2} & \text{if } T_c > T_L \\ \frac{1.5 \cdot S_{D1}}{\frac{T_c}{s}} & \text{otherwise} \end{cases} \quad S_{ac} = 0.389$$

$$S_{ai} := \begin{cases} \frac{S_{D1} \cdot \left( \frac{T_L}{s} \right)}{\left( \frac{T_i}{s} \right)^2} & \text{if } T_i > T_L \\ \frac{S_{D1}}{\frac{T_i}{s}} & \text{if } T_s < T_i \leq T_L \\ S_{DS} & \text{otherwise} \end{cases} \quad S_{ai} = 1.2$$

$C_s$  = sloshing spectral acceleration parameter(sloshing) (ASCE 15.7.6 eq.15.7-6)

$$C_{s\text{rigid}} := .3 \cdot S_{DS} \cdot I_s \quad \text{Eq. 15.4-5}$$

$$C_{s12\text{min}} := \begin{cases} .01 & \text{if } S_1 < 0.6 \\ \frac{.5 \cdot S_1}{\frac{rmf}{I_s}} & \text{if } S_1 \geq 0.6 \wedge \frac{.5 \cdot S_1}{\frac{rmf}{I_s}} > .01 \\ .01 & \text{otherwise} \end{cases} \quad \text{Eq. 12.8-5,6}$$

$$C_{s12\_8\_2} := \frac{S_{DS}}{\frac{rmf}{I_s}} \quad \text{Eq. 12.8-2} \quad C_{s12\_8\_2} = 0.6$$

$$C_{s15\text{min}} := \begin{cases} .03 & \text{if } S_1 < 0.6 \\ \frac{.8 \cdot S_1}{\frac{rmf}{I_s}} & \text{if } S_1 \geq 0.6 \wedge \frac{.8 \cdot S_1}{\frac{rmf}{I_s}} > .01 \\ .03 & \text{otherwise} \end{cases} \quad \text{Eq. 15.4-1,2}$$

$$C_{s15\text{min}} = 0.24$$

$$C_{s\text{max}} := \begin{cases} \frac{S_{D1}}{\frac{T_i}{s} \cdot \left( \frac{rmf}{I_s} \right)} & \text{if } T_i \leq T_L \\ \frac{S_{D1} \cdot \frac{T_L}{s}}{\left( \frac{T_i}{s} \right)^2 \cdot \left( \frac{rmf}{I_s} \right)} & \text{otherwise} \end{cases} \quad \text{Eq. 12.8-3,4}$$

$$C_{s12} := \begin{cases} C_{s\text{max}} & \text{if } C_{s12\_8\_2} > C_{s\text{max}} \\ C_{s12\_8\_2} & \text{if } C_{s12\text{min}} < C_{s12\_8\_2} \leq C_{s\text{max}} \\ C_{s12\text{min}} & \text{if } C_{s12\text{min}} > C_{s12\_8\_2} \end{cases}$$

$$C_{s\text{nonrigid}} := \max(C_{s12}, C_{s15\text{min}}) \quad C_{s\text{nonrigid}} = 0.6$$

$$C_s := \begin{cases} C_{s\text{rigid}} & \text{if } T_i < 0.06 \cdot s \\ C_{s\text{nonrigid}} & \text{otherwise} \end{cases} \quad C_{sv\text{tank}} := 0.2 \cdot S_{DS} \cdot I_s = 0.36$$

$$C_s := C_s = 0.6$$

$$M_{asceT} := C_s \cdot W_T = 4.388 \times 10^4 \text{ lb}$$

$A_i$  = impulsive design response spectrum acceleration coefficient  
 $A_c$  = convective spectral acceleration parameter

$$R_{wi} := 4 \quad R_{wc} := 2$$

$$A_i := \begin{cases} \frac{2}{3} \cdot F_a \cdot S_s \cdot \frac{I_s}{R_{wi}} & \text{if } \frac{2}{3} \cdot F_a \cdot S_s \cdot \frac{I_s}{R_{wi}} \geq 0.007 \\ 0.007 & \text{otherwise} \end{cases} \quad A_i = 0.45$$

$$A_c := \begin{cases} F_a \cdot S_s \cdot \frac{T_s}{T_c} \cdot \frac{I_s}{R_{wc}} & \text{if } T_c \leq T_L \\ F_a \cdot S_s \cdot \frac{T_s \cdot T_L}{T_c^2} \cdot \frac{I_s}{R_{wc}} & \text{otherwise} \end{cases} \quad A_c = 0.292$$

### Sloshing Wave and Free Board Calculation

For closed top tanks, the min. free board specified below has to be met. Otherwise, tank head should be designed for additional pressure.

$$A_f := \begin{cases} F_a \cdot S_s \cdot \frac{T_s}{T_c} & \text{if } T_c \leq T_L \\ F_a \cdot S_s \cdot \frac{T_s \cdot T_L}{T_c^2} & \text{otherwise} \end{cases} \quad A_f = 0.389$$

Sloshing Wave Height:  $\delta_s := 0.42 \cdot D \cdot A_f = 27.433 \text{ in}$

### Calculation of Overturning Moment and Shear Force

Cumulative Shell Height:  $H_{s_i} := \sum_{j=1}^i L_j$   $H_s = \begin{pmatrix} 78 \\ 189 \\ 300 \\ 432 \end{pmatrix} \text{ in}$

Moment Arm for Each Section:  $X_{s_i} := \frac{H_{s_i}}{2}$   $X_s = \begin{pmatrix} 39 \\ 94.5 \\ 150 \\ 216 \end{pmatrix} \text{ in}$

Diameter-to-height Ratios:  $R_{dh_i} := \frac{D}{H_{s_i}}$   $R_{dh} = \begin{pmatrix} 2.15 \\ 0.89 \\ 0.56 \\ 0.39 \end{pmatrix}$

Liquid Content Weight:  $W_t := \begin{pmatrix} 0 \\ 0 \\ 0 \\ \frac{W_L}{lb} \end{pmatrix} \cdot lb$   $W_t = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 24007 \end{pmatrix} \text{ lb}$

Internal Weight  $W_{int} := w t b d \cdot lb = 1.339 \times 10^4 \text{ lb}$

Internal Moment Arm  $L_{int} := \begin{pmatrix} 337.5 \\ 226.5 \\ 115.5 \\ 0 \end{pmatrix} \cdot \text{in} = \begin{pmatrix} 337.5 \\ 226.5 \\ 115.5 \\ 0 \end{pmatrix} \text{ in}$

### Internal Moment

$$M_{int} := \begin{bmatrix} 0 \\ W_{int}(L_{int_1} - L_4 - L_3) + W_{int}(L_{int_2} - L_4 - L_3) \\ W_{int}(L_{int_1} - L_4) + W_{int}(L_{int_2} - L_4) + W_{int}(L_{int_3} - L_4) \\ W_{int} \cdot L_{int_1} + W_{int} \cdot L_{int_2} + W_{int} \cdot L_{int_3} \end{bmatrix} = \begin{bmatrix} 0 \\ 1.044 \times 10^6 \\ 3.796 \times 10^6 \\ 9.099 \times 10^6 \end{bmatrix} \text{in}\cdot\text{lb}$$

### Effective Weight Calculation (API 650 E.6.1.1)

#### Impulsive Weight Factor

$$\Gamma I_i := \text{if} \left[ R_{dh_i} \geq 1.33, \frac{\tanh(0.866 \cdot R_{dh_i})}{0.866 \cdot R_{dh_i}}, (1.0 - 0.218 \cdot R_{dh_i}) \right] \quad \Gamma I = \begin{pmatrix} 0.511 \\ 0.806 \\ 0.878 \\ 0.915 \end{pmatrix}$$

#### Impulsive Weight

$$W_{1i} := \Gamma I_i \cdot W_{ti}$$

$$W_1 = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 2.197 \times 10^4 \end{pmatrix} \text{lb}$$

#### Convective Weight Factor

$$\Gamma C_i := 0.230 \cdot R_{dh_i} \cdot \tanh\left(\frac{3.67}{R_{dh_i}}\right)$$

$$\Gamma C = \begin{pmatrix} 0.464 \\ 0.204 \\ 0.129 \\ 0.089 \end{pmatrix}$$

#### Convective Weight

$$W_{2i} := \Gamma C_i \cdot W_{ti}$$

$$W_2 = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 2.147 \times 10^3 \end{pmatrix} \text{lb}$$

### Center of Action for Effective Lateral Forces

The moment arm is measured from the base of the tank to the center of action for the equivalent lateral forces from the liquid. X1 and X2 are impulsive and convective moment arms separately.  
 Ref: API 650 Appendix E, 6.1.2.1-1 and 6.1.2.1-2.

The center of action for the impulsive lateral forces for the tank shell, roof and appurtenances is assumed to act through the center of gravity of the component.

Impulsive Weight Moment  
 Arm Factor:

$$\Psi I_i := \text{if}\left[R_{dh_i} \geq 1.33, 0.375, \left(0.5 - 0.094 \cdot R_{dh_i}\right)\right]$$

Impulsive Weight Moment Arm:

$$X_{I_i} := \Psi I_i \cdot H_{S_i}$$

$$\Psi I = \begin{pmatrix} 0.375 \\ 0.416 \\ 0.447 \\ 0.463 \end{pmatrix}$$

$$X_I = \begin{pmatrix} 29.25 \\ 78.708 \\ 134.208 \\ 200.208 \end{pmatrix} \text{ in}$$

Convective Weight Mmoment  
 Arm Factor:

$$\Psi C_i := \left( 1 - \frac{\cosh\left(\frac{3.67}{R_{dh_i}}\right) - 1}{\frac{3.67}{R_{dh_i}} \cdot \sinh\left(\frac{3.67}{R_{dh_i}}\right)} \right)$$

Convective Weight Moment Arm:

$$X_{C_i} := \Psi C_i \cdot H_{S_i}$$

$$\Psi C = \begin{pmatrix} 0.594 \\ 0.765 \\ 0.848 \\ 0.894 \end{pmatrix}$$

$$X_C = \begin{pmatrix} 46.318 \\ 144.674 \\ 254.354 \\ 386.231 \end{pmatrix} \text{ in}$$

Moment Arm for Top Head:  $X_R := H + \frac{h_d}{3} = 441.467 \text{ in}$

Moment Arm for Shell:

$$X_s = \begin{pmatrix} 39 \\ 94.5 \\ 150 \\ 216 \end{pmatrix} \text{ in}$$

$$\Delta L_{r_i} := \sum L_i + \frac{h_d}{3}$$

$$W_{s_i} := \sum_{j=1}^i (\eta \cdot \rho_{frp} \cdot \pi \cdot D \cdot t_{stot_j} \cdot L_j) \quad W_s = \begin{pmatrix} 1.046 \times 10^3 \\ 2.535 \times 10^3 \\ 4.024 \times 10^3 \\ 6.68 \times 10^3 \end{pmatrix} \text{ lb}$$

### Calculate Seismic Overturning Moment

Content impulsive overturning moment:  $M_{l_i} := A_i \cdot W_{l_i} \cdot X_{l_i}$

Content convective overturning moment:  $M_{2_i} := A_c \cdot W_{2_i} \cdot X_{2_i}$

Overturning moment for shell:  $M_{s_i} := A_i \cdot W_{s_i} \cdot X_{s_i}$

Overturning moment for top head:  $M_{r_i} := A_i \cdot (\eta \cdot W_R) \cdot (\Delta L_{r_i})$

Overturning moment for internals  $M_{intr_i} := A_i \cdot M_{int_i}$

### Total Overturning Moment Due to Seismic at Bot. of Each Mod

$$M_{eu_i} := M_{s_i} + M_{r_i} + M_{l_i} + M_{2_i} + M_{intr_i}$$

$$M_{eu} = \begin{pmatrix} 4.711 \times 10^4 \\ 6.43 \times 10^5 \\ 2.082 \times 10^6 \\ 7.11 \times 10^6 \end{pmatrix} \text{ in-lb}$$

### Calculate Seismic Shear:

$$V_{eu_i} := A_i \cdot (W_{s_i} + \eta \cdot W_R + W_{l_i} + W_{int}) + A_c \cdot W_{2_i}$$

$$V_{eu} = \begin{pmatrix} 6824.9 \\ 7495.0 \\ 8165.0 \\ 19873.5 \end{pmatrix} \text{ lb}$$

checkgoverningM := if( $M_{eu_n} \geq M_{W_n}$ , "seismic governs M", "wind governs M") = "seismic governs M"

checkgoverningV := if( $V_{eu_n} \geq V_{W_n}$ , "seismic governs V", "wind governs V") = "seismic governs V"

$$M_c := M_{eu}$$

$$V_c := V_{eu}$$

## Chapter 8 Shell Combined Stress

$$\text{Shell Effective Flexural Modulus} \quad E_{\text{eff}} := \overrightarrow{\sqrt{E_{\text{af}} \cdot E_{\text{hf}}}}$$

$$\text{Shell Axial Strength} \quad S_a := 0.01 \cdot E_a = \begin{pmatrix} 1.65 \times 10^4 \\ 1.65 \times 10^4 \\ 1.65 \times 10^4 \\ 1.71 \times 10^4 \end{pmatrix} \cdot \text{psi}$$

$$\text{Flexural Stress:} \quad \sigma_f := \frac{\overrightarrow{M_c}}{S} \quad \sigma_f = \begin{pmatrix} 8.852 \\ 120.836 \\ 391.167 \\ 781.323 \end{pmatrix} \cdot \text{psi}$$

### Shell Under Combined Axial Tensile Load

RTP - 13A-221(c)

$$t_{s-t_i} := \frac{M_{c_i}}{\pi \cdot R^2 \cdot \frac{F_t}{F_t}} + \frac{P_{\text{int}} \cdot D}{4 \cdot \frac{F_t}{F_t}}$$

$$t_{s-t} = \begin{pmatrix} 5.225 \times 10^{-3} \\ 0.013 \\ 0.033 \\ 0.098 \end{pmatrix} \text{ in}$$

## Shell Under Combined Axial Compressive Load

RTP- 1 3A-222(b) Sustained Load

$$t_{s\_c\_s1\_i} := \frac{W_{s_i} + W_R}{S_{a_i}} + \frac{P_{ext} \cdot D}{4 \cdot F_s}$$

$$t_{s\_c\_s1} = \begin{pmatrix} 1.93 \times 10^{-3} \\ 3.64 \times 10^{-3} \\ 5.349 \times 10^{-3} \\ 8.105 \times 10^{-3} \end{pmatrix} \text{ in}$$

$$t_{s\_c\_s2\_i} := \left[ \left( \frac{W_{s_i} + W_R}{\pi \cdot D} + \frac{P_{ext} \cdot D}{4} \right) \cdot \frac{F_t \cdot \frac{D}{2}}{0.3 \cdot E_{eff\_i}} \right]^{0.5}$$

$$t_{s\_c\_s2} = \begin{pmatrix} 0.052 \\ 0.071 \\ 0.086 \\ 0.096 \end{pmatrix} \text{ in}$$

$$t_{s\_c\_s\_i} := \max(t_{s\_c\_s1\_i}, t_{s\_c\_s2\_i})$$

$$t_{s\_c\_s} = \begin{pmatrix} 0.052 \\ 0.071 \\ 0.086 \\ 0.096 \end{pmatrix} \text{ in}$$

RTP- 1 3A-222(c) Transient Load

$$t_{s\_c\_t1_i} := \frac{M_{c_i}}{\pi \cdot R^2 \cdot \frac{S_{a_i}}{F_t}} + \frac{W_{s_i} + W_R}{\pi \cdot D \cdot \frac{S_{a_i}}{F_t}} + \frac{P_{ext} \cdot D}{4 \cdot \frac{S_{a_i}}{F_t}}$$

$$t_{s\_c\_t1} = \begin{pmatrix} 1.609 \times 10^{-3} \\ 0.011 \\ 0.031 \\ 0.098 \end{pmatrix} \text{ in}$$

$$t_{s\_c\_t2_i} := \left[ \left( \frac{M_{c_i}}{\pi \cdot R^2} + \frac{W_{s_i} + W_R}{\pi \cdot D} + \frac{P_{ext} \cdot D}{4} \right) \cdot \frac{F_t \cdot \frac{D}{2}}{0.3 \cdot E_{eff_i}} \right]^{0.5}$$

$$t_{s\_c\_t2} = \begin{pmatrix} 0.067 \\ 0.172 \\ 0.294 \\ 0.47 \end{pmatrix} \text{ in}$$

$$t_{s\_c\_t_i} := \max(t_{s\_c\_t1_i}, t_{s\_c\_t2_i})$$

$$t_{s\_c\_t} = \begin{pmatrix} 0.067 \\ 0.172 \\ 0.294 \\ 0.47 \end{pmatrix} \text{ in}$$

Min. shell thk. due to combined axial load:  $t_{s\_cm\_min_i} := \max(t_{s\_c\_s_i}, t_{s\_c\_t_i})$

$$t_{s\_cm\_min} = \begin{pmatrix} 0.067 \\ 0.172 \\ 0.294 \\ 0.47 \end{pmatrix} \text{ in}$$

checkshellthkforcombinedaxialload<sub>i</sub> := if( $t_{stot_i} \geq t_{s\_cm\_min_i}$ , "OK", "Inadequate")

checkshellthkforcombinedaxialload =  $\begin{pmatrix} "OK" \\ "OK" \\ "OK" \\ "OK" \end{pmatrix}$

## Combined Strain at Base of Each Mod

Compressive Stress  $\sigma_{c_i} := \frac{W_{s_i} + \eta \cdot W_R}{\pi \cdot D \cdot t_{stot_i}} + \frac{P_{ext} \cdot D}{4 \cdot t_{stot_i}}$   $\sigma_c = \begin{pmatrix} 9.9 \\ 18.197 \\ 26.495 \\ 27.53 \end{pmatrix}$  psi

Combined Axial Strain  $\epsilon_{a_i} := \frac{\sigma_{f_i}}{E_{a_i}} + \frac{\sigma_{c_i}}{E_{a_i}}$

Hoop Strain  $\epsilon_{h\_s} = \begin{pmatrix} 3.285 \times 10^{-5} \\ 3.285 \times 10^{-5} \\ 3.285 \times 10^{-5} \\ 6.485 \times 10^{-5} \end{pmatrix}$

Combined Strain  $\epsilon_c := \sqrt{\overline{\epsilon_a^2 + \epsilon_{h\_s}^2}}$   $\epsilon_c = \begin{pmatrix} 3.476 \times 10^{-5} \\ 9.042 \times 10^{-5} \\ 2.552 \times 10^{-4} \\ 4.774 \times 10^{-4} \end{pmatrix}$

## Check for Buckling at Base of Each Mod

$\sigma_{cr} := \frac{\overline{0.3E_{eff} \cdot t_{stot}}}{R}$   $\sigma_{cr} = \begin{pmatrix} 2015 \\ 2015 \\ 2015 \\ 3855 \end{pmatrix}$  psi

$$\frac{\overrightarrow{\sigma_{cr}}}{\sigma_f} = \begin{pmatrix} 227.577 \\ 16.672 \\ 5.15 \\ 4.934 \end{pmatrix}$$

Calculate the critical buckling moment :

$$M_{cr} := \overline{\pi \cdot R^2 \cdot t_{stot} \cdot \sigma_{cr}} \quad M_{cr} = \begin{pmatrix} 15183222 \\ 15183222 \\ 15183222 \\ 43578126 \end{pmatrix} \text{ in-lb}$$

Determine Adequacy of Safety Factor Against Buckling :

$$SF := \frac{\overrightarrow{M_{cr}}}{M_c} \quad SF = \begin{pmatrix} 322.3 \\ 23.6 \\ 7.3 \\ 6.1 \end{pmatrix}$$

$$\text{checkshellthkforbuckling}_i := \text{if}\left(SF_i \geq 5, \text{"OK"}, \text{"Inadequate"}\right)$$

$$\text{checkshellthkforbuckling} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \end{pmatrix}$$

**A minimum safety factor against buckling of 5.0 is required per RTP-1.**

## Chapter 9 Opening Reinforcement

Reference: ASME D3299 7.3.2.4

$P_{int} = 0.4 \cdot \text{psi}$	= Design Pressure
$F_d := 10$	= Design Factor
$d_n$	= Nozzle Diameter
$h_n$	= Nozzle Elevation
$P_n$	= Pressure at Nozzle Centerline
$t_r$	= Required Reinforcement Thickness
$D_r$	= Required Reinforcement Diameter
$t_n$	= Nozzle Neck Thickness
$t_i$	= Inside Bond Thickness
$t_o$	= Outside Bond Thickness
$H_L = 30 \text{ in}$	= Max Liquid Height
$SG_L = 1.00$	= Specific Gravity of Contents
$S_r := S_{th} = 1.5 \times 10^4 \cdot \text{psi}$	= Repad Tensile Strength

### 9.1 Shell Nozzle Reinforcement

$$d_n := \begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 10 \\ 30 \\ 30 \\ \sqrt{60-15} \end{pmatrix} \cdot \text{in} \quad h_n := \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 30 \\ 30 \\ 30 \\ 30 \end{pmatrix} \cdot \text{in} \quad \Delta h := H_L - h_n = \begin{pmatrix} 30 \\ 30 \\ 30 \\ 30 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \cdot \text{in}$$

$$j := 1 .. \text{last}(d_n)$$

**Calculate Pressure At Each Nozzle:**

$$P_{n_j} := P_{int} + \rho_c \cdot \Delta h_j \quad P_n = \begin{pmatrix} 1.44 \\ 1.44 \\ 1.44 \\ 1.44 \\ 0.36 \\ 0.36 \\ 0.36 \\ 0.36 \end{pmatrix} \cdot \text{psi}$$

**Calculate Reinforcement Diameter:**

$$D_{r_j} := \overrightarrow{\text{if}\left[\left(d_{n_j}\right) > 6 \cdot \text{in}, \left(2 \cdot d_{n_j}\right), \left(d_{n_j} + 6 \cdot \text{in}\right)\right]}$$

Required Cutout Reinforcement Diameter:  $D_r = \begin{pmatrix} 7 \\ 8 \\ 9 \\ 10 \\ 20 \\ 60 \\ 60 \\ 60 \end{pmatrix} \cdot \text{in}$

$$\text{Repad Width} \quad w_{r_d} := \frac{\overrightarrow{D_r - d_n}}{2} = \begin{pmatrix} 3 \\ 3 \\ 3 \\ 3 \\ 5 \\ 15 \\ 15 \\ 15 \end{pmatrix} \text{in}$$

**Calculate Coefficient "K":**

$$K_{n_j} := \text{if} \left[ d_{n_j} < 6 \cdot \text{in}, \left( \frac{d_{n_j}}{D_{r_j} - d_{n_j}} \right), 1.0 \right]$$

$$K_n = \begin{pmatrix} 0.17 \\ 0.33 \\ 0.50 \\ 0.67 \\ 1.00 \\ 1.00 \\ 1.00 \\ 1.00 \end{pmatrix}$$

**Calculate Reinforcement Thickness:**

$$t_{r_ip_j} := \frac{P_{n_j} \cdot D \cdot K_{n_j}}{2 \cdot \frac{S_r}{F_d}}$$

**Calculate Coefficient "M":**

Laminate Type: type := "X"

Hoop Tensile Strength for Shell:

$$\sigma := 0.01 \cdot \begin{pmatrix} E_{h_4} \\ E_{h_4} \\ E_{h_4} \\ E_{h_4} \\ E_{h_4} \\ E_{h_4} \\ E_{h_3} \\ E_{h_1} \end{pmatrix}$$

Factor M

$$M_r := \overrightarrow{\left( \frac{\sigma}{S_r} \right)}$$

Calculated Structural Thk:

$$T_{cn} := \begin{pmatrix} t_{s_4} \\ t_{s_4} \\ t_{s_4} \\ t_{s_4} \\ t_{s_4} \\ t_{s_4} \\ t_{s_3} \\ t_{s_1} \end{pmatrix} \quad d_n = \begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 10 \\ 30 \\ 30 \\ 30 \end{pmatrix} \text{ in}$$

Allowable Strain:

$$\varepsilon_{al} := 0.001$$

Theoretical Structural Thk:

$$T_t := T_{cn}$$

Factor V

$$V_j := \frac{1}{2}$$

(pressure governs V=1, vacuum governs V=1/2)

### Calculate Reinforcement Thickness:

$$t_{r\_ep_j} := V_j \cdot M_{r_j} \cdot K_{n_j} \cdot T_{t_j} - M_{r_j} \cdot (T_{cn_j} - T_{t_j})$$

$$t_{r\_ep_j} := \overrightarrow{\text{if}\left(t_{r\_ep_j} \geq 0.12\text{-in}, t_{r\_ep_j}, 0.12\text{-in}\right)}$$

$$t_{r\_min_j} := \max(t_{r\_ip_j}, t_{r\_ep_j})$$

$$t_{r_j} := \text{if}\left(t_{r\_min_j} \geq 0.129\text{-in}, t_{r\_min_j}, 0\text{-in}\right)$$

$$t_r = \begin{pmatrix} 0 \\ 0.167 \\ 0.25 \\ 0.334 \\ 0.501 \\ 0.501 \\ 0.217 \\ 0.217 \end{pmatrix} \text{ in}$$

#### Required Reinforcement Thickness:

$$t_r = \begin{pmatrix} 0 \\ 0.167 \\ 0.25 \\ 0.334 \\ 0.501 \\ 0.501 \\ 0.217 \\ 0.217 \end{pmatrix} \cdot \text{in}$$

#### Use Reinforcement Thickness:

$$t_{rd} := \begin{pmatrix} 0 \\ 0.19 \\ 0.27 \\ 0.36 \\ 0.51 \\ 0.51 \\ 0.24 \\ 0.24 \end{pmatrix} \cdot \text{in}$$

Reinforcement should be made of type II laminate with alternating mat and woven.

#### Shell Nozzle Opening Reinforcement Summary

Nozzle ID

Repad Thk.

Repad OD

$$d_n = \begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 10 \\ 30 \\ 30 \\ 30 \end{pmatrix} \cdot \text{in}$$

$$t_{rd} = \begin{pmatrix} 0 \\ 0.19 \\ 0.27 \\ 0.36 \\ 0.51 \\ 0.51 \\ 0.24 \\ 0.24 \end{pmatrix} \text{ in}$$

$$D_r = \begin{pmatrix} 7 \\ 8 \\ 9 \\ 10 \\ 20 \\ 60 \\ 60 \\ 60 \end{pmatrix} \cdot \text{in}$$

Use 10" repad width on 15"x60" inlet.

## 9.2 Top Head Nozzle Reinforcement

$$d_{nc} := (66) \cdot \text{in}$$

$$\Delta h_{Lc} := (0) \cdot \text{in}$$

$$m := 1 .. \text{last}(d_{nc}) \quad \text{last}(d_{nc}) = 1$$

### Calculate Pressure At Each Nozzle:

$$P_{nc_m} := P_{int} + \rho_c \cdot \Delta h_{Lc_m}$$

$$P_{nc} = (0.36) \cdot \text{psi}$$

### Calculate Reinforcement Diameter:

$$D_{rc_m} := \overrightarrow{\text{if}\left[\left(d_{nc_m}\right) > 6 \cdot \text{in}, \left(2 \cdot d_{nc_m}\right), \left(d_{nc_m} + 6 \cdot \text{in}\right)\right]}$$

### Calculate Coefficient "K":

$$K_{nc_m} := \text{if}\left[d_{nc_m} < 6 \cdot \text{in}, \left(\frac{d_{nc_m}}{D_{rc_m} - d_{nc_m}}\right), 1.0\right] \quad K_{nc} = (1)$$

### Calculate Reinforcement Thickness:

$$t_{rc_ip_m} := \frac{P_{nc_m} \cdot D \cdot K_{nc_m}}{2 \cdot \frac{S_r}{F_d}}$$

### Calculate Coefficient "M":

Laminate Type:  $\text{type}_c := \text{"II"}$

Factor M  $M_{rc_m} := 1$

Calculated Structural Thk:  $T_{sc_m} := t_{th}$

Theoretical Structural Thk.:  $T_{tc_m} := T_{sc_m}$

$$V_{rc_m} := \frac{1}{2} \quad (\text{pressure governs } V=1, \text{ vacuum/bending governs } V=1/2)$$

### Calculate Reinforcement Thickness:

$$t_{rc\_ep_m} := V_{rc_m} \cdot M_{rc_m} \cdot K_{nc_m} \cdot T_{tc_m}$$

$$t_{rc\_min_m} := \max(t_{rc\_ip_m}, t_{rc\_ep_m})$$

$$t_{rc_m} := \text{if}\left(t_{rc\_min_m} \geq 0.129\text{-in}, t_{rc\_min_m}, 0\text{-in}\right)$$

**Required Reinforcement Thickness:**

$$t_{rc} = (0.135)\text{-in}$$

$$t_{rc\_ep} = (0.135)\text{ in}$$

**Use Reinforcement Thickness:**

$$t_{rcd} := (0.16)\text{-in}$$

**Reinforcement should be made of type II laminate with alternating mat and woven roving.**

### Top Head Nozzle Opening Reinforcement Summary

$$d_{nc} = (66)\text{-in} \quad t_{rcd} = (0.16)\text{-in} \quad D_{rc} = (132)\text{-in}$$

## Chapter 10 Lifting Lug Design

### Lifting Lugs are Attached by Hoop Filament Wound Glass

Lug Material 316 Stainless Steel

Design Capacity  $W_{cap} := 9000 \cdot \text{lb}$

Number of Lugs  $N_L := 2$

Shock Factor  $\lambda := 1.25$

Thickness of Lift Lug  $t_L := 0.75 \cdot \text{in}$

Width of Lift Lug  $b_L := 8 \cdot \text{in}$

Height of Lift Lug  $h_L := 11 \cdot \text{in}$

Load Eccentricity  $x := 2.25 \cdot \text{in}$

$$c := t_L \div 2$$

Distance to Neutral Axis  $c = 0.375 \text{ in}$

Lug Allowable Stress  $\sigma_{all} := 30000 \cdot 0.6 \cdot \text{psi} = 1.8 \times 10^4 \cdot \text{psi}$

FRP Shear Strength  $S_v := 2000 \cdot \text{psi}$

Design Factor  $DF := 3$

### Cross-Sectional Area of Lug

$$A_L := t_L \cdot (b_L) \quad A_L = 6.00 \text{ in}^{2.00}$$

Lug Moment of Inertia (for Each Leg)

$$I_L := \frac{b_L \cdot t_L^3}{12} \quad I_L = 0.281 \text{ in}^4$$

**Load per Lift Lug x 1.25 Shock Factor:**

$$P_L := \frac{\lambda \cdot W_{cap}}{N_L}$$

$$P_L = 5625 \text{ lb}$$

Moment in Lift Lug (for Each Leg)

$$M_{lift} := \frac{1}{2} P_L \cdot (x)$$

$$M_{lift} = 6328 \text{ in} \cdot \text{lb}$$

Resulting Stress:

$$\sigma_{act} := \frac{M_{lift} \cdot (c)}{I_L}$$

$$\sigma_{act} = 8438 \cdot \text{psi} \quad \text{where} \quad \sigma_{all} = 18000 \cdot \text{psi}$$

$$\text{Lug\_Stress} := \text{if}(\sigma_{act} \leq \sigma_{all}, \text{"OK"}, \text{"Excessive"})$$

$$\text{Lug\_Stress} = \text{"OK"} \quad \text{for} \quad N_L = 2 \quad \text{Lift Lugs}$$

$$\text{Shell Repad Thk.} \quad t_{pd} := 0.5 \cdot \text{in}$$

$$\text{Shear Across Vessel Wall} \quad t_{st} := t_{stot_1} + t_{pd} \quad t_{st} = 0.84 \text{ in}$$

Mean Radius  $R_{mL} := R + \frac{t_{st}}{2}$

### Check Overwind:

Overwind Thickness

$$t_{Lo} := 0.45 \cdot \text{in}$$

**Overwind to be continuous around the full circumference of the tank.**

Unit Radial Load on Overwind

$$W_o := \frac{3(P_L) \cdot (x)}{h_L^2} \quad W_o = 313.8 \frac{\text{lb}}{\text{in}}$$

Radial Load Due to Moment

$$P_{rL} := W_o \cdot \left( \frac{h_L}{2} \right)$$

$$P_{rL} = 1726 \text{ lb}$$

Hoop Overwind Load  $T_{rL} := \frac{P_{rL} \cdot R_{mL}}{b_L} = 1.821 \times 10^4 \text{ lb}$

Hoop Overwind Tensile Stress  $\sigma_{rL} := \frac{T_{rL}}{t_{Lo} \cdot h_L} = 3.679 \times 10^3 \cdot \text{psi}$

$$\text{checkoverwindtension} := \text{if} \left( \sigma_{rL} \leq \frac{40000}{5} \cdot \text{psi}, \text{"OK"}, \text{"Excessive Tension"} \right) = \text{"OK"}$$

$$\tau_{wL} := \frac{P_{rL}}{t_{st} \cdot b_L}$$

$$\tau_{wL} = 257 \cdot \text{psi}$$

$$\text{Wall_Shear} := \text{if}\left(\left|\tau_{wL}\right| \leq \frac{3000 \cdot \text{psi}}{2}, \text{"OK"}, \text{"Too High"}\right)$$

Wall\_Shear = "OK"

### Shear on Lug Overlay

Coefficient of Bending on Vessel Wall       $\beta_L := \frac{1.28}{\sqrt{R_m L \cdot t_{st}}} = 0.152 \frac{1}{\text{in}}$

Unit Radial Load       $p_{stL} := \frac{P_{rL}}{b_L}$        $p_{stL} = 215.732 \frac{\text{lb}}{\text{in}}$

Bending Moment       $M_{axL} := \frac{p_{stL}}{4 \cdot \beta_L} = 354.818 \text{ lb}$

$$\nu_L := 0.3$$

$$M_{hpL} := \nu_L \cdot M_{axL}$$

Overlay Bending Stress:       $\sigma_{axL} := \frac{6 \cdot M_{axL}}{t_{st}^2} = 3.017 \times 10^3 \cdot \text{psi}$

$$\sigma_{hpL} := \frac{6 \cdot M_{hpL}}{t_{st}^2} = 905.149 \cdot \text{psi}$$

$$\sigma_{axL\_al} := 0.002 \cdot E_{a_1} = 3.301 \times 10^3 \cdot \text{psi}$$

$$\sigma_{hpL\_al} := 0.002 \cdot E_{h_1} = 5.415 \times 10^3 \cdot \text{psi}$$

$$\text{checkoverlaybending} := \text{if}\left(\sigma_{axL} \leq \sigma_{axL\_al} \wedge \sigma_{hpL} \leq \sigma_{hpL\_al}, \text{"OK"}, \text{"Excessive Stress"}\right) = \text{"OK"}$$

**See Appendix A for Lifting Lug Attachment Detail.**

## Chapter 11 Anchor Lug Design

**Lug Attachment Method:** Filament Wound

316 Stainless Steel = Anchor Lug Material

$\sigma_{f_n} = 781 \text{ psi}$  = Stress Based on Overturning Moment at Tank Base

$V_{c_n} = 19874 \text{ lb}$  = Shear Force at Tank Base

$N = 16$  = Number of Anchor Lugs

$L_s := \pi \cdot \frac{D}{N}$  = Lug Spacing

$b_L := 0 \cdot \text{in}$  = Width of Liquid Band Used for Resisting Overturning

$$\text{Uplift Force per Lug} \quad F_L := \frac{4 \cdot (M_{c_n})}{N \cdot D} + \pi \cdot R^2 \cdot \frac{P_{int}}{N} - \frac{(W_{s_n} + W_R + W_B) \cdot \eta}{N} - b_L \cdot H_L \cdot L_s \cdot \rho_c$$

$$F_L = 10515 \text{ lb}$$

Anchor Lug Dimensions:

$w_{lug} := 5 \cdot \text{in}$  = Lug Width

$h_{lug} := 15 \cdot \text{in}$  = Total Lug Height

$h_{o1} := 15 \cdot \text{in}$  = Overwind Height

$h_1 := 10 \cdot \text{in}$  = Overwind Height on Lug Vertical Leg

$e := 2.5 \cdot \text{in}$  = Load Eccentricity

$t_{s0} := t_{s_n} = 0.41 \text{ in}$  = Bot Section Shell Thk.

$$t_k := 1.01 \cdot \text{in} + t_{s0} = 1.42 \text{ in} \quad = \text{Thickness of Lug Attachment Area}$$

$$t_{o1} := 0.77 \cdot \text{in} \quad = \text{Lug Overwind Thickness}$$

$$\sigma_0 := \sigma_{f_n}$$

$$\text{Mean radius at overwind} \quad R_{mo} := R + \frac{t_k + t_{stot_n}}{2} = 84.965 \text{ in}$$

$$\text{Average shear force per lug} \quad P_s := \frac{V_{c_n}}{N} = 1.242 \times 10^3 \text{ lb}$$

$$\text{Lug bending moment} \quad M_{lug} := F_L \cdot e = 2.629 \times 10^4 \text{ in-lb}$$

$$\text{Unit radial load on overwrap} \quad W_{MAX} := 3 \cdot \frac{F_L \cdot e}{h_{lug}} = 350.486 \frac{\text{lb}}{\text{in}}$$

$$\text{Radial load due to lug moment} \quad P_r := W_{MAX} \cdot \frac{h_{lug}}{2} = 2.629 \times 10^3 \text{ lb}$$

$$\text{Hoop overwind tension} \quad T_{tot} := \frac{P_r \cdot R_{mo}}{w_{lug}} \quad T_{tot} = 4.467 \times 10^4 \text{ lb}$$

$$\text{Hoop overwind tensile stress} \quad \sigma_T := \frac{T_{tot}}{h_1 \cdot t_{o1}}$$

$$\sigma_T = 5.801 \times 10^3 \cdot \text{psi} \quad < 6000 \text{ psi allowable OK}$$

$$\text{Shear across vessel wall} \quad \tau_w := \frac{P_r}{t_k \cdot w_{lug}}$$

$$\tau_w = 370.231 \cdot \text{psi} \quad < 1500 \text{ psi allowable OK}$$

Coefficient of bending in the vessel wall:  $\beta := \frac{\left[3 \cdot (1 - v^2)\right]^{0.25}}{(R_{mo} \cdot t_k)^{0.5}} = 0.118 \frac{1}{\text{in}}$

Unit radial loading  $P_u := \frac{P_r}{w_{lug}}$

Axial and hoop bending moments  $M_{ax} := \frac{P_u}{4 \cdot \beta}$

$$M_{hp} := v \cdot M_{ax}$$

Axial load due to internal pressure  $N_{ax} := \frac{P_{int} \cdot R_{mo}}{2} = 15.294 \frac{\text{lb}}{\text{in}}$

Hoop load due to internal pressure  $N_{hp} := (H_L \cdot \rho_c + P_{int}) \cdot R_{mo} = 122.604 \frac{\text{lb}}{\text{in}}$

Axial stress  $\sigma_{ax} := \frac{N_{ax}}{t_k} + \frac{6 \cdot M_{ax}}{t_k^2} = 3.328 \times 10^3 \cdot \text{psi}$

Hoop stress  $\sigma_{hp} := \frac{N_{hp}}{t_k} + \frac{6 \cdot M_{hp}}{t_k^2} = 915.633 \cdot \text{psi}$

Max. allowable axial stress  $\sigma_{ax\_al} := 0.002 \cdot E_{a_n} = 3.42 \times 10^3 \cdot \text{psi}$

Max. allowable hoop stress  $\sigma_{hp\_al} := 0.002 \cdot E_{h_n} = 7.33 \times 10^3 \cdot \text{psi}$

checkshellstressatanchor := if( $\sigma_{ax} \leq \sigma_{ax\_al} \wedge \sigma_{hp} \leq \sigma_{hp\_al}$ , "OK", "Excessive Stress") = "OK"

## Chapter 12 Media Bed Support Design

Bed Area  $A := \frac{1}{4} \cdot \pi \cdot D^2 = 153.938 \cdot \text{ft}^2$

Bed Depth  $h_{\text{bed}} := 7 \cdot \text{ft} + 3 \cdot \text{in} = 87 \text{ in}$

Media Bed Density  $\rho_{\text{bed}} := 12 \cdot \frac{\text{lb}}{\text{ft}^3}$

Media Bed Total Weight  $W_{\text{bed}} := \rho_{\text{bed}} \cdot A \cdot h_{\text{bed}} = 1.339 \times 10^4 \text{ lb}$  wtbd ≈ 13390

Load % Supported by Beams  $\xi := 0.75$  (The rest of the load is supported by ring. )

Qty of Beams  $N_{\text{bm}} := 4$

Weight on Each Beam  $w_{\text{bed}} := \frac{W_{\text{bed}} \cdot \xi}{N_{\text{bm}}} = 2.511 \times 10^3 \text{ lb}$  Weight on Each Beam

Beam Min. Length  $l_{\text{beam}} := 2 \cdot \sqrt{7^2 - \left(\frac{16}{12}\right)^2} \cdot \text{ft} = 164.924 \text{ in}$

Line Load  $q := \frac{w_{\text{bed}}}{l_{\text{beam}}} = 15.226 \frac{\text{lb}}{\text{in}}$

Bending Moment Beam w/ fixed ends with uniformly distributed load.

Max. Bending Moment  $M_{\text{max}} := \frac{q \cdot l_{\text{beam}}^2}{12} = 3.451 \times 10^4 \text{ in-lb}$

### Beam Size & Properties

Beam Material FRP Box Beams

Flexural Modulus  $E := 1500 \cdot \text{ksi}$

Flexural Strength  $S_f := 15 \cdot \text{ksi}$

Allowable Bending Stress  $\sigma_{b\_al} := \frac{S_f}{F_t} = 3 \times 10^3 \cdot \text{psi}$

Beam Width  $b_{beam} := 6 \cdot \text{in}$

Beam Height  $h_{beam} := 8 \cdot \text{in}$

Beam Thk.  $t_{beam} := 0.5 \cdot \text{in}$

Beam MOI  $I_{beam} := \frac{1}{12} \cdot \left[ (b_{beam} + 2 \cdot t_{beam}) (h_{beam} + 2 \cdot t_{beam})^3 - b_{beam} \cdot h_{beam}^3 \right]$

$$I_{beam} = 169.25 \text{ in}^4$$

Section Modulus  $Z_b := \frac{I_{beam}}{\frac{h_{beam}}{2}} = 42.313 \cdot \text{in}^3$

Bending Stress in Beam  $\sigma_{beam} := \frac{M_{max}}{Z_b} = 815.645 \cdot \text{psi}$

Max. Deflection  $\delta_{max} := \frac{q \cdot I_{beam}^4}{384 \cdot E \cdot I_{beam}} = 0.116 \text{ in}$

Less than 1/2". Acceptable.

Shear Force at Each Support       $F_{sh} := \frac{W_{bed} \cdot \xi}{N_{bm} \cdot 2} = 1.256 \times 10^3 \text{ lb}$

Shear Stress       $\tau_s := \frac{F_{sh}}{12 \cdot \text{in} \cdot 6 \cdot \text{in}} = 17.438 \cdot \text{psi}$       Less than 200 psi OK.

See Appendix A for Attachment Detail.

### Media Support Grating

IGF 1 1/2"x1 1/2"x1 1/2" Molded Grating

Allowable Deflection       $\delta_{gr\_al} := \frac{1}{4} \cdot \text{in}$

Governing Free Span      span := 36·in      max span

Data for governing span (Ref: IGF Grating Catalog)

Uniform Load       $P_{gr} := (50 \ 75 \ 100 \ 150 \ 200) \cdot \text{psf}$

Resulting Deflection       $\delta_{gr} := (0.1 \ 0.15 \ 0.2 \ 0.3 \ 0.4) \cdot \text{in}$

Uniform Design Load of Grating       $p_{gr} := \frac{W_{bed}}{A} = 87 \cdot \text{psf}$

Deflection of Grating Under Design Uniform Load (Linear Interpolation)

$$\zeta_{gr} := \text{interp}\left(P_{gr}^T, \delta_{gr}^T, p_{gr}\right) = 0.174 \text{ in}$$

$$\text{checkdeflectiongrating} := \text{if}\left(\zeta_{gr} \leq \delta_{gr\_al}, \text{"OK"}, \text{"Excessive Deflection"}\right) = \text{"OK"}$$

## Packing Support Ring

Load on Ring

$$q := \frac{W_{bed} \cdot (1 - \xi)}{\pi \cdot D} = 6.344 \frac{\text{lb}}{\text{in}}$$

Ring Width

$$b_r := 3 \cdot \text{in}$$

Ring Thk.

$$t_{rg} := 0.75 \cdot \text{in}$$

Ring Section Modulus

$$Z_b := \frac{1}{6} \cdot 1 \cdot \text{in} \cdot t_{rg}^2 = 0.094 \cdot \text{in}^3$$

Ring Bending Modulus

$$I_b := \frac{1}{12} \cdot 1 \cdot \text{in} \cdot t_{rg}^3$$

Max. Bending Moment

$$M_{max} := \frac{q \cdot b_r^2}{2} = 28.547 \cdot \text{lb} \cdot \text{in}$$

Young's Modulus

$$E := 1500 \cdot \text{ksi}$$

Flexural Strength

$$S_f := 15 \cdot \text{ksi}$$

Allowable Bending Stress

$$\sigma_{b\_al} := \frac{S_f}{F_t} = 3 \times 10^3 \cdot \text{psi}$$

Bending Stress in Beam

$$\sigma_{beam} := \frac{M_{max}}{Z_b} = 304.5 \cdot \text{psi}$$

Max. Deflection

$$\delta_{max} := \frac{q \cdot b_r^4}{8 \cdot E \cdot I_b} = 1.218 \times 10^{-3} \text{ in}$$

Less than 1/4". Acceptable.

Shear Stress       $\tau_s := \frac{q \cdot b_r}{6 \cdot \text{in} \cdot 1 \cdot \text{in}} = 3.172 \cdot \text{psi}$       Less than 200 psi OK.

See Appendix A for Attachment Detail.

# Appendix A

## Design Summary

Sheet 1

### FRP Lamination Sequences Corresponding to Thicknesses Used in Design:

0.34 in = V,M090-2(FW,U),2FW = Shell 1-3

0.51 in = V,M090-3(2FW,U),FW = Shell 4

0.37 in = V,M090-3(C,R)C = Vessel Dish Top

0.375 in = V,M090-3(C,R)C,c = Vessel Flat Bottom

Corrosion barrier is 100 mil thk.

### Nomenclature

FW - 0.05" thk. @75 deg., 1 cycle of hoop wound glass

H - 0.025" thk @ 90 deg., 1 pass hoop wound glass

U - 0.02" thk @ 0 deg, uni glass

C - 0.043", chopped strand glass applied by chopper gun, 1.5 oz/ft<sup>2</sup>

c - 0.02", chopped strand glass applied by chopper gun, 0.75 oz/ft<sup>2</sup>

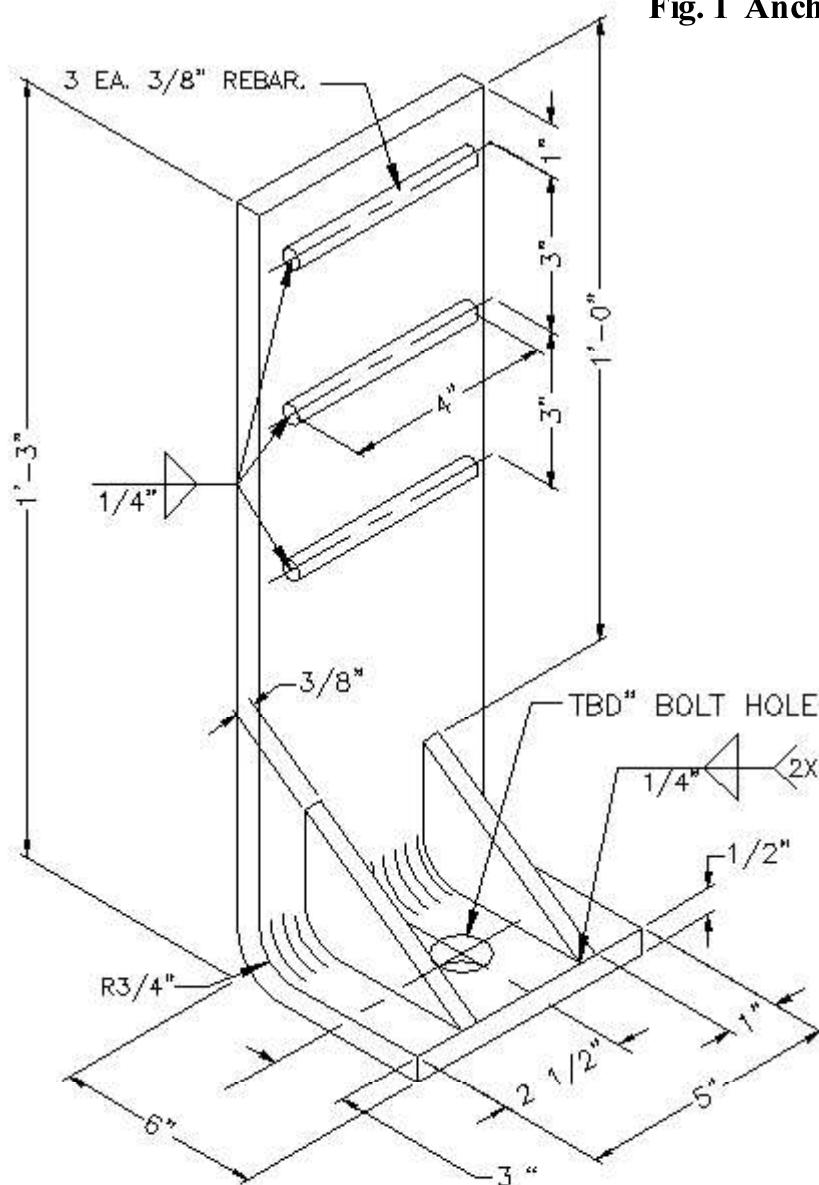
M - 0.043", chopped strand glass mat, 1.5 oz/ft<sup>2</sup>

R - 0.033", woven roving, 24 oz/sq. yd.

V - 10 mil, 1 ply surfacing veil

## Design Summary      Sheet 2

**Fig. 1 Anchor Lug Detail**



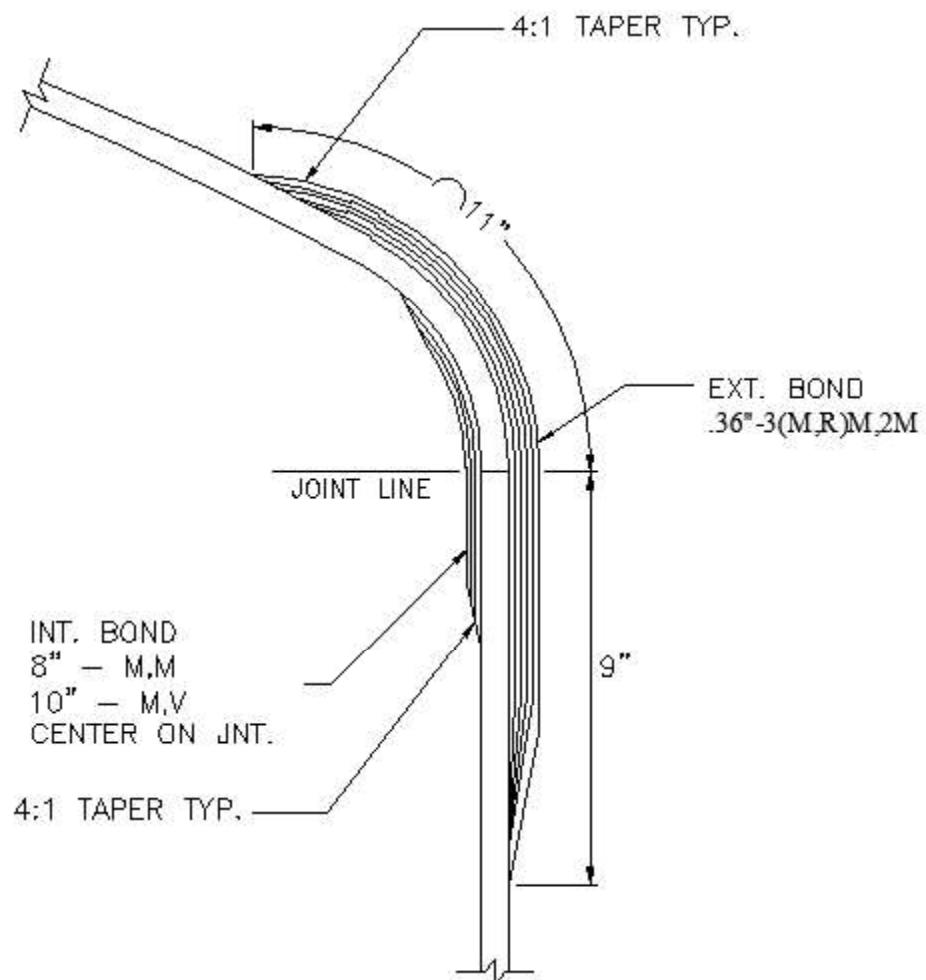
$N = 16$       = Number of Lugs       $h_{o1} = 15$  in      = Overlay Height

$e = 2.5 \cdot \text{in}$       = Load Eccentricity       $t_{o1} = 0.77 \cdot \text{in}$       = Overlay Thk.

0.77"-13FW,U,2FW

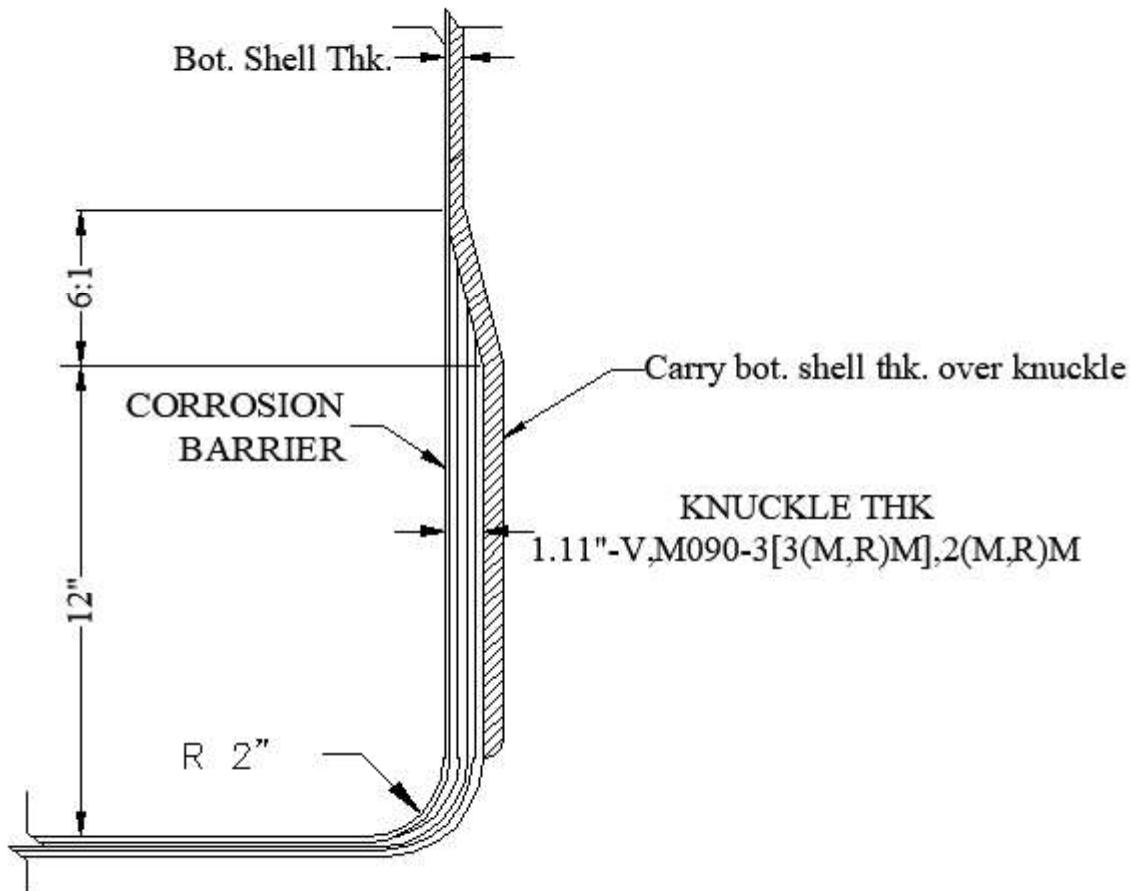
## Design Summary      Sheet 3

**Fig. 2 Dished Head to Shell  
Joint Detail**



**Design Summary      Sheet 4**

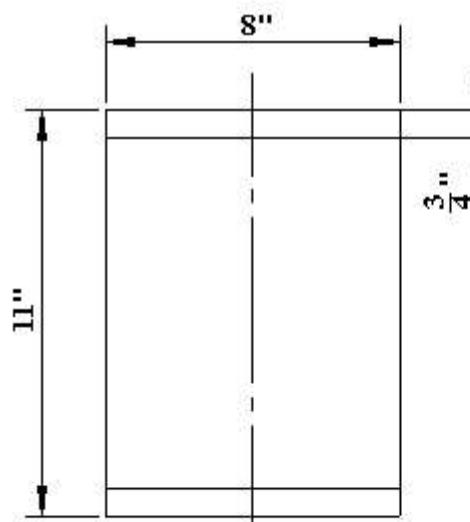
**Fig. 3 Bottom Knuckle Detail**



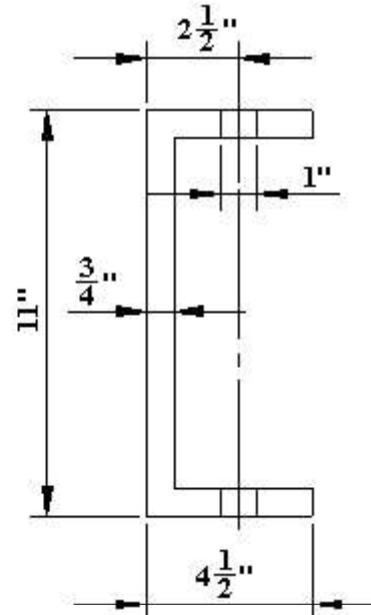
## Design Summary Sheet 5

Lifting lugs are designed to lift the empty tank only  
with no media bed.

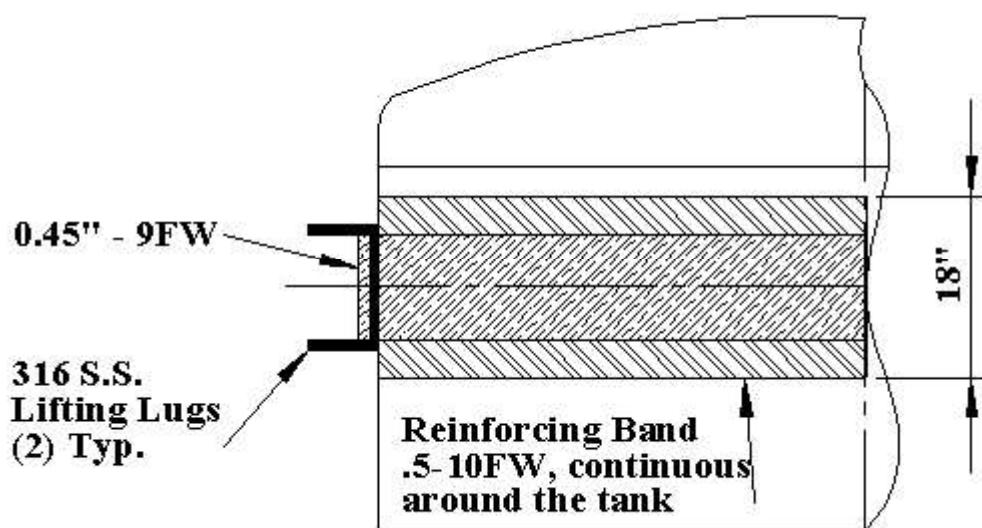
Fig. 4 Lifting Lug Detail



Front View

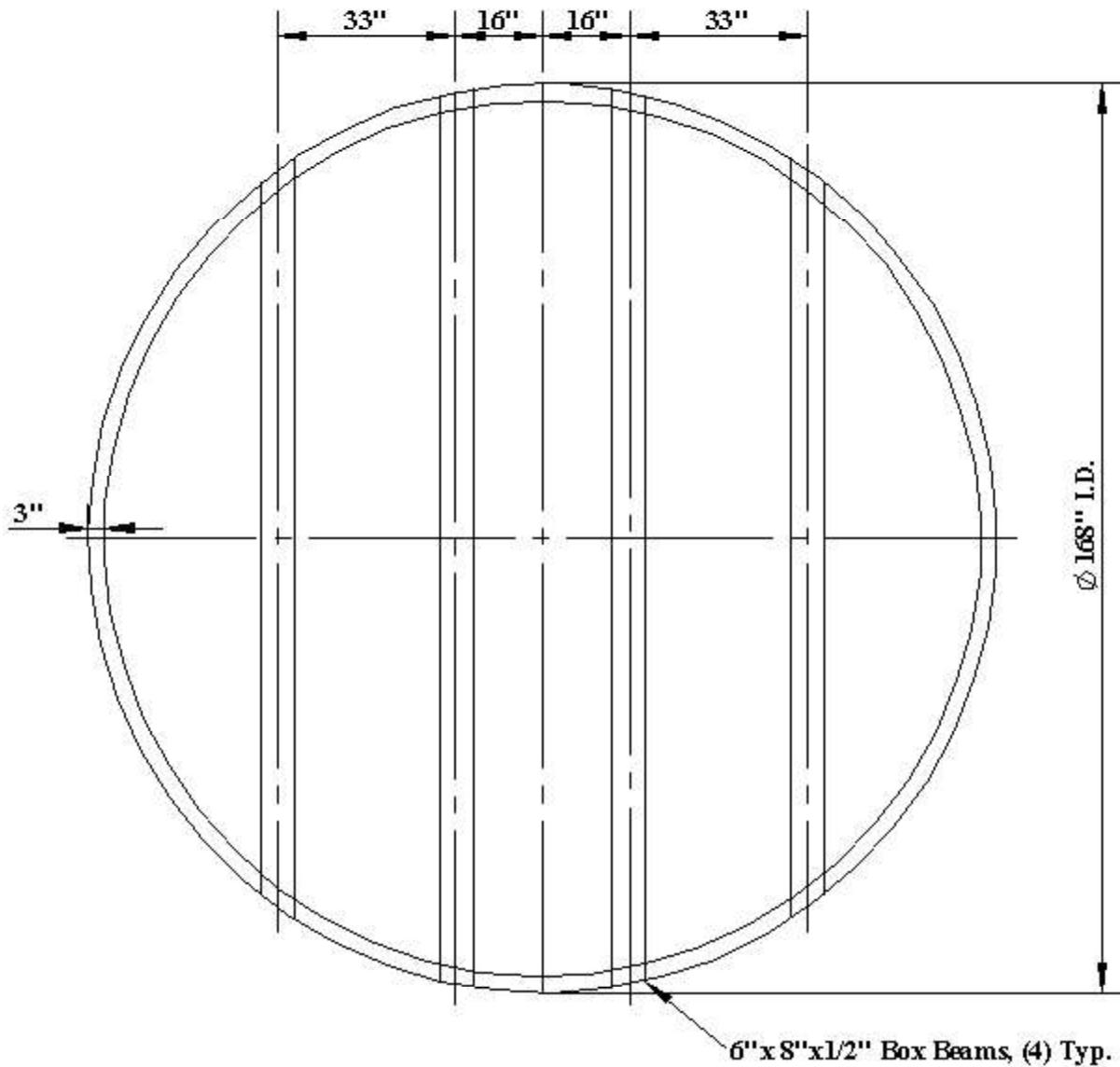


Side View



**Design Summary      Sheet 6**

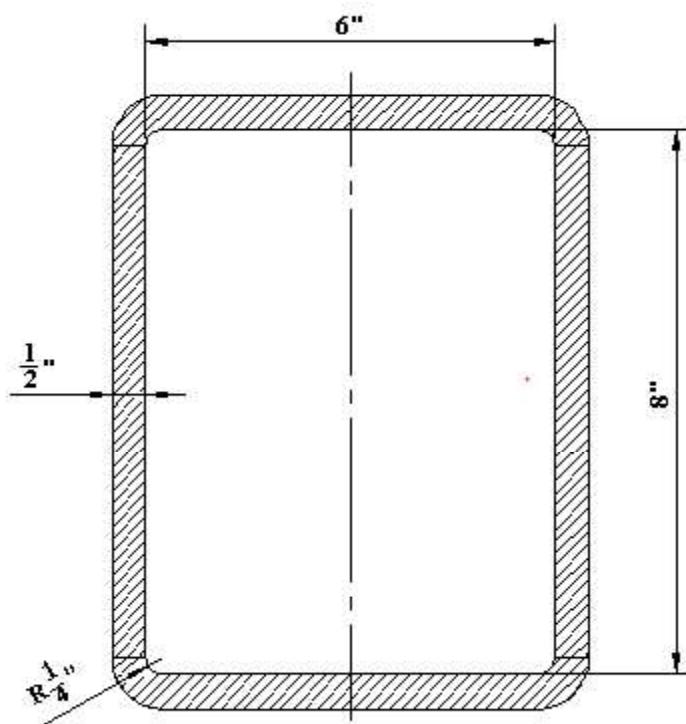
**Fig. 5 Media Bed Support**



Note : Top of support ring should be flush with the top of the beams.

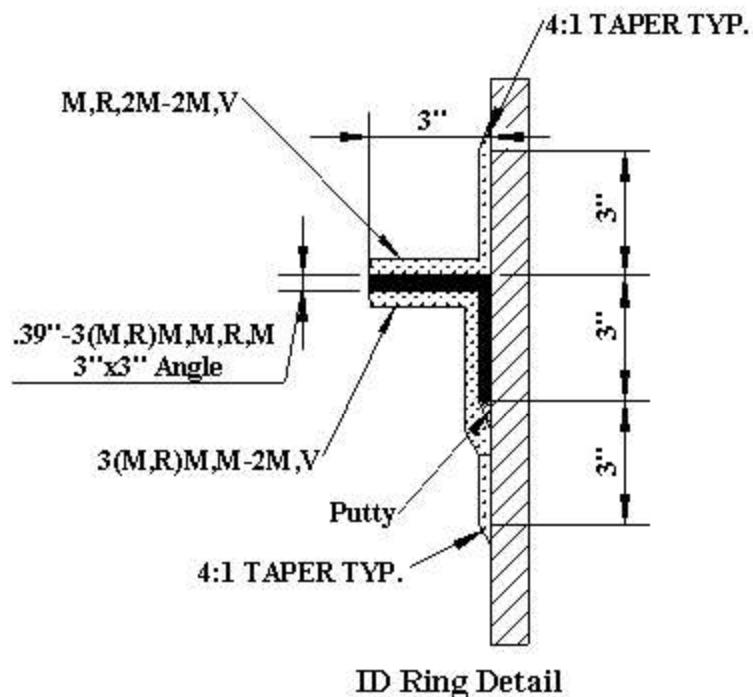
**Design Summary      Sheet 7**

**Fig. 6 Support Beam Detail**



**Design Summary      Sheet 8**

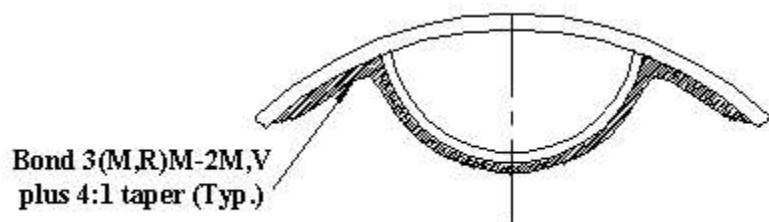
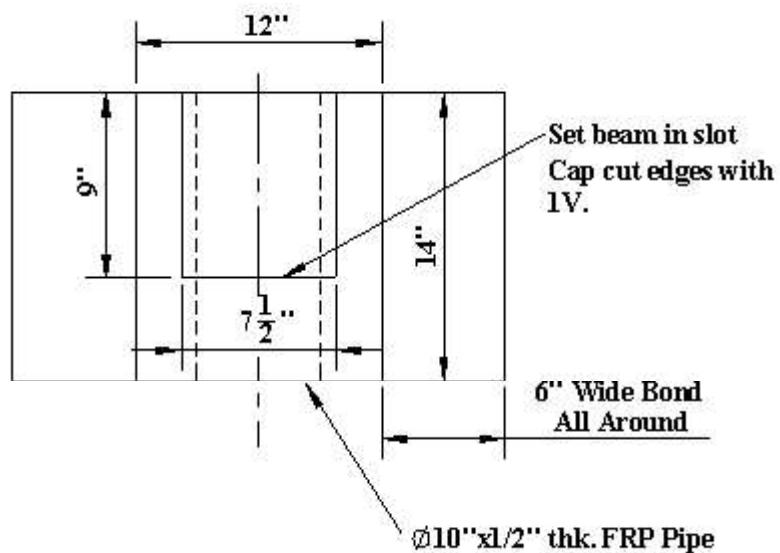
**Fig. 7 Support Ring Detail**



**ID Ring Detail**

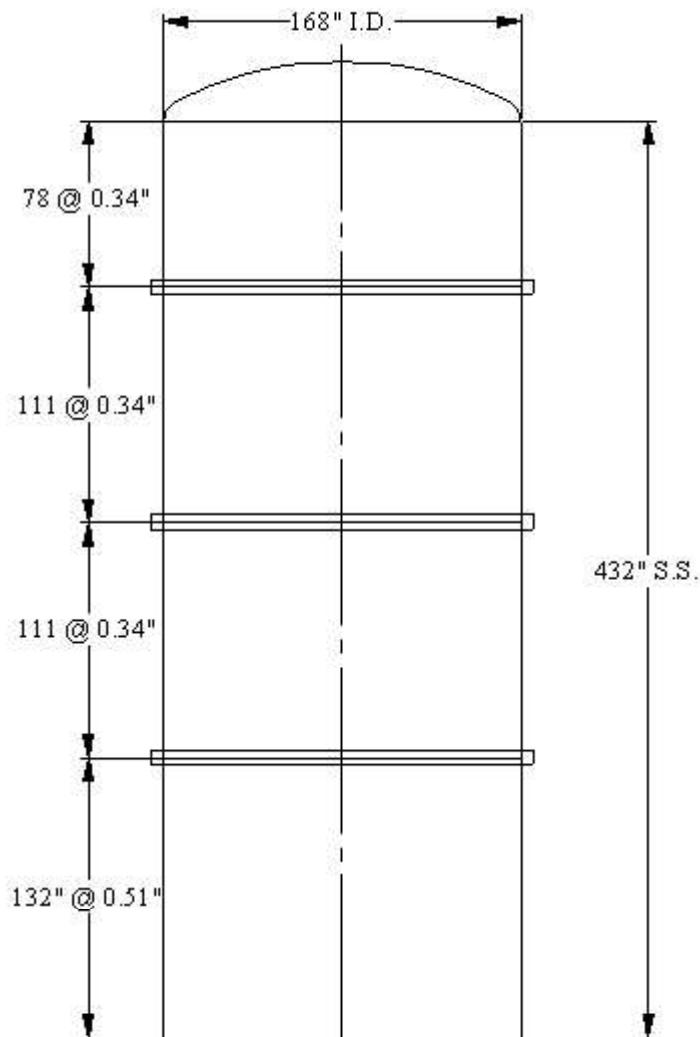
## Design Summary      Sheet 9

Fig. 8 Support Beam Pocket Detail



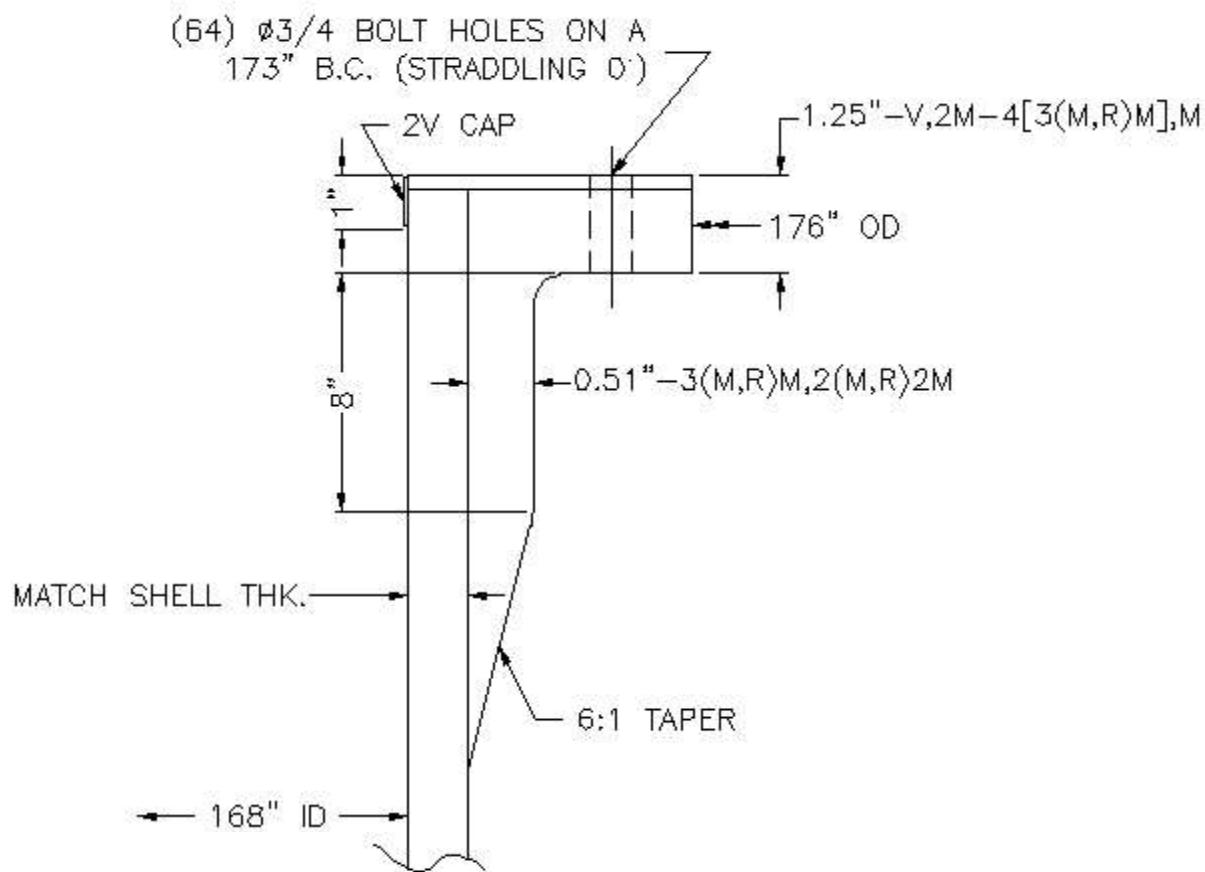
**Design Summary      Sheet 10**

**Fig. 9 Shell Elevation View Detail**



**Design Summary      Sheet 11**

**Fig. 10 Body Flange Detail**



# Appendix B

## Lamination Analysis Using Trilam

### MOD 1-3 Laminate Sequence

Layer	Thickness in	Reinforcement %wt	Reinforcement oz/sq ft	Orientation Degrees	Reinforcement	Matrix
1	0.043	28.6	1.50	Random	E-Chop	Corezyn8401
2	0.043	28.6	1.50	Random	E-Chop	Corezyn8401
3	0.025	67.8	2.56	75.0	E Glass Roving	Corezyn8401
4	0.025	67.8	2.56	-75.0	E Glass Roving	Corezyn8401
5	0.020	62.2	1.76	0.0	Uni-Glass	Corezyn8401
6	0.025	67.8	2.56	75.0	E Glass Roving	Corezyn8401
7	0.025	67.8	2.56	-75.0	E Glass Roving	Corezyn8401
8	0.020	62.2	1.76	0.0	Uni-Glass	Corezyn8401
9	0.025	67.8	2.56	75.0	E Glass Roving	Corezyn8401
10	0.025	67.8	2.56	-75.0	E Glass Roving	Corezyn8401
11	0.025	67.8	2.56	75.0	E Glass Roving	Corezyn8401
12	0.025	67.8	2.56	-75.0	E Glass Roving	Corezyn8401

## MOD 1-3 Lamine Properties

<b>Tensile</b>		<b>Modulus</b>
- Longitudinal	= 1684003	psi
- Transverse	= 2763332	psi
- Normal	= 1200262	psi
<b>Flexural</b>		
- Longitudinal	= 1284456	psi
- Transverse	= 2232629	psi
<b>Shear</b>		
- L-T (Inplane)	= 557797	psi
- L-N	= 427225	psi
- T-N	= 386365	psi
Poisson ratios - Load direction / Strain direction		
- L/T = 0.19	- T/L = 0.31	
- L/N = 0.29	- N/L = 0.20	
- T/N = 0.28	- N/T = 0.12	
Neutral axis (measured from the centroid)		
- Longitudinal	= 0.009	in
- Transverse	= 0.030	in
Thermal expansion coefficient		
- Longitudinal	= 16.57E-06	/F
- Transverse	= 80.85E-07	/F
- Normal	= 30.00E-06	/F
Specific heat	= 0.201	Btu/lb F
Thermal conductance	= 5.343	Btu/hr sq ft F
Laminate weight	= 2.83	lb/sq ft
Reinforcement Wt.	= 1.67	lb/sq ft
Total reinforcement	= 58.90%	% by weight
Laminate density	= 0.060	lb/cu in
Laminate thickness	= 0.326	in

### MOD 4 Laminate Sequence

Layer	Thickness	Reinforcement %wt	Reinforcement oz/sq ft	Orientation Degrees	Reinforcement	Matrix
1	0.043	28.6	1.50	Random	E-Chop	Corezyn8401
2	0.043	28.6	1.50	Random	E-Chop	Corezyn8401
3	0.025	67.8	2.56	89.0	E Glass Roving	Corezyn8401
4	0.025	67.8	2.56	-89.0	E Glass Roving	Corezyn8401
5	0.025	67.8	2.56	89.0	E Glass Roving	Corezyn8401
6	0.025	67.8	2.56	-89.0	E Glass Roving	Corezyn8401
7	0.020	62.2	1.76	0.0	Uni-Glass	Corezyn8401
8	0.025	67.8	2.56	89.0	E Glass Roving	Corezyn8401
9	0.025	67.8	2.56	-89.0	E Glass Roving	Corezyn8401
10	0.025	67.8	2.56	89.0	E Glass Roving	Corezyn8401
11	0.025	67.8	2.56	-89.0	E Glass Roving	Corezyn8401
12	0.020	62.2	1.76	0.0	Uni-Glass	Corezyn8401
13	0.025	67.8	2.56	89.0	E Glass Roving	Corezyn8401
14	0.025	67.8	2.56	-89.0	E Glass Roving	Corezyn8401
15	0.025	67.8	2.56	89.0	E Glass Roving	Corezyn8401
16	0.025	67.8	2.56	-89.0	E Glass Roving	Corezyn8401
17	0.020	62.2	1.76	0.0	Uni-Glass	Corezyn8401
18	0.025	67.8	2.56	89.0	E Glass Roving	Corezyn8401
19	0.025	67.8	2.56	-89.0	E Glass Roving	Corezyn8401

## MOD 4 Laminate Properties

Tensile	Modulus
- Longitudinal	= 1745522 psi
- Transverse	= 3740083 psi
- Normal	= 1298260 psi
Flexural	
- Longitudinal	= 1532705 psi
- Transverse	= 3044367 psi
Shear	
- L-T (Inplane)	= 426475 psi
- L-N	= 475686 psi
- T-N	= 405945 psi
Poisson ratios - Load direction / Strain direction	
- L/T = 0.12	- T/L = 0.25
- L/N = 0.30	- N/L = 0.23
- T/N = 0.31	- N/T = 0.11
Neutral axis (measured from the centroid)	
- Longitudinal	= 0.020 in
- Transverse	= 0.027 in
Thermal expansion coefficient	
- Longitudinal	= 18.19E-06 /F
- Transverse	= 65.69E-07 /F
- Normal	= 28.62E-06 /F
Specific heat	= 0.200 Btu/lb F
Thermal conductance	= 3.663 Btu/hr sq ft F
Laminate weight	= 4.43 lb/sq ft
Reinforcement Wt.	= 2.74 lb/sq ft
Total reinforcement	= 61.87% * by weight
Laminate density	= 0.062 lb/cu in
Laminate thickness	= 0.496 in

## **SECTION 5**

### **QUALITY CONTROL PROCEDURES AND WARRANTY**

# **DANIEL COMPANY**

Air & Water Pollution Control Systems



## **QUALITY CONTROL PROCEDURE**

### **I. SCOPE:**

This procedure is established to set forth areas of focus to ensure a quality product is provided.

### **II. RESPONSIBILITY:**

The Engineering Manager is responsible for the quality control program and all applicable procedures and documentation necessary to maintain required quality levels.

### **III. AREAS OF CONTROL:**

- a. Engineering design and document control.
- b. Materials documentation and control.
- c. Purchased items documentation and control.
- d. Calibration of quality control instrumentation.
- e. Manufacturing and inspection documentation and control.



## **QUALITY CONTROL PROCEDURE**

### **A. Engineering Design and Document Control:**

All drawings, calculations, specifications, and submittal data are reviewed for general conformance to the customer specifications and requirements as well as for accuracy by the Engineering Manager. All modifications are made prior to submittal and/or fabrication.

All change requests are reviewed by the Engineering Manager and the Sales Manager to ensure that the changes do not adversely affect the purchase contract.

### **B. Materials Documentation and Control:**

All materials used in the manufacturing process are inspected for conformance with specifications and logged by date of receipt and batch number by Receiving Personnel.

All substandard materials are places in a lock-up area until a disposition is made by the Engineering Manager or General Manager. The disposition shall be made the same date that the defective material is received to prevent production delays.

### **C. Purchased Items Documentation and Control:**

All purchased items are inspected and matched to the purchase order by Receiving Personnel for conformance and to detect any damage due to shipping. All specialty items are inspected by the Quality Control Inspector for materials, dimensions, and general quality. All purchased items are to be inspected upon receipt to prevent delays.

### **D. Calibration of Quality Control Instrumentation:**

All quality control equipment is checked daily to ensure accurate readings. Any instrument that does not read in the specified range of accuracy is re-calibrated or sent to an instrumentation expert for re-calibration before it can be used.

### **E. Manufacturing and Inspection Documentation and Control:**

The Quality Control Inspector is responsible to inspect all materials for defects or dimensional errors. Some in-process inspections may be performed by the area Foreman to avoid delays in the manufacturing process. All discrepancies are documented and approved prior to final acceptable.

## QUALITY ASSURANCE SUMMARY REPORTS

Date: \_\_\_\_\_ QA Inspector: \_\_\_\_\_  
Job No.: \_\_\_\_\_ Project Name: \_\_\_\_\_  
Vendor: \_\_\_\_\_ P.O. Number: \_\_\_\_\_  
Specification Number: \_\_\_\_\_

### MATERIAL VERIFICATION

Resin Type: \_\_\_\_\_ Additives: \_\_\_\_\_  
Surface Veil: \_\_\_\_\_ 1.5 oz. Mat.: \_\_\_\_\_  
Woven Roving: \_\_\_\_\_ Gun Roving: \_\_\_\_\_  
Winding Strand: \_\_\_\_\_ Undirectional: \_\_\_\_\_  
Surface Coat: \_\_\_\_\_

<u>DRAWING COMPLIANCE:</u>	<u>OK</u>	<u>DOCUMENTED</u>	<u>COMMENTS</u>
Diameter	( )	( )	_____
Overall Length/Height	( )	( )	_____
Flange:	Elevations Orientations Projections Flatness	( ) ( ) ( ) ( )	_____ _____ _____ _____
Stiffener dim./Elevation	( )	( )	_____
Lug Elevation/Orientation	( )	( )	_____
I.D. Tag/Logo	( )	( )	_____

<u>LAMINATE PROPERTIES</u>	<u>OK</u>	<u>DOCUMENTED</u>	<u>COMMENTS</u>
Secondary Laminate Thickness	( )	( )	_____
Shell Wall Thickness	( )	( )	_____
Bottom Thickness	( )	( )	_____
Dome/Flat Top Thickness	( )	( )	_____
Flange Thickness	( )	( )	_____
Acetone Sensitivity	( )	( )	_____
Barcol Hardness	( )	( )	_____

<u>VISUAL INSPECTION</u>	<u>OK</u>	<u>DOCUMENTED</u>	<u>COMMENTS</u>
(Per ASTM D 2563)			
Visual Defects	( )	( )	_____
Liner	( )	( )	_____
Filament Winding	( )	( )	_____
HLU Bottoms/Domes	( )	( )	_____
Interior Joints	( )	( )	_____
Exterior Joints	( )	( )	_____
Flange Construction	( )	( )	_____
Flange Spot Faced	( )	( )	_____

<u>SHIPPING/HANDLING</u>	<u>OK</u>	<u>DOCUMENTED</u>	<u>COMMENTS</u>
Chokes/Pads	( )	( )	_____
Brace/Tie Downs	( )	( )	_____
Flange Protection	( )	( )	_____

---

Q.A. Inspector

---

Date

---

Vendor Representative

---

Date

# BARCOL TESTING

**Job Number:** \_\_\_\_\_

Rel: \_\_\_\_\_

Date: \_\_\_\_\_

Customer: \_\_\_\_\_

Foreman: \_\_\_\_\_

**Job Description:** \_\_\_\_\_

Drawing Number \_\_\_\_\_ Inspected By: \_\_\_\_\_

Type of Resin Required: \_\_\_\_\_

**Manufacturer:**

## **Hardness Level Per Manufacturer:**

**Number of Readings Required:**

## Type of Impressor Used Barber Colman

1.                   7.                   13.                   19.                   25.

2.                   8.                   14.                   20.                   26.

3.                  9.                  15.                  21.                  27.

4.                   10.                   16.                   22.                   28.

5.                  11.                  17.                  23.                  29.

6.                   12.                   18.                   24.                   30.

Average Reading:

**Comments:**

## RESIN SHEET

JOB NAME: \_\_\_\_\_

JOB NUMBER: \_\_\_\_\_

DATE: \_\_\_\_\_

LOT #: \_\_\_\_\_

TYPE OF RESIN REQUIRED: \_\_\_\_\_

RESIN MANUFACTURER: \_\_\_\_\_

RESIN MANUFACTURER'S PHONE NUMBER: \_\_\_\_\_

RESIN MANUFACTURER CONTACT: \_\_\_\_\_

RESIN SHELF LIFE EXPIRATION DATE: \_\_\_\_\_

RESIN QUALITY CONTROL BY: \_\_\_\_\_

VISCOSITY: \_\_\_\_\_

PROMOTED: (YES OR NO): \_\_\_\_\_

PROMOTION TYPE: \_\_\_\_\_

CATALYST TYPE: \_\_\_\_\_

COMMENTS: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



## **HANDLING, STORAGE & PACKAGING**

### **Handling:**

All parts must be handled with care at all times. Caution must be used while unloading either open flat beds or closed vans. Cranes with swings made of netting are required to unload the larger pieces of ductwork. Attention must be paid so that the headers are lifted one at a time ensuring that the parts do not collide with each other on the truck. Avoid subjecting any laterals or taps protruding from the headers to any shear stress or pressure. If ductwork is nested, caution must be taken not to scrape or mar the interior lining of the ductwork when extracting any piece from another. Nested parts must be removed and lifted from the truck prior to removing the larger parts that encase them. Parts must not be dropped, hit or run into so as to avoid damage to the duct walls, flanges, or any other section of the part. Dampers, Flex Connectors, and other FRP Duct Fittings can be unloaded using forklifts with padded forks applied to their outer walls only. Care must be taken that the FRP duct and parts do not become soiled and scuffed.

### **Storage:**

All parts must be stored in a clean dry environment. Duct must be stored horizontally and should not be stacked more than two high so to prevent warping and becoming out of round. Ductwork should be stored out of direct sunlight to protect it from UV rays. Wood blocks should be used to prevent the parts from resting on laterals or flanges that are attached at the factory. Part identification numbers must be showing to facilitate inventorying and selection of respective parts.

### **Packaging:**

Loose parts such as dampers and flexible connectors will typically be secured to pallets. The parts should not be subjected to undue weight. All parts are labeled with part number per packing list and shop drawings. Attention must be paid to labels stenciled to boxes and crates such as "HANDLE WITH CARE" and "THIS END UP." Bond Kits shall be stored on individual pallets containing 55-gallon drums of resin, wrap, jointing tools and catalyst. Notice shall be taken of all attached Material Safety Data Sheets and if labeled Hazardous shall be treated as such. Any parts having metal moving parts such as damper worm gear operators shall be coated with protective grease.



## **PROCEDURES FOR SHIPPING AND INSTALLATION OF FIBERGLASS REINFORCED PLASTIC VESSELS**

This document has been provided to aid in the inspection, handling and installation of fiberglass vessels for the installation contractor.

Handling and installation instructions in this document are only recommendations and do not relieve the purchaser from full responsibility of safe and proper inspection, handling and installation of such a vessel. Situations or conditions not covered in this document must also be the responsibility of the Purchaser. The Purchaser also accepts all liability for the loss or damage to the vessel due to improper handling or installation.

### **PREPARATION FOR SHIPMENT**

Tall vessels are usually shipped on their sides and strapped directly to the bed of a flat bed trailer. The vessels can be cradles or chocked into position or placed in a specially designed saddle trailer. Smaller vessels or chemical tanks may be fastened to a crate in the upright position and strapped down to the trailer.

All flanged nozzles shall be protected with plywood blind flanges attached with shipping bolts.

### **RECEIVING INSPECTION**

The vessel will have already been inspected at the factory for manufacturing quality. It is the intention here to inspect for damage that may have occurred during the shipment. This inspection should occur immediately upon arrival at the jobsite and before unloading or signing acceptance of delivery.

If damage has occurred, file a claim promptly with the delivery carrier. If no claim is filed, the customer may be held responsible for a damaged vessel.

1. Inspect the vessel inside and out.
2. The high point and wide points during shipment are most susceptible to damage.
3. Check all protruding nozzles or flanges.
4. Check for cracking or crazing, especially near support points during shipment.

### **GENERAL HANDLING INSTRUCTIONS**

The following are some normal precautions to prevent damage to the vessel:

1. Operators of hoist equipment should follow proper rigging procedures at all times. Care should be taken to prevent the vessel from swinging out of control.
2. Always lift—NEVER roll or slide a vessel.
3. When moving a vessel, do not drop or allow hard impact.
4. Never let tools strike or drop on either the inside or outside of the vessel.
5. Ladders used inside the vessels should be wood or have rubber protectors.
6. Workmen entering a vessel should wear soft-soled shoes.



7. Never use cables or chains around the vessels.
8. When loading, offloading, and/or installing a vessel, never lift it by using any fittings or appurtenance including lifting lugs. Lifting lugs are provided as part of the equipment for guiding the vessel only. Woven fabric slings of 3-inch minimum width are recommended for lifting and tilting the vessel.
9. In storing vessels prior to installation, tie down securely. Vessels should be placed only on firm level surfaces which are free of stones, tools, and other small hard objects, because these cause high stress points. When stored outdoors, vessels should be adequately secured to prevent movement due to wind or water flotation.
10. Do not allow cables, hooks, or spreader bar to swing against the vessel.

## UNLOADING

A spreader bar shall be used to unload vessels shipped on a flat bed trailer. The angle between the lifting lines and top of tank must always be 60 degrees or greater. Vessels should be lifted off using two canvas or nylon slings or straps and a spreader bar which is attached to the hoist cable. This method of unloading is shown in Figure 1.

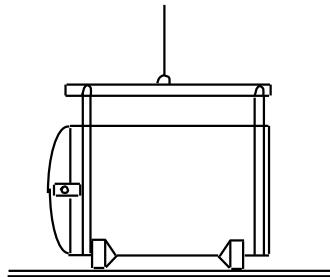


FIGURE 1: TANK HANDLING

Use guide lugs to guide the vessel only! Do NOT use lugs for lifting!

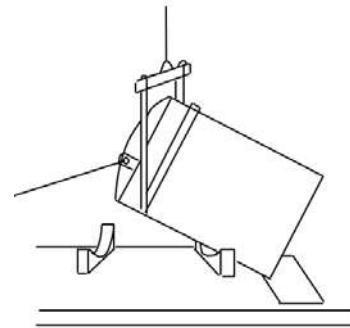


FIGURE 2: TANK HANDLING

Large vessels should be righted, as shown in Figure 2, by hoisting with spreader bar and straps, while choking the vessels. Adequate padding is necessary to protect the pivot point. Workmen should keep control over the vessel with guidelines attached to the lifting lugs to ensure the vessel is gently brought to rest upon its base.

For insulated fiberglass reinforced plastic tanks, do not choke or cinch the lifting straps around the insulated portions of the tank. This may crush the insulation. Instead, use spreader bars to evenly distribute the load over all the lifting lugs.

Use a spreader bar and lines or clevis lines to appropriately move vessel when in an upright position. Ensure size of lifting equipment, lines, clevis's, are capable of handling the weight of the vessel.

# **DANIEL COMPANY**

Air & Water Pollution Control Systems



## **MANUFACTURER'S LETTER OF WARRANTY**

May 27, 2025

Nan, Inc.  
161 Silva St., Hilo, HI 96720  
Attn: Jyun-Cheng Jhuo

**RE: Hilo WWTP Rehabilitation and Replacement Project Phase 1**

**Subject: Warranty Letter for Biotrickling Filters**

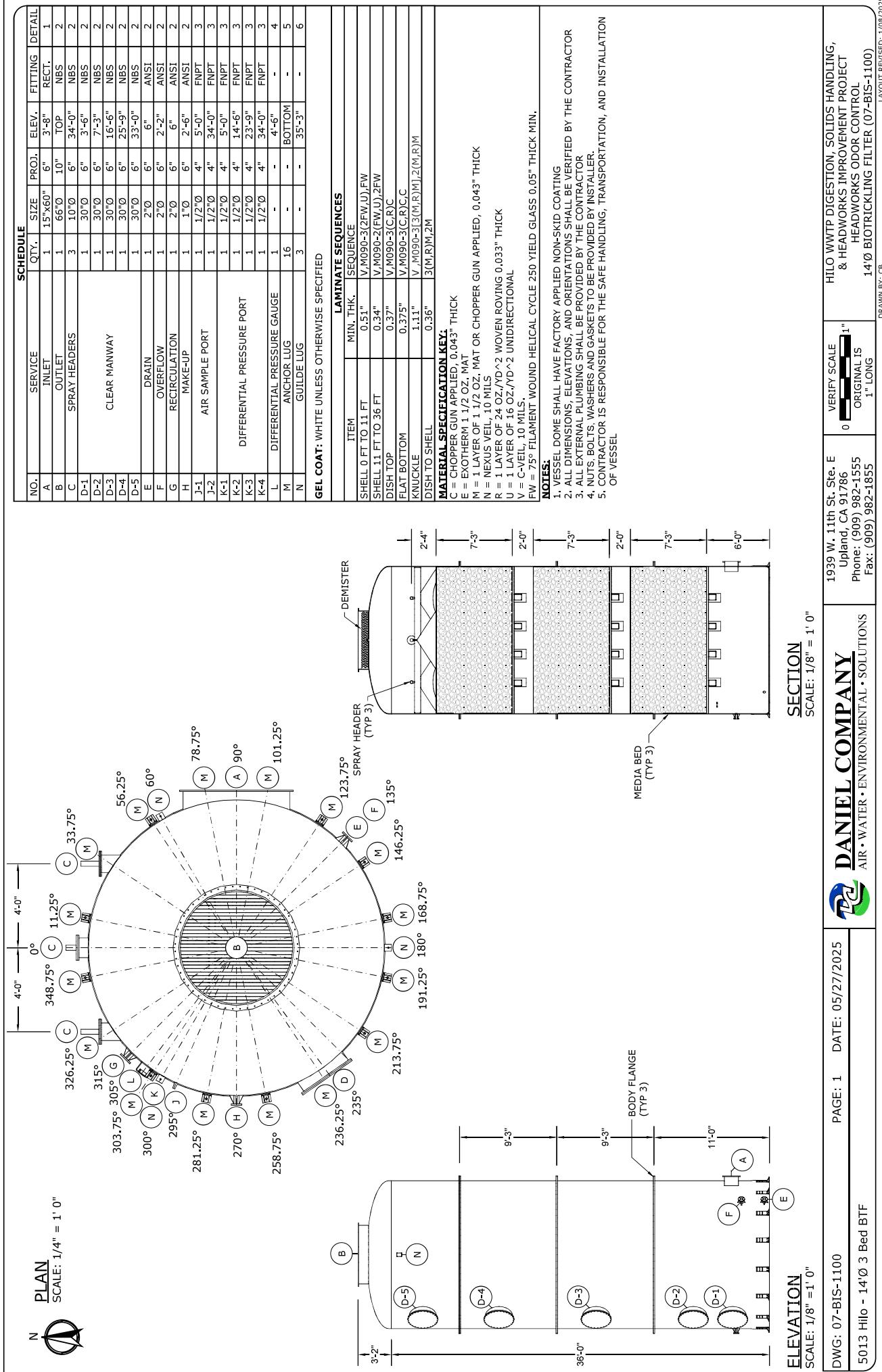
---

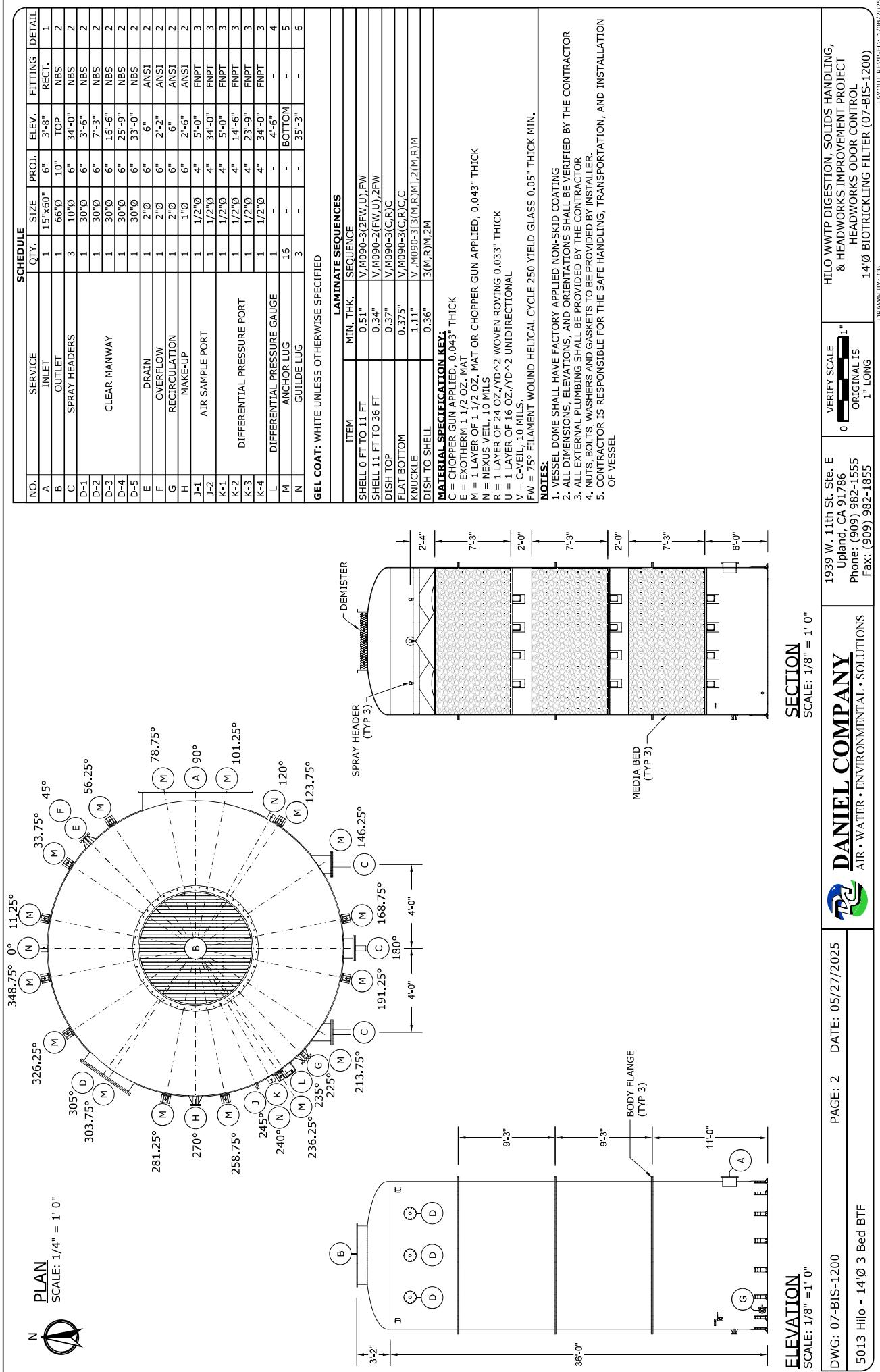
To Whom It May Concern:

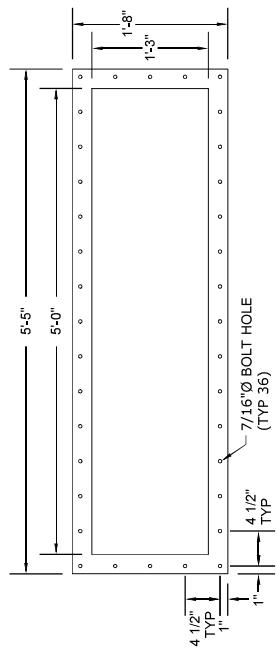
Daniel Company warrants the biotrickling filter vessels represented herein, against defects in materials and workmanship for a period of three (3) years from date of Acceptance. During the warranty period, Daniel Company will at its option, either repair or replace all or any part of products that prove to be defective. All transportation charges, taxes or duties for such parts (defective parts) that are part of the system and not caused by unauthorized, improper, or inadequate maintenance or installation by the Owner shall be paid by manufacturer/supplier of the odor control system. Daniel Company shall have the sole right to determine whether defective parts shall be replaced or repaired. This warranty does not apply to defects resulting from unauthorized, improper or inadequate maintenance, use or installation by the Owner. Daniel Company assumes no liability for damages and delays caused by defective materials and no allowance will be made for local repair expenses without prior written approval from Daniel Company.

## **SECTION 6**

### **BIOTRICKLING FILTER VESSEL DRAWINGS AND PERFORMANCE DATA**

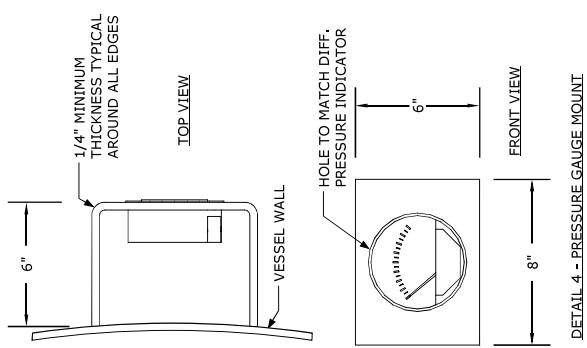




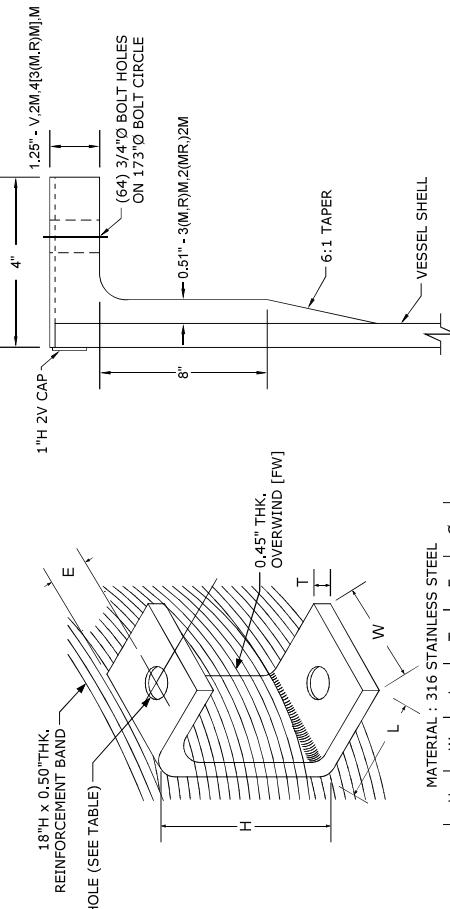


SPEC. (INCHES)	FIG. (INCHES)	SIZE	OD OF FLANGE	OD OF BOLT CIRCLE	NUMBER OF BOLTS	BOLT HOLE DIAMETER (MIN.)	T
ANSI 1"Ø	4 1/4"	3 1/8"	4	3 3/4"	4	5/8"	9 1/2"
ANSI 2"Ø	6 1/2"	6 1/2"	6	6 1/2"	4	3/4"	9 1/2"
NBS 10"Ø	14 3/8"	14 3/8"	13	13"	12	7/16"	3/4"
NBS 30"Ø	34 3/8"	34 3/8"	33	33"	28	7/16"	3/4"
NBS 66"Ø	72 5/8"	72 5/8"	70	70"	52	9/16"	3/8"

DETAIL 2 - ROUND FLANGES



DETAIL 5 - TYPE ITC ANCHOR LUG



DETAIL 6 - GUIDE LUG

DWG: DETAILS 1	PAGE: 3	DATE: 05/27/2025	1939 W. 11th St. Ste. E	VERIFY SCALE
5013 Hilo - 14"Ø 3 Bed BTF		Upland, CA 91786	0 ORIGINALS 1"	1" LONG
		Phone: (909) 982-1555	Fax: (909) 982-1855	DRAWN BY: CB

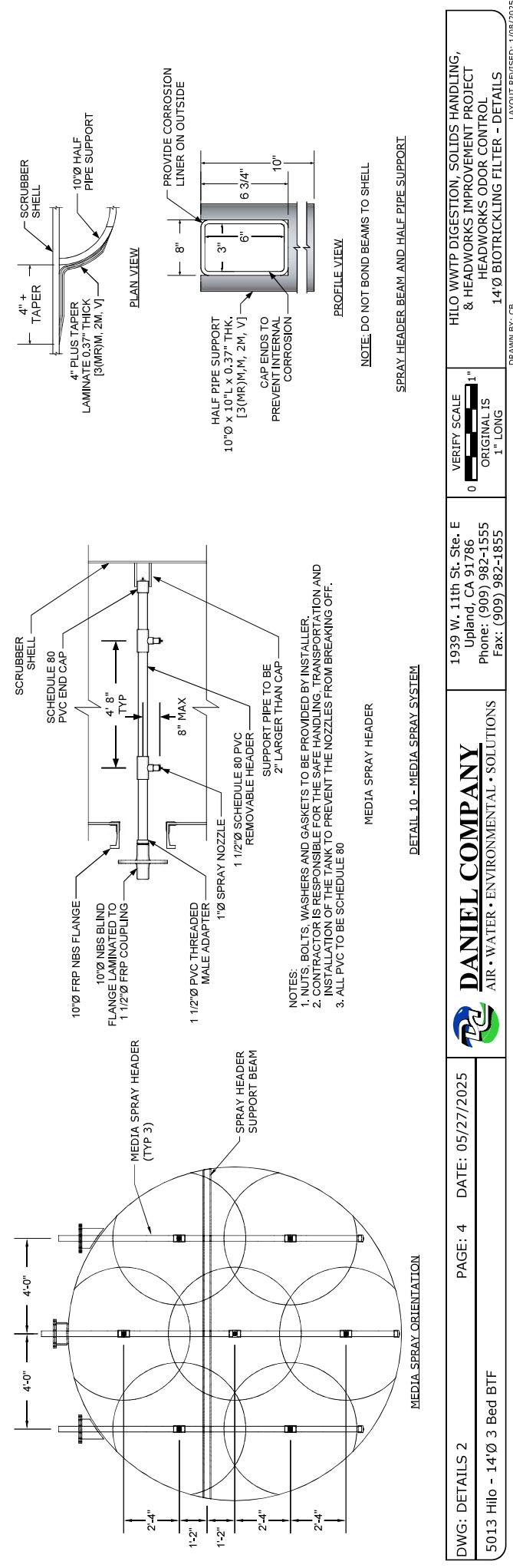
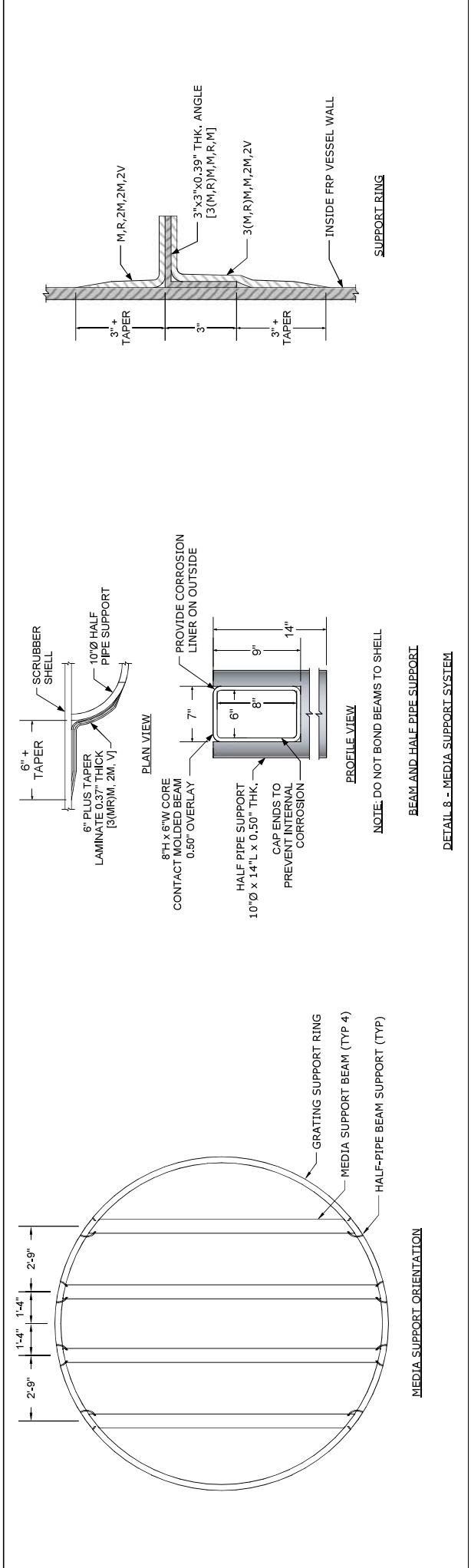
HILLO WWTP DIGESTION, SOLIDS HANDLING,

& HEADWORKS IMPROVEMENT PROJECT

HEADWORKS ODOR CONTROL

14"Ø BIOTRICKLING FILTER - DETAILS

LAYOUT REVISED: 1/08/2025



# **DANIEL COMPANY**

Fiberglass Air Pollution Control Systems

**Project:** 5013 Hilo

**Date:** 05/27/2025

**Revision:** 0

## **Utility and Nutrient Usage**

**BTF Estimated Nutrient Usage (Per Vessel):**

Flowrate (CFM)	H2S Conc. Avg. (ppm)	TBC3X Nutr. Amount Added (gal)	Potable Water Dilution Amount (gal)	Multiplier	TBC3X Usage Rate (gal/day)	TBC3X Usage Rate (gal/year)	Days to empty	Total Tank Fill (gallons)	Dilute Solution Rate for pump (gal/hour)	Dilute Solution Rate (gal/day)	Rated Pump Maximum Flowrate (gal/hr)	% of Rated Max Flowrate (gal/hr)	Required Beats per minute (360=max)
11,500	70	50.00	50.00	900000	0.8944	326.5	55.90	100.00	0.0745	1.7889	0.80	9.32%	34

# DANIEL COMPANY

Fiberglass Air Pollution Control Systems

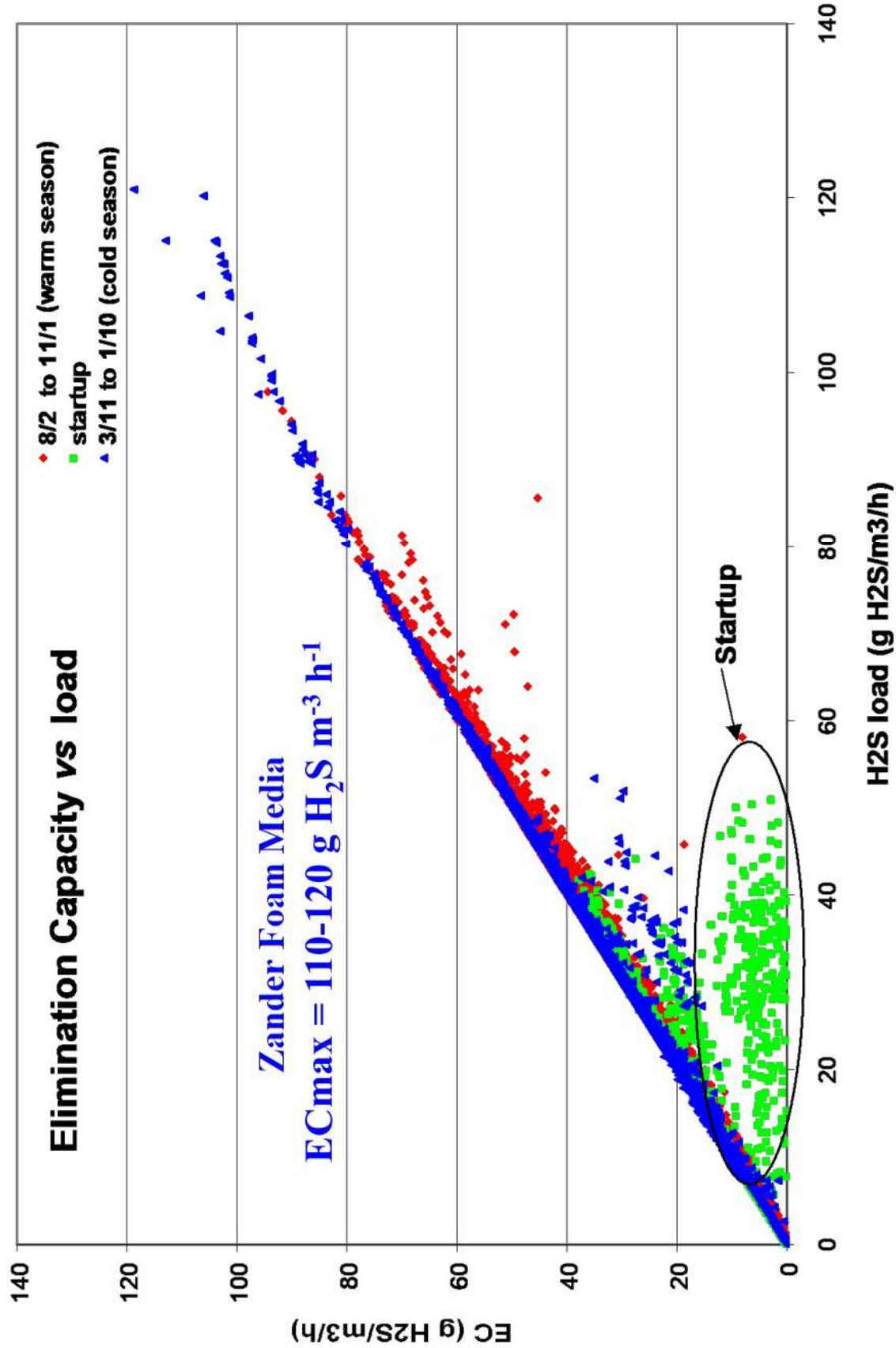
## Water Usage Calcs (Per Vessel):

Air Flow Rate (cfm) =	11500	ft^3/min
Air Flow Rate (m^3/hr) =	19539	m^3/hr
Temp in °C (use 25) =	25	Celsius
Temp in Kelvin =	298.15	Kelvin
Vessel Gauge Pressure =	6	in-w.c.
Pressure, P =	1.015	Atm
Atm. Press. in =	760	mm-Hg
Volume, V =	22.40	Liters
Ideal Gas Constant, R =	0.0821	L atm / mol K
Volume = RT/P =	24.10399	Liters

Avg Concentration (ppmv)	CAS #	Compound	Formula	Molecular Weight	Units	Mass Concentration mg/m³	Mass Concentration μg/m³	Contaminant weight over time lbs./day	Contaminant weight over time lbs./hour
70	7783-06-4	Hydrogen Sulfide	H <sub>2</sub> S	34.08088	gmol	0.0989737	98.97	98973.74	102.3197

M.W. of H <sub>2</sub> SO <sub>4</sub>	M.W. of H <sub>2</sub> S	Fraction	Ibs. of H <sub>2</sub> SO <sub>4</sub> created per hour	pH Setpoint	H <sub>2</sub> SO <sub>4</sub> Concentration n (%)	Required lbs H <sub>2</sub> O per hour	H <sub>2</sub> O required per min (gal/min)	Total Alkalinity = 100mg/L	Corrected Irrigation (gal/min)	Corrected Irrigation (gal/hour)	Corrected Irrigation (gal/day)
98.07754	34	2.8846	12.175143	15	0.2380%	5116	85.3	10.2	9.0	539.78	12955
		H <sub>2</sub> SO <sub>4</sub> in grams	5522.547425	1.6	0.1832%	6645	110.8	13.3	11.7	11.69	701.20
		Moles H <sub>2</sub> SO <sub>4</sub> /hr	56.30743254	1.7	0.1429%	8349	142.5	17.1	15.0	15.03	16829
				1.8	0.1088%	11188	186.5	22.4	19.7	19.67	21648
				1.9	0.0850%	14318	238.6	25.2	25.18	25.18	28331
				2.0	0.0654%	18605	310.1	37.2	32.7	32.7	36259
										1963.15	47116

## ZANDER FOAM MEDIA EC-CURVE



## ESTIMATED PRESSURE DROP CALCULATIONS

### BioDan Biotrickling Filter

Flowrate (CFM)	Diameter (ft)	# of Vessels	Flowrate per Vessel (CFM)	Bed Height (ft)	EBRT (sec)	Bed Surface Area (ft <sup>2</sup> )	Superficial Face Velocity (ft/min)	Bio-Media Volume (ft <sup>3</sup> )	Zander Foam Differential Pressure (in-w.c.)
23000	14	2	11500	21.75	17.47	153.94	74.71	6696.30	1.81

1.81in-w.c with 1.25x factor of safety:  $1.81\text{in-w.c} * 1.25 = 2.26\text{in-w.c}$

Add 0.5in-w.c for mist eliminators, add 0.5in-w.c for vessel/inlet outlet losses :  $0.5\text{in-w.c} + 0.5\text{in-w.c} = 1\text{in-w.c}$

BTF Total Pressure Drop = 3.26in-w.c

## **SECTION 7**

### **BIOTRICKLING FILTER VESSEL ACCESSORIES**

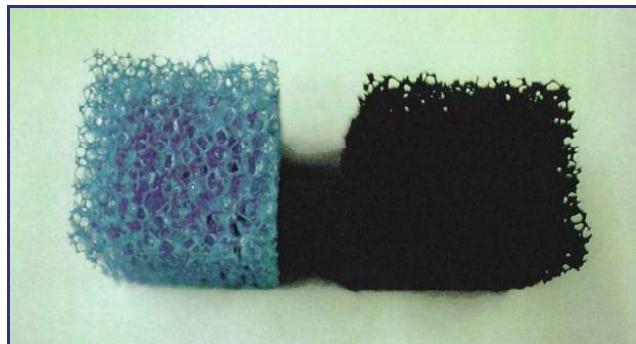
# PRODUCT INFORMATION

## SLTEC 33455

### Bio Trickling Filter Media

#### Technische Daten *Technical Data*

Artikel/Bezeichnung: <i>Article / Description</i>	33455	
Beschreibung: <i>Description</i>	Offenzelliger Filterschaum auf Polyether PUR Basis <i>Open cell filter foam, based on polyether polyol</i>	
Prüfmethode / Test		Werte / Result
Raumgewicht <i>Density</i>	ISO 845	28 – 32 kg/m <sup>3</sup>
Stauchhärte bei 40% <i>Compression Resistance at 40%</i>	ISO 3386/1	≥ 7 kPa
Bruchdehnung <i>Ultimate Elongation</i>	ISO 1798	≥ 70 %
Zugfestigkeit <i>Tensile Strength</i>	ISO 1798	≥ 65 kPa
Temperaturbeständigkeit <i>Temperatur Resistance</i>		-40°C – 120°C
Zelldurchmesser <i>Cell diameter</i>	Recticel/T.013.4	3400 – 5600 micron



Kleinreuther Weg 88  
D-90408 Nürnberg

Fon: +49/171/6829276  
Fax: +49/911/3957388  
E-Mail: [info@loy.tc](mailto:info@loy.tc)

# **PRODUCT STORAGE INFORMATION**

## **TR 33450/TR33455**

### **Bio Trickling Filter Media**

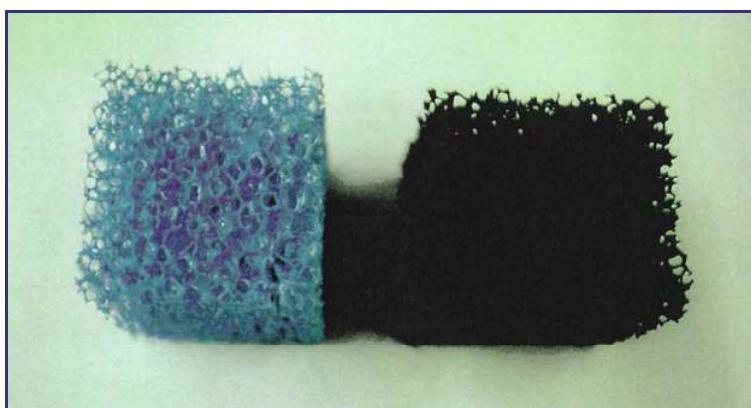
#### **Storage of Polyurethane foam TR33450/TR33455:**

Media is usually packed in plastic sheet or plastic sheet in cardboard

- store in dry area, keep dry,
- Protect against ultraviolet rays and sunlight
- no fire, flames of ignition allowed
- storage temperature range: 5 to 50 °Celsius
- precautions against vermin, rats, mouses or other rodents
- no usage of thinner or solvents effecting stability of the foam

Dont damage packing material to avoid loss of material and contamination with dust .

For storing the media in an outside area the given instruction have to be considered. Storage Area has to be secured and material protected by covering!



Kleinreuther Weg 88  
D- 90408 Nürnberg

Telephone: +49/171/6829276  
Fax: +49/911//3957388  
E-Mail: info@loy.tc

# PRODUCT WARRANTY TERMS

## **SLTEC 33455**

### **Bio Trickling Filter Media**

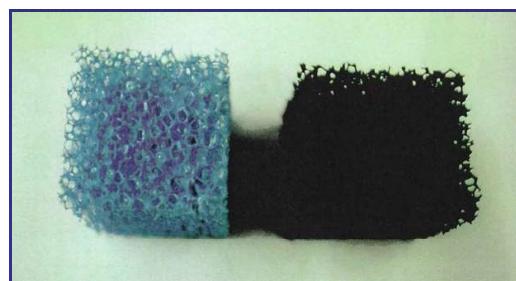
#### **Warranty terms - Polyurethane foam SLTEC 33455:**

**Warranty for the media is 5 years for stability, property and structure under the following conditions:**

- dust deposits by exhaust gas have to be excluded
- Particle deposits by nutrients and spray irrigation have to be excluded
- Skilled maintenance and media check by trained staff annually
- pH in a range of 2,5 to 10 (short term pH level to 1,5 can be accepted, but less than 5% operation time)
- No damages by improper operations and wrong technical parameters
- No damages by uncontrolled growth of biomass
- No usage of softening agents and foam damaging VOC in gas or water will be accepted

**Warranty can be extended to 10 years under the following conditions:**

- Continuous recording of technical parameters (flow rate, pH, irrigation rates, pressure drop)
- Maintenance contract with SLTEC, including
- Physical and chemical check of media annually



SL-TEC GmbH &  
Co.KG

Kleinreuther Weg 88  
D- 90408 Nürnberg

Telephone: +49/171/6829276  
Fax: +49/911//3957388  
E-Mail: [info@loy.tc](mailto:info@loy.tc)

## Biotrickling Applications

### Odour Removal

- Tobacco Industry
- Slaughterhouses
- Waste Water Treatment Plants
- Composting Plants
- Chocolate Production

### VOC Removal

- Printing Industry
- Coating Industry
- Chemical Industry
- Semiconductor Industry



## EDT Aktiengesellschaft

SÜDRING 11  
90542 Eckental-Eckenthal  
Germany

Telephone: ++49-9126-2979810  
Fax: ++49-9126-2979808



## Biotrickling Filter Foam

Polyurethane Foam for Biotrickling Filter Application



EDT FILTREN TM 23450

EDT FILTREN TR 33450

Colours: Blue/Black/Nature

## Inert Carrier for Biotrickling Filters

### EDT FILTRENT TR 33450

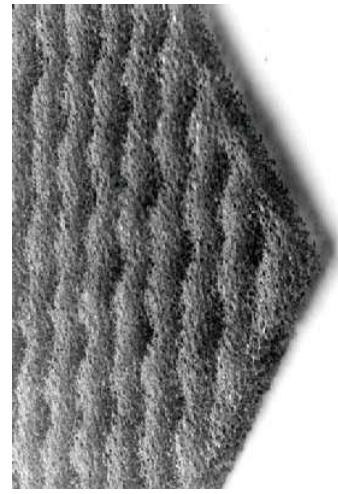
### EDT FILTRENT TM 23450

Both types have been developed since 1994 as an inert carrier for settling microorganism in Biotrickling Filter applications for odour and VOC removal. For traditional polyurethane foams could not guarantee the stability and homogeneous pore size distribution, this special type had to be created. In several applications in Europe and in the last few years also in USA and Asia this inert carrier was installed in different industrial Biotrickling Plants.

This media has important advantages:

- Low consistent pressure drop ► reduced operating costs
  - Excellent water storage capacity
  - Perfect media for settling microorganism
  - Good water and nutrient distribution
  - Chemical resistant
  - No exchange necessary
  - Adaptable to any construction
- Core Density 25 - 38 kg/m<sup>3</sup>
  - Compr.—Middle 5,2 - 9,7 KPA
  - Elongation 50% - 75 %
  - Tensile Strength 50% - 75 %
  - Tear Resistance 2,2 - 4,9 N/cm
  - Visiocell 2700 - 6800  $\mu$

### Polyurethane Foam



#### Delivery Units:

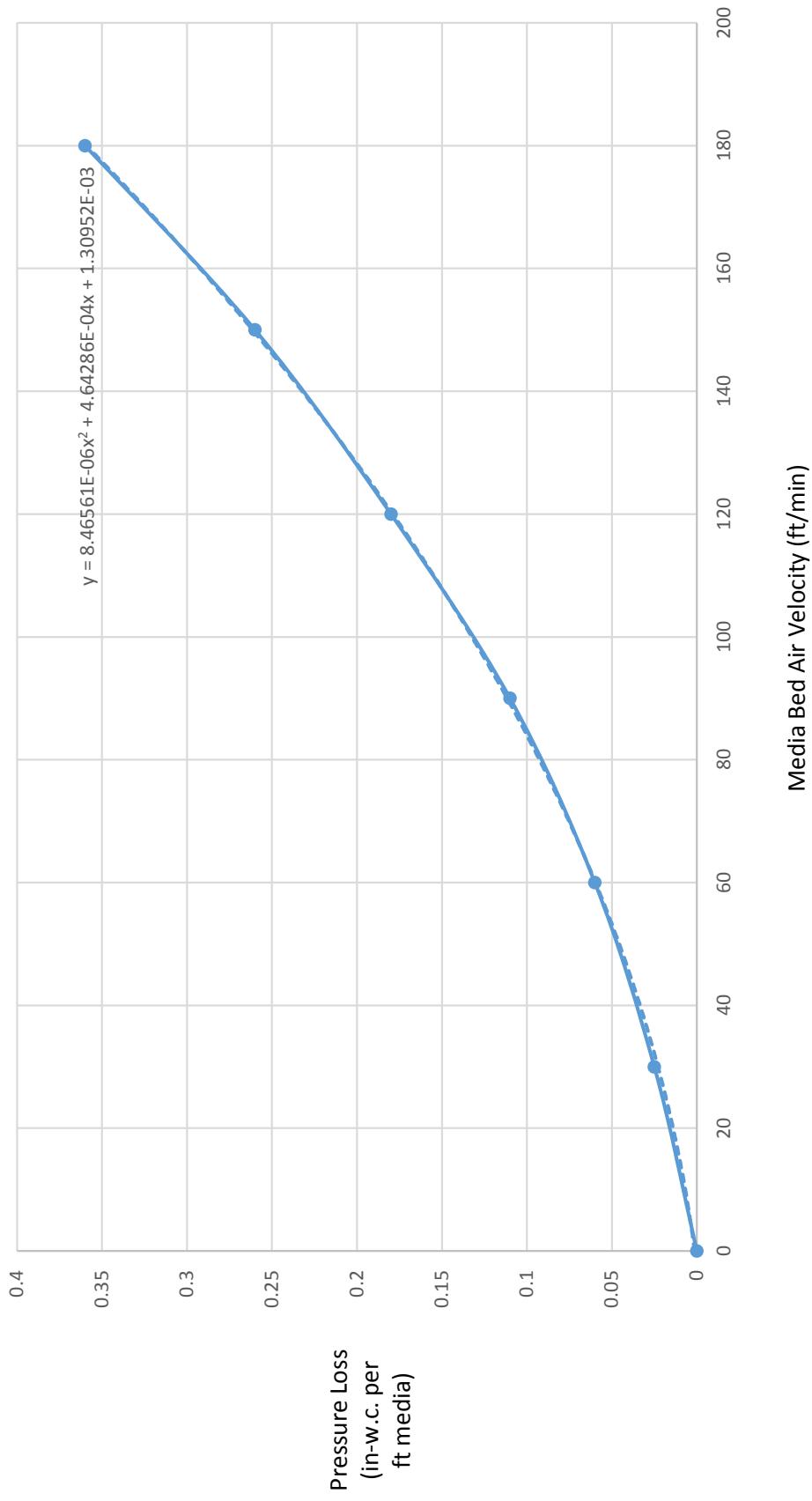
- 40 mm x 40 mm x 40mm
- 400 mm x 400 mm x 500 mm
- 2000 mm x 1000 mm x 500 mm
- Individual dimensions on request



#### Characteristic Data:

- EDT Aktiengesellschaft**  
SÜDRING 11  
90542 Eckental-Eckenhaid  
Germany
- Telephone: ++49-9126-2979810  
Fax: ++49-9126-2979808
- 

### Zander Foam BioDan Media



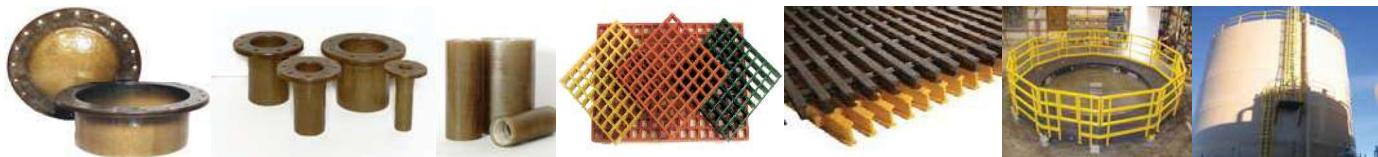
Media Bed Air Velocity (ft/min)

Notes:

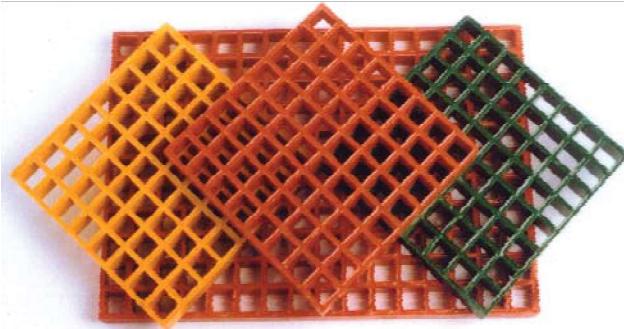
15ppi Reticulated Polyurethane Foam

6ft bed depth, 1.5" cube, Random Dumped

Continuous wetting rate 0.5gpm/sf media SA, 1.1 SG Liquid



# Fiberglass Grating and Custom Fabrication



IGF molded grating is available in a variety of standard sizes and colors. Custom colors and panel sizes are available upon request. All grating that carries our name is manufactured in our own ISO registered facility.

***ISO 9001:2008  
Certified Factories***

**Corrosion Resistant**

**Long Life**

**Ease of Installation**

**Fire Retardant**

**Slip Resistant**

**Nonconductive**

**Low Maintenance**

**Impact Resistant**

**UV Resistance**

# Benefits of Molded Grating

## Lightweight & Bi-Axial

IGF molded grating reduces installation and fabrication costs because it is lightweight and has bi-axial strength and stiffness. Full panels can easily be handled by two men. Unlike steel grating, which must be cut with a gas torch, IGF molded grating can be cut with a rotary saw.

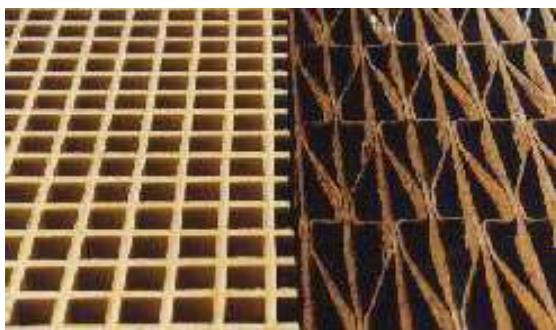
Because IGF molded grating has bi-axial strength and stiffness, it can be cut to complex curved shapes without adding extra supports. In addition, holes can be cut for pipes and structurals without having to box support these cutouts.



## Corrosion Resistant

IGF molded grating is available in three resin systems for a wide range of corrosion resistant properties. IGF vinyl ester grating is our premium grade and has the widest range of chemical resistance. IGF isophthalic grating has an excellent chemical resistance including solvent resistance. IGF general purpose grating is ideal for mildly corrosive environments such as marine and waste water and is very competitively priced.

Whether exposed to continuous submersion, splash, spills, fumes or gases, IGF molded grating outperforms steel and aluminum grating.



## Impact Resistant

IGF molded grating is very flexible and may be repeatedly deflected without causing permanent deformation. Once the load is removed, fiberglass grating will return to its original shape, unlike metallic grating, which will remain deformed and require replacement. The energy absorption and flexibility of IGF molded grating makes it impact resistant.

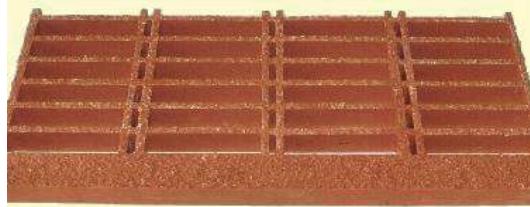


## Slip Resistant

The slip resistant meniscus surface of IGF molded grating is created during the molding process by the formation of a concave cross-section on the walking surface of each batch. The no slip fiberglass grating has a coarse clear grit applied to the concave surface. Both the meniscus and no slip grit surface are safer than concrete or diamond plate, especially in wet conditions.

## Stair Tread

IGF molded stair tread features a 1-1/2" x 6" grid, is 1-1/2" thick and has a solid leading edge which increases the stiffness and durability. Stair tread is available in all three IGF resin systems and in a grit surface finish. The open grid is self cleaning, prevents build-up of liquids and is corrosion resistant.



## Clips

IGF offers 316 Stainless Steel "J" & "M" Clips

# Details and Selection

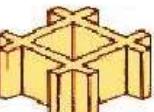
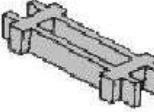
## IGF Resin Systems

Because different applications present different requirements, IGF offers three resin systems in our molded grating. IGF VE (Bisphenol Vinyl Ester) provides a maximum level of corrosion resistance. IGF ISO (Isophthalic Polyester) provides an intermediate level of chemical resistance in moderately corrosive environments. For mildly corrosive applications such as marine and waste water, IGF also offers an excellent line of general purpose resin molded grating.

Resin Type	Performance	Resin System	Flame Spread Rating ASTM E84	Color*
IGF-VE	Superior corrosion resistance to strong acids & bases. Inherent toughness and high elongation.	Vinyl Ester	Class 1, 25 or less	Orange Light Gray Dark Gray
IGF-ISO	Excellent corrosion resistance including solvent resistance.	Isophthalic Polyester	Class 1, 25 or less	Green Light Gray Dark Gray
IGF-GP	Good corrosion resistance. Good for marine, waste water, etc. applications.	Polyester	Class 1, 25 or less	Green Yellow Gray-light/dark

\*Standard colors. Other colors available upon request

## Standard Grating Sizes and Specifications

Grating Style	Grid Size & Thickness	Bar Size	Structural Properties	Panel Size
	1-1/2 x 1-1/2 inch grid 1 inch thick	Space Between Bars: 1.20 inch  Bar Thickness: 0.30 inch  Approximate Open Area: 64%	Average El= 300,000 Lb-in <sup>2</sup> where A=1.92in <sup>2</sup> l=.16in4 S=.32in3	36" x 120" 48" x 96" 48" x 144"  Approx. Weight: 2.7 lb/ft <sup>2</sup>
	1-1/2 x 1-1/2 inch grid 1-1/2 inch thick	Space Between Bars: 1.20 inch  Bar Thickness: 0.30 inch  Approximate Open Area: 64%	Average El= 900,000 Lb-in <sup>2</sup> where A=2.75in <sup>2</sup> l=.52in4 S=.69in3	36" x 120" 48" x 96" 48" x 144" 60" x 120" 60" x 156"  Approx. Weight: 3.9 lb/ft <sup>2</sup>
	2 x 2 inch grid 2 inch thick	Space Between Bars: 1.67 inch  Bar Thickness: 0.33 inch  Approximate Open Area: 69%	Average El= 2,500,000 Lb-in <sup>2</sup> where A=3.15in <sup>2</sup> l=1.05in4 S=1.05in3	48" x 144"  Approx. Weight: 4.0 lb/ft <sup>2</sup>
	1 x 4 inch grid 1 inch thick	Space Between Bars: 0.75 x 3.50 inch  Bar Thickness: 0.25 & 0.50 inch  Approximate Open Area: 66%	Average El= 500,000 Lb-in <sup>2</sup> where A=2.72 in <sup>2</sup> l=.23in4 S=.45in3	48" x 144"  Approx. Weight: 3.4 lb/ft <sup>2</sup>

\* Other panels sizes available by special order



# NC

## Threaded Connection/Plastic Material

### DESIGN FEATURES

- Complete line of full cone nozzles made of plastic
- Male and female connections
- Flanged connection available in larger models—see NCFL (p. 29)
- For metal alloy nozzles, refer to MaxiPass (pp. 39, 39), SC (pp. 36, 37), or TC (p. 35) Series

### SPRAY CHARACTERISTICS

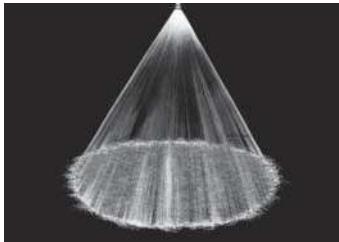
**Spray pattern:** Full Cone with uniform distribution. For square patterns, please contact BETE.

**Spray angles:** 60°, 90°, and 120° standard

**Flow rates:** 2.01 to 2150 gpm  
(Higher flow rates available)



Male 120°



Full Cone 60° (N)



Full Cone 90° (M)



Full Cone 120° (W)

Dimensions are approximate. Check with BETE for critical dimension applications.

### NC Flow Rates and Dimensions

Full Cone, Narrow 60°(N), Medium 90°(M) and Wide 120° (W) Spray Angles, 3/4" to 6" Pipe Sizes

Male or Female Pipe Size	Nozzle Number	K Factor	GALLONS PER MINUTE @ PSI									Approx. Orifice Dia. (in.)	Free Pass. Dia. (in.)	Approximate Dimensions (in.) A B C D	Wt. (oz.) Male
			3 PSI	5 PSI	7 PSI	10 PSI	20 PSI	40 PSI	60 PSI	80 PSI	100 PSI				
3/4	NC 0703	1.20	2.01	2.56	3.00	3.55	4.91	6.81	8.23	9.43	10.5	0.25	0.16		
	NC 0704	1.60	2.69	3.41	4.00	4.73	6.55	9.07	11.0	12.6	14.0	0.25	0.19	1.75 1.12 2.12 1.50	1.00
	NC 0707	2.80	4.70	5.98	7.00	8.28	11.5	15.9	19.2	22.0	24.4	0.33	0.23		
1	NC 1009	3.61	6.04	7.68	9.00	10.6	14.7	20.4	24.7	28.3	31.4	0.38	0.25	2.19 1.38 2.50 1.75	1.25
	NC 1012	4.81	8.06	10.2	12.0	14.2	19.7	27.2	32.9	37.7	41.9	0.45	0.30		
1 1/4	NC 1214	5.61	9.40	12.0	14.0	16.6	22.9	31.8	38.4	44.0	48.9	0.47	0.34	3.25 1.75 3.25 2.00	3.75
	NC 1217	6.81	11.4	14.5	17.0	20.1	27.8	38.6	46.7	53.4	59.3	0.53	0.38		
1 1/2	NC 1516	6.41	10.7	13.7	16.0	18.9	26.2	36.3	43.9	50.3	55.8	0.50	0.38		
	NC 1520	8.01	13.4	17.1	20.0	23.7	32.8	45.4	54.9	62.8	69.8	0.56	0.41	4.25 2.00 4.25 2.50	6.75
	NC 1524	9.62	16.1	20.5	24.0	28.4	39.3	54.4	65.9	75.4	83.8	0.61	0.44		
2	NC 2017	6.81	11.4	14.5	17.0	20.1	27.8	38.6	46.7	53.4	59.3	0.53	0.38		
	NC 2020	8.01	13.4	17.1	20.0	23.7	32.8	45.4	54.9	62.8	69.8	0.56	0.41		
	NC 2033	13.2	22.2	28.2	33.0	39.0	54.1	74.9	90.6	104	115	0.72	0.55	5.81 2.50 5.81 3.00	12.7
	NC 2040	16.0	26.9	34.1	40.0	47.3	65.5	90.7	110	126	140	0.80	0.63		
	NC 2045	18.0	30.2	38.4	45.0	53.2	73.7	102	124	141	157	0.84	0.63		

$$\text{Flow Rate (GPM)} = K (\text{PSI})^{0.47}$$

**Standard Materials:** PVC, Polypropylene, and PTFE.

**NOTE for PTFE nozzles:** if operating temperature is to exceed 300°F, or the operating pressure is to exceed the values listed in the table above, please contact BETE Applications Engineering for assistance.

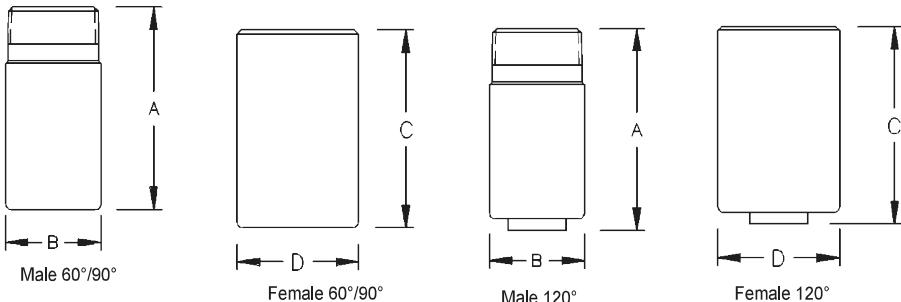
Spray angle performance varies with pressure. Contact BETE for specific data on critical applications.



# FULL CONE



Female 120°



Dimensions are approximate. Check with BETE for critical dimension applications.

## NC Flow Rates and Dimensions

Full Cone, Narrow 60° (N), Medium 90° (M) and Wide 120° (W) Spray Angles, 3/4" to 6" Pipe Sizes

Male or Female Pipe Size	Nozzle Number	K Factor	GALLONS PER MINUTE @ PSI									Approx. Approx. Free Pass. Dia. (in.)	Approximate Dimensions (in.)	Wt. (lbs.)
			3 PSI	5 PSI	7 PSI	10 PSI	20 PSI	40 PSI	60 PSI	80 PSI	100 PSI			
2	NC 2050	20.0	33.6	42.7	50.0	59.1	<b>81.9</b>	113	137	157	174	0.89	0.60	5.81 2.50 5.81 3.00
	NC 2060	24.0	40.3	51.2	60.0	71.0	<b>98.3</b>	136	165	189	209	0.94	0.63	
	NC 2065	26.0	43.6	55.5	65.0	76.9	<b>106</b>	147	178	204	227	1.00	0.67	
	NC 2070	28.1	47.0	59.8	70.0	82.8	<b>115</b>	159	192	220	244	1.05	0.68	
2 1/2	NC 2570	28.1	47.0	59.8	70.0	82.8	<b>115</b>	159	192	220	244	1.05	0.68	5.88 3.00 5.88 3.50
	NC 2580	32.1	53.7	68.3	80.0	94.6	<b>131</b>	181	220	251	279	1.13	0.69	
	NC 2590	36.1	60.4	76.8	90.0	106	<b>147</b>	204	247	283	314	1.19	0.78	
3	NC 3058	23.2	38.9	49.5	58.0	68.6	<b>95.0</b>	132	159	182	202	0.95	0.63	5.88 3.50 5.88 4.00
	NC 3084	33.7	56.4	71.7	84.0	99.3	<b>138</b>	191	231	264	293	1.17	0.88	
	NC 3096	38.5	64.5	82.0	96.0	114	<b>157</b>	218	264	302	335	1.12	0.95	
	NC 30117	46.9	78.6	99.9	117	138	<b>192</b>	265	321	368	408	1.36	0.97	
4	NC 40125	50.1	83.9	107	125	148	<b>205</b>	284	343	393	436	1.39	0.98	5.88 4.50 7.25 5.00
	NC 40130	52.1	87.3	111	130	154	<b>213</b>	295	357	409	454	1.42	1.00	
	NC 40180	72.1	121	154	180	213	<b>295</b>	408	494	566	628	1.69	1.31	
	NC 40250	100	168	213	250	296	<b>409</b>	567	686	786	872	1.98	1.586	
6	NC 60350	140	235	299	350	414	<b>573</b>	794	961	1100	1220	2.38	1.70	9.50 6.63 11.0 7.19
	NC 60480	192	322	410	480	568	<b>786</b>	1090	1320	1510	1670	2.75	1.75	
	NC 60615	246	413	525	615	727	<b>1010</b>	1390	1690	1930	2150	3.11	1.97	

$$\text{Flow Rate (GPM)} = K(\text{PSI})^{0.47}$$

Standard Materials: PVC, Polypropylene and PTFE.

NOTE for PTFE nozzles: if operating temperature is to exceed 300°F, or the operating pressure is to exceed the values listed in the table above, please contact BETE Applications Engineering for assistance.

Spray angle performance varies with pressure. Contact BETE for specific data on critical applications.

CALL 413-772-0846  
Call for the name of your nearest BETE representative.

Mist Elimination Division

## T-271 and T-272

High Efficiency Impingement Separators



### Vertical Flow Mist Eliminators

The T-271™ and T-272™ vertical flow, high-efficiency separators from Munters are designed specifically for vertical flow applications at high gas velocities. They operate at nearly twice the velocity of mesh pads, meet or exceed compliance standards, recover expensive chemicals and reduce operating costs. They are the preferred choice for use in many pulp and paper processes and other industrial applications ranging from flue gas desulfurization systems to blast furnace scrubbers.

### Features

The T-271 and T-272 from Munters have multi-pass profile with opposing-angle chevron collection grooves which assure maximum liquid removal without risk of reentrainment. This Munters Mist Eliminator is proven in the industry to consistently remove large volumes of liquid. To reduce liquid carryover which may lead to stack rain, a T-271/T-272 is an excellent choice. The vertical flow mist eliminators are available in a variety of materials, including a selection of thermoplastics and metal alloys. They're shipped fully assembled as easy to handle modules. Easy retrofits typically achieve improved performance and very often a reduction in pressure drop. The static pressure loss savings may result in big savings with retrofit to T-272. The proven cleanability allows longer on-line operation, minimizing down time required for maintenance.

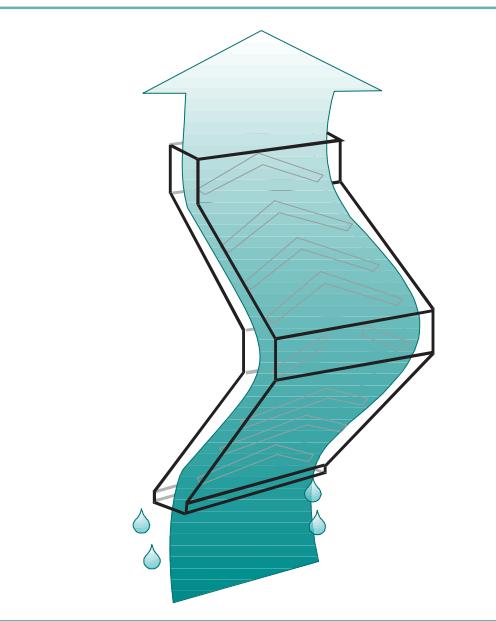
### PRODUCT INFORMATION

#### Target Applications

- Flue Gas Cleaning: used with variety of scrubber reagents such as lime, limestone, sodium and magnesium salts to minimize liquid carryover
- Process Gas Cleaning: control carryover from evaporators and process vessels, enhance gas quality and protect downstream equipment and processes
- Exhaust Gas Cleaning: remove entrained liquids from stack gas, exhaust or incinerator scrubbers while enhancing emissions reduction and insuring compliance with regulatory standards

#### Features

- Ideal Geometry
- Variety of Materials
- Fully Assembled
- Easy Retrofit
- Proven Cleanability
- High-Efficiency
- Low Pressure Drop
- Wide Velocity Range



The Humidity Expert



## Function

The Munters T-271 and T-272 mist eliminators are often used as a single stage in scrubber systems. They may also be used together in a two-stage system where liquid and/or particulate loading are too high for a single-stage separator, especially when frequent, on-line washing is required. In high-liquid loading applications, the T-271 is typically installed as the final elimination step after a Munters first-stage bulk entrainment T-272 separator.

## Design

Munters T-271 and T-272 vertical flow mist eliminators have been engineered to operate at higher velocities, recover expensive chemicals, reduce operating costs and provide performance far superior to any conventional chevron or baffle type eliminator.

Opposing angle chevron collection grooves on each profile surface provide a low velocity zone where collected droplets accumulate and drain to the edges of the profile subsections. Agglomerated liquids then drain from the modules as large droplets as large droplets forming a liquid stream without risk of being carried back into the separator by the up-flowing gas stream.

Both mist eliminator models use the same primary profile, however, the spacing between T-272 profiles is twice that of T-271. This more open design is better suited for high-liquid and particulate-laden gases, making the T-272 ideal for use in applications prone to scaling or solids build-up, or as a low pressure drop, high-efficiency, bulk entrainment separator.

## Material

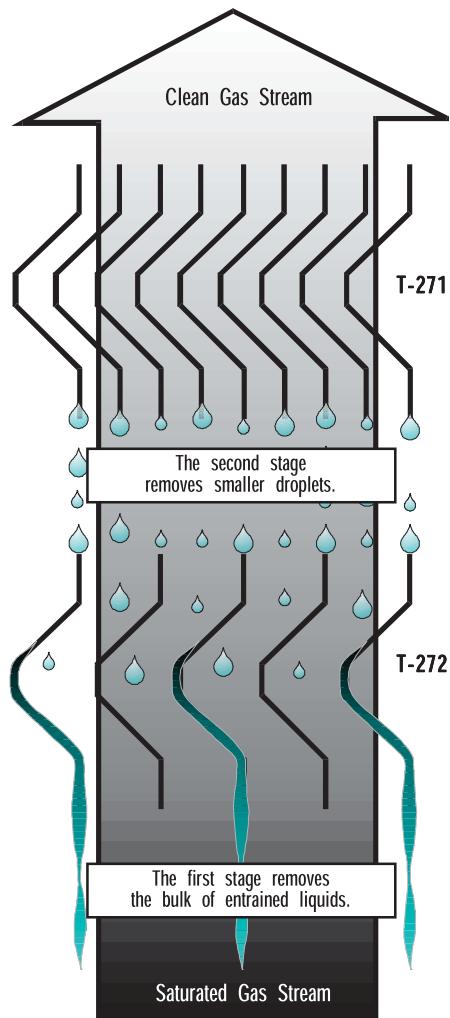
The Munters T-271 and T-272 modules are fabricated from a wide range of thermoplastic and metallic materials suited to meet your every need. These include polypropylene, glass coupled polypropylene, Noryl®, Ryton®, stainless steel and other alloys.

## Delivery

The Munters T-271 and T-272 mist eliminator modules are supplied as complete units, easy to handle and ready for installation. Individual modules can be cut to fit your tower size. Munters Corporation can cut these modules at our factory to fill tower size from 2' to over 70'ID. to fit existing towers.

Munters also supplies a complete line of vessels, transitions, supports and cleaning systems, as well as engineering and sales assistance to aid in the design, operation and maintenance of your system. Call today for more information.

Specifications for T-271 & T-272 Mist Eliminators			
Material	Weight (lb./ft. <sup>2</sup> ) T-271	Weight (lb./ft. <sup>2</sup> ) T-272	Max. Op. Temp. (F)
Polypropylene	4.9	3.4	165
Glass Coupled	4.9	3.4	265
Polypropylene			
Noryl®	6.5	4.4	220
Ryton® R-4	7.5	—	430
Stainless	8.9	7.5	—
Other Alloys	8.9	7.5	—



T-271 and T-272 are Trademarks of Munters Corporation  
ISO 9001 Certified



## Munters Corporation

Mist Elimination Division | PO Box 6428 | Fort Myers, FL 33911 USA  
Tel: (239)936-1555 | Toll Free: (800)446-6868  
Fax: (239)278-1316 | E-Mail: [moreinfo\\_me@americas.munters.com](mailto:moreinfo_me@americas.munters.com)  
[www.munters.us](http://www.munters.us)



The Humidity Expert



THE MUNTERS CORPORATION  
108 6TH STREET S.E.  
P.O. BOX 6428  
FT. MYERS FLORIDA 33911  
PHONE (239) 936-1555  
FAX (239) 278-1316

ACAD:LDSTD T27110 MICRON

NOTICE: THIS DRAWING IS THE PROPERTY OF THE MUNTERS CORP.  
FT. MYERS, FL AND IS LOANED SUBJECT TO THE CONDITION  
THAT IT SHALL NOT BE REPRODUCED, COPIED, LOANED OR  
SUBMITTED TO OUTSIDE PARTIES FOR EXAMINATION WITHOUT  
OUR WRITTEN CONSENT, AND SHALL UPON REQUEST, BE  
RETURNED. DO NOT SCALE DRAWING FOR CONSTRUCTION.

COPYRIGHT ©1999 BY MUNTERS CORPORATION

# MUNTERS MIST ELIMINATOR LIMIT DROP CURVE T-271

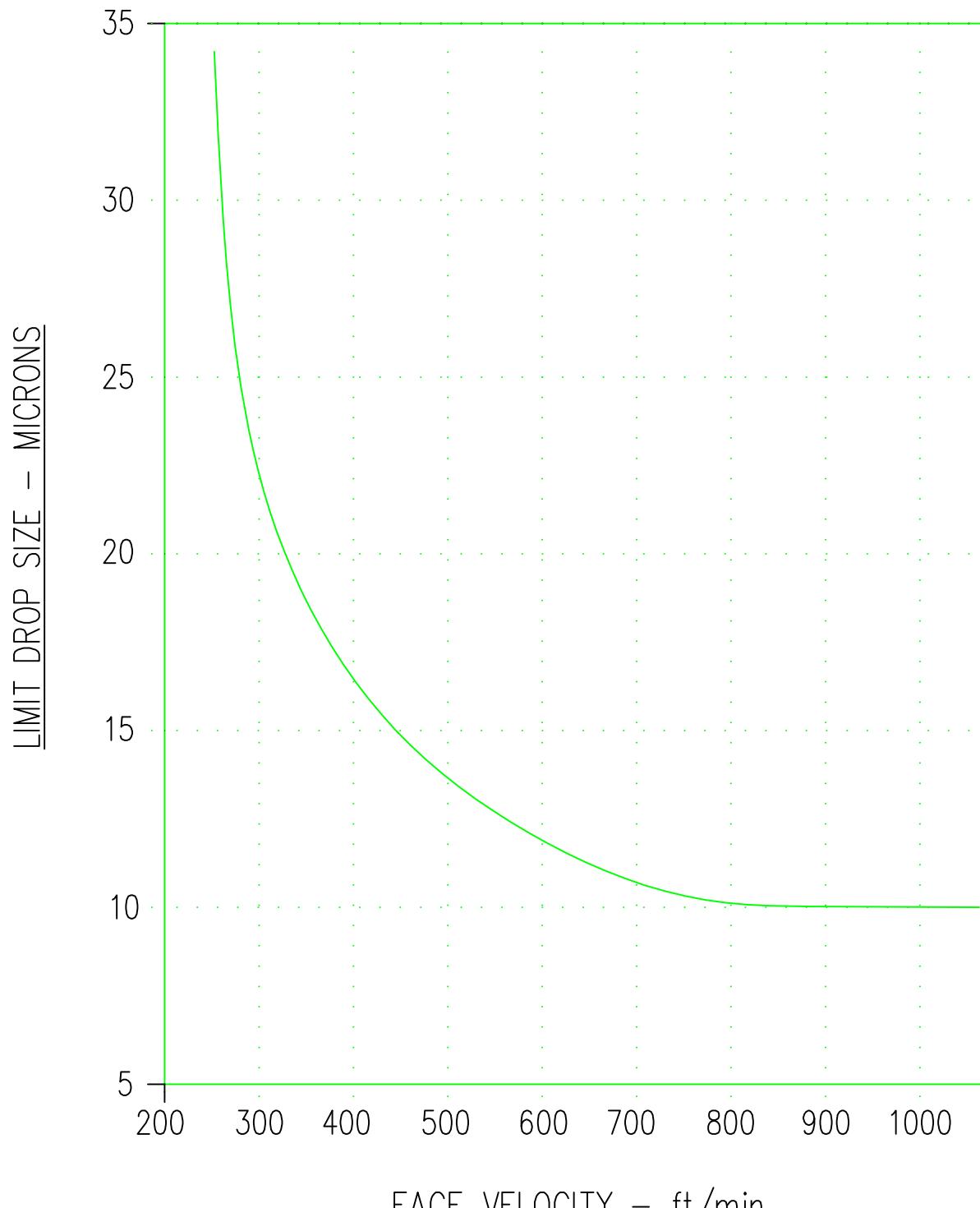
CUSTOMER:

PROJECT:

DRAWING:

DATE:

DRAWN BY	CHECKED BY	APPROVED BY	SYM	REVISION	BY	DATE
DC			0			10/11/02



FACE VELOCITY - ft/min

Ambient Air-Water Sys  
± 25% Gas Distribution



THE MUNTERS CORPORATION  
108 6TH STREET S.E.  
P.O. BOX 6428  
FT. MYERS FLORIDA 33911  
PHONE (239) 936-1555  
FAX (239) 278-1316 ACADPDSTD CURVE-T271

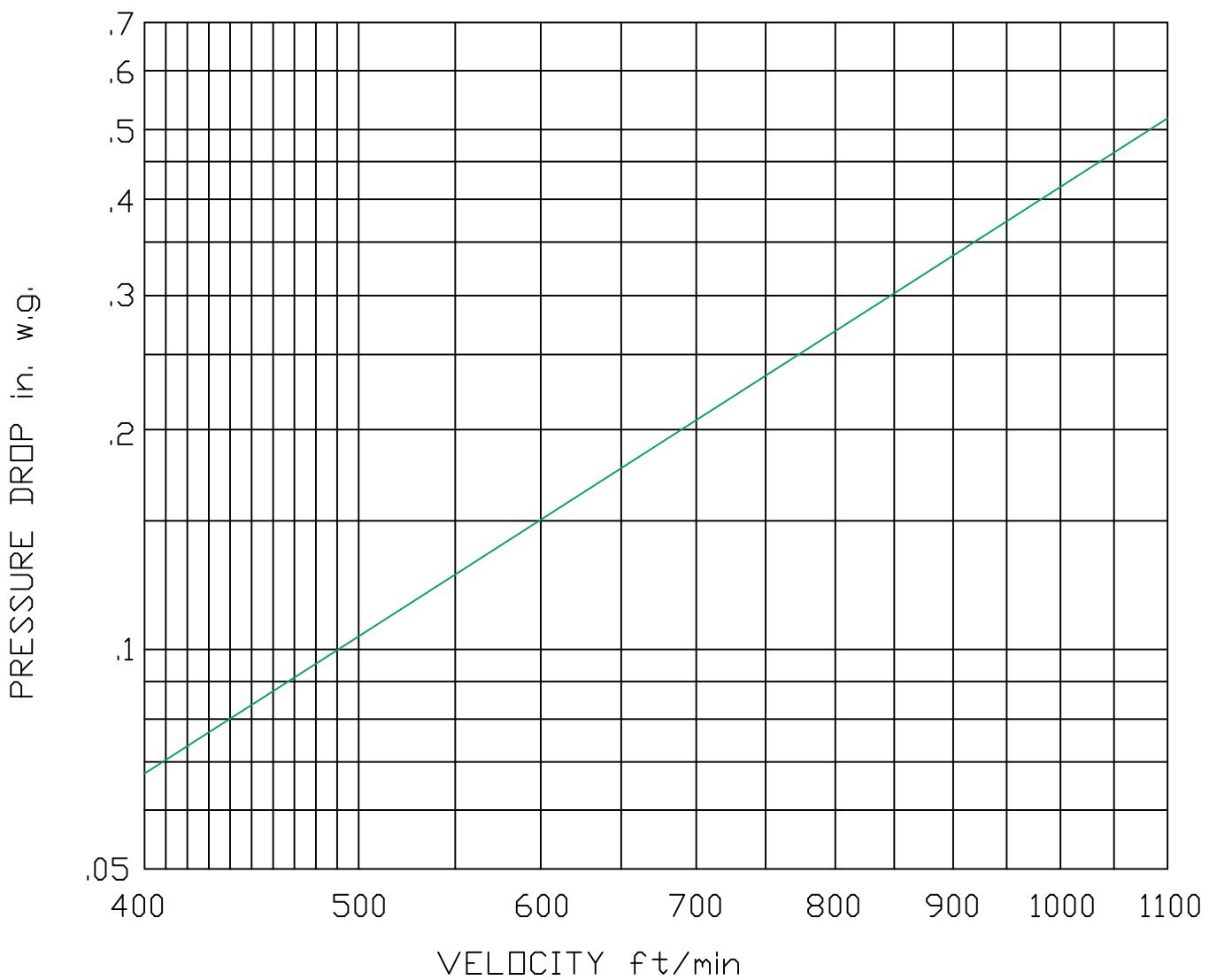
NOTICE: THIS DRAWING IS THE PROPERTY OF THE MUNTERS CORP.  
FT. MYERS, FL AND IS LOANED SUBJECT TO THE CONDITION  
THAT IT SHALL NOT BE REPRODUCED, COPIED, LOANED OR  
SUBMITTED TO OUTSIDE PARTIES FOR EXAMINATION WITHOUT  
OUR WRITTEN CONSENT, AND SHALL UPON REQUEST, BE  
RETURNED. DO NOT SCALE DRAWING FOR CONSTRUCTION.

COPYRIGHT © 1999 BY MUNTERS CORPORATION

MUNTERS MIST ELIMINATOR  
PRESSURE DROP CURVE FOR T-271  
CUSTOMER:  
PROJECT:  
DRAWING:

DATE:

DRAWN BY	CHECKED BY	APPROVED BY	SYM	REVISION	BY	DATE
DC			0			10/11/02



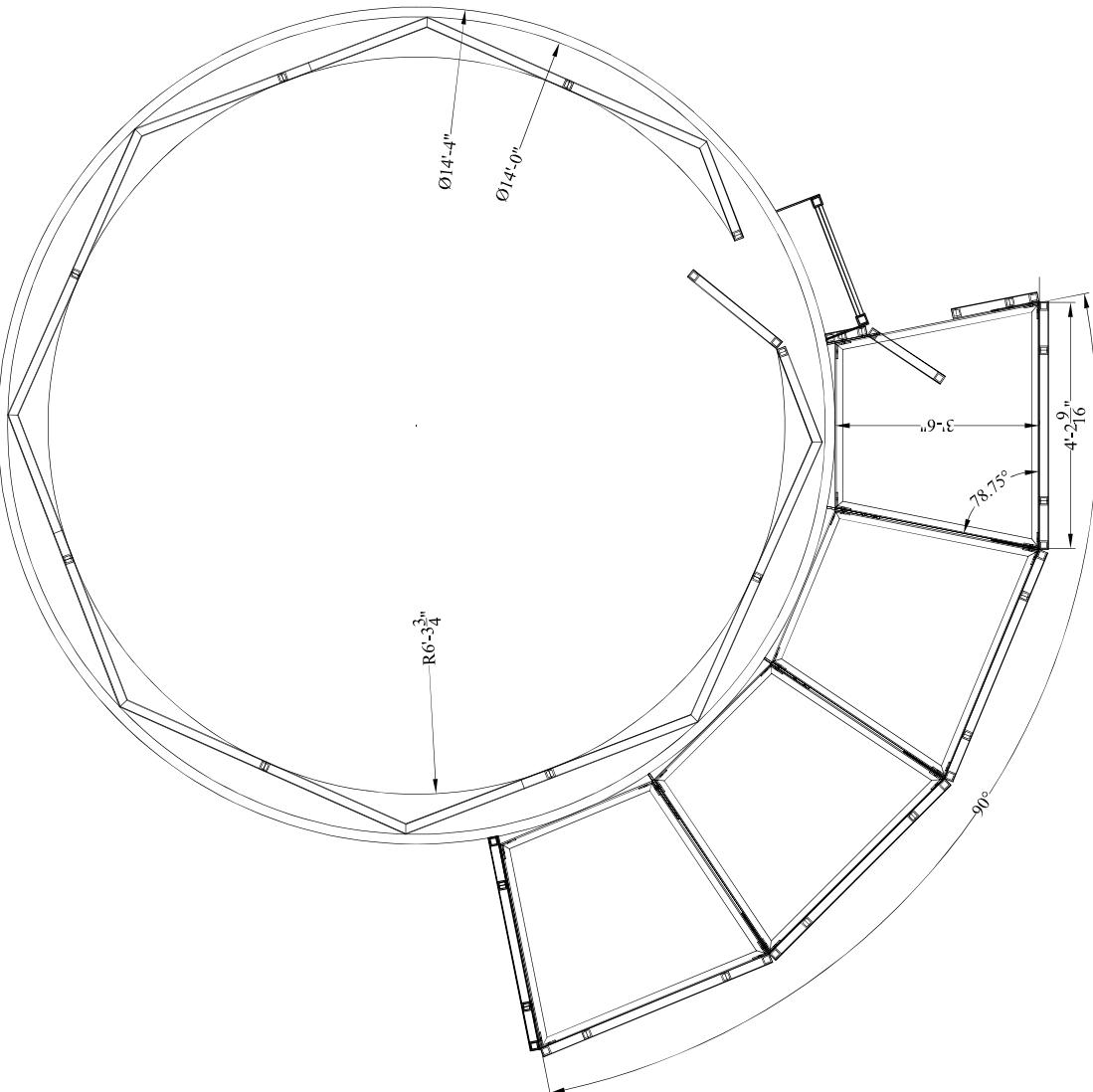
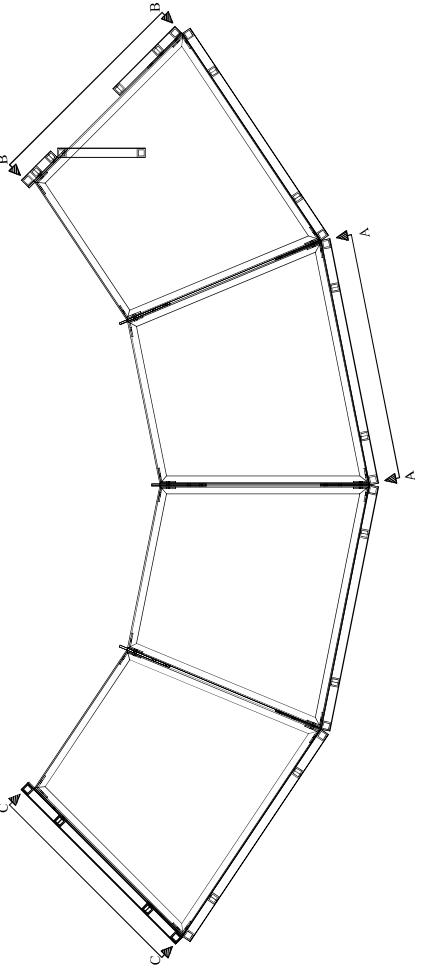
#### DESIGN CRITERIA

INLET GAS VELOCITY DEVIATION - ± 25 % RMS

GAS DENSITY - .075 lb/cu ft

BILL OF MATERIALS

DESCRIPTION	MATERIAL	RESIN
A HANDBRALL POSTS	1-3/4" X 1" SQUARE TUBE	VINYL ESTER
B HANDBRALL RAILS	2" X 2" X 1/8" SQUARE TUBE	VINYL ESTER
C HANDBRALL ANCHOR CLIPS	FRP ANGLE	VINYL ESTER
D TOEPLATE CIRCULAR	4" X 1/8" FLAT STRIP	VINYL ESTER
E LADDER RAILS	2" X 1" SQUARE TUBE	VINYL ESTER
F LADDER RUNGS	1-1/2" FLUTED TUBING	VINYL ESTER
G LADDER RUNGS FOR FALL PROT.	1-1/2" FLUTED SOLID ROD	VINYL ESTER
H LADDER CLIPS (GUSSETED)	BY OTHERS	VINYL ESTER
I LADDER ANCHOR CLIPS	3" X 3" X 1" ANGLE	VINYL ESTER
J PLATFORM STRUCTURAL	6" X 1-3/8" CHANNEL	VINYL ESTER
K PLATFORM KNEE BRACING	3" X 3" X 1" ANGLE	VINYL ESTER
L MOLDED GRATING WITH GRIT	1.5" THICK WITH 1.5" X 1.5" GRID	VINYL ESTER
M BOLTING HARDWARE	316 STAINLESS STEEL	



International Grating & Flanges, Inc.

Harrison, Arkansas 72602-2477  
Ph: (870) 741-6500 Fax: (870) 741-6512

P.O. Box 2477

APPROVED BY:

DANIEL COMPANY  
5013 HLO

DRAWN BY:  
AH

SCALE NTS

DATE: 5-19-2025

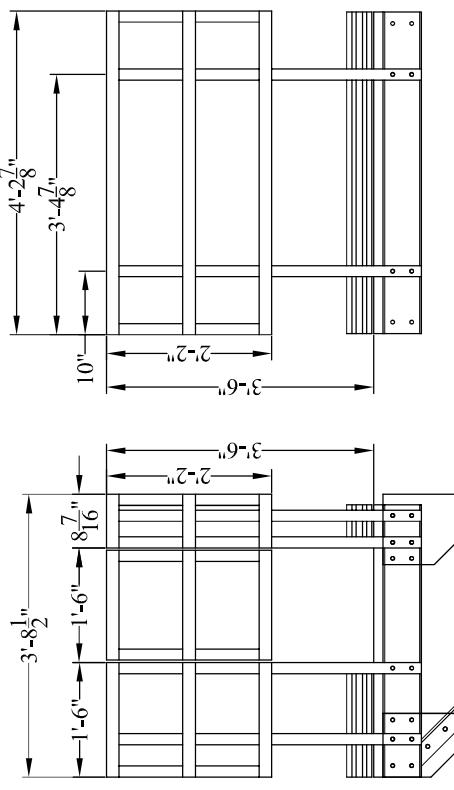
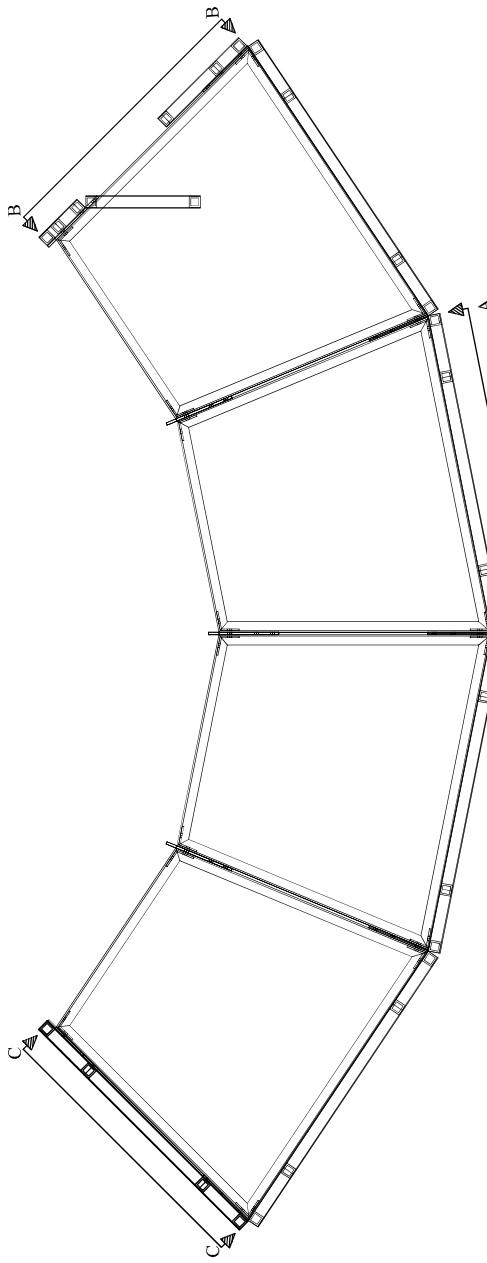
REV. NO. 0

QUOTE 3781

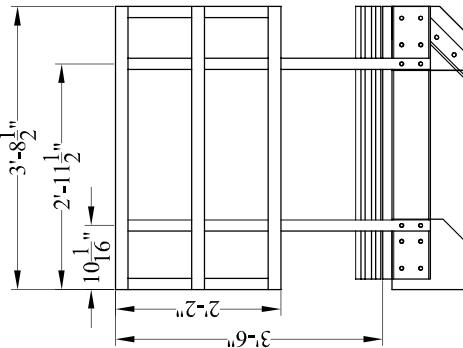
SHEET NO. 1

BILL OF MATERIALS

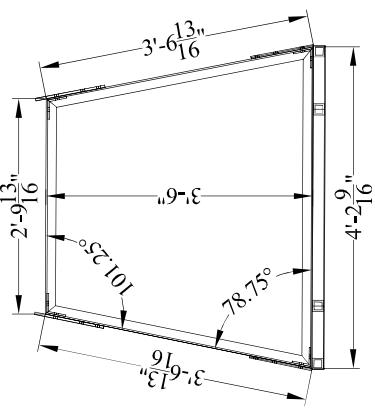
DESCRIPTION	MATERIAL	RESIN
A HANDBRAIL POSTS	1-3/4" X 3" SQUARE TUBE	VINYL ESTER
B HANDBRAIL RAILS	2" X 2" X 1/8" SQUARE TUBE	VINYL ESTER
C HANDBRAIL ANCHOR CLIPS	FRP ANGLE	VINYL ESTER
D TOEPLATE, CIRCULAR	4" X 1/8" FLAT STRIP	VINYL ESTER
E LADDER RAILS	2" X 3" SQUARE TUBE	VINYL ESTER
F LADDER RUNGS	1-1/2" FLUTED TUBING	VINYL ESTER
G LADDER RUNGS, FOR FALL PROT.	1-1/2" FLUTED SOLID ROD	VINYL ESTER
H LADDER CLIPS (GUSSETED)	BY OTHERS	VINYL ESTER
I LADDER ANCHOR CLIPS	3" X 3" X 3/8" ANGLE	VINYL ESTER
J PLATFORM STRUCTURAL	6" X 1-1/8" X 2" CHANNEL	VINYL ESTER
K PLATFORM KNEE BRACING	3" X 3" X 3/8" ANGLE	VINYL ESTER
L MOULDED GRATING WITH GRIT	1.5" THICK WITH 1.5" X 1.5" GRID	VINYL ESTER
M BOLTING HARDWARE	316 STAINLESS STEEL	



VIEW B-B



VIEW C-C



International Grating & Flanges, Inc.

Harrison, Arkansas 72602-2477  
Ph: (870) 741-6500  
Fax: (870) 741-6512

DANIEL COMPANY  
5013 HILO

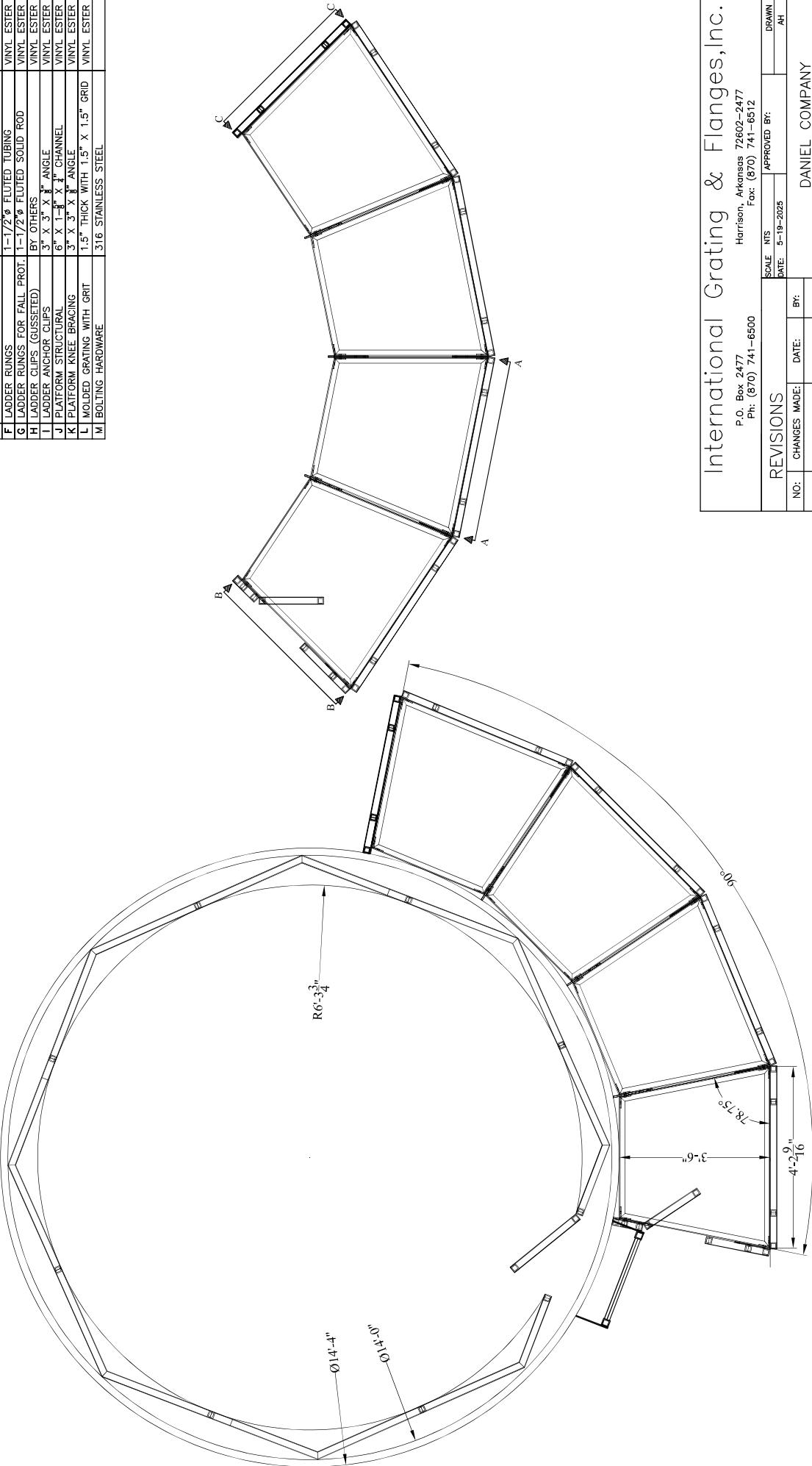
APPROVED BY: DRAWN BY:  
DATE: 5-10-2005 DATE: 5-10-2005

NO:	CHANGES MADE:	DATE:	BY:
-	-	-	-
-	-	-	-

SHEET NO. 2 QUOTE 3781  
REV. NO. 0

## BILL OF MATERIALS

BILL OF MATERIALS		RESIN
DESCRIPTION	MATERIAL	VINYL ESTER
A HANDBRAIL POSTS	1-3/4" X 1" SQUARE TUBE	VINYL ESTER
B HANDBRAIL RAILS	2" X 2" X 1/8" SQUARE TUBE	VINYL ESTER
C HANDBRAIL ANCHOR CLIPS	2" X 1/8" FLAT STRIP	VINYL ESTER
D TOEPLATE CIRCULAR	4" X 1/8" FLAT STRIP	VINYL ESTER
E LADDER RAILS	2" X 1" SQUARE TUBE	VINYL ESTER
F LADDER RUNGES	1-1/2" X 1" FLUTED TUBING	VINYL ESTER
G LADDER RINGS FOR FALL PROT.	1-1/2" X 1" FLUTED TUBING	VINYL ESTER
H LADDER CLIPS (CUSHIONED)	3" X 3" X 1/8" ANGLE	VINYL ESTER
I LADDER ANCHOR CLIPS	3" X 3" X 1/8" ANGLE	VINYL ESTER
J PLATFORM STRUCTURAL	6" X 1-5/8" X 1" CHANNEL	VINYL ESTER
K KNEE BRACING	3" X 3" X 1/8" ANGLE	VINYL ESTER
L MOLDED KNEE BRACING WITH GRIT	1.5" THICK WITH 1.5" X 1.5" GRID	VINYL ESTER
M BOLTING HARDWARE	316 STAINLESS STEEL	

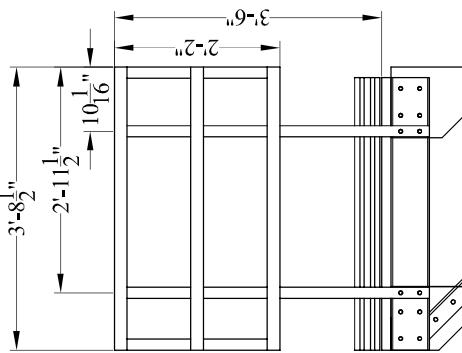
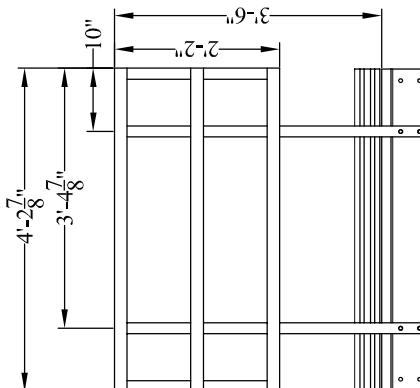
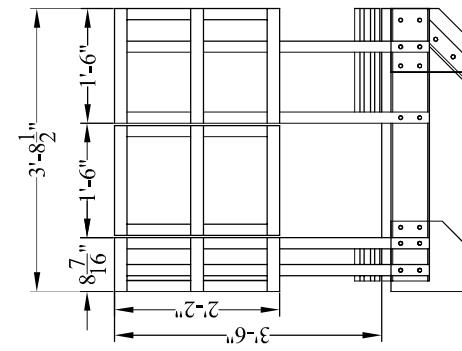
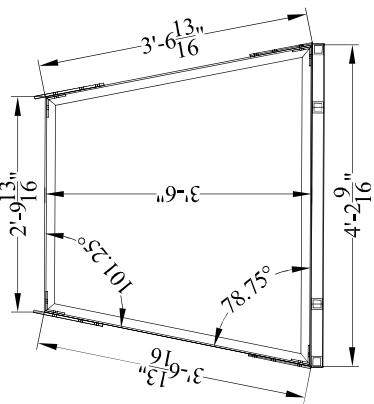
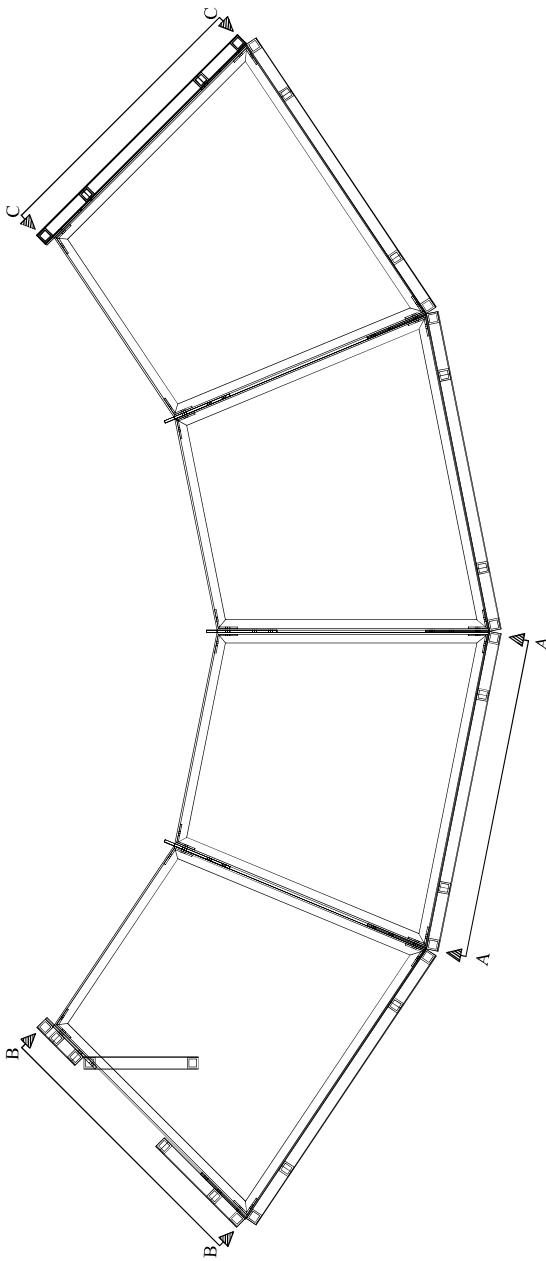


International Grating & Flanges, Inc.

DANIEL COMP  
5013 WILCOX

BILL OF MATERIALS

DESCRIPTION	MATERIAL	RESIN
A HANDBRAIL POSTS	1-3/4" X 3" SQUARE TUBE	VINYL ESTER
B HANDBRAIL RAILS	2" X 2" X 1/8" SQUARE TUBE	VINYL ESTER
C HANDBRAIL ANCHOR CLIPS	FRP ANGLE	VINYL ESTER
D TOEPLATE, CIRCULAR	4" X 1/8" FLAT STRIP	VINYL ESTER
E LADDER RAILS	2" X 3" SQUARE TUBE	VINYL ESTER
F LADDER RUNGS	1-1/2" Ø FLUTED TUBING	VINYL ESTER
G LADDER RUNGS, FOR FALL PROT.	1-1/2" Ø FLUTED SOLID ROD	VINYL ESTER
H LADDER CLIPS (GUSSETED)	BY OTHERS	VINYL ESTER
I LADDER ANCHOR CLIPS	3" X 3" X 3/8" ANGLE	VINYL ESTER
J PLATFORM STRUCTURAL	6" X 1-1/8" X 2" CHANNEL	VINYL ESTER
K PLATFORM KNEE BRACING	3" X 3" X 3/8" ANGLE	VINYL ESTER
L MOULDED GRATING WITH GRIT	1.5" THICK WITH 1.5" X 1.5" GRID	VINYL ESTER
M BOLTING HARDWARE	316 STAINLESS STEEL	



VIEW A-A

VIEW B-B

VIEW C-C

International Grating & Flanges, Inc.

Harrison, Arkansas 72602-2477  
Ph: (870) 741-6500  
Fax: (870) 741-6512

REVISIONS	DATE:	BY:
-	-	-
-	-	-

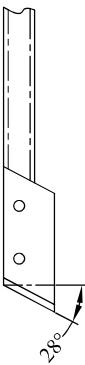
SCALE	NTS	APPROVED BY:	DRAWN BY:
			4H

DATE:	5-10-2005	SHEET NO. 4	QUOTE 3781

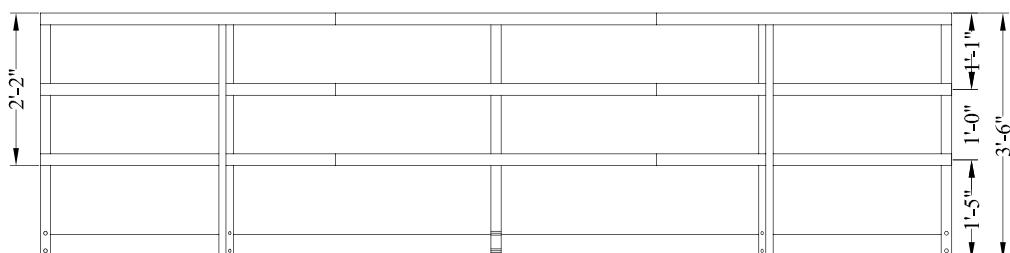
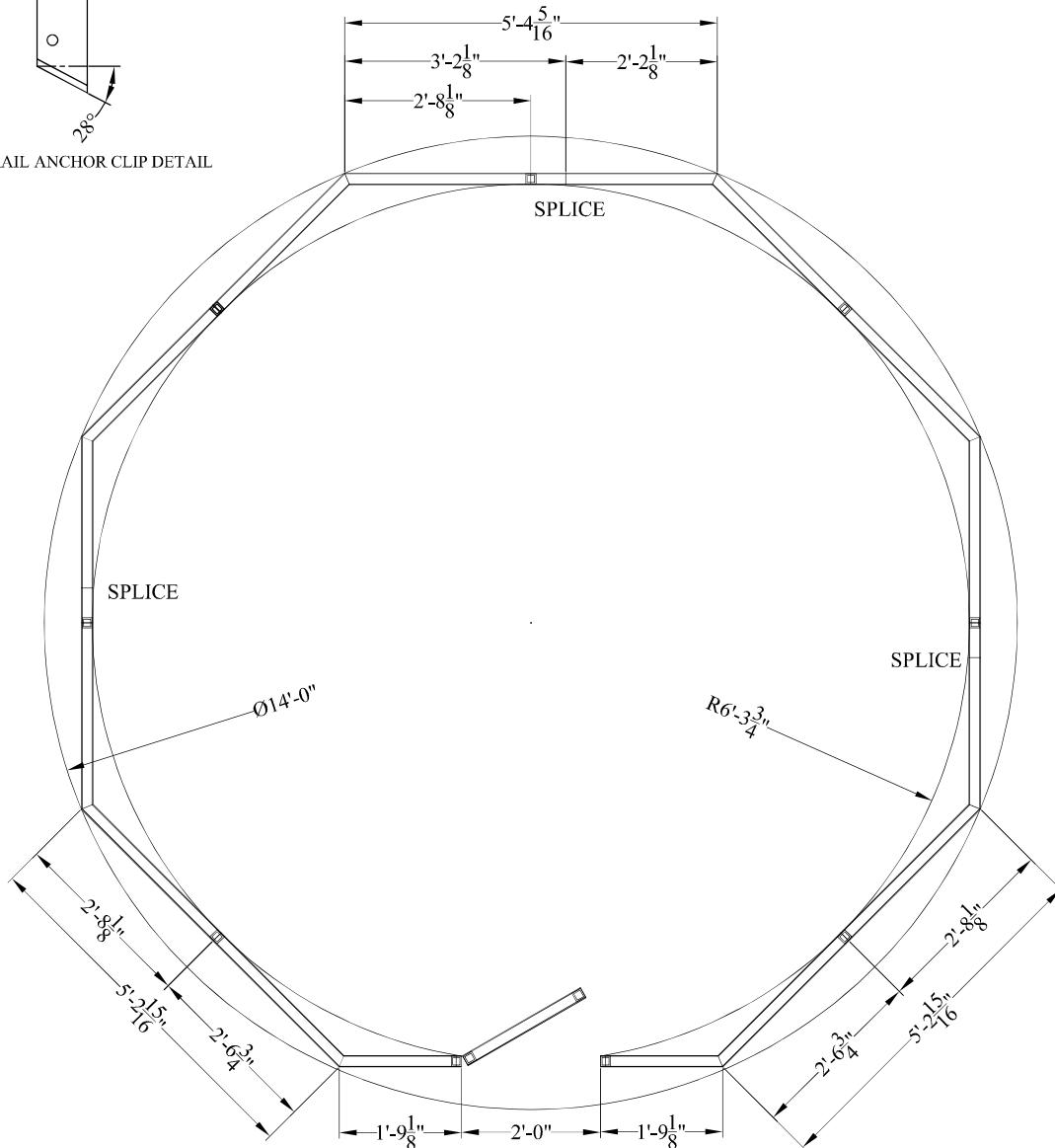
REV. NO. 0			

# BILL OF MATERIALS

	DESCRIPTION	MATERIAL	RESIN
A	HANDRAIL POSTS	1-3/4" X 1/4" SQUARE TUBE	VINYL ESTER
B	HANDRAIL RAILS	2" X 2" X 1/8" SQUARE TUBE	VINYL ESTER
C	HANDRAIL ANCHOR CLIPS	FRP ANGLE	VINYL ESTER
D	TOEPLATE CIRCULAR	4" X 1/8" FLAT STRIP	VINYL ESTER
E	BOLTING HARDWARE	316 STAINLESS STEEL	



HANDRAIL ANCHOR CLIP DETAIL



**International Grating & Flanges, Inc.**

P.O. Box 2477  
Ph: (870) 741-6500

Harrison, Arkansas 72602-2477  
Fax: (870) 741-6512

## REVISIONS :

SCALE	NTS	APPROVED BY:	DRAWN BY:
DATE: 5-19-2025			AH

DANIEL COMPANY  
5013 HILO

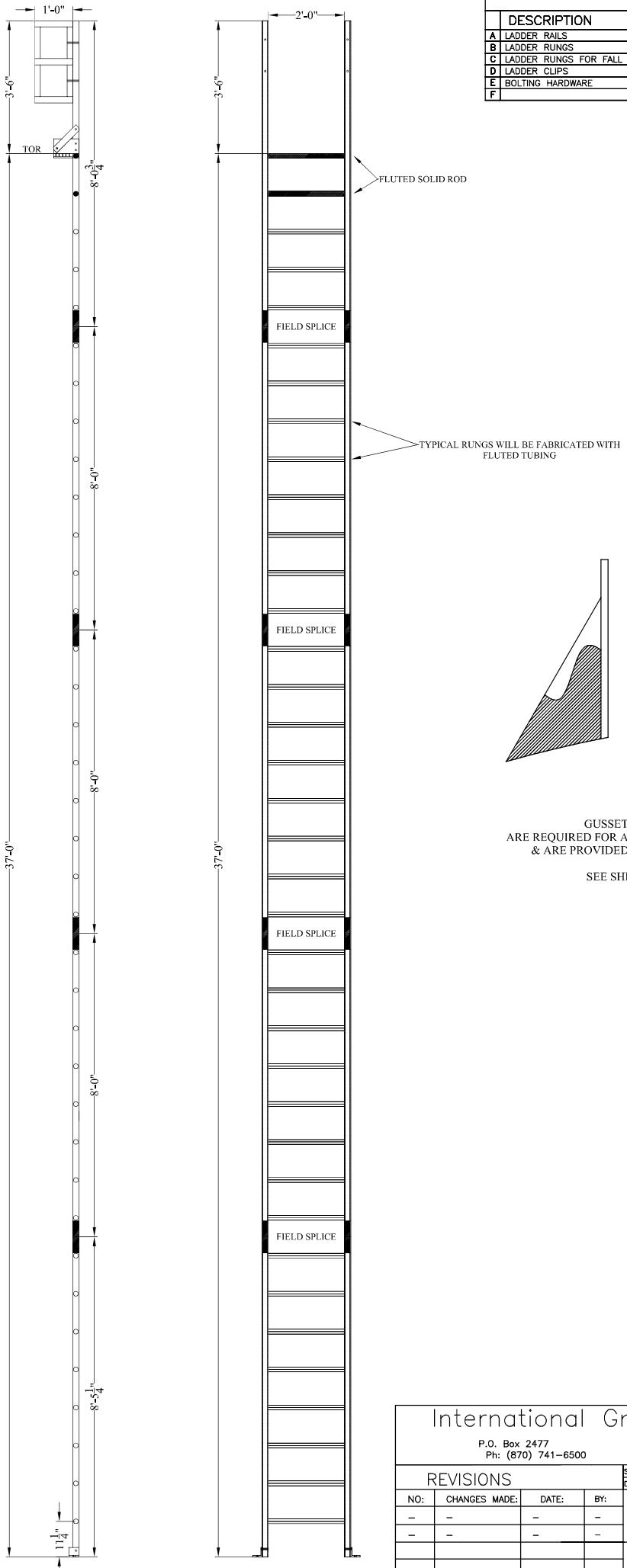
TOP HANDRAIL  
14'-0"Ø 3-RAIL WITH  
SAFETY GATE

SHEET  
NO. 5

QUOTE 3781  
REV. NO. 0

## BILL OF MATERIALS

DESCRIPTION	MATERIAL	RESIN
A LADDER RAILS	2" X 4" SQUARE TUBE	VINYL ESTER
B LADDER RUNGS	1-1/2" FLUTED ALL AROUND	VINYL ESTER
C LADDER RUNGS FOR FALL PROT.	1-1/2" FLUTED SOLID ROD	VINYL ESTER
D LADDER CLIPS	SEE DETAIL SHEET 7	VINYL ESTER
E BOLTING HARDWARE	316 STAINLESS STEEL	
F		



GUSSETED LADDER CLIPS  
ARE REQUIRED FOR ALL FALL PROTECTION LADDERS  
& ARE PROVIDED FOR BY DANIEL COMPANY

SEE SHEET 7 FOR DETAIL

International Grating & Flanges, Inc.

P.O. Box 2477  
Ph: (870) 741-6500

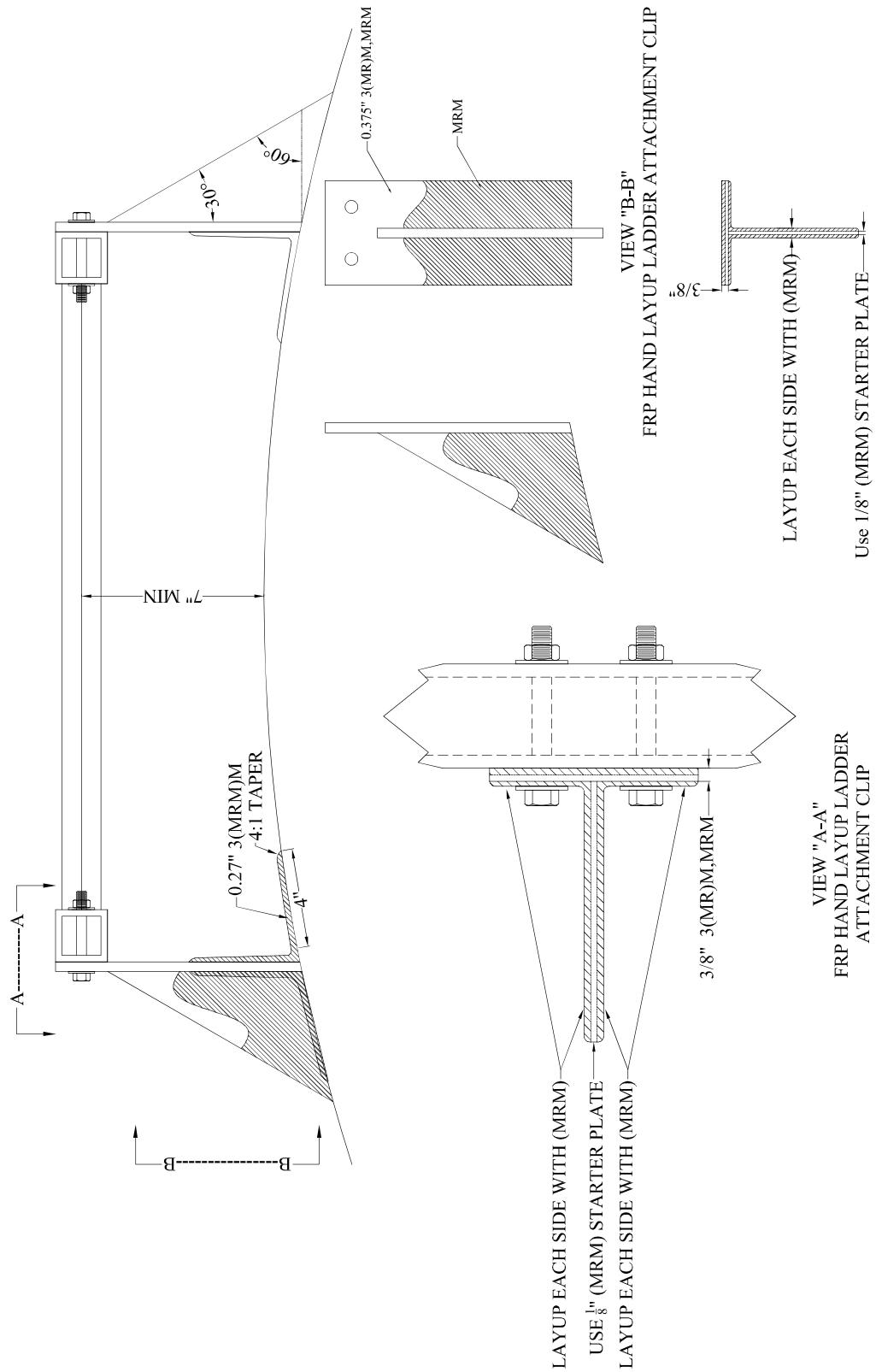
Harrison, Arkansas 72602-2477  
Fax: (870) 741-6512

REVISIONS

NO: CHANGES MADE: DATE: BY:

- - - - -

- - - - -



**International Grating & Flanges, Inc.**

P.O. Box 2477  
Harrison, Arkansas 72602-2477  
Ph: (870) 741-6500  
Fax: (870) 741-6512

DRAWN BY:  
AH

GUSSETED LADDER ATTACHMENT CLIPS  
ARE REQUIRED FOR ALL FALL PROTECTION LADDERS  
PROVIDED FOR BY DANIEL COMPANY

REVISIONS	:	SCALE	NTS	APPROVED BY:	DRAWN BY:
NO.	CHANGES MADE:	DATE:	BY:		AH
-	-	-	-		
-	-	-	-		
				GUSSETED LADDER ATTACHMENT CLIP	SHEET NO. 7
					QUOTE 3781
					REV. NO. 0

## **SECTION 8**

### **RECIRCULATION PUMPS & ACCESSORIES**



QUOTE NO:  
CUSTOMER:  
FTI PART NUMBER: UC1516AECSSEF52521XX

DATE: 8/7/2024  
CUSTOMER REF NUMBER:  
SIZE: 1.5" x 1" x 6"

DESIGN FLOW: 80 GPM

DESIGN HEAD: 90 FT

FLUID: Sodium Hydroxide, 10%

MINIMUM FLOW: 5GPM

MAXIMUM PRESSURE: 175 PSI

SPECIFIC GRAVITY: 1.11

TEMPERATURE: 68 F

IMPELLER TYPE: CLOSED

SPEED: 3500 RPM

VISCOSITY: 1 cSt

MINIMUM IMPELLER DIAMETER: 4 INCH



MAXIMUM IMPELLER DIAMETER: 6.375 INCH  
NON-OVERLOADING POWER: 9.78 HP

DESIGN IMPELLER DIAMETER: 5.25 INCH

HEAD @ DESIGN FLOW: 92.4 FEET

EFFICIENCY @ DESIGN FLOW: 47 PERCENT

POWER @ DESIGN FLOW: 4.4 HP

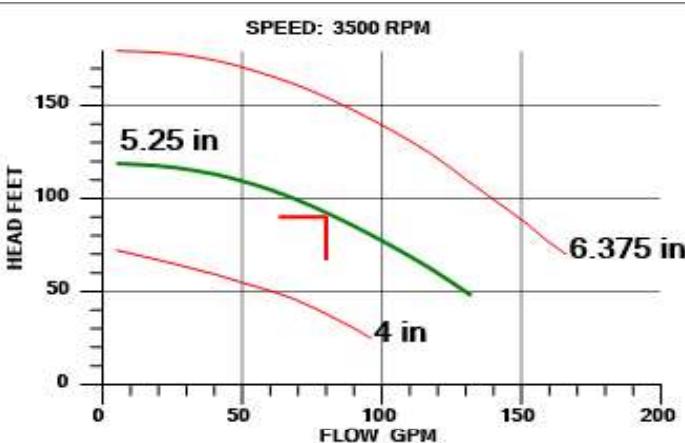
NPSHR @ DESIGN FLOW: 5.5 FEET

NOL POWER: 5.1 HP

SHUT OFF HEAD: 118.9 FEET

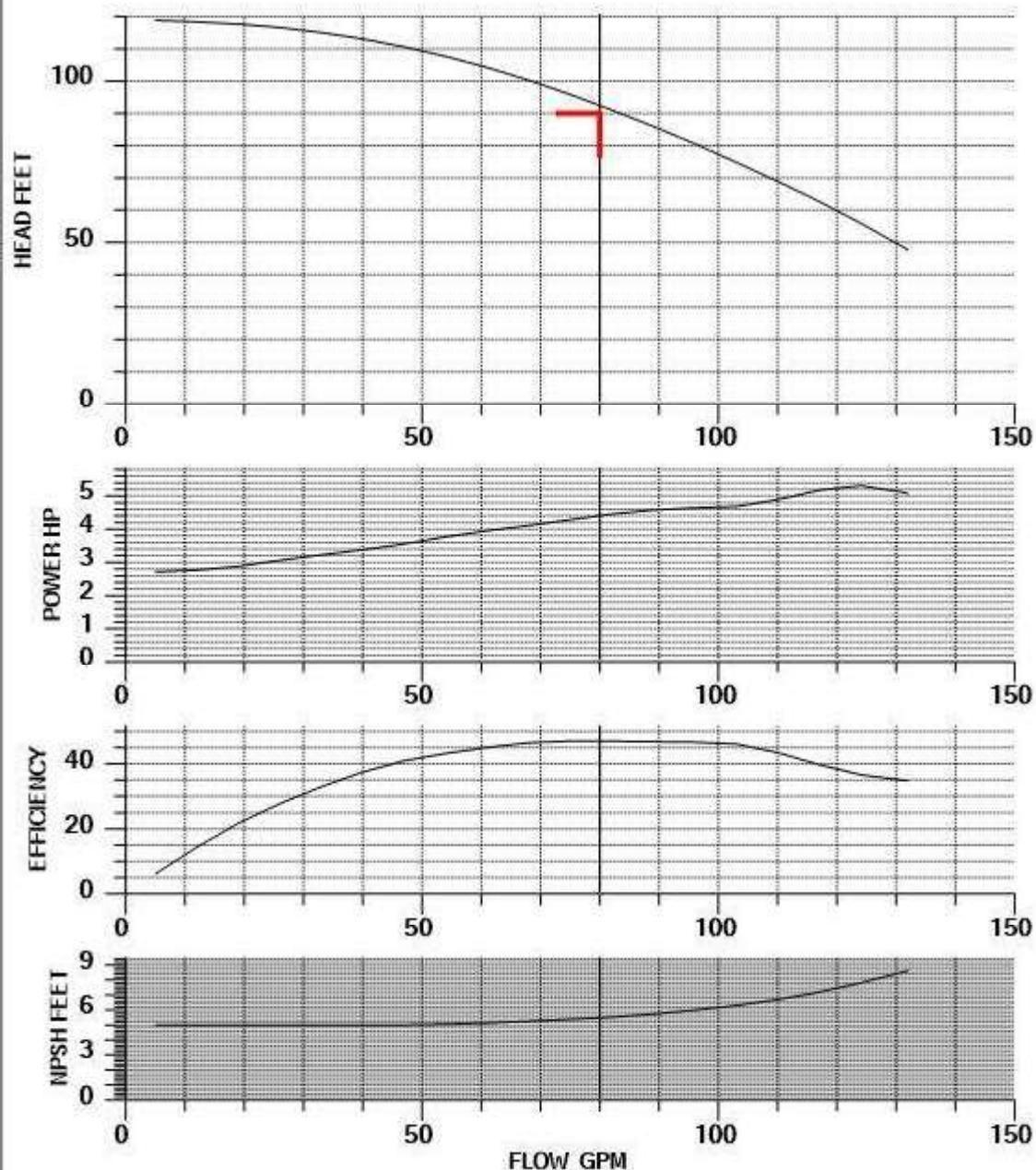
SHUT OFF PRESSURE: 57.2 PSI

BEP: 47 PERCENT @ 75 GPM



7-1/2hp, 3450rpm, 3ph, 60hz, NEMA 213TC IEEE841 Chem-duty motor with 120V SH & RTD's mod

**Model: UC1516 Diameter: 5.25 Inches (Closed) Discharge: 1 Inches Speed: 3500 RPM**  
**Viscosity: 1 Centistokes Trimmed Diameter: 5.25 SG 1.11**  
**Part Number UC1516AECSSEF52521XX**



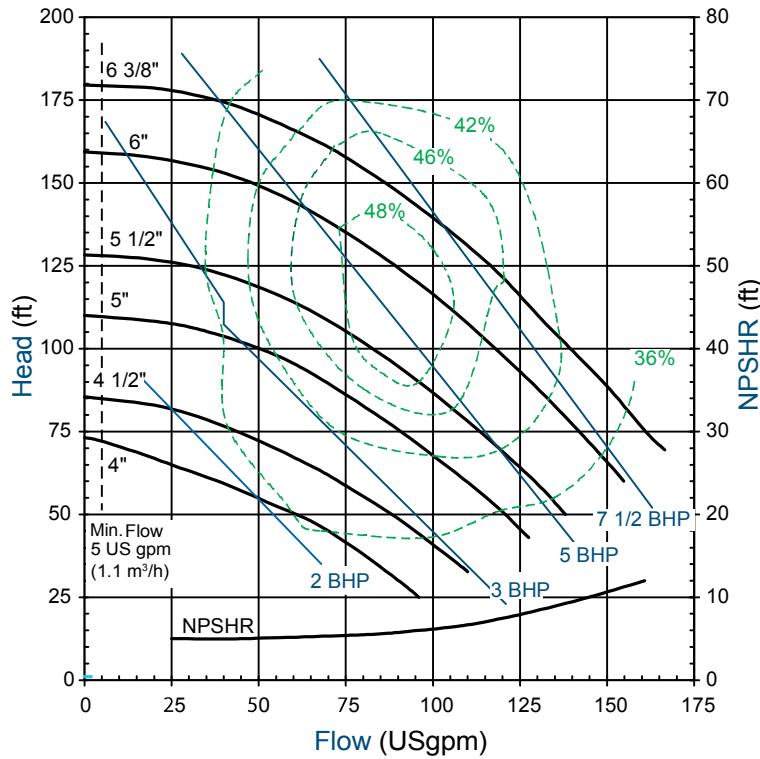


# UC SERIES

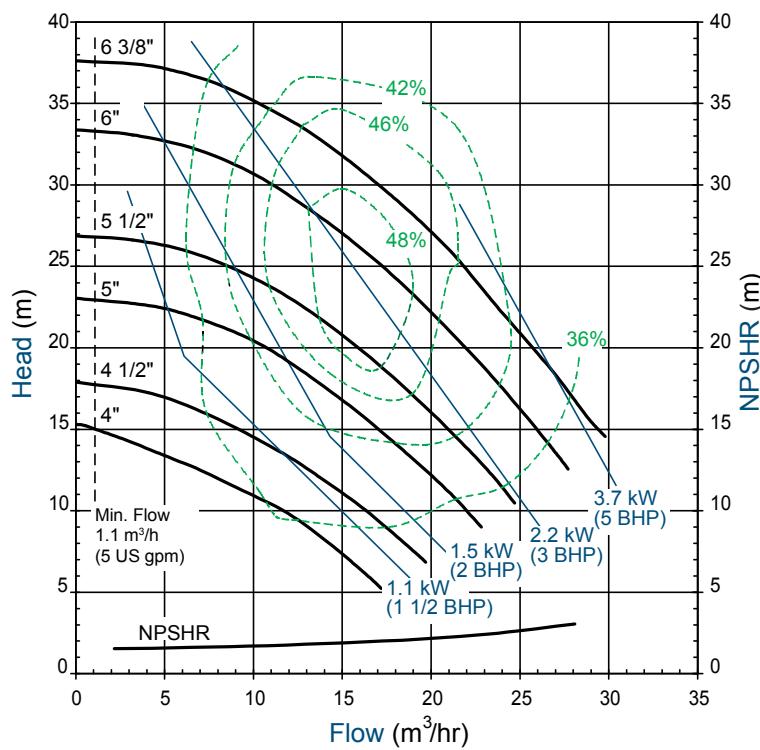
## MODEL UC1516 (AA - 1-1/2X1X6)



### UC1516 PERFORMANCE 3500 RPM, 60 Hz



### UC1516 PERFORMANCE 2900 RPM, 50 Hz



### FEATURES

- Durable, corrosion-resistant ETFE lined ductile iron casing
- Casing meets ANSI B73.1m & B73.3 for foot and flange location
- Powerful neodymium magnets for dependable, leak-free operation
- Modified concentric volute reduces radial thrust load
- Rear sealing ring and balance holes balance axial thrust
- Dual bushings provide optimum alignment
- Suction shaft support with integral straightening vanes
- Easy-set measurement free outer drive
- Back pull-out design
- Exclusive vapor protection package to protect outer magnetic drive and motor face from corrosive fumes
- Replaceable 2-piece impeller and drive hub
- Run dry capability with carbon or Dri-Coat SiC bushing
- Casing drain standard
- Specific gravity over 1.8
- Accepts standard NEMA 143-286 or IEC 90-160 motor frames
- ANSI or ISO flange mountable
- ATEX certified models available



### TYPICAL APPLICATIONS

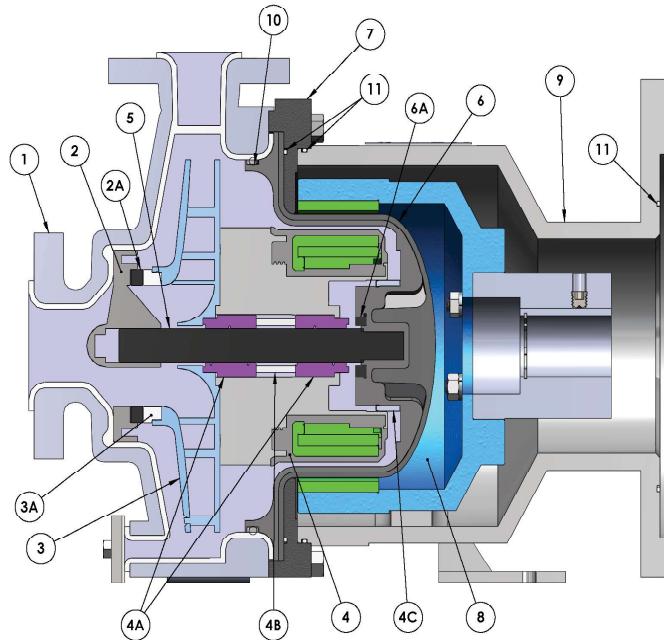
- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li>Paper Mills</li> <li>Water treatment</li> <li>Plating &amp; metal finishing</li> <li>Chemical manufacturing, blending, distribution</li> </ul> | <ul style="list-style-type: none"> <li>Fume scrubbers</li> <li>Pharmaceuticals</li> <li>Truck loading/unloading</li> <li>Metals manufacturing</li> </ul> |
|---|--|

### TYPICAL CHEMICALS

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>Sodium hydroxide</li> <li>Sulfuric acid</li> <li>Hydrochloric acid</li> <li>Sodium hypochlorite</li> </ul> | <ul style="list-style-type: none"> <li>Plating solutions</li> <li>Corrosive blends</li> <li>Solvents</li> <li>Wastewater</li> </ul> |
|---|---|

# UC SERIES

Item No.	Description	Construction
1	Casing	Cast ductile iron, ETFE lined
2	Shaft support	Carbon fiber filled ETFE
2A	Front thrust ring	Alpha sintered silicon carbide
3	Impeller	Carbon fiber filled ETFE
3A	Impeller thrust washer	Fluorosint® or alpha sintered silicon carbide
4	Inner drive	Neodymium iron boron magnets encapsulated in ETFE
4A	Bushing	Alpha sintered silicon carbide, Dri-Coat silicon carbide, or carbon
4B	Bushing spacer	PTFE
4C	Rear sealing ring	GF molybdenum disulfide-filled PTFE
5	Shaft	Alpha sintered silicon carbide
6	Barrier	Molded carbon fiber filled ETFE liner with woven glass reinforced vinyl ester external shell
6A	Barrier thrust ring	Alpha sintered silicon carbide
7	Clamp ring	Steel
8	Outer drive magnet	Nickel-plated neodymium iron boron magnets/steel
9	Motor adapter	Ductile iron
10	O-ring	FKM, EPDM, Kalrez®, Simriz®, or Aflas®
11	Vapor Protection O-Rings	Buna



Kalrez® is a registered trademark of DuPont Performance Elastomers  
 Simriz® Perfluoroelastomer is a registered trademark of Simrit® division of Freudenberg-NOK.  
 Aflas® is a trademark of the Asahi Glass Co., Ltd.  
 Fluorosint® is a registered trademark of Quadrant DSM Engineering Plastic Products.

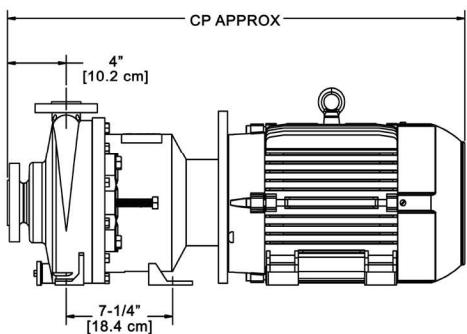
## SPECIFICATIONS

HP (kW)	Impeller Diameter	Suction	Discharge	Max. Flow 3500 rpm		Max. Head 3500 rpm		Max. Working Pressure psi (Bar)	Max. Viscosity cP	Max. Specific Gravity	Max. Temp. °F (°C)
				in (cm)	in (cm)	gpm	m³/hr				
3 - 30 (1.1 - 22.0)	4 - 6 3/8 (10.2 - 16.2)	1 1/2 (3.81)	1 (2.54)	167	37.9	180	55	175 (12)	200	1.8	250 (121)

Note: Impeller trims available every 1/8" (.32 cm) between the smallest and largest diameters.

## DIMENSIONS

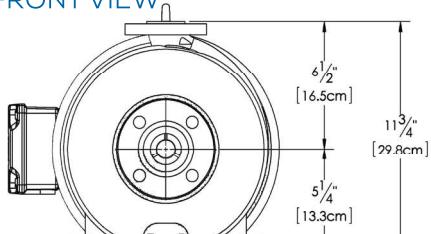
### SIDE VIEW



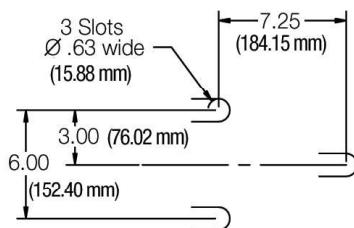
ANSI 150# & ISO/DIN PN20 flanges are in compliance with bolting dimensions only.

Motor Frames	CP (approx.)	
	(in)	(cm)
<b>NEMA</b>		
143-145TC	23-17/32	59.8
182/184TC	28-3/32	71.3
213/215TC	31-5/32	79.1
254/256TC	34-9/32	81.7
284/286TSC	36-11/16	93.2
<b>IEC</b>		
90	23-19/32	59.9
100/112	25-1/32	63.6
132	31-3/32	79
160	34-27/32	88.5

### FRONT VIEW



### BOTTOM VIEW



finishthompson.com

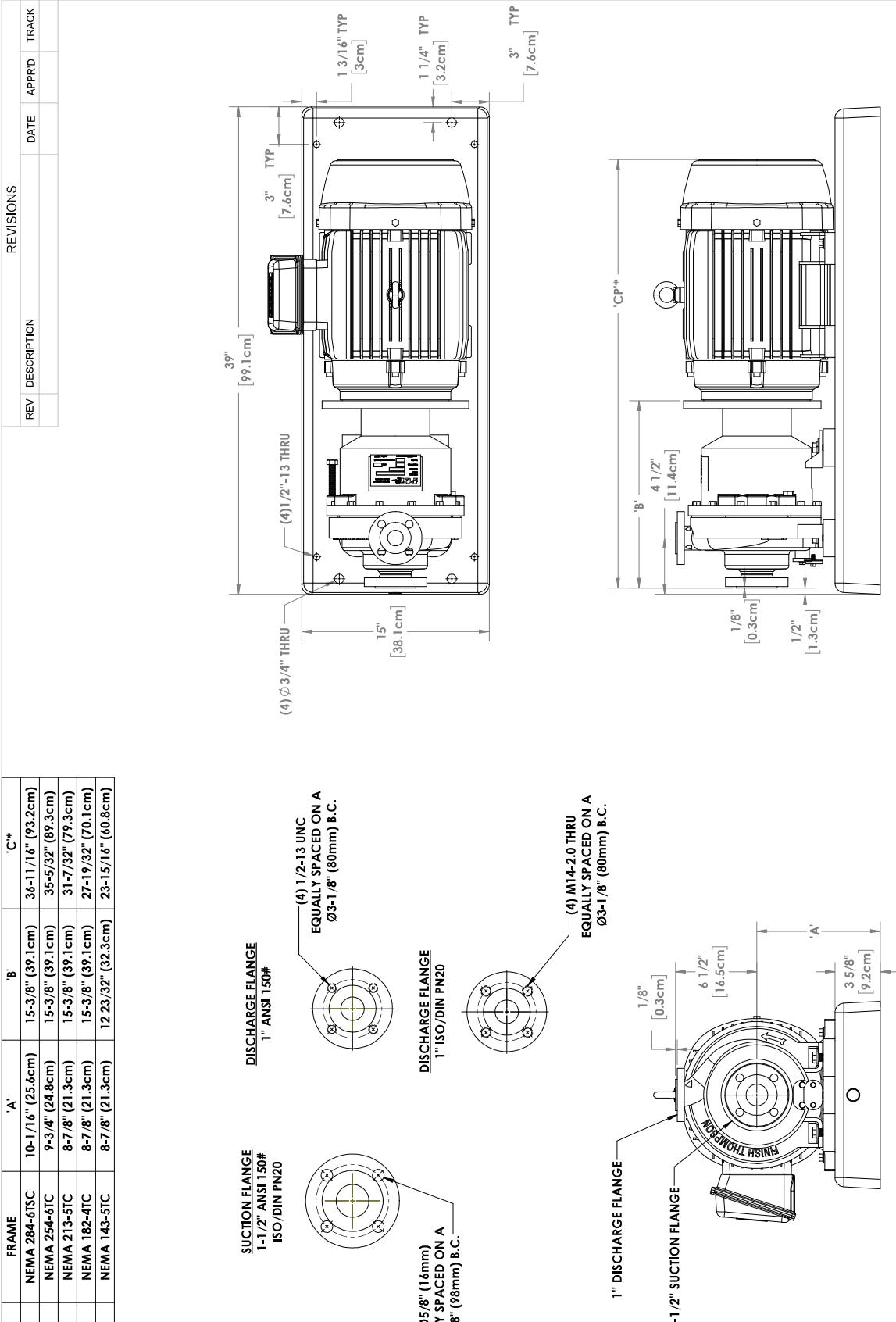
### FINISH THOMPSON INC. - HEADQUARTERS

921 Greengarden Road | Erie, PA 16501  
 800.934.9384 | ph 814.455.4478 | fx 814.455.8518  
 email sales@finishthompson.com

### FINISH THOMPSON INC. - EUROPE CENTER

Otto-Hahn-Strasse 16 | Maintal, D-63477 Germany  
 49 (0)6181-90878-0 | fx 49 (0)6181-90878-18  
 email europecenter@finishthompson.com

PUMP MODEL	FRAME	'A'	'B'	'C'*
UC1516(L)	NEMA 284-6TSC	10-1/16" (25.6cm)	15-3/8" (39.1cm)	36-11/16" (93.2cm)
UC1516(L)	NEMA 254-6TC	9-3/4" (24.8cm)	15-3/8" (39.1cm)	35-5/32" (89.3cm)
UC1516(L)	NEMA 213-5TC	8-7/8" (21.3cm)	15-3/8" (39.1cm)	31-7/32" (79.3cm)
UC1516(L)	NEMA 182-4TC	8-7/8" (21.3cm)	15-3/8" (39.1cm)	27-19/32" (70.1cm)
UC1516(L)	NEMA 143-5TC	8-7/8" (21.3cm)	12 23/32" (32.3cm)	23-15/16" (60.8cm)



REVISIONS	
REV	DESCRIPTION

	PHONE (814) 452-4783 FAX (814) 452-5018
	PHONE (814) 452-4783 FAX (814) 452-5018
UC1516/UC1516L	OUTLINE DIM + BASETEK BASE
REV C	SHEET 1 OF 1
R102065	CHECKED

**NOTES:**

1. DIMENSIONS ARE TO BE USED FOR REFERENCE USE ONLY
2. C\* DIMENSION MAY VARY DEPENDING ON MOTOR MANUFACTURER
3. ANSI 150# AND ISO/DIN PN20 FLANGES ARE INCOMPLIANCE WITH BOLTING DIMENSIONS ONLY

UNLESS OTHERWISE SPECIFIED	DEPT	DEPT	DEPT	DEPT
DIMENSIONS ARE IN INCHES	PUMP ASSM	IN J MOLD	REC'D 201 FRENZ GARDEN ROAD	REC'D 201 FRENZ GARDEN ROAD
TOLERANCES ARE: XX = .005 X = .010 XX/XX = .005/.010 FRAC. = 1/32 DEGREE = 1° BRUSH = 15	STILL ASSM	PURCH	FIRE PINE PENNSYLVANIA 15501	FIRE PINE PENNSYLVANIA 15501
SIGNATURES	WELD SHOP	SALES	PRODUCCT	PRODUCT
DRAWN: TDS	MACH SHOP	ADV	X	X
ENGR:	5/23/16	THIRD ANGLE		
DO NOT SCALE DRAWINGS	CAD GENERATED DRAWING	PROJECTION		



## UC SERIES ACCESSORIES - BASETEK POLYMER CONCRETE BASEPLATES



### FEATURES

- Bases are manufactured of Zanite® Plus, a proprietary polymer concrete material which is a blend of pure silicon dioxide, ceramic quartz aggregate and high strength epoxy resins for exceptional strength and corrosion resistance.
- Superior flatness, 0.002"/foot
- 303 stainless steel cast in place threaded inserts for pump, motor and leveling
- Superior damping compared to conventional steel bases
- Foundation bolt holes
- Standard grout hole
- Integrated drip pan - Sloped towards a 3/4" NPT drainage port
- Meets all engineering specifications for polymer/BaseTek bases
- Custom designed shims with stainless steel hardware for 213/215 and larger (143/145 and 182/184 motors are cantilevered)
- Nine bases cover our entire UC Series offering, custom bases available upon request, including optional red Novolac epoxy
- Unique multi-insert patterns allow two bases to cover UC1516/L, UC1518/L, & UC326 models 140 through 250 frames, one for true NEMA TC and one for non-NEMA TC dimension motors with a different BA dimension (for example where the manufacturer installs a C face on a T frame motor - see table on back)
- Slotted shims allow for mounting both NEMA and non-NEMA motors on all other bases



Base Plate Only & Fully Assembled with Pump (Includes Base Plate, Shims, & Hardware)



BaseTek Polymer Concrete Baseplates for UC Series Pumps				
Description	Frame Size	Base Plate Dimensions (in)	Base Plate Weight (lbs)	Part Number
<b>Base Plate Fully Assembled (Includes Base Plate, Shims, Hardware &amp; Labor)</b>				
For use with models: UC1516/1516L UC1518/1518L UC3156, UC326	143-145TC , 182-184TC	39 x 15 x 3-5/8	160	110552
For use with models: UC1516/1516L UC1518/1518L	213-215TC (BA=4.25)*	39 x 15 x 3-5/8	-	110552-3
	213-215TC WEG (BA=3.5)*	39 x 15 x 3-5/8	-	110552-1
	254-256TC (BA=4.75)*	39 x 15 x 3-5/8	-	110552-4
	254-256TC WEG (BA=4.25)*	39 x 15 x 3-5/8	-	110552-2
	284-286TC/TSC	39 x 15 x 3-5/8	-	110552-5
For use with models: UC3156, UC326	213-215TC (BA=4.25)	39 x 15 x 3-5/8	-	110552-20
	213-215TC WEG (BA=3.5)	39 x 15 x 3-5/8	-	110552-19
	254-256TC (BA=4.75)	39 x 15 x 3-5/8	-	110552-21
	254-256TC WEG (BA=4.25)	39 x 15 x 3-5/8	-	110552-18
	284-286TC/TSC	39 x 15 x 3-5/8	-	110552-22
For use with models: UC2110, UC3158 UC326H, UC328 UC436, UC436L, UC438 UC4310H	143-145TC , 182-184TC	32 x 15 x 3-5/8	127.3	110552-6
	213-215TC	45 x 15 x 3-5/8	184.4	110552-7
	254-256TC	45 x 15 x 3-5/8	184.4	110552-8
	284-286TC/TSC	52 x 18 x 4	288.5	110552-9
	324/326 TC/TSC	52 x 18 x 4	288.5	110552-10
	364/365TC/TSC	52 x 18 x 4	288.5	110552-11
For use with model: UC6410	143-145TC , 182-184TC	32 x 15 x 3-5/8	127.3	110552-12
	213-215TC	45 x 15 x 3-5/8	184.4	110552-13
	254-256TC	45 x 15 x 3-5/8	184.4	110552-14
	284-286TC/TSC	52 x 18 x 4	288.5	110552-15
	324/326 TC/TSC	52 x 18 x 4	288.5	110552-16
	364/365TC/TSC	52 x 18 x 4	288.5	110552-17
For use with all UCII Models	404/405TSC	58 x 21 x 4	395	110552-25
<b>Base Plate Only</b>				
For use with models: UC1516/1516L UC1518/1518L UC3156, UC326	143-145TC , 182-184TC	39 x 15 x 3-5/8	160	110509
For use with models: UC1516/1516L UC1518/1518L	213-215TC (BA=4.25)*	39 x 15 x 3-5/8	160	110510
	213-215TC WEG (BA=3.5)*	39 x 15 x 3-5/8	160	110509
	254-256TC (BA=4.75)*	39 x 15 x 3-5/8	160	110510
	254-256TC WEG (BA=4.25)*	39 x 15 x 3-5/8	160	110509
	284-286TC/TSC	39 x 15 x 3-5/8	160	110555
For use with models: UC3156, UC326	213-215TC (BA=4.25)*	39 x 15 x 3-5/8	160	110715
	213-215TC WEG (BA=3.5)*	39 x 15 x 3-5/8	160	110714
	254-256TC (BA=4.75)*	39 x 15 x 3-5/8	160	110715
	254-256TC WEG (BA=4.25)*	39 x 15 x 3-5/8	160	110714
	284-286TC/TSC	39 x 15 x 3-5/8	160	110716
For use with models: UC2110, UC3158 UC326H, UC328 UC436, UC436L, UC438 UC4310H, UC6410	143-145TC , 182-184TC	32 x 15 x 3-5/8	127.3	110511
	213-215TC	45 x 15 x 3-5/8	184.4	110512
	254-256TC	45 x 15 x 3-5/8	184.4	110516
	284-286TC/TSC	52 x 18 x 4	288.5	110513
	324/326 TC/TSC	52 x 18 x 4	288.5	110514
	364/365TC/TSC	52 x 18 x 4	288.5	110515
For use with all UCII Models	404/405TSC	58 x 21 x 4	395	111255

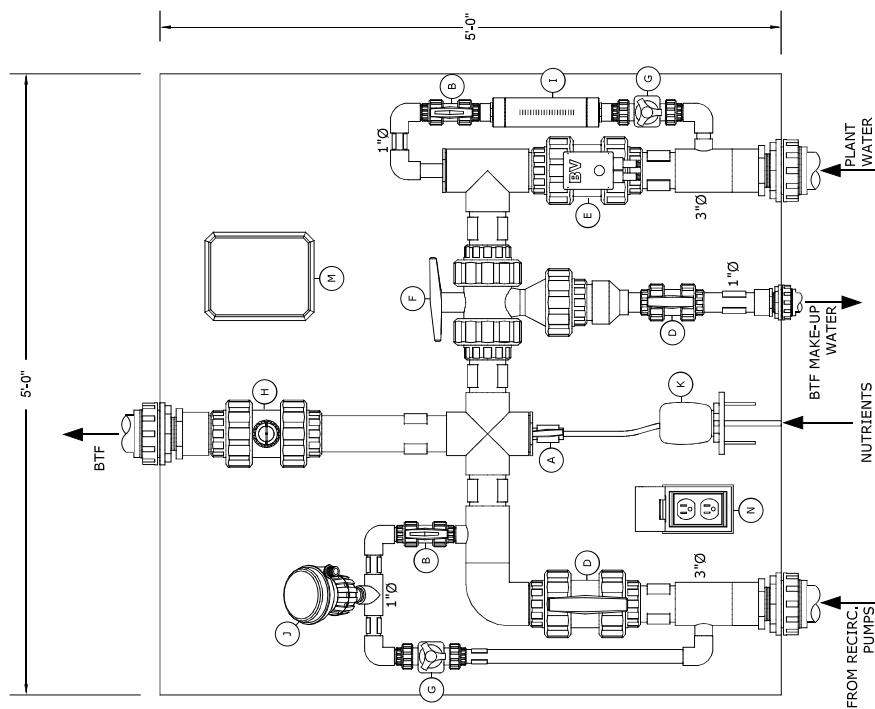
\*If ordering a base plate for 213-256TC frame motors, you must verify the motor's "BA" dimension and order accordingly.

<b>BaseTek Polymer Concrete Baseplates for UC Series Pumps</b>				
Description	Frame Size	Base Plate Dimensions (in)	Base Plate Weight (lbs)	Part Number
<b>Shims &amp; Hardware Only</b>				
For use with models: UC1516/1516L UC1518/1518L UC3156, UC326	143-145TC , 182-184TC	-	-	110551
	213-215TC	-	-	110551-1
	254-256TC	-	-	110551-2
	284-286TC/TSC	-	-	110551-5
For use with models: UC2110, UC3158 UC326H, UC328 UC436, UC436L, UC438 UC4310H	143-145TC , 182-184TC	-	-	110551-6
	213-215TC	-	-	110551-7
	254-256TC	-	-	110551-8
	284-286TC/TSC	-	-	110551-9
	324/326 TC/TSC	-	-	110551-10
	364/365TC/TSC	-	-	110551-11
For use with model: UC6410	143-145TC , 182-184TC	-	-	110551-12
	213-215TC	-	-	110551-13
	254-256TC	-	-	110551-14
	284-286TC/TSC	-	-	110551-15
	324/326 TC/TSC	-	-	110551-16
	364/365TC/TSC	-	-	110551-17
For use with all UCII Models	404/405TSC	-	-	110551-18



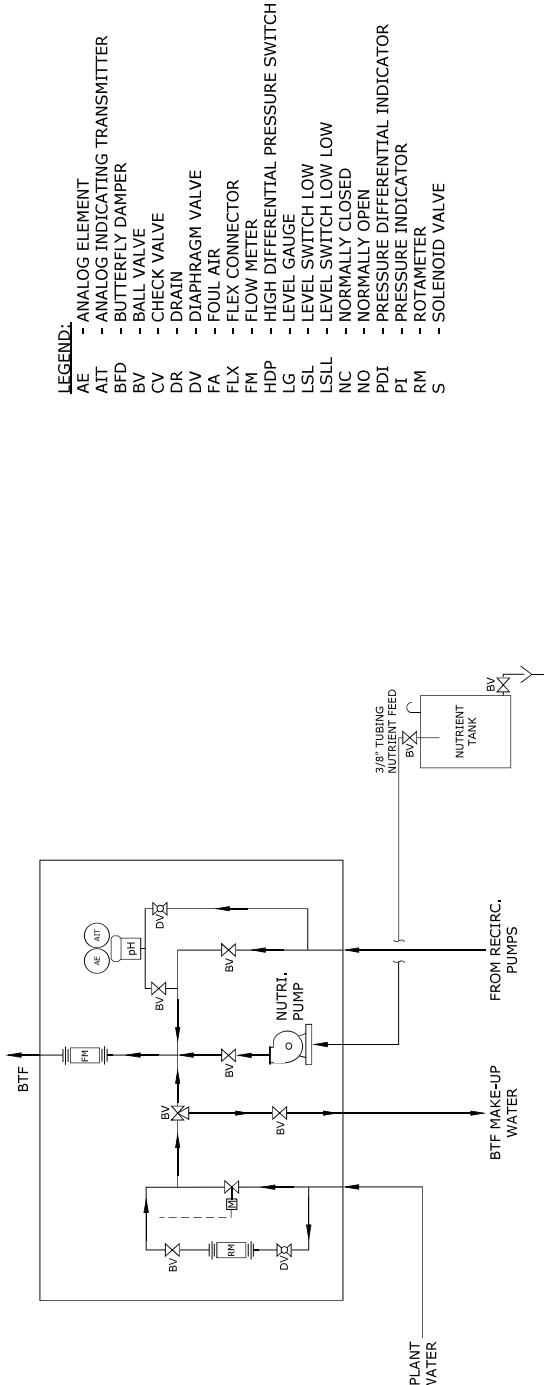
## **SECTION 9**

### **WATER CONTROL PANELS & ACCESSORIES**



## TYP (2)

DWG: WATER CONTROL PANEL	PAGE: 1	DRAWN BY: CB	 DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 ORIGINALS 1" LONG	1" LONG	HILO WWTP DIGESTION, SOLIDS HANDLING, & HEADWORKS IMPROVEMENT PROJECT HEADWORKS ODOR CONTROL 14" BIOTRICKLING FILTER WATER CONTROL PANEL
DIR: 5013 Hilo - Water Panel	DATE: 05/28/2025						LAYOUT REVISED: 7/23/2018



DWG: P&ID	PAGE: 2	DRAWN BY: CB	 <b>DANIEL COMPANY</b> AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 - 1" ORIGINALS 1" LONG	HILO WWTP DIGESTION, SOLIDS HANDLING, & HEADWORKS IMPROVEMENT PROJECT HEADWORKS ODOR CONTROL WATER CONTROL PANEL - P&ID
DIR: 5013 Hilo - Water Panel		DATE: 05/28/2025				LAYOUT REVISED: 7/23/2018

## STAINLESS STEEL TWO-DOOR FLOOR STAND 3-POINT LATCHES TYPE 4X



These two-door enclosures provide industry-leading protection for large components or complex mounting configurations in highly corrosive environments. Three-point latching with the HOFFMAN PowerGlide padlocking handles and a foam-in-place gasket combine convenience with security. They are well-suited for use in petrochemical plants; pulp and paper processing; water treatment facilities; and food, pharmaceutical and packaging applications.

### FEATURES & BENEFITS

Backs are 10 or 12 gauge stainless steel with x-form stiffeners

Seams continuously welded and ground smooth; no holes or knockouts

Removable centerpost for easy panel installation

Collar studs provided for mounting optional panels

Panel supports included

Heavy-duty lifting eyes are Type 316L stainless steel

Heavy-duty 3-point latching mechanism operated by Type 316L stainless steel PowerGlide padlocking handles

Body flange trough collar excludes liquids and contaminants

Heavy-duty stainless steel continuous hinges support each door

Bonding provision on doors; grounding studs on body

Accessory mounting channel provided in enclosure top

Data pocket is high-impact thermoplastic

12-in. (305-mm) removable floor stands are bolted to enclosure

Seamless foam-in-place one-piece gasket provides oil-tight and dust-tight seal against contaminants

External hardware manufactured of Type 316 stainless steel

## SPECIFICATIONS

**Color** Unpainted

**Finish** Brushed #4

**Thickness** 12 ga

Table 1/2

Catalog Number	Height	Width	Depth	Protection Rating	Material	Panel Size
A62H4812SSLP3PT	62.06 in	48.06 in	12.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 304	56.00 x 44.00 in
A62H4812SS6LP3PT	62.06 in	48.06 in	12.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 316L	56.00 x 44.00 in
A62H4818SSLP3PT	62.06 in	48.06 in	18.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 304	56.00 x 44.00 in
A62H4818SS6LP3PT	62.06 in	48.06 in	18.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 316L	56.00 x 44.00 in
A62H6012SSLP3PT	62.06 in	60.06 in	12.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 304	56.00 x 56.00 in
A62H6012SS6LP3PT	62.06 in	60.06 in	12.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 316L	56.00 x 56.00 in
A62H6018SSLP3PT	62.06 in	60.06 in	18.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 304	56.00 x 44.00 in
A62H6018SS6LP3PT	62.06 in	60.06 in	18.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 316L	56.00 x 44.00 in

<b>Catalog Number</b>	<b>Height</b>	<b>Width</b>	<b>Depth</b>	<b>Protection Rating</b>	<b>Material</b>	<b>Panel Size</b>
A74H6012SSLP3PT	74.06 in	60.06 in	12.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 304	68.00 x 56.00 in
A74H6012SS6LP3PT	74.06 in	60.06 in	12.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 316L	68.00 x 56.00 in
A74H6018SSLP3PT	74.06 in	60.06 in	18.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 304	68.00 x 56.00 in
A74H6018SS6LP3PT	74.06 in	60.06 in	18.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 316L	68.00 x 56.00 in
A74H7212SSLP3PT	74.06 in	72.06 in	12.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 304	68.00 x 68.00 in
A74H7212SS6LP3PT	74.06 in	72.06 in	12.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 316L	68.00 x 68.00 in
A74H7218SSLP3PT	74.06 in	72.06 in	18.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 304	68.00 x 68.00 in
A74H7218SS6LP3PT	74.06 in	72.06 in	18.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 316L	68.00 x 68.00 in
A74H7224SSLP3PT	74.06 in	72.06 in	24.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 304	68.00 x 68.00 in
A74H7224SS6LP3PT	74.06 in	72.06 in	24.06 in	NEMA Type 12; NEMA Type 13; NEMA Type 4; NEMA Type 4X; NEMA Type 3; NEMA Type 3R; IP66	Stainless Steel 316L	68.00 x 68.00 in

Table 2/2

<b>Catalog Number</b>	<b>Conductive Panel</b>	<b>Panel</b>	<b>Stainless Steel Type</b>
-----------------------	-------------------------	--------------	-----------------------------

A62H4812SSLP3PT	A60P48G	A60P48	304
A62H4812SS6LP3PT	A60P48G	A60P48	316L
A62H4818SSLP3PT	A60P48G	A60P48	304
A62H4818SS6LP3PT	A60P48G	A60P48	316L
A62H6012SSLP3PT	A60P60G	A60P60	304
A62H6012SS6LP3PT	A60P60G	A60P60	316L
A62H6018SSLP3PT	A60P60G	A60P60	304
A62H6018SS6LP3PT	A60P60G	A60P60	316L
A74H6012SSLP3PT	A72P60G	A72P60	304
A74H6012SS6LP3PT	A72P60G	A72P60	316L
A74H6018SSLP3PT	A72P60G	A72P60	304
A74H6018SS6LP3PT	A72P60G	A72P60	316L
A74H7212SSLP3PT	A72P72G	A72P72	304
A74H7212SS6LP3PT	A72P72G	A72P72	316L
A74H7218SSLP3PT	A72P72G	A72P72	304
A74H7218SS6LP3PT	A72P72G	A72P72	316L
A74H7224SSLP3PT	A72P72G	A72P72	304
A74H7224SS6LP3PT	A72P72G	A72P72	316L

Purchase panels separately.

2100 Hoffman Way  
Anoka, MN 55303-1745 | USA  
763.421.2240



Our powerful portfolio of brands:  
**nVent.com CADDY ERICO HOFFMAN RAYCHEM SCHROFF TRACER**

© 2022 nVent. All nVent marks and logos are owned or licensed by nVent Services GmbH or its affiliates. All other trademarks are the property of their respective owners.

nVent reserves the right to change specifications without notice.



## Valves Technical True Union 2000 Standard Ball Valves



### Sample Engineering Specification

All thermoplastic ball valves shall be True Union 2000 Standard type manufactured to ASTM F 1970 and constructed from PVC Type I, ASTM D 1784 Cell Classification 12454 or CPVC Type IV, ASTM D 1784 Cell Classification 23447. All O-rings shall be EPDM or FKM. All valves shall have Safe-T-Shear® stem with O-ring stem seal. All handles shall be polypropylene. All union nuts shall have Buttress threads. All seal carriers shall be Safe-T-Blocked®. All EPDM valves shall be certified by NSF® International for use with potable water. All 1/2" - 2" valves shall be pressure rated to 235 psi, all 2-1/2" - 4" and all flanged valves to 150 psi for water @ 73°F, as manufactured by Spears® Manufacturing Company.

### Quick-View Valve Selection Chart

Valve Size	O-ring Material	PVC Part Number <sup>1</sup>					Pressure Rating
		Socket	Threaded	SR Threaded	Flanged	Spigot	
1/2	EPDM	3629-005	included	3621-005SR	3623-005	3627-005	235 psi Non-Shock Water @ 73°F
	FKM	3639-005	included	3631-005SR	3633-005	3637-005	
3/4	EPDM	3629-007	included	3621-007SR	3623-007	3627-007	(Flanged 150 psi Non-Shock Water @ 73°F)
	FKM	3639-007	included	3631-007SR	3633-007	3637-007	
1	EPDM	3629-010	included	3621-010SR	3623-010	3627-010	
	FKM	3639-010	included	3631-010SR	3633-010	3637-010	
1-1/4	EPDM	3629-012	included	3621-012SR	3623-012	3627-012	
	FKM	3639-012	included	3631-012SR	3633-012	3637-012	
1-1/2	EPDM	3629-015	included	3621-015SR	3623-015	3627-015	
	FKM	3639-015	included	3631-015SR	3633-015	3637-015	
2	EPDM	3629-020	included	3621-020SR	3623-020	3627-020	
	FKM	3639-020	included	3631-020SR	3633-020	3637-020	
2-1/2	EPDM	3622-025	3621-025	3621-025SR	3623-025	3627-025	
	FKM	3632-025	3631-025	3631-025SR	3633-025	3637-025	
3	EPDM	3622-030	3621-030	3621-030SR	3623-030	3627-030	150 psi Non-Shock Water @ 73°F
	FKM	3632-030	3631-030	3631-030SR	3633-030	3637-030	
4	EPDM	3622-040	3621-040	3621-040SR	3623-040	3627-040	
	FKM	3632-040	3631-040	3631-040SR	3633-040	3637-040	

1: For CPVC valve, add the letter "C" to the part number (e.g., 3629-005C, 3621-005CSR)

### Features — PVC, CPVC

Economical, low profile quarter-turn shutoff valve is excellent for general purpose and many O.E.M applications. PVC and CPVC valves are available in IPS sizes 1/2" through 4" with socket, regular thread, SR threaded (Special Reinforced), flanged or spigot end connectors.

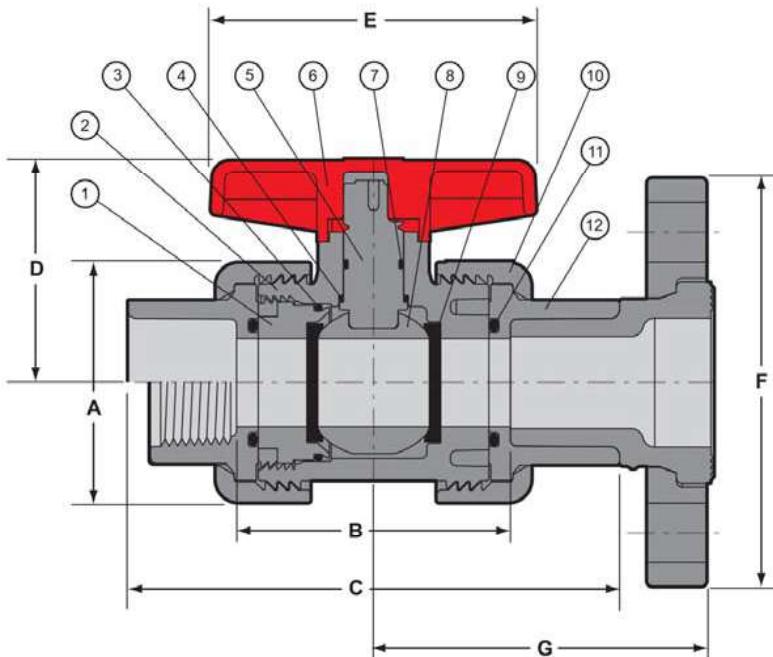
- Chemical & Corrosion Resistant PVC or CPVC Construction
- Interchangeable with all True Union 2000 Valves, Mates with Union 2000 Pipe Unions
- High Impact Polypropylene Handle
- Schedule 80 Full-Port Design
- Strong, Buttress Thread Union Nuts
- Spears® Single O-ring Safe-T-Shear® Stem Design
- Spears® Safe-T-Blocked® Seal Carrier
- Replaceable PTFE/HDPE Floating Seat Design
- EPDM or FKM O-rings
- Sizes 1/2" - 2" pressure rated to 235 psi @ 73°F
- Sizes 2-1/2" - 4" and all flanged pressure rated to 150 psi @ 73°F
- EPDM valves NSF® Certified for Potable Water use
- Suitable for Vacuum Service
- Assembled with Silicone-Free, Water Soluble Lubricants
- Manufactured to ASTM F 1970

### Optional Accessories\*

- Retro-Fit End Connector Sets for Valve Replacement
- Split-Nut Repair Kits for Union Nut Replacement
- Supplemental End Connectors
- Round Safety Handles
- Stem Extension Kits
- Square Operator Nuts
- Multi Mount Valve/ Actuation Mounting Kits
- Mini-Mount Actuation Mounting Kits

\* See "**BALL VALVE ACCESSORIES**" section for details of individual products.

**Valves Technical**  
**True Union 2000 Standard Ball Valves**



### Replacement Parts

No.	Component	Qty.	Material
1	Seal Carrier	1	PVC/CPVC
2	Body	1	PVC/CPVC
3	Carrier O-ring	1	EPDM/FKM
4	Stem Bearing <sup>1,2</sup>	1	PP
5	Stem	1	PVC/CPVC
6	Handle	1	PP
7	Stem O-ring	1	EPDM/FKM
8	Ball	1	PVC/CPVC
9	Seat	2	PTFE/HDPE
10	Union Nut	2	PVC/CPVC
11	End Connector O-ring	2	EPDM/FKM
12	End Connector	2	PVC/CPVC

1: O-Ring up to 2"

2: PTFE Thrust Bearing: 2-1/2", 3" & 4"

3: An additional O-ring is used behind each seat on 2-1/2" or larger.

### Dimensions, Weights, Operating Torque & Cv Values

Nominal Size	A	B <sup>1</sup>		C			D	E	F	G	Approx. Wt. (Lbs.)		Oper. <sup>2</sup> Torque (in. lbs.)	Cv <sup>3</sup> Values	
		Soc/Thd	Spigot	Socket	Thread	Spigot					PVC	CPVC		Soc/Thd/Spig	Flanged
1/2	1-15/16	2-1/2	2-15/16	4-1/4	3-15/16	4-3/4	1-5/8	2-1/2	3-1/2	2-31/32	.33	.35	12	29	18
3/4	2-3/8	2-13/16	3-5/16	4-13/16	4-1/4	5-5/16	2	3	3-7/8	3-5/16	.51	.54	20	63	39
1	2-5/8	2-15/16	3-1/2	5-3/16	4-11/16	5-3/4	2-5/16	3-3/8	4-1/4	3-5/8	.71	.75	25	120	73
1-1/4	3-3/16	3-3/16	3-13/16	5-13/16	5-3/16	6-3/8	2-13/16	3-1/2	4-5/8	4	1.12	1.17	35	243	151
1-1/2	3-9/16	3-9/16	4	6-5/16	5-7/16	6-13/16	3-1/16	3-7/8	5	4-13/16	1.47	1.53	45	357	223
2	4-5/16	4-13/16	5-1/4	7-13/16	6-3/4	8-1/4	3-3/4	4-15/16	6	5-1/4	2.62	2.75	94	599	395
2-1/2	6-3/16	7-1/8	8	10-9/16	9-7/8	11-1/2	5-1/2	7-5/8	7	6-5/8	10.49	7.70	120	856	579
3	6-3/16	7-1/16	8	10-13/16	9-7/8	11-3/4	5-1/2	7-5/8	7-1/2	6-27/32	11.22	7.81	120	1416	974
4	7-3/4	7-3/8	8-7/16	11-7/8	10-3/8	12-15/16	6-1/8	9	9	7-1/2	18.46	12.48	336	2865	1952

1: Valve Lay Length

2: Torque required at valve maximum internal pressure rating, 5ft/sec. Flow velocity; due to adjustment differences during installation, actual valves may vary.

3: Gallons per minute at 1 psi pressure drop. Valves calculated from laying length, based on derivative of Hazen-Williams equation with surface roughness factor of C=150.

### Temperature Pressure Rating

System Operating Temperature °F (°C)			100 (38)	110 (43)	120 (49)	130 (54)	140 (60)	150 (66)	160 (71)	170 (77)	180 (82)	190 (88)	200 (93)	210 (99)
Valve Pressure Rating psi (MPa)	1/2" - 2"	PVC	235 (1.62)	211 (1.45)	150 (1.03)	75 (.52)	50 (.34)	-0- (-0-)	-0- (-0-)	-0- (-0-)	-0- (-0-)	-0- (-0-)	-0- (-0-)	-0- (-0-)
		CPVC	235 (1.62)	219 (1.51)	170 (1.17)	145 (1.00)	130 (.90)	110 (.76)	90 (.62)	80 (.55)	70 (.48)	60 (.41)	50 (.34)	40 (-0-)
	2-1/2" - 4"	PVC	150 (1.03)	135 (.93)	110 (.76)	75 (.52)	50 (.34)	-0- (-0-)	-0- (-0-)	-0- (-0-)	-0- (-0-)	-0- (-0-)	-0- (-0-)	-0- (-0-)
		CPVC	150 (1.03)	140 (.97)	130 (.90)	120 (.83)	110 (.76)	100 (.70)	90 (.62)	80 (.55)	70 (.48)	60 (.41)	50 (.34)	40 (-0-)

# BĀSIKS

## Electrically Actuated Ball Valves

### Standard Actuator Features

- Dome style visual position indicator
- 2 x End of travel confirmation switches for remote indication
- Emergency manual override
- CE Marked, IP67 ingress protection
- Thermally protected motor
- Standard on-off function with optional failsafe or high speed available

### Smart Actuator Features

- Digital position sensing
- Modulating, High-speed and failsafe options
- OLED display
- Programmable features (adjustable features)
- Local Control (Only with power supplied)



NSF PVC or CPVC ball valves with compact Actuators

AC/DC 95V-265V

AC/DC 24V

DC 24V, AC 24V / 110V/230V

### Design & Materials

High performance brushless actuator motor with overload/overheat protection.

Valve body and piping connections are available in PVC or CPVC, with EPDM or Viton seals. Actuator housing is constructed of ABS and is IP67 rated. ISO drive and mounting unit are aluminum. Mounting fasteners are stainless steel. For other materials consult factory.



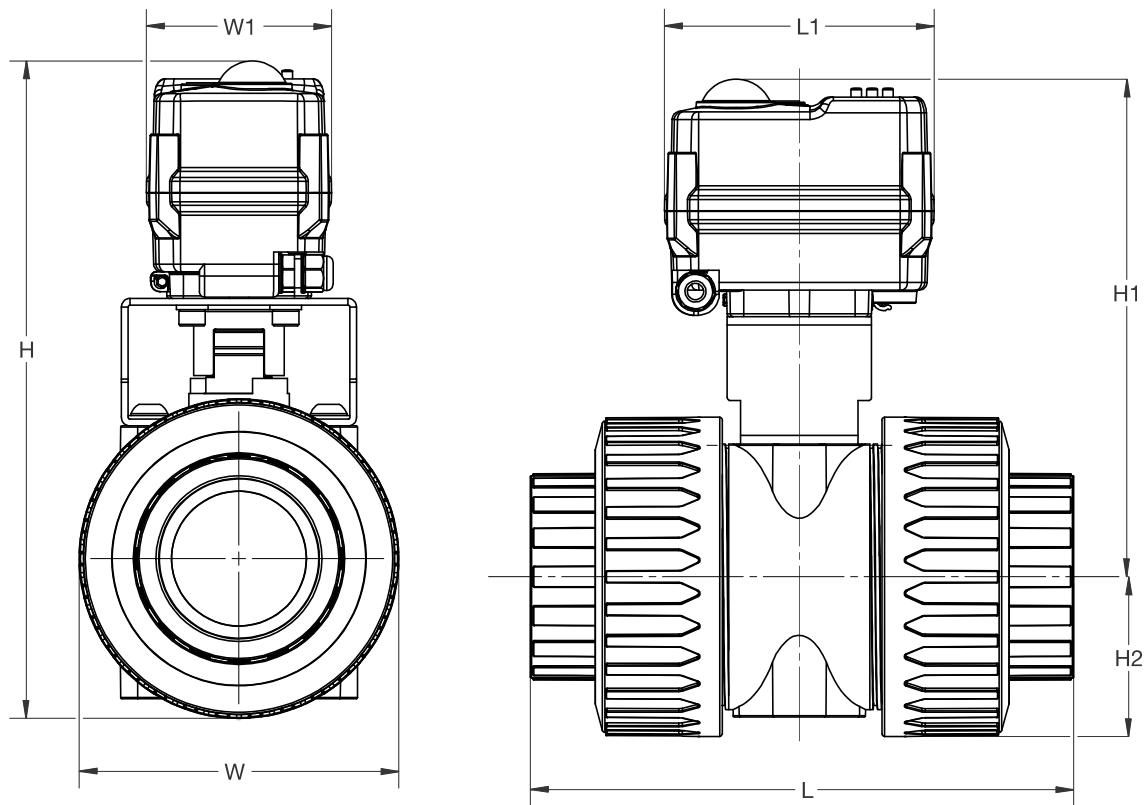
**888-689-8258**

[www.basiks.us](http://www.basiks.us)  
[info@basiks.us](mailto:info@basiks.us)



## Dimensions

1/2" - 2"  
15-50 DIN



MODEL	SIZE		L		L1		H		H1		H2		W		W1	
	IN.	DN	IN.	MM.	IN.	MM.	IN.	MM.	IN.	MM.	IN.	MM.	IN.	MM.	IN.	MM.
EBT-050	1/2"	15	4.5	114.3	4.0	101.6	6.9	175.3	5.7	144.8	1.1	27.9	2.1	53.3	2.8	71.1
EBT-075	3/4"	20	4.9	124.5	4.0	101.6	7.3	185.4	6.0	152.4	1.3	33.0	2.5	63.5	2.8	71.1
EBT-100	1"	25	5.6	142.2	4.0	101.6	7.6	193.0	6.1	154.9	1.4	35.6	2.8	71.1	2.8	71.1
EBT-125	1-1/4"	32	7.0	177.8	4.0	101.6	8.9	226.1	7.0	177.8	1.9	48.3	3.8	96.5	2.8	71.1
EBT-150	1-1/2"	40	7.0	177.8	4.0	101.6	8.9	226.1	7.0	177.8	1.9	48.3	3.8	96.5	2.8	71.1
EBT-200	2"	50	8.0	203.2	4.0	101.6	9.8	248.9	7.4	188.0	2.4	70.0	4.7	119.4	2.8	71.1



**888-689-8258**

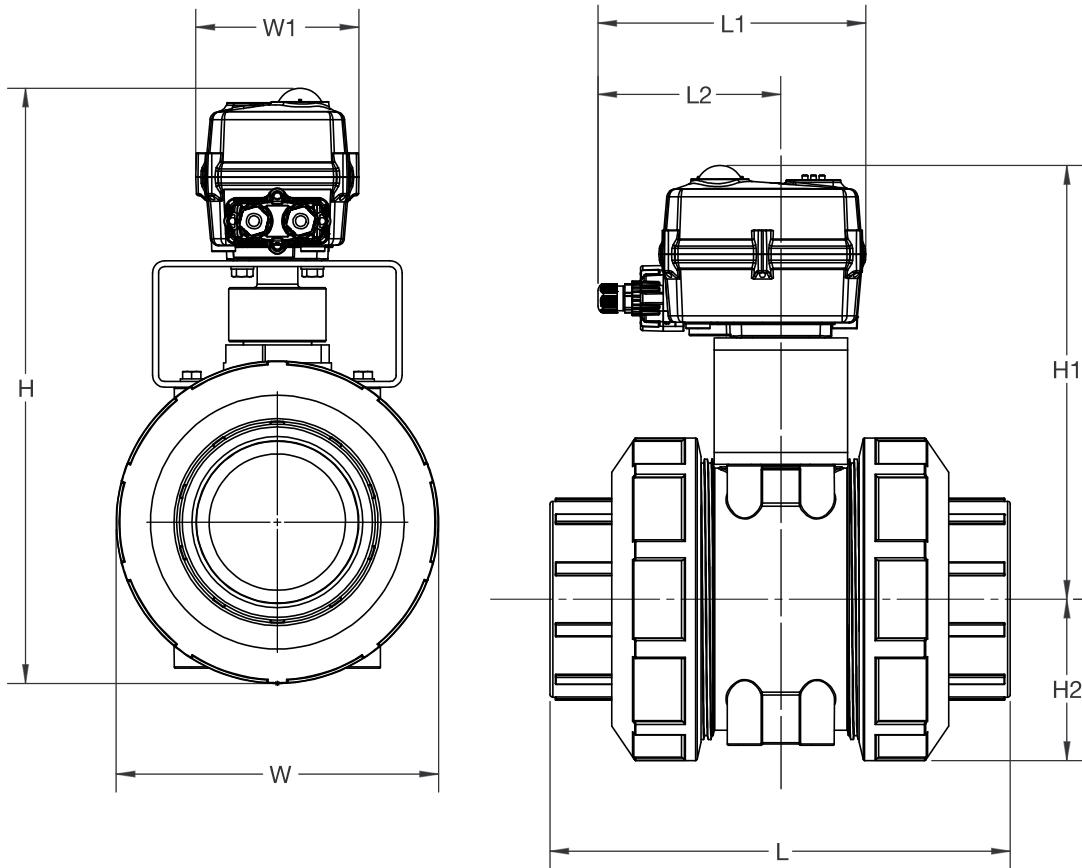
[www.basiks.us](http://www.basiks.us)   [info@basiks.us](mailto:info@basiks.us)

A Value Line by Plast-O-Matic Valves, Inc. • 1384 Pompton Ave., Cedar Grove, NJ 07009 USA

06/18

## Dimensions

3" & 4"/  
80 & 100 DIN



## Information

MODEL	SIZE		L		L1		L2		H		H1		H2		W		W1	
	IN.	DN	IN.	MM.	IN.	MM.	IN.	MM.	IN.	MM.	IN.	MM.	IN.	MM.	IN.	MM.	IN.	MM.
EBT-300	3"	80	10.9	276.9	7.4	188	5.1	129.5	15.0	381	11.2	284.5	3.7	94	7.2	182.9	4.5	115
EBT-400	4"	100	12.8	325.12	7.4	188	5.1	129.5	16.5	419.1	12.0	304.8	4.5	114.3	8.9	226.1	4.5	115



**888-689-8258**

[www.basiks.us](http://www.basiks.us)    [info@basiks.us](mailto:info@basiks.us)

A Value Line by Plast-O-Matic Valves, Inc. • 1384 Pompton Ave., Cedar Grove, NJ 07009 USA

06/18

# Base Actuator Specifications

Sizes		1/2" - 2"		
Actuator	B20	B24	B29	
Model	Open/Close	Open/Close Failsafe	High-Speed Open/Close	
Voltage (AC (1ph) or DC)	DC 12, 24V; AC 24, 110, 230V	DC 24V, AC 95-265	DC 24V	
Working Time - Sec. 0-90° (No Load) ±10%	10s	15s	1s	
Maximum Run / Torque Nm / in./lbs.	20/177	15/133	15/133	
Maximum Break / Torque Nm / in./lbs.	20/177	20/177	15/133	
On/Off Duty Rating %	75	75	75	
IP Rating - IEC 60529	IP67	IP67	IP67	
Working Angle Standard	90°	90°	90°	
Temperature Range (F)	-4° to +140°	-4° to +140°	-4° to +140°	
Motor Switch	2 x SPDT	2 x SPDT	2 x SPDT	
Volt Free End of Travel Confirmation	2 x SPDT	2 x SPDT	2 x SPDT	
Anti-Condensation Heater (W)	5W	2W	2W	
Current Full Load:	12VDC	1A	N/A	N/A
INRUSH CURRENT IS 3X THE STATED LOAD	24VDC	.5A	1.5A	5A
	24V/1ph	.45A	NA	N/A
	110V/1ph	.135A	.18A	N/A
	240V/1PH	.06A	.09A	N/A
	Weight (lbs)	1.37	1.37	1.37

Sizes		3" and 4"		
Actuator	B80	B84	B89	
Model	Open/Close	Open/Close Failsafe	High-Speed Open/Close	
Voltage (AC (1ph) or DC)	DC 12, 24V; AC 24, 110, 230V	DC 24V, AC 24, 95-265V	DC 24V, AC 24, 95-265V	
Working Time - Sec. 0-90° (No Load) ±10%	20s	10s	3-5s	
Maximum Run / Torque Nm / in./lbs.	80 / 708	80 / 708	80 / 708	
Maximum Break / Torque Nm / in./lbs.	90 / 796	90 / 796	90 / 796	
On/Off Duty Rating %	75	75	75	
IP Rating - IEC 60529	IP67	IP67	IP67	
Working Angle Standard	90°	90°	90°	
Temperature Range (F)	-4° to +140°	-4° to +140°	-4° to +140°	
Motor Switch	2 x SPDT	2 x SPDT	2 x SPDT	
Volt Free End of Travel Confirmation	2 x SPDT	2 x SPDT	2 x SPDT	
Anti-Condensation Heater (W)	5W	5W	5W	
Current Full Load:	12VDC	4.5A	N/A	N/A
INRUSH CURRENT IS 3X THE STATED LOAD	24VDC	2.5A	5A	5A
	24V/1ph	2.5A	5A	5A
	110V/1ph	0.6A	1.04A	1.04A
	240V/1PH	.3A	.52A	.52A
	Weight (lbs)	4.85	4.85	4.85

NOTE: Consult factory for 12 volt options.



**888-689-8258**

[www.basiks.us](http://www.basiks.us)   [info@basiks.us](mailto:info@basiks.us)

A Value Line by Plast-O-Matic Valves, Inc. • 1384 Pompton Ave., Cedar Grove, NJ 07009 USA

# Smart Actuator Specifications 1/2" - 2"

Sizes		1/2" and 2"		
Actuator	S20.10	S20.14	S20.19	
Model	Smart Screen High-Speed Open/Close	Smart Screen Failsafe Open/Close	Smart Screen High-Speed Open/Close	
Voltage (AC (1ph) or DC)	24V AC/DC, 95-265 AC/DC	24V AC/DC, 95-265 AC/DC	DC 24V	
Working Time - Sec. 0-90° (No Load) ±10%	10s	15s	1s	
Maximum Run / Torque Nm / in./lbs.	20/177	15/133	15/133	
Maximum Break / Torque Nm / in./lbs.	20/177	20/177	15/133	
On/Off Duty Rating %	75	75	75	
IP Rating - IEC 60529	IP67	IP67	IP67	
Working Angle Standard	90°	90°	90°	
Temperature Range (F)	-4° to +140°	-4° to +140°	-4° to +140°	
Motor Switch	Digital Sensing	Digital Sensing	Digital Sensing	
Volt Free End of Travel Confirmation	Digital Sensing	Digital Sensing	Digital Sensing	
Anti-Condensation Heater (W)	2W	2W	2W	
Current Full Load:	12VDC	N/A	N/A	N/A
INRUSH CURRENT IS 3X THE STATED LOAD	24VDC	.35A	.35A	4.5A
	24V/1ph	.35A	.35A	N/A
	110V/1ph	.075A	.075A	N/A
	240V/1PH	.035A	.035A	N/A
	Weight (lbs)	1.37	1.37	1.37

Sizes		1/2" and 2"		
Actuator	S20.25	S20.26	S20.29	
Model	Smart Screen Modulating	Smart Screen Failsafe Modulating	Smart Screen High-Speed Modulating	
Voltage (AC (1ph) or DC)	DC 12, AC/DC 24, 95-265 AC	24V AC/DC, 95-265 AC	24V DC	
Working Time - Sec. 0-90° (No Load) ±10%	10s	15s	1s	
Maximum Run / Torque Nm / in./lbs.	20/177	15/133	15/133	
Maximum Break / Torque Nm / in./lbs.	20/177	20/177	15/133	
On/Off Duty Rating %	100	100	100	
IP Rating - IEC 60529	IP67	IP67	IP67	
Working Angle Standard	90°	90°	90°	
Temperature Range (F)	-4° to +140°	-4° to +140°	-4° to +140°	
Motor Switch	Digital Sensing	Digital Sensing	Digital Sensing	
Volt Free End of Travel Confirmation	Digital Sensing	Digital Sensing	Digital Sensing	
Anti-Condensation Heater (W)	2W	2W	2W	
Current Full Load:	12VDC	.35A	N/A	N/A
INRUSH CURRENT IS 3X THE STATED LOAD	24VDC	.35A	.35A	5A
	24V/1ph	.35A	.35A	N/A
	110V/1ph	.075A	.075A	N/A
	240V/1PH	.035A	.035A	N/A
	Weight (lbs)	1.37	1.37	1.37

NOTE: Consult factory for 12 volt options.



**888-689-8258**

[www.basiks.us](http://www.basiks.us)   [info@basiks.us](mailto:info@basiks.us)

A Value Line by Plast-O-Matic Valves, Inc. • 1384 Pompton Ave., Cedar Grove, NJ 07009 USA

06/18

**Smart  
Actuator  
Specifications  
3" & 4"**

<b>Sizes</b>		<b>3" and 4"</b>		
Actuator		S80.10	S80.14	S80.25
Model		Smart Screen Open/Close	Smart Screen Failsafe Open/Close	Smart Screen Modulating
Voltage (AC (1ph) or DC)		24V AC/DC, 95-265 AC/DC	24V AC/DC, 95-265 AC/DC	DC 24V
Working Time - Sec. 0-90° (No Load) ±10%		10s	12s	10s
Maximum Run / Torque Nm / in./lbs.		80 / 708	80 / 708	80 / 708
Maximum Break / Torque Nm / in./lbs.		90 / 796	90 / 796	90 / 796
On/Off Duty Rating %		75	75	100
IP Rating - IEC 60529		IP67	IP67	IP67
Working Angle Standard		90°	90°	90°
Temperature Range (F)		-4° to +140°	-4° to +140°	-4° to +140°
Motor Switch		Digital Sensing	Digital Sensing	Digital Sensing
Volt Free End of Travel Confirmation		Digital Sensing	Digital Sensing	Digital Sensing
Anti-Condensation Heater (W)		5W	5W	5W
INRUSH CURRENT IS 3X THE STATED LOAD	12VDC	4.5A	N/A	4.5A
	24VDC	2.5A	4.5A	2.2A
	24V/1ph	2.5A	4.5A	2.2A
	110V/1ph	.52A	1.1A	0.52A
	240V/1PH	0.26A	.52A	0.26A
Weight (lbs)		4.85	4.85	4.85

<b>Sizes</b>		<b>3" and 4"</b>	
Actuator		S80.26	S80.29
Model		Smart Screen Failsafe Modulating	Smart Screen High-Speed Modulating
Voltage (AC (1ph) or DC)		AC/DC 24; AC 95-265V	AC/DC 24; AC 95-265V
Working Time - Sec. 0-90° (No Load) ±10%		12s	5s
Maximum Run / Torque Nm / in./lbs.		80 / 708	80 / 708
Maximum Break / Torque Nm / in./lbs.		90 / 796	90 / 796
On/Off Duty Rating %		100	100
IP Rating - IEC 60529		IP67	IP67
Working Angle Standard		90°	90°
Temperature Range (F)		-4° to +140°	-4° to +140°
Motor Switch		Digital Sensing	Digital Sensing
Volt Free End of Travel Confirmation		Digital Sensing	Digital Sensing
Anti-Condensation Heater (W)		5W	5W
INRUSH CURRENT IS 3X THE STATED LOAD	12VDC	9.0A	N/A
	24VDC	4.5A	4.5A
	24V/1ph	4.5A	4.5A
	110V/1ph	1.10A	1.06A
	240V/1PH	0.52A	0.52A
Weight (lbs)		4.85	4.85

NOTE: Consult factory for 12 volt options.

All S60 have the capacity to accept both 4-20mA and 0-10V signal by changing wiring configuration.



**888-689-8258**

[www.basiks.us](http://www.basiks.us)    [info@basiks.us](mailto:info@basiks.us)

A Value Line by Plast-O-Matic Valves, Inc. • 1384 Pompton Ave., Cedar Grove, NJ 07009 USA

01/23

## Ordering Information

<b>EBT</b>	<b>B20 - 1PHB</b>	<b>050</b>	<b>EP</b>	<b>S</b>	<b>PV</b>
<b>BASIKS Model Valve</b>					
Actuator		Valve Size		Seal Material	
1/2" - 2"		050 - 1/2" ANSI/ NPT		EP- EPDM	
Base		075 - 3/4"		V-Viton FKM	
B20-1PHB, (AC 230V)		100 - 1"			
B20-2PHB, (AC110V)		150 - 1 1/2"			
B20-3PHB, (AC 24V)		200 - 2"			
B20-4PHB, (DC 24V)		300 - 3"			
B24-5PHB, (AC 95-265V)		400 - 4"			
B24-6PHB, (DC 24V)		050D -20mm DIN/BSP			
B29-4PHB, (DC 24V)		075D -25mm			
Smart		100D - 32mm			
S20.10-5PHE, (95-265V AC/DC)		125D - 40mm			
S20.10-6PHE, (24V AC/DC)		150D - 50mm			
S20.14-5PHE, (95-265V AC/DC)		200D - 63mm			
S20.14-6PHE, (24V AC/DC)		300D - 90mm			
S20.19-5PHE, (DC 24V)		400D - 110mm			
Smart w/Modulation		050J - 22mm JIS/BSP			
S20.25-5PHI, (95-265V AC/DC) <sup>2</sup>		075J - 26mm			
S20.25-5PHU, (95-265V AC/DC) <sup>1</sup>		100J - 32mm			
S20.25-6PHP, (24V AC/DC) <sup>2</sup>		125J - 38mm			
S20.25-6PHU, (24V AC/DC) <sup>1</sup>		150J - 48mm			
S20.26-5PHP, (95-265V AC/DC) <sup>2</sup>		200J - 60mm			
S20.26-5PHU, (95-265V AC/DC) <sup>1</sup>		300J - 89mm			
S20.26-6PHP, (24V AC/DC) <sup>2</sup>		400J - 114mm			
S20.26-6PHU, (24V AC/DC) <sup>1</sup>					
S20.29-6PHP, (24V AC/DC) <sup>2</sup>					
S20.29-6PHU, (24V AC/DC) <sup>1</sup>					
3"+ 4"					
Base					
B80-1PHB, (AC 230V)					
B80-2PHB, (AC110V)					
B80-3PHB, (AC 24V)					
B80-4PHB, (DC 24V)					
B84-5PHB, (24V AC/DC)					
B84-6PHB, (95-265V AC/DC)					
B89-6PHB, (24V AC/DC)					
B89-5PHB-17, (95-265V AC/DC)					
Smart					
S80.10-5PHE, (95-256V AC/DC)					
S80.10-6PHE, (24V AC/DC)					
S80.14-5PHE, (95-256V AC/DC)					
S80.14-6PHE, (24V AC/DC)					
Smart w/Modulation					
S80.25-5PHP, (95-256V AC/DC) <sup>3</sup>					
S80.25-6PHP, (24V AC/DC) <sup>3</sup>					
S80.26-5PHP, (95-256V AC/DC) <sup>3</sup>					
S80.26-6PHP, (24V AC/DC) <sup>3</sup>					
S80.29-5PHP, (95-256V AC/DC)					
S80.29-6PHP, (24V AC/DC) <sup>3</sup>					



### Modulation:

<sup>1</sup> 0-10V

<sup>2</sup> 4-20mA

<sup>3</sup> 0-10V or 4-20mA



**888-689-8258**

www.basiks.us      info@basiks.us

A Value Line by Plast-O-Matic Valves, Inc. • 1384 Pompton Ave., Cedar Grove, NJ 07009 USA

01/23



**Schedule 80 PVC Industrial Products & Accessories**  
**True Union 2000 Industrial 3-Way Ball Valves**

Pressure Rating @ 73°F (23°C), Water

1/2" - 2" 235 psi

2-1/2" - 4" 150 psi

Flanged 150 psi

Maximum Service Temperature

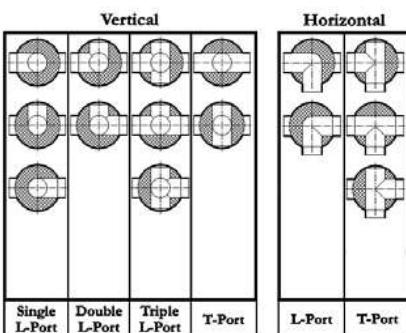
PVC = 140°F (60°C)

Temperature/Pressure De-ratings Apply  
Vertical 3-Way or Horizontal Diverter Design  
(No Branch Shut-off)

All Standard Carton Quantities are one  
All Valves assembled with Silicone-Free,  
Water Soluble Lubricant

See Ball Valve Accessories & Repair Kits Section  
for Additional Options and Features

Ball Port Options



Ball port options viewed from top of valve



Horizontal Diverter Valve



Vertical 3-Way Valve

### PVC Horizontal Diverter Ball Valves

Material		EPDM					FKM					Disc Code
Size	Joint	Socket	SR Thread	Spigot	Flanged	Socket	SR Thread	Spigot	Flanged	Part #	Price Each	
Size	Ball Port	Part #	Part #	Part #	Part #	Part #	Part #	Part #	Part #	Part #	Part #	Part #
<b>1/2</b>	L-Port	5022L1-005 <b>102.54</b>	5021L1-005SR <b>105.85</b>	5027L1-005 <b>102.54</b>	5023L1-005 <b>209.43</b>	5032L1-005 <b>111.22</b>	5031L1-005SR <b>116.24</b>	5037L1-005 <b>111.22</b>	5033L1-005 <b>218.79</b>	5033L1-005 <b>218.79</b>	5033L1-005 <b>218.79</b>	615
	T-Port	5022T1-005 <b>102.54</b>	5021T1-005SR <b>105.85</b>	5027T1-005 <b>102.54</b>	5023T1-005 <b>209.43</b>	5032T1-005 <b>111.22</b>	5031T1-005SR <b>116.24</b>	5037T1-005 <b>111.22</b>	5033T1-005 <b>218.79</b>	5033T1-005 <b>218.79</b>	5033T1-005 <b>218.79</b>	615
<b>3/4</b>	L-Port	5022L1-007 <b>122.29</b>	5021L1-007SR <b>126.36</b>	5027L1-007 <b>122.29</b>	5023L1-007 <b>219.13</b>	5032L1-007 <b>131.63</b>	5031L1-007SR <b>135.73</b>	5037L1-007 <b>131.63</b>	5033L1-007 <b>231.24</b>	5033L1-007 <b>231.24</b>	5033L1-007 <b>231.24</b>	615
	T-Port	5022T1-007 <b>122.29</b>	5021T1-007SR <b>126.36</b>	5027T1-007 <b>122.29</b>	5023T1-007 <b>219.13</b>	5032T1-007 <b>131.63</b>	5031T1-007SR <b>135.73</b>	5037T1-007 <b>131.63</b>	5033T1-007 <b>231.24</b>	5033T1-007 <b>231.24</b>	5033T1-007 <b>231.24</b>	615
<b>1</b>	L-Port	5022L1-010 <b>148.27</b>	5021L1-010SR <b>152.26</b>	5027L1-010 <b>148.27</b>	5023L1-010 <b>312.32</b>	5032L1-010 <b>163.35</b>	5031L1-010SR <b>167.40</b>	5037L1-010 <b>163.35</b>	5033L1-010 <b>341.42</b>	5033L1-010 <b>341.42</b>	5033L1-010 <b>341.42</b>	615
	T-Port	5022T1-010 <b>148.27</b>	5021T1-010SR <b>152.26</b>	5027T1-010 <b>148.27</b>	5023T1-010 <b>312.32</b>	5032T1-010 <b>163.35</b>	5031T1-010SR <b>167.40</b>	5037T1-010 <b>163.35</b>	5033T1-010 <b>341.42</b>	5033T1-010 <b>341.42</b>	5033T1-010 <b>341.42</b>	615
<b>1-1/4</b>	L-Port	5022L1-012 <b>171.86</b>	5021L1-012SR <b>179.63</b>	5027L1-012 <b>171.86</b>	5023L1-012 <b>590.69</b>	5032L1-012 <b>193.32</b>	5031L1-012SR <b>201.44</b>	5037L1-012 <b>193.32</b>	5033L1-012 <b>625.67</b>	5033L1-012 <b>625.67</b>	5033L1-012 <b>625.67</b>	615
	T-Port	5022T1-012 <b>171.86</b>	5021T1-012SR <b>179.63</b>	5027T1-012 <b>171.86</b>	5023T1-012 <b>590.69</b>	5032T1-012 <b>193.32</b>	5031T1-012SR <b>201.44</b>	5037T1-012 <b>193.32</b>	5033T1-012 <b>625.67</b>	5033T1-012 <b>625.67</b>	5033T1-012 <b>625.67</b>	615
<b>1-1/2</b>	L-Port	5022L1-015 <b>200.95</b>	5021L1-015SR <b>213.94</b>	5027L1-015 <b>200.95</b>	5023L1-015 <b>608.53</b>	5032L1-015 <b>220.00</b>	5031L1-015SR <b>232.98</b>	5037L1-015 <b>220.00</b>	5033L1-015 <b>636.42</b>	5033L1-015 <b>636.42</b>	5033L1-015 <b>636.42</b>	615
	T-Port	5022T1-015 <b>200.95</b>	5021T1-015SR <b>213.94</b>	5027T1-015 <b>200.95</b>	5023T1-015 <b>608.53</b>	5032T1-015 <b>220.00</b>	5031T1-015SR <b>232.98</b>	5037T1-015 <b>220.00</b>	5033T1-015 <b>636.42</b>	5033T1-015 <b>636.42</b>	5033T1-015 <b>636.42</b>	615
<b>2</b>	L-Port	5022L1-020 <b>246.51</b>	5021L1-020SR <b>259.48</b>	5027L1-020 <b>246.51</b>	5023L1-020 <b>790.23</b>	5032L1-020 <b>287.39</b>	5031L1-020SR <b>301.48</b>	5037L1-020 <b>287.39</b>	5033L1-020 <b>829.91</b>	5033L1-020 <b>829.91</b>	5033L1-020 <b>829.91</b>	615
	T-Port	5022T1-020 <b>246.51</b>	5021T1-020SR <b>259.48</b>	5027T1-020 <b>246.51</b>	5023T1-020 <b>790.23</b>	5032T1-020 <b>287.39</b>	5031T1-020SR <b>301.48</b>	5037T1-020 <b>287.39</b>	5033T1-020 <b>829.91</b>	5033T1-020 <b>829.91</b>	5033T1-020 <b>829.91</b>	615
<b>2-1/2</b>	L-Port	5022L1-025 <b>831.12</b>	5021L1-025SR <b>867.49</b>	5027L1-025 <b>831.12</b>	5023L1-025 <b>1387.52</b>	5032L1-025 <b>883.79</b>	5031L1-025SR <b>920.15</b>	5037L1-025 <b>883.79</b>	5033L1-025 <b>1626.02</b>	5033L1-025 <b>1626.02</b>	5033L1-025 <b>1626.02</b>	615
	T-Port	5022T1-025 <b>831.12</b>	5021T1-025SR <b>867.49</b>	5027T1-025 <b>831.12</b>	5023T1-025 <b>1387.52</b>	5032T1-025 <b>883.79</b>	5031T1-025SR <b>920.15</b>	5037T1-025 <b>883.79</b>	5033T1-025 <b>1626.02</b>	5033T1-025 <b>1626.02</b>	5033T1-025 <b>1626.02</b>	615
<b>3</b>	L-Port	5022L1-030 <b>848.09</b>	5021L1-030SR <b>886.21</b>	5027L1-030 <b>848.09</b>	5023L1-030 <b>1405.72</b>	5032L1-030 <b>897.64</b>	5031L1-030SR <b>934.00</b>	5037L1-030 <b>897.64</b>	5033L1-030 <b>1633.48</b>	5033L1-030 <b>1633.48</b>	5033L1-030 <b>1633.48</b>	615
	T-Port	5022T1-030 <b>848.09</b>	5021T1-030SR <b>886.21</b>	5027T1-030 <b>848.09</b>	5023T1-030 <b>1405.72</b>	5032T1-030 <b>897.64</b>	5031T1-030SR <b>934.00</b>	5037T1-030 <b>897.64</b>	5033T1-030 <b>1633.48</b>	5033T1-030 <b>1633.48</b>	5033T1-030 <b>1633.48</b>	615
<b>4</b>	L-Port	5022L1-040 <b>1535.97</b>	5021L1-040SR <b>1577.56</b>	5027L1-040 <b>1535.97</b>	5023L1-040 <b>2042.29</b>	5032L1-040 <b>1553.29</b>	5031L1-040SR <b>1594.87</b>	5037L1-040 <b>1553.29</b>	5033L1-040 <b>2232.33</b>	5033L1-040 <b>2232.33</b>	5033L1-040 <b>2232.33</b>	615
	T-Port	5022T1-040 <b>1535.97</b>	5021T1-040SR <b>1577.56</b>	5027T1-040 <b>1535.97</b>	5023T1-040 <b>2042.29</b>	5032T1-040 <b>1553.29</b>	5031T1-040SR <b>1594.87</b>	5037T1-040 <b>1553.29</b>	5033T1-040 <b>2232.33</b>	5033T1-040 <b>2232.33</b>	5033T1-040 <b>2232.33</b>	615

**Schedule 80 PVC Industrial Products & Accessories**  
**True Union 2000 Industrial 3-Way Ball Valves**



**PVC Vertical 3-Way Ball Valves**

Material		EPDM				FKM				Disc Code
Joint	Socket	SR Thread	Spigot	Flanged	Socket	SR Thread	Spigot	Flanged		
1/2	Ball Port	Part # Price Each	Part # Price Each	Part # Price Each	Part # Price Each	Part # Price Each	Part # Price Each	Part # Price Each	Part # Price Each	615
	L-Port	4722L1-005 102.03	4721L1-005SR 103.65	4727L1-005 102.03	4723L1-005 210.83	4732L1-005 110.51	4731L1-005SR 112.15	4737L1-005 110.51	4733L1-005 218.43	
	Double L-Port	4722L2-005 203.20	4721L2-005SR 204.83	4727L2-005 203.20	4723L2-005 311.99	4732L2-005 211.68	4731L2-005SR 213.33	4737L2-005 211.68	4733L2-005 319.60	
	Triple L-Port	4722L3-005 203.20	4721L3-005SR 204.83	4727L3-005 203.20	4723L3-005 311.99	4732L3-005 211.68	4731L3-005SR 213.33	4737L3-005 211.68	4733L3-005 319.60	
3/4	T-Port	4722T1-005 102.03	4721T1-005SR 103.65	4727T1-005 102.03	4723T1-005 210.83	4732T1-005 110.51	4731T1-005SR 112.15	4737T1-005 110.51	4733T1-005 218.43	615
	L-Port	4722L1-007 119.68	4721L1-007SR 123.78	4727L1-007 119.68	4723L1-007 221.38	4732L1-007 130.43	4731L1-007SR 134.49	4737L1-007 130.43	4733L1-007 230.74	
	Double L-Port	4722L2-007 220.86	4721L2-007SR 224.92	4727L2-007 220.86	4723L2-007 322.56	4732L2-007 231.60	4731L2-007SR 235.66	4737L2-007 231.60	4733L2-007 331.89	
	Triple L-Port	4722L3-007 220.86	4721L3-007SR 224.92	4727L3-007 220.86	4723L3-007 322.56	4732L3-007 231.60	4731L3-007SR 235.66	4737L3-007 231.60	4733L3-007 331.89	
1	T-Port	4722T1-007 119.68	4721T1-007SR 123.78	4727T1-007 119.68	4723T1-007 221.38	4732T1-007 130.43	4731T1-007SR 134.49	4737T1-007 130.43	4733T1-007 230.74	615
	L-Port	4722L1-010 145.49	4721L1-010SR 149.58	4727L1-010 145.49	4723L1-010 315.78	4732L1-010 161.98	4731L1-010SR 166.03	4737L1-010 161.98	4733L1-010 341.77	
	Double L-Port	4722L2-010 246.69	4721L2-010SR 250.76	4727L2-010 246.69	4723L2-010 416.96	4732L2-010 263.12	4731L2-010SR 267.20	4737L2-010 263.12	4733L2-010 442.94	
	Triple L-Port	4722L3-010 246.69	4721L3-010SR 250.76	4727L3-010 246.69	4723L3-010 416.96	4732L3-010 263.12	4731L3-010SR 267.20	4737L3-010 263.12	4733L3-010 442.94	
1-1/4	T-Port	4722T1-010 145.49	4721T1-010SR 149.58	4727T1-010 145.49	4723T1-010 315.78	4732T1-010 161.98	4731T1-010SR 166.03	4737T1-010 161.98	4733T1-010 341.77	615
	L-Port	4722L1-012 175.99	4721L1-012SR 184.15	4727L1-012 175.99	4723L1-012 595.20	4732L1-012 207.36	4731L1-012SR 215.49	4737L1-012 207.36	4733L1-012 629.48	
	Double L-Port	4722L2-012 277.17	4721L2-012SR 285.31	4727L2-012 277.17	4723L2-012 696.36	4732L2-012 308.53	4731L2-012SR 316.65	4737L2-012 308.53	4733L2-012 730.66	
	Triple L-Port	4722L3-012 277.17	4721L3-012SR 285.31	4727L3-012 277.17	4723L3-012 696.36	4732L3-012 308.53	4731L3-012SR 316.65	4737L3-012 308.53	4733L3-012 730.66	
1-1/2	T-Port	4722T1-012 175.99	4721T1-012SR 184.15	4727T1-012 175.99	4723T1-012 595.20	4732T1-012 207.36	4731T1-012SR 215.49	4737T1-012 207.36	4733T1-012 629.48	615
	L-Port	4722L1-015 203.52	4721L1-015SR 216.54	4727L1-015 203.52	4723L1-015 617.38	4732L1-015 223.11	4731L1-015SR 236.11	4737L1-015 223.11	4733L1-015 636.42	
	Double L-Port	4722L2-015 304.71	4721L2-015SR 317.68	4727L2-015 304.71	4723L2-015 718.53	4732L2-015 324.26	4731L2-015SR 337.26	4737L2-015 324.26	4733L2-015 737.58	
	Triple L-Port	4722L3-015 304.71	4721L3-015SR 317.68	4727L3-015 304.71	4723L3-015 718.53	4732L3-015 324.26	4731L3-015SR 337.26	4737L3-015 324.26	4733L3-015 737.58	
2	T-Port	4722T1-015 203.52	4721T1-015SR 216.54	4727T1-015 203.52	4723T1-015 617.38	4732T1-015 223.11	4731T1-015SR 236.11	4737T1-015 223.11	4733T1-015 636.42	615
	L-Port	4722L1-020 249.61	4721L1-020SR 263.73	4727L1-020 249.61	4723L1-020 795.60	4732L1-020 289.81	4731L1-020SR 303.92	4737L1-020 289.81	4733L1-020 830.80	
	Double L-Port	4722L2-020 350.76	4721L2-020SR 364.91	4727L2-020 350.76	4723L2-020 896.78	4732L2-020 390.98	4731L2-020SR 405.07	4737L2-020 390.98	4733L2-020 931.93	
	Triple L-Port	4722L3-020 350.76	4721L3-020SR 364.91	4727L3-020 350.76	4723L3-020 896.78	4732L3-020 390.98	4731L3-020SR 405.07	4737L3-020 390.98	4733L3-020 931.93	
2-1/2	T-Port	4722T1-020 249.61	4721T1-020SR 263.73	4727T1-020 249.61	4723T1-020 795.60	4732T1-020 289.81	4731T1-020SR 303.92	4737T1-020 289.81	4733T1-020 830.80	615
	L-Port	4722L1-025 877.91	4721L1-025SR 914.28	4727L1-025 877.91	4723L1-025 1393.58	4732L1-025 887.78	4731L1-025SR 924.17	4737L1-025 887.78	4733L1-025 1624.14	
	Double L-Port	4722L2-025 979.05	4721L2-025SR 1015.43	4727L2-025 979.05	4723L2-025 1494.75	4732L2-025 988.94	4731L2-025SR 1025.31	4737L2-025 988.94	4733L2-025 1725.31	
	Triple L-Port	4722L3-025 979.05	4721L3-025SR 1015.43	4727L3-025 979.05	4723L3-025 1494.75	4732L3-025 988.94	4731L3-025SR 1025.31	4737L3-025 988.94	4733L3-025 1725.31	
3	T-Port	4722T1-025 877.91	4721T1-025SR 914.28	4727T1-025 877.91	4723T1-025 1393.58	4732T1-025 887.78	4731T1-025SR 924.17	4737T1-025 887.78	4733T1-025 1624.14	615
	L-Port	4722L1-030 895.91	4721L1-030SR 932.28	4727L1-030 895.91	4723L1-030 1412.80	4732L1-030 903.87	4731L1-030SR 940.25	4737L1-030 903.87	4733L1-030 1634.89	
	Double L-Port	4722L2-030 997.07	4721L2-030SR 1033.46	4727L2-030 997.07	4723L2-030 1513.98	4732L2-030 1005.05	4731L2-030SR 1041.41	4737L2-030 1005.05	4733L2-030 1736.04	
	Triple L-Port	4722L3-030 997.07	4721L3-030SR 1033.46	4727L3-030 997.07	4723L3-030 1513.98	4732L3-030 1005.05	4731L3-030SR 1041.41	4737L3-030 1005.05	4733L3-030 1736.04	
4	T-Port	4722T1-030 895.91	4721T1-030SR 932.28	4727T1-030 895.91	4723T1-030 1412.80	4732T1-030 903.87	4731T1-030SR 940.25	4737T1-030 903.87	4733T1-030 1634.89	615
	L-Port	4722L1-040 1548.61	4721L1-040SR 1590.18	4727L1-040 1548.61	4723L1-040 2053.91	4732L1-040 1563.68	4731L1-040SR 1605.25	4737L1-040 1563.68	4733L1-040 2151.25	
	Double L-Port	4722L2-040 1649.80	4721L2-040SR 1691.34	4727L2-040 1649.80	4723L2-040 2155.07	4732L2-040 1664.85	4731L2-040SR 1706.43	4737L2-040 1664.85	4733L2-040 2252.42	
	Triple L-Port	4722L3-040 1649.80	4721L3-040SR 1691.34	4727L3-040 1649.80	4723L3-040 2155.07	4732L3-040 1664.85	4731L3-040SR 1706.43	4737L3-040 1664.85	4733L3-040 2252.42	
	T-Port	4722T1-040 1548.61	4721T1-040SR 1590.18	4727T1-040 1548.61	4723T1-040 2053.91	4732T1-040 1563.68	4731T1-040SR 1605.25	4737T1-040 1563.68	4733T1-040 2151.25	



## Thermoplastic Valves Product Guide & Engineering Specifications

### True Union, Spigot, Flanged Diaphragm Valves



### Features – PVC, CPVC & PP

This full-featured valve is engineered to provide accurate throttling control and shutoff for industrial, chemical and water treatment applications. Weir-type design eliminates entrapped fluids in valve and is excellent for handling liquids with suspended solids, viscous fluids and slurries. Available in PVC, CPVC and Glass Filled Polypropylene with a variety of Diaphragm material options. PVC & CPVC 1/2" - 2" valves with Flanged Body, Spigot Body or True Union style Socket & Threaded ends or Optional Special Reinforced (SR) Threads, and sizes 2-1/2" - 8" with Flanged Body. Polypropylene 1/2" - 2" valves with True Union style Special Reinforced (SR) Threaded ends and sizes 2-1/2" - 8" with Flanged Body. True Union style also available in metric socket and BSP thread sizes 1/2" through 2".

- True Union Style with Buttress Thread Union Nuts - Mate with Spears® True Union 2000 Ball valves and Union 2000 Pipe Unions.
- EPDM, FKM, or Elastomer Backed (EPDM or FKM) PTFE Diaphragms.
- PVC & CPVC Sizes 1/2" - 2" Pressure Rated to 235 psi @ 73°F, Sizes 2-1/2" - 4" and all Flanged and all PTFE Diaphragm through 4" Pressure Rated to 150 psi @ 73°F, 6" Pressure Rated to 100 psi and 8" to 75 psi @ 73°F
- Polypropylene Sizes 1/2" - 4" Pressure rated to 150 psi @ 73°F
- Easy-Grip, High Impact Polypropylene Handwheel
- Built-in, Clear-View Position Indicator
- Stainless Steel External Hardware
- Fully Serviceable, Replaceable Components
- Suitable for Vacuum Service (except with PTFE Diaphragms)
- Assembled with Silicone-Free Lubricants (no lubricant in media contact area)



### Sample Engineering Specification

All thermoplastic Diaphragm valves shall be Weir-type constructed from PVC Type I, ASTM D 1784 Cell Classification 12454 or CPVC Type IV, ASTM D 1784 Cell Classification 23447, or Polypropylene, ASTM D 4101. All diaphragms shall be EPDM, FKM or PTFE with EPDM or FKM backing. All valves shall have built-in position indicator with polypropylene handwheel. All True Union style valve union nuts shall have Buttress threads. All PVC and CPVC 1/2" through 2" valves shall be pressure rated to 235 psi, all 2-1/2" through 4" and all flanged valves and valves with PTFE through 4" backing, shall be pressure rated to 150 psi, all 6" valves shall be pressure rated to 100 psi, and all 8" valves shall be pressure rated to 75 psi for water at 73°F. All Polypropylene valves shall be pressure rated to 150 psi for water at 73°F, as manufactured by Spears® Manufacturing Company.

### Special Options

- Hypalon® (CSM) Diaphragms
- Natural Polypropylene Body
- Electric or Pneumatic Actuation



## PVC, CPVC & PP Diaphragm Valve Quick-View Selection Chart

Size	O-ring Material	Diaphragm Material	PVC Part Number <sup>1</sup>				PP Part Number		Pressure Rating
			Soc/Thd	SR Threaded	Spigot	Flanged	SR Threaded	Flanged	
1/2	EPDM	EPDM	2729-005	2721-005SR	2727-005	2723-005	2721-005PSR		True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>	2729T-005	2721T-005SR	2797T-005	2793T-005	2721T-005PSR		
	FKM	FKM	2739-005	2731-005SR	2737-005	2733-005	2731-005PSR		
		PTFE <sup>2</sup>	2739VT-005	2731VT-005SR	2797VT-005	2793VT-005	2731VT-005PSR		
3/4	EPDM	EPDM	2729-007	2721-007SR	2727-007	2723-007	2721-007PSR		True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>	2729T-007	2721T-007SR	2797T-007	2793T-007	2721T-007PSR		
	FKM	FKM	2739-007	2731-007SR	2737-007	2733-007	2731-007PSR		
		PTFE <sup>2</sup>	2739VT-007	2731VT-007SR	2797VT-007	2793VT-007	2731VT-007PSR		
1	EPDM	EPDM	2729-010	2721-010SR	2727-010	2723-010	2721-010PSR		True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>	2729T-010	2721T-010SR	2797T-010	2793T-010	2721T-010PSR		
	FKM	FKM	2739-010	2731-010SR	2737-010	2733-010	2731-010PSR		
		PTFE <sup>2</sup>	2739VT-010	2731VT-010SR	2797VT-010	2793VT-010	2731VT-010PSR		
1-1/4	EPDM	EPDM	2729-012	2721-012SR	2727-012	2723-012	2721-012PSR		True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>	2729T-012	2721T-012SR	2797T-012	2793T-012	2721T-012PSR		
	FKM	FKM	2739-012	2731-012SR	2737-012	2733-012	2731-012PSR		
		PTFE <sup>2</sup>	2739VT-012	2731VT-012SR	2797VT-012	2793VT-012	2731VT-012PSR		
1-1/2	EPDM	EPDM	2729-015	2721-015SR	2727-015	2723-015	2721-015PSR		True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>	2729T-015	2721T-015SR	2797T-015	2793T-015	2721T-015PSR		
	FKM	FKM	2739-015	2731-015SR	2737-015	2733-015	2731-015PSR		
		PTFE <sup>2</sup>	2739VT-015	2731VT-015SR	2797VT-015	2793VT-015	2731VT-015PSR		
2	EPDM	EPDM	2729-020	2721-020SR	2727-020	2723-020	2721-020PSR		True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>	2729T-020	2721T-020SR	2797T-020	2793T-020	2721T-020PSR		
	FKM	FKM	2739-020	2731-020SR	2737-020	2733-020	2731-020PSR		
		PTFE <sup>2</sup>	2739VT-020	2731VT-020SR	2797VT-020	2793VT-020	2731VT-020PSR		
2-1/2	EPDM	EPDM				2723-025		2723-025P	True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>				2793T-025		2793T-025P	
	FKM	FKM				2733-025		2733-025P	
		PTFE <sup>2</sup>				2793VT-025		2793VT-025P	
3	EPDM	EPDM				2723-030		2723-030P	True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>				2793T-030		2793T-030P	
	FKM	FKM				2733-030		2733-030P	
		PTFE <sup>2</sup>				2793VT-030		2793VT-030P	
4	EPDM	EPDM				2723-040		2723-040P	True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>				2793T-040		2793T-040P	
	FKM	FKM				2733-040		2733-040P	
		PTFE <sup>2</sup>				2793VT-040		2793VT-040P	
6	EPDM	EPDM				2723-060		2723-060P	True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>				2793T-060		2793T-060P	
	FKM	FKM				2733-060		2733-060P	
		PTFE <sup>2</sup>				2793VT-060		2793VT-060P	
8	EPDM	EPDM				2723-080		2723-080P	True Union & Spigot Style w/ Elastomer Diaphragms 235 psi Non-Shock Water @ 73°F
		PTFE <sup>2</sup>				2793T-080		2793T-080P	
	FKM	FKM				2733-080		2733-080P	
		PTFE <sup>2</sup>				2793VT-080		2793VT-080P	

1: For CPVC valves, add the letter "C" to part numbers listed (e.g., 2729-005C). Custom end connections available upon request.

2: Elastomer-backed PTFE (standard EPDM backed; special order FKM backed)



# 7200 Series

ACRYLIC TUBE

A real value in general purpose rotameters. Vertical connections are from 3/8" NPT to 2" NPT.



## DESCRIPTION

Metering Tube	Machined cast acrylic
Internal Components	316L SS
Fitting Material	PVC (for water service only) 316 SS, brass, aluminum (for water and air service)
Inlet/Outlet Fittings	NPT, vertical
O-Ring	Standard: EPR Optional: Buna-N, Viton

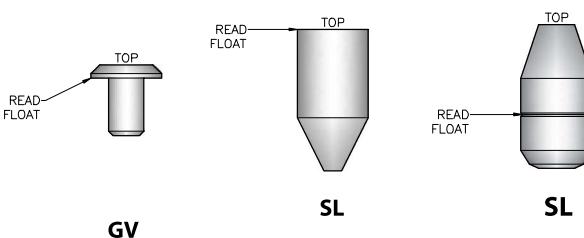
## PERFORMANCE

Capacities	Water 1 to 200 GPM Air 4 to 245 SCFM
Scale	127 mm (5") direct reading
Accuracy	$\pm 3\%$ to $\pm 6\%$ of full scale flow See Specifications table
Turndown	10:1 unless otherwise indicated
Repeatability	1% to 2% See Specifications table
Maximum Temperature	Water 130° F (54° C) Air 100° F (38° C)
Maximum Pressure	Water 150 psig Air 125 psig
Ambient Temperature	33° F to 125° F (1° C to 52° C)

## OPTIONS

Certified Calibrations	Conform to ISA RP 16.6
Scales	Any volumetric unit

## FLOATS



**CAUTION:** Meters used in gas service are designed to operate at 14.7 psia. Meters used in pressure gas service must be shielded using 3/8" polycarbonate to protect personnel and equipment in the event of tube failure.

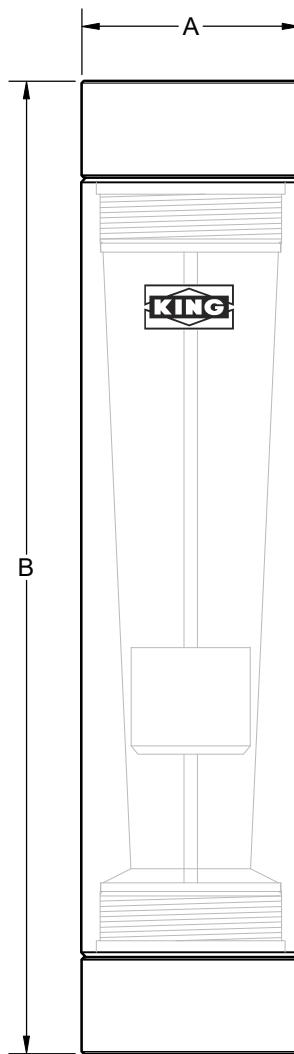
# 7200 Specifications

ACRYLIC TUBE

Order Number	Flow GPM Water	Flow SCFM Air	F.S. Accuracy Repeatability	Pressure Drop (Inches of water)	Float Type	Actual Turndown	Connection Size
0051	1	4.3	3%/2%	2.9	GV	10:1	3/8" FNPT
0052	1	4.3	3%/2%	2.9	GV	10:1	1/2" FNPT
0061	2	8	3%/2%	5.2	GV	10:1	3/8" FNPT
0062	2	8	3%/2%	5.2	GV	10:1	1/2" FNPT
0071	3.5	14	3%/2%	9.5	SL	10:1	3/8" FNPT
0072	3.5	14	3%/2%	9.5	SL	10:1	1/2" FNPT
0081	5	20	3%/2%	13.1	SL	10:1	3/8" FNPT
0082	5	20	3%/2%	13.1	SL	10:1	1/2" FNPT
0151	5	20	3%/1%	10	GV	10:1	1" FNPT
0161	10	43	3%/1%	12	SL	10:1	1" FNPT
0171	15	62	3%/1%	18	SL	10:1	1" FNPT
0181	21	86	3%/1%	22	SL	10:1	1" FNPT
0191	30.5	—	3%/1%	26	SL	10:1	1" FNPT
0201	40	—	6%/2%	32	SL	10:1	1 1/2" MNPT
0211	50	—	6%/2%	38	SL	10:1	1 1/2" MNPT
0221	40	165	4%/1%	18	SL	10:1	2" FNPT
0231	60	245	4%/1%	25	SL	10:1	2" FNPT
0241	80	—	4%/1%	30	SL	10:1	2" FNPT
0251	100*	—	4%/1%	35	SL	5:1	2" FNPT
0261	120*	—	6%/2%	45	SL	4:1	2" FNPT
0271	160*	—	6%/2%	60	SL	3.55:1	2" FNPT
0281	200*	—	6%/2%	80	SL	3.63:1	2" FNPT

\*These meters have less than 10:1 turndown.

## DIMENSION DIAGRAM



## ACTUAL TURNDOWN:

Order Number	Flow Range	Actual Turndown
0251	20-100 GPM	5:1
0261	30-120 GPM	4:1
0271	45-160 GPM	3.55:1
0281	55-200 GPM	3.63:1

## Dimensions (Inches)

Order Number	Dimensions A	Dimensions B
0051-0082	1.375"	8.25"
0151-0191	2.000"	10.25"
0201 - 0211	2.000"	12.06"
0221 - 0281	3.000"	13.25"

## ORDERING:

Use the following guide to determine the specific product number you require.



Meter Series	Order Number	Fitting Material	O-ring Material	Fluid Metered	Scale
	See Specification above	Brass - 1 316L SS - 2 PVC* - 3 Aluminum - 6	EPR - 1 Buna-N - 2 Viton® - 3	GPM - Liquid - W SCFM - Air - A	Standard - Leave Blank Non-Standard - N

\* PVC for water service only



PVC Sensor (gray body and cap)

Standard Sensor (blue cap)

Integral Sensor

Wet-Tap Sensor

Simple to install with time-honored reliable performance, Signet 2536 Rotor-X Paddlewheel Flow Sensors are highly repeatable, rugged sensors that offer exceptional value with little or no maintenance. The Model 2536 has a process-ready open collector signal with a wide dynamic flow range of 0.1 to 6 m/s (0.3 to 20 ft/s). The sensor measures liquid flow rates in full pipes and can be used in low pressure systems.

The Signet 2536 sensors are offered in a variety of materials for a wide range of pipe sizes and insertion configurations. The many material choices including PP and PVDF make this model highly versatile and chemically compatible to many liquid process solutions.

Sensors can be installed in DN15 to DN900 (½ to 36 in.) pipes (except the 2536 PVC versions, which can be installed in DN15 to DN100 (½ to 4 in.) pipes), using Signet's comprehensive line of custom fittings. These custom fittings, which include tees, saddles, and weldolets, seat the sensor to the proper insertion depth into the process flow. The sensors are also offered in configurations for wet-tap installation requirements.

## Features

- Operating range 0.1 to 6 m/s (0.3 to 20 ft/s)
- Wide turndown ratio of 66:1
- Open-collector output
- Highly repeatable output
- Simple, economical design
- Installs into pipe sizes DN15 to DN900 (½ to 36 in.)
- PVC 2536 version DN15 to DN100 (½ to 4 in.) for concentrated Sodium Hypochlorite 12.5% applications
- High resolution and noise immunity
- Test certificate included for -X0, -X1
- Chemically resistant materials



Certified to  
NSF/ANSI 61 & 372

(3-2536-PX  
version only)

## Applications

- Pure Water Production
- Filtration Systems
- Chemical Production
- Liquid Delivery Systems
- Pump Protection
- Scrubber/Gas Stacks
- Gravity Feed Lines
- Not suitable for gas
- Sodium Hypochlorite transfer/injection/batching (3-2536-U0)

# Specifications

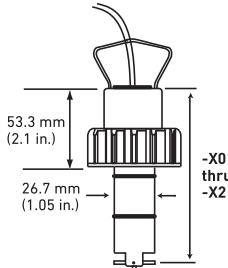
General		
Operating Range	0.1 to 6 m/s	0.3 to 20 ft/s
Pipe Size Range	DN15 to DN900	½ to 36 in.
PVC	DN15 to DN100	½ to 4 in.
Linearity	±1% of max. range @ 25 °C (77 °F)	
Repeatability	±0.5% of max. range @ 25 °C (77 °F)	
Min. Reynolds Number Required	4500	
Wetted Materials		
Sensor Body	Glass-filled PP (black), PVDF (natural) or PVC (gray)	
O-rings	FKM (std) optional EPR (EPDM) or FFKM	
Rotor Pin	Titanium, Hastelloy-C or PVDF; optional Ceramic, Tantalum or Stainless Steel	
Rotor	Black PVDF or Natural PVDF; optional ETFE, with or w/o carbon fiber reinforced PTFE sleeve for rotor pin	
Electrical		
Frequency	49 Hz per m/s nominal	15 Hz per ft/s nominal
Supply Voltage	5 to 24 VDC ±10%, regulated	
Supply Current	<1.5 mA @ 3.3 to 6 VDC	<20 mA @ 6 to 24 VDC
Output Type	Open collector, sinking 10 mA max.	
Cable Type	2-conductor twisted pair with shield, 22 AWG	
Cable Length	7.6 m (25 ft) can be extended up to 305 m (1000 ft) maximum	
Max. Temperature/Pressure Rating - Standard and Integral Sensor		
PP	12.5 bar @ 20 °C 1.7 bar @ 85 °C	180 psi @ 68 °F 25 psi @ 185 °F
PVDF	14 bar @ 20 °C 1.7 bar @ 85 °C	200 psi @ 68 °F 25 psi @ 185 °F
PVC	12.5 bar @ 20 °C 6.9 bar @ 60 °C	180 psi @ 68 °F 100 psi @ 140 °F
Operating Temperature		
PP	-18 °C to 85 °C	0 °F to 185 °F
PVDF	-18 °C to 85 °C	0 °F to 185 °F
PVC	0 °C to 50 °C	32 °F to 122 °F
Max. Temperature/Pressure Rating - Wet-Tap Sensor		
PP	7 bar @ 20 °C 1.4 bar @ 60 °C	100 psi @ 68 °F 20 psi @ 140 °F
Operating Temperature	-18 °C to 60 °C	
Max. Wet-Tap Sensor Removal Rating	1.7 bar @ 22 °C	
Shipping Weight		
3-2536-X0	0.454 kg	1.00 lb
3-2536-X1	0.476 kg	1.05 lb
3-2536-X2	0.680 kg	1.50 lb
3-2536-X3	0.780 kg	1.72 lb
3-2536-X4	0.800 kg	1.76 lb
3-2536-X5	0.880 kg	1.94 lb
3-8512-X0	0.35 kg	0.77 lb
3-8512-X1	0.37 kg	0.81 lb
Standards and Approvals		
CE, FCC, NSF (3-2536-PX only)		
RoHS compliant, China RoHS		
Manufactured under ISO 9001 for Quality and ISO 14001 for Environmental Management and OHSAS 18001 for Occupational Health and Safety		

See Temperature and Pressure Graphs for more information

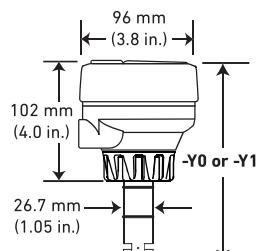
## Dimensions

Standard Mount

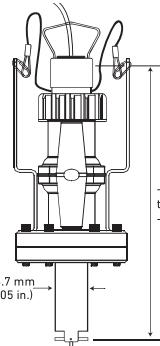
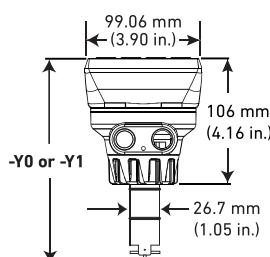
PVC Mount  
(0.5 to 4 in. pipe range only)



Integral Mount  
(shown with Transmitter  
sold separately)



**Wet-Tap Mount Sensor  
with 3519 Wet-Tap Valve**  
(See 3519 product page for  
more information).



Pipe range

0.5 to 4 in.	-X0 = 104 mm (4.1 in.)
5 to 8 in.	-X1 = 137 mm (5.4 in.)
10 in. and up	-X2 = 213 mm (8.4 in.)

Pipe range

0.5 to 4 in.	-Y0 = 152 mm (6.0 in.)
5 to 8 in.	-Y1 = 185 mm (7.3 in.)

Pipe range

0.5 to 4 in.	-P3 = 297 mm (11.7 in.)
5 to 8 in.	-P4 = 333 mm (13.1 in.)
10 in. and up	-P5 = 409 mm (16.1 in.)

## System Overview

Panel Mount	Pipe, Tank, Wall Mount	Field (Integral) Mount	Automation System
Signet Instruments 8900 9900 9900-1BC 9950 OR	Signet Instruments 9900-1P 9900-1BC with Rear Enclosure 9950 +	Signet Instruments 8550 9900 with 3-8051-X Integral Mount Kit OR  +	0486 Profibus Concentrator and Customer Supplied Programmable Logic Controller or Programmable Automation Controller +
Signet 2536 PVC, Standard, Wet-Tap or 8512 Integral Mount Flow Sensors	   	   	
Signet Fittings	   	   	All sold separately

For overview of Wet-Tap System, see 3519 product page

## Application Tips

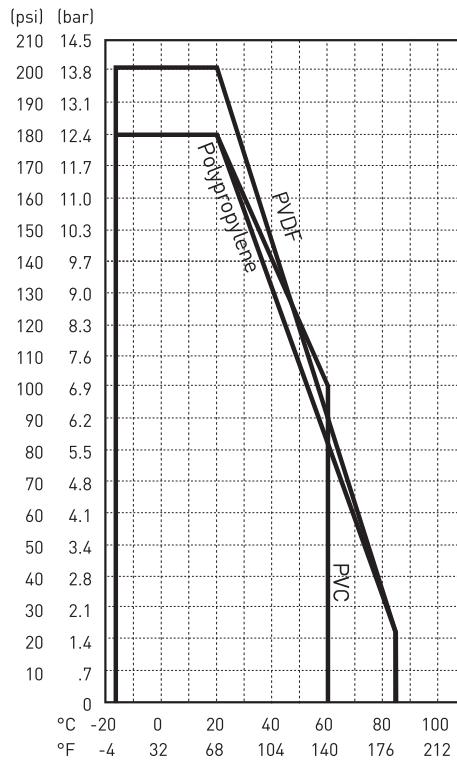
- Use the Conduit Adapter Kit to protect the cable-to-sensor connection when used in outdoor environments. See Accessories section for more information.
- Use a sleeved rotor in abrasive liquids to reduce wear.

- Sensor plug can be used to plug installation fitting after extraction of sensor from pipe.
- For liquids containing ferrous particles, use Signet Magmeters.
- For systems with components of more than one material, the maximum temperature/pressure specification must always be referenced to the component with the lowest rating.

# Temperature/Pressure Graphs

## Note:

The pressure/temperature graphs are specifically for the Signet sensor. During system design the specifications of all components must be considered. In the case of a metal piping system, a plastic sensor will reduce the system specification. When using a PVDF sensor in a PVC piping system, the fitting will reduce the system specification.



## Ordering Notes

- 1) Most common part number combinations shown. For all other combinations contact factory.
- 2) Other rotor and pin materials are available for purchase from the factory and can be easily replaced in the field. See Accessories section.

## Ordering Information

### Model 2536 Standard Mount Paddlewheel

When choosing this style of sensor, the instrument can be mounted nearby on a pipe or wall or in a remote location up to 305 m (1000 ft) by connecting the sensor through a standard 3-8050-1 universal junction box. Standard cable length is 7.6 m (25 ft). Use Signet fittings for proper seating of the sensor into the process flow.

Mfr. Part No.	Code	Body	Rotor	Pin Material
Flow Sensor for use with remote mount instrument				
DN15 to DN100 - 1/2 to 4 in.				
3-2536-P0	<b>198 840 143</b>	Polypropylene	Black PVDF	Titanium
3-2536-T0	<b>198 840 149</b>	Natural PVDF	Natural PVDF	Natural PVDF
3-2536-U0	<b>159 001 843</b>	PVC	Sleeved ETFE	Titanium
3-2536-V0	<b>198 840 146</b>	Natural PVDF	Natural PVDF	Hastelloy-C
DN125 to DN 200 - 5 to 8 in				
3-2536-P1	<b>198 840 144</b>	Polypropylene	Black PVDF	Titanium
3-2536-V1	<b>198 840 147</b>	Natural PVDF	Natural PVDF	Hastelloy-C
DN250 to DN900 - 10 to 36 in.				
3-2536-P2	<b>198 840 145</b>	Polypropylene	Black PVDF	Titanium

## Ordering Information (continued)

### Model 2536 Integral Mount Paddlewheel

When choosing this style of sensor, the instrument is mounted directly onto the sensor for a local display. See guidelines below for instructions.

Mfr. Part No.	Code	Body	Rotor	Pin Material
Flow sensor for integral mounting on the 8150 or 9900 instrument using the 3-8051-X Flow Sensor Integral Mount Kit (sold separately)				
DN15 to DN100 - ½ to 4 in.				
3-8512-P0	<b>198 864 513</b>	Polypropylene	Black PVDF	Titanium
3-8512-T0	<b>198 864 518</b>	Natural PVDF**	Natural PVDF	Natural PVDF
3-8512-V0	<b>198 864 516</b>	Natural PVDF**	Natural PVDF	Hastelloy-C
DN125 to DN200 - 5 to 8 in. (PP only)				
3-8512-P1	<b>198 864 514</b>	Polypropylene	Black PVDF	Titanium

\*\*Natural PVDF available ½ in. to 4 in. only

### Guidelines: Combining a 2536 integral mount flow sensor with an integrally mounted instrument

Once an integral mount sensor is chosen, it can be mounted directly to a field mount transmitter by following these guidelines:

- Order the 3-8051-X flow sensor integral mounting kit (sold separately) to connect the sensor to an instrument.
- Order a field mount transmitter (sold separately). The following part number is compatible:  
3-9900-1.
- Assembling the sensor with the integral adapter and instrument is quick and simple.

### Model 2536 Wet-Tap Mount Paddlewheel Flow Sensor

When choosing this style of sensor, the instrument can be mounted nearby on a pipe or wall or in a remote location up to 305 m (1000 ft) by connecting the sensor through a standard 3-8050-1 universal junction box. Standard cable length is 7.6 m (25 ft). This style of sensor uses the 3519 Wet-Tap valve only (see individual product page for more information).

Mfr. Part No.	Code	Body	Rotor	Pin Material
Flow Sensor for wet-tap mounting with the 3519 Wet-Tap Valve (sold separately)				
DN15 to DN100 - ½ to 4 in.				
3-2536-P3	<b>159 000 758</b>	Polypropylene	Black PVDF	Titanium
DN125 to DN200 - 5 to 8 in.				
3-2536-P4	<b>159 000 759</b>	Polypropylene	Black PVDF	Titanium
DN250 to DN900 - 10 to 36 in.				
3-2536-P5	<b>159 000 760</b>	Polypropylene	Black PVDF	Titanium

### Guideline: Combining a 2536 Wet-Tap Sensor with a 3519 Wet-Tap Valve

- Once a sensor is chosen, it can be mounted in a 3519 Wet-Tap Valve (sold separately)
- Assembling a sensor with a 3519 Wet-Tap valve is quick and simple. These parts can also be ordered as complete assemblies. See 3519 product page.

### Model 2536 Ordering Notes

Other rotor and pin materials are available for purchase from the factory and can be easily replaced in the field. See Accessories section.

Please refer to Wiring, Installation, Accessories and Fittings sections for more information.

## Accessories and Replacement Parts

Mfr. Part No.	Code	Description
<b>Rotors</b>		
3-2536.320-1	<b>198 820 052</b>	Rotor, PVDF Black
3-2536.320-2	<b>159 000 272</b>	Rotor, PVDF Natural
3-2536.320-3	<b>159 000 273</b>	Rotor, ETFE
3-2536.322-1	<b>198 820 056</b>	Sleeved rotor, PVDF Black
3-2536.322-2	<b>198 820 057</b>	Sleeved rotor, PVDF Natural
3-2536.322-3	<b>198 820 058</b>	Sleeved rotor, ETFE
<b>Rotor Pins</b>		
M1546-1	<b>198 801 182</b>	Pin, Titanium
M1546-2	<b>198 801 183</b>	Pin, Hastelloy-C
M1546-3	<b>198 820 014</b>	Pin, Tantalum
M1546-4	<b>198 820 015</b>	Pin, Stainless Steel
P51545	<b>198 820 016</b>	Pin, Ceramic
<b>O-Rings</b>		
1220-0021	<b>198 801 000</b>	O-ring, FKM (2 required per sensor)
1224-0021	<b>198 820 006</b>	O-ring, EPR (EPDM) (2 required per sensor)
1228-0021	<b>198 820 007</b>	O-ring, FFKM (2 required per sensor)
<b>Miscellaneous</b>		
P31536	<b>198 840 201</b>	Sensor plug, Polypropylene
P31542-3	<b>159 000 464</b>	Sensor cap, Blue
3-2536.555	<b>159 500 532</b>	Sensor cap, Gray
P31934	<b>159 000 466</b>	Conduit cap
P51589	<b>159 000 476</b>	Conduit adapter kit
5523-0222	<b>159 000 392</b>	Cable (per foot), 2 cond. w/shield, 22 AWG
3-2536.321	<b>198 820 054</b>	PVDF Natural, Rotor kit (rotor and pin)
3-8050	<b>159 000 184</b>	Universal mount kit
3-8050-1	<b>159 000 753</b>	Universal junction box
3-8050.390-1	<b>159 001 702</b>	Retaining nut replacement kit, NPT, Valox (for use with 8510 and 8512)
3-8050.390-3	<b>159 310 116</b>	Retaining nut replacement kit, NPT, PP (for use with 8510 and 8512)
3-8050.390-4	<b>159 310 117</b>	Retaining nut replacement kit, NPT, PVDF (for use with 8510 and 8512)
3-8051	<b>159 000 187</b>	Transmitter integral adapter (for use with 8510 and 8512)
3-8051-1	<b>159 001 755</b>	Transmitter integral mounting kit, NPT, PP (for use with 8510 and 8512)
3-8051-2	<b>159 001 756</b>	Transmitter integral mounting kit, NPT, PVDF (for use with 8510 and 8512)

# Signet 2724-2726 pH/ORP Electrodes

+GF+

Compatible with ALL Signet pH/ORP Instruments



Flat  
Glass



Protected  
Bulb

The Signet 2724-2726 pH and ORP Electrodes features a patented reference electrode design and uses the unique foul-proof patented DryLoc® connector. The large area PE reference junction and pathway is constructed to increase the total reference effectiveness and ensures long service life.

The DryLoc® connector with corrosion resistant gold plated contacts readily connects the sensor to the mating 2760 preamplifier or the 2750 sensor electronics. The robust Ryton® threaded sensor body and choice of flat pH, bulb pH, or flat ORP sensing elements provides broad range of chemical compatibility for a wide variety of applications. There are two optional pH sensing versions available, HF and LC. The HF version is for applications where traces of hydrofluoric acid (2% or less) will attack standard pH glass in levels of pH 6 and below. The LC version can be used for low conductivity fluids 20 - 100  $\mu\text{S}/\text{cm}$  nominal and below 20  $\mu\text{S}$  when mounted under controlled conditions.

The quick temperature response is available in either a PT1000 or 3 K $\Omega$  temperature sensor and allows compatibility with all Signet pH/ORP instruments. The 2724-2726 electrodes are general-purpose sensors ideal for a wide range of applications. The sensors incorporate  $\frac{3}{4}$  inch NPT or ISO 7/1-R 3/4 threads for installing into standard pipe-tees. They can also be mounted directly into Signet standard fittings, DN15 to DN100 ( $\frac{1}{2}$  to 4 inch)

## Features

- Patented reference design for exceptional performance \*
- Mounts in Signet standard fittings from DN15 to DN100 ( $\frac{1}{2}$  to 4 in.)
- $\frac{3}{4}$ " NPT or ISO 7/1-R 3/4 threaded sensors for use with reducing tees DN15 to DN100 ( $\frac{1}{2}$  to 4 in.)
- Special design allows for installation at any angle, even inverted or horizontal
- Ryton® (PPS) body for broad range of chemical compatibility
- Patented DryLoc® connector with gold plated contacts
- Quick temperature response
- Bulb HF Resistant glass available for trace HF, less than 2% concentration, applications
- Low conductivity sensor available for liquids down to 20  $\mu\text{S}/\text{cm}$
- New! Flat HF resistant glass available for trace HF, less than 2% concentration applications. Especially in applications with abrasive particles or that require extensive probe cleaning

## Applications

- Water & Wastewater Treatment
- Neutralization Systems
- Effluent Monitoring
- Sanitization Systems
- Pool & Spa Control
- Aquatic Animal Life Support Systems
- Process Control
- Cooling Towers

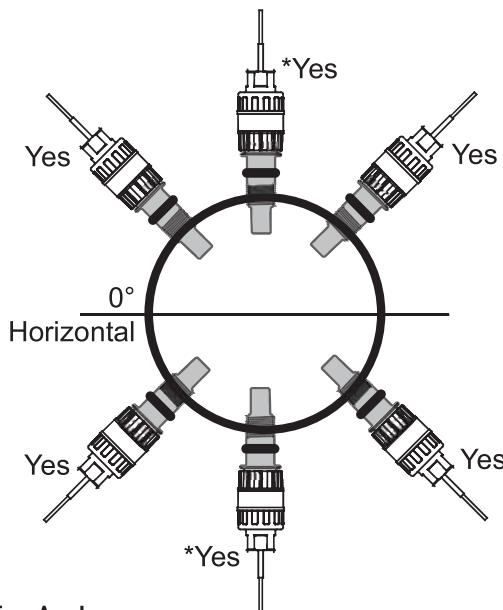
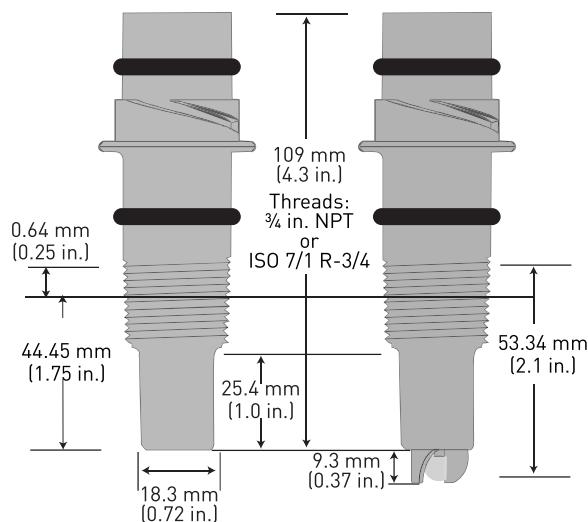
\*U.S. Patent Nos.: 6,666,701,  
7,799,193 B2, 7,867,371 B2 and  
8,211,282 B2

# Specifications

General					
Performance	Efficiency		>97% @ 25 °C (77 °F)		
Operating Range	pH	0 to 14 pH			
	ORP	±2000 mV			
	3-2726-LC	Low conductivity fluids; 20 - 100 µS/cm nominal < 20 µS; flow must be less than 150 ml/min in a properly grounded system			
	3-2724-HF, 3-2726-HF	Hydrofluoric acid resistant glass, pH 6 or below; trace HF ≤2%			
Compatibility					
	2750 Electronic (for 8900, 9900, 4 to 20 mA), 2760 Preamplifier (8750)				
Temperature Sensor					
	PT1000 versions	Compatible with Signet 2750 pH/ORP Sensor electronics for connection to a PLC or to the Signet 8900 or 9900 instruments			
	3 KΩ Balco versions	Compatible with the Signet 2760 pH/ORP preamplifier for connection to the Signet 8750 pH/ORP Transmitter and 2750 with 8900 or 9900 instruments			
Process Connection					
	¾ in. NPT	ISO 7/1-R ¾	Mounts into Signet fittings		
Wetted Materials					
	pH	Ryton® (PPS), glass, UHMW PE, FPM			
	ORP	Ryton® (PPS), glass, UHMW PE, FPM, Platinum			
Max. Temperature/Pressure Rating					
Operating Temperature Range*	-10 °C to 85 °C		14 °F to 185 °F		
Operating Pressure Range	0 to 6.9 bar (0 to 100 psi) @ -10 °C to 65 °C (14 °F to 149 °F)				
	Linearity Derated 6.9 to 4.0 bar (100 to 58 psi) @ 65 °C to 85 °C (149 °F to 185 °F)				
*Best performance for 2724-HF and 2726-HF sensors is above 10 °C (50 °F)					
Recommended Storage Temperature					
	0 °C to 50 °C		32 °F to 122 °F		
The electrode glass will shatter if shipped or stored at temperature below 0 °C (32 °F)					
The performance life of the electrode will shorten if stored at temperatures above 50 °C (122 °F)					
Mounting					
In-line Mounting	Use the sensor threads				
	Use a Signet standard fitting ½ to 4 in.				
	Sensor can be mounted at any angle				
Submersible Mounting	Use threads on models 2750 or 2760				
	Requires ¾ inch NPT or ISO 7/1-R 3/4 male threaded liquid tight extension conduit.				
Shipping Weight					
	0.25 kg	0.55 lb			
Standards and Approvals					
	RoHS Compliant, China RoHS				
	Manufactured under ISO 9001 for Quality, ISO 14001 for Environmental Management and OHSAS 18001 for Occupational Health and Safety				

See Temperature and Pressure graphs for more information

## Dimensions

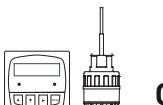
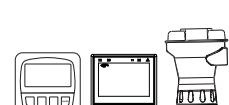
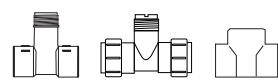


### Mounting Angle

Models 2724-2726 may be mounted at any angle without affecting the performance.

\*Avoid locations with air pockets and sediment.

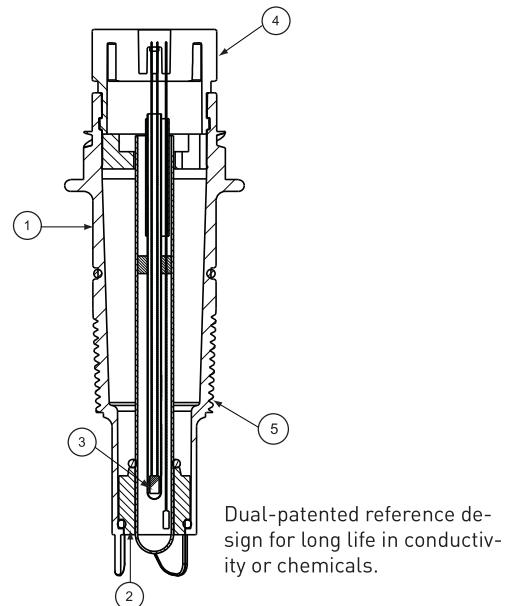
## System Overview

Panel Mount	Field Mount - Pipe, Tank, Wall	4 to 20 mA Input
Signet Instruments 8750 with 2760 Preamplifier 9900 with 2750 Electronics	Signet Instruments 9900 with 2750 Electronics and 3-8050 Universal Mount kit	3-2750 Sensor Electronics and customer supplied Chart Recorder or Programmable Logic Controller
 OR 		
Signet 2724-2726 DryLoc® pH/ORP Electrodes		All sold separately
In-Line Installation - Signet and threaded fittings only  Submersible Installation - Customer supplied pipe extension or conduit with 3/4 in. NPT or ISO 7/1-R 3/4 threads* 		

\*Refer to the Signet Submersion brochure located in the K-Factors Fittings and More Kit [3-0000-709] for installation suggestions and options.

## Electrode Key Features and Benefits:

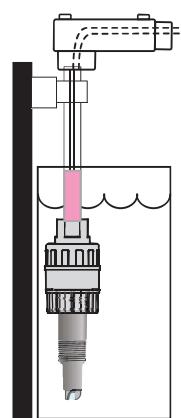
1. Ryton® body for chemical compatibility with most harsh chemicals.
  2. Porous UHMW PE (ultra high molecular weight polyethylene) junction resists fouling and build-up.
  3. Internal temperature sensor located in the glass stem for a quick temperature response.
  4. DryLoc® connector with corrosion resistant gold pins for quick and easy sensor removal.
    - Resists moisture and dirt intrusion.
  5. Dual-patented reference design with a 406 mm (16 inch) reference pathway enhances longer life. This enables the sensor to last significantly longer than other standard pH/ORP electrodes in most applications.
  - 5a. With the new patented reference design, the Signet 2726-LC version performs better in low conductivity water between 20 - 100  $\mu\text{S}$  and lasts longer than previous "DI" electrodes.
  - 5b. The 2726-LC sensor also performs in applications with extremely low (less than 20  $\mu\text{S}$ ) conductivity. Special precautions must be taken to avoid measurement complications.
- Please note the following.
- Electrostatic charges (streaming potentials) can cause dramatic offsets in a system with very low conductivity water. To minimize this, sensors should be placed in a well grounded system.
  - To enhance performance, a low flow cell is recommended to provide a steady flow rate (150 ml/minute). Sensors placed in high flow applications will experience noisier readings due to streaming potential.
6. Threads for NPT or ISO process connection into reducing tees
    - Use off-the-shelf GF reducing tees DN20 to DN100 (3/4 in. to 4 in.).
  7. Mounts directly into Signet fittings (1/2 in. 4 in.) for easy sensor retrofitting.
  8. Mount submersed into a tank via the 2750 or 2760 back threads.



⑥ Sensor in threaded reducing tee



⑦ Sensor in Signet fitting

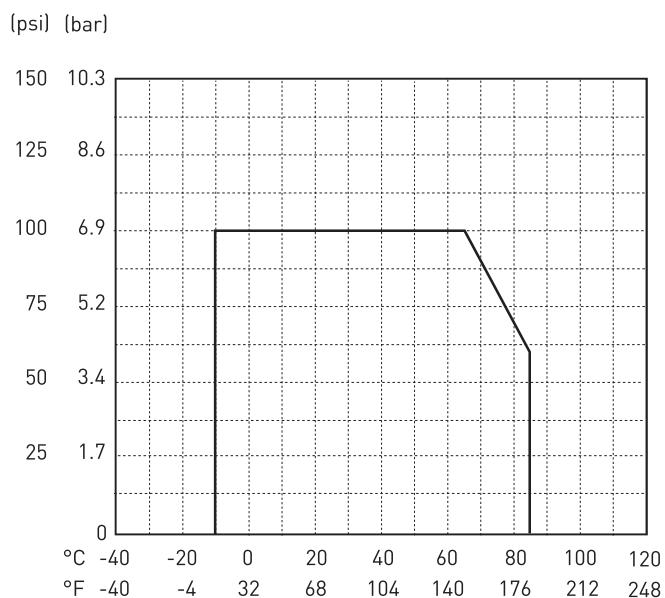


⑧ Sensor submersible installation

# Operating Temperature/Pressure Graph

## Note:

The pressure/temperature graphs are specifically for the Signet sensor. During system design the specifications of all components must be considered. In the case of a metal piping system, a plastic sensor will reduce the system specification.



## Application Tips

- Use the flat glass electrodes when a self-cleaning feature is desired; especially useful in applications with abrasive chemicals.
- Use bulb protected electrodes for general purpose applications
- ORP electrodes are generally used for chemical reaction monitoring, not control.
- Ensure that sensor materials are chemically compatible with the process liquid.
- Keep electrode tip wet, avoid air pockets and sediment.

## Model 2724-2726 Ordering Notes

- 1) pH and ORP electrodes require connection to model 2750 sensor electronics or 2760 preamplifier.
- 2) The 2750 "EasyCal" feature recognizes common pH and ORP buffer values of 4, 7 and 10 pH and +87 and +264 mV for ORP.

## Buffer Solutions

3822-7004  
3822-7007  
3822-7010

## Quinhydrone

3822-7115



The Signet pH buffers are ideal for calibration. The liquid solutions are conveniently packaged in one pint (473 ml) bottles. pH buffer kits in powder pillows are available for mixing fresh solutions with water at the time of use.

All pH buffers are color coded for easy identification; 4.01 pH is red, 7.00 pH is yellow, and 10.00 pH is blue. All pH buffers are traceable to NIST standards. These buffer solutions can be used to calibrate ORP sensors when saturated with quinhydrone.

## Ordering Information

Mfr. Part No.	Code	Tip design	Process Connection Thread Options
<b>pH Electrodes</b>			
Temperature element PT1000; use with 2750 sensor electronics*			
3-2724-00	<b>159 001 545</b>	Flat	3/4 in. NPT, Thread
3-2724-01	<b>159 001 546</b>	Flat	ISO 7/1-R 3/4 Thread
3-2726-00	<b>159 001 553</b>	Bulb	3/4 in. NPT, Thread
3-2726-01	<b>159 001 554</b>	Bulb	ISO 7/1-R 3/4 Thread
3-2726-HF-00	<b>159 001 549</b>	Bulb, HF resistant <sup>1</sup>	3/4 in. NPT, Thread
3-2726-HF-01	<b>159 001 550</b>	Bulb, HF resistant <sup>1</sup>	ISO 7/1-R 3/4 Thread
3-2726-LC-00	<b>159 001 557</b>	Bulb, Low Conductivity <sup>2</sup>	3/4 in. NPT, Thread
3-2726-LC-01	<b>159 001 558</b>	Bulb, Low Conductivity <sup>2</sup>	ISO 7/1-R 3/4 Thread
Temperature element 3 KΩ Balco; use with 2760 preamplifier** or 2750 sensor electronics*			
3-2724-10	<b>159 001 547</b>	Flat	3/4 in. NPT, Thread
3-2724-11	<b>159 001 548</b>	Flat	ISO 7/1-R 3/4 Thread
3-2724-HF-10	<b>159 001 771</b>	Flat, HF resistant <sup>1</sup>	3/4 in. NPT, Thread
3-2724-HF-11	<b>159 001 772</b>	Flat, pH resistant <sup>1</sup>	7/1-R 3/4 Thread
3-2726-10	<b>159 001 555</b>	Bulb	3/4 in. NPT, Thread
3-2726-11	<b>159 001 556</b>	Bulb	ISO 7/1-R 3/4 Thread
3-2726-HF-10	<b>159 001 551</b>	Bulb, HF resistant <sup>1</sup>	3/4 in. NPT, Thread
3-2726-HF-11	<b>159 001 552</b>	Bulb, HF resistant <sup>1</sup>	ISO 7/1-R 3/4 Thread
3-2726-LC-10	<b>159 001 559</b>	Bulb, Low Conductivity <sup>2</sup>	3/4 in. NPT, Thread
3-2726-LC-11	<b>159 001 560</b>	Bulb, Low Conductivity <sup>2</sup>	ISO 7/1-R 3/4 Thread
ORP Electrodes; Compatible with both the 2750 sensor electronics* and the 2760 preamplifier**			
3-2725-60	<b>159 001 561</b>	Flat	3/4 in. MNPT, Thread
3-2725-61	<b>159 001 562</b>	Flat	ISO 7/1-R 3/4 Thread

\*The 2750 sensor electronics has a digital (S<sup>3</sup>L) output which is used with 8900 or 9900 instruments.  
It also has a 4 to 20 mA output for connections to PLC's, data recorders, etc.

\*\*The 2760 preamplifier is used for connection directly to Signet 8750 Transmitter or other analog transmitters.

<sup>1</sup>HF resistant <2% HF

<sup>2</sup>Low conductivity applications, 20 - 100 µS/cm recommended

**Note:**

The 3K Balco temperature element electrodes are also compatible with the 2750 sensor electronics, 8900 and 9900 instruments.

## Accessories and Replacement Parts

Mfr. Part No.	Code	Description
1220-0021	<b>198 801 000</b>	O-ring, FPM
3-2700.395	<b>159 001 605</b>	Calibration kit: includes 3 polypropylene cups, box used as cup stand, 1 pint (473 ml) pH 4.01, 1 pint (473 ml) pH 7.00
3822-7115	<b>159 001 606</b>	20 gm bottle quinhydrone for ORP calibration (must use pH 4.01 and/or pH 7.00 buffer solutions)
3-2759	<b>159 000 762</b>	pH/ORP System Tester (adapter cable sold separately)
3-2759.391	<b>159 000 764</b>	2759 DryLoc® Adapter Cable (for use with 2750 and 2760)
3-0700.390	<b>198 864 403</b>	pH Buffer Kit (1 each 4, 7, 10 pH buffer in powder form, makes 50 ml of each)
3822-7004	<b>159 001 581</b>	pH 4.01 buffer solution, 1 pint (473 ml) bottle
3822-7007	<b>159 001 582</b>	pH 7.00 buffer solution, 1 pint (473 ml) bottle
3822-7010	<b>159 001 583</b>	pH 10.00 buffer solution, 1 pint (473 ml) bottle



# GF 2751 DryLoc® pH/ORP Smart Sensor Electronics



In-line  
2751-1

In-line EasyCal  
2751-2

Submersible  
2751-3 or 2751-4

DryLoc® Electrodes sold separately

The GF 2751 pH/ORP Smart Sensor Electronics featuring the DryLoc® connector, is the solution for field-free calibration, out of range glass impedance and broken glass detection, alerting the operator to probe failure or maintenance needs.

The 2751 features two different outputs: a two-wire 4 to 20 mA loop output with optional EasyCal function or a digital (S<sup>3</sup>L) output which allows for longer cable lengths and is compatible with all GF 8900, 9900 and 9950\* instruments or in blind, 4 to 20 mA.

The pH/ORP Smart Sensor Electronics will allow for calibration of electrodes in a laboratory setting and installation of pre-calibrated probes in the field, reducing system downtime. Memory chip enabled electrodes will store operational data such as minimum and maximum pH/mV readings, runtime, minimum and maximum temperature (pH only), for troubleshooting and operational evaluation. To take full advantage of all features and benefits of the 2751, use with GF 9900 (Generation IV or later), 9950 Transmitter or 0486 Profibus Concentrator.

The 2751 self-configures for pH or ORP operation via automatic recognition of the electrode type. The optional EasyCal feature allows simple push-button calibration and includes an LED indicator for visual feedback.

The 2751 submersible pH/ORP Smart Sensor Electronics can also be used in-line when used with the 3/4" or 1" threaded sensors including the 272X, 273X, 274X, 275X and 277X series of electrodes. The 2751 in-line sensor electronics can be used with GF fittings up to DN100 (4 in.) and Wet-Tap assemblies.

## Features

- Probe health monitoring, glass impedance and broken glass detection
- Memory chip interface that allows for transferable calibration, runtime data, and manufacturing information
- In-line integral mount and submersible installation versions
- Automatic temperature compensation
- Auto configuration for pH or ORP operation
- Optional EasyCal calibration aid with automatic pH buffer recognition for 4, 7 and 10 pH and ORP solutions: quinhydrone saturated pH 4 or 7 buffers and Light's Solution +469 mV
- Junction boxes for convenient wiring
- Patented DryLoc® connector provides a quick and secure connection to the sensor\*\*



## Applications

- Water and Wastewater Treatment
- Neutralization Systems
- Scrubber Control
- Effluent Monitoring
- Surface Finishing
- Flocculent Coagulation
- Heavy Metal Removal and Recovery
- Toxics Destruction
- Sanitization Systems
- Pool & Spa Control
- Aquatic Animal Life Support Systems

\*Users of 9950 Gen I and 9950 (Gen 2a) should update to 9950 (Gen 2b or later) to take full advantage of the 2751 features and benefits. Visit [www.gfps.com](http://www.gfps.com) for the latest software update.

\*\*U.S. Patent No.: 6,666,701

# Specifications

## General

### Compatible Electrodes

DryLoc® pH and ORP Electrodes, Models 2724-2726, 2734-2736, 2744-2747, 2756-2757 Wet-Tap, 2774-2777

Operating Range	pH	-1 to 15 pH
	ORP	±2000 mV
Response Time	pH	Electrode dependent
	ORP	Application dependent
Materials	In-line	PBT (thermal plastic polyester) and polypropylene (retaining nut)
	Submersible	CPVC

## Electrical

Cable	4.6 m	15 ft	3-conductor shielded (3-2751-1 in-line and the 3-2751-3 or -4 submersible sensor electronics only) See ordering information for additional cable sizes
	22 AWG		For 9900, 9950 and 4 to 20 mA max. cable length is 305 m (1,000 ft). For 8900, please refer to the Cable Calculation Table of the catalog for max. cable length.
Power	12 to 24 VDC		±10%, regulated for 4 to 20 mA output
	5 to 6.5 VDC		±5% regulated recommended, 3 mA max., for digital (S <sup>3</sup> L) output
Current Output	pH		Fixed 4 to 20 mA, isolated, = 0 to 14 pH (custom scaling available with 0252 tool)
	ORP		Fixed 4 to 20 mA, isolated, = -1000 to +2000 mV (custom scaling available from ± 2000 mV with 0252 tool)
Max. Loop Resistance	100 Ω max. @ 12 V	325 Ω max. @ 18 V	600 Ω max. @ 24 V
Accuracy	±32 µA		
Resolution	±5 µA		
Update Rate	0.5 seconds		
Error Indication	3.6 mA, 22 mA, or none		
Digital (S <sup>3</sup> L) Output	Serial ASCII, TTL level 9600 bps		
Accuracy	pH	± 0.02 pH @ 25 °C	± 0.02 pH @ 77 °F
	ORP	± 1.5 mV @ 25 °C	± 1.5 mV @ 77 °F
	Temperature	≤ 0.4 °C	0.72 °F
Resolution	pH	≤ 0.01 pH	
	ORP	1.5 mV	
Update Rate	0.5 seconds		
Available Data	Raw mV, pH or ORP, Temperature (pH), Glass Impedance (pH), Minimum mV (pH), Maximum mV (pH), Minimum Temperature (pH), Maximum Temperature (pH), Model Number, Serial Number, Manufacturing Date, Runtime, Slope pH/mV, Measurement Offset, and Temperature		
Error Indication	Open input diagnostic, broken glass detection (pH), High Impedance		
Input Impedance, Z	>10 <sup>11</sup> Ω		

## Environmental

Enclosure	3-2751-1 & -2	NEMA 4X/IP65 with electrode connected
	3-2751-3 & -4	NEMA 6P/IP68 with electrode and watertight conduit and/or extension pipe connected

## Maximum Temperature/Pressure Rating

### Operating Temperature

Submersible	0 °C to 85 °C	32 °F to 185 °F
In-line	0 °C to 85 °C	32 °F to 185 °F
Storage Temperature	-20 °C to 85 °C	-4 °F to 185 °F

### Relative Humidity

0 to 95%, non-condensing (without electrode connected)

## Shipping Weight (based on 4.6 m (15 ft) cable lengths)

2751-2	0.75 kg	1.65 lb
2751-1, -3 & -4	0.64 kg	1.41 lb

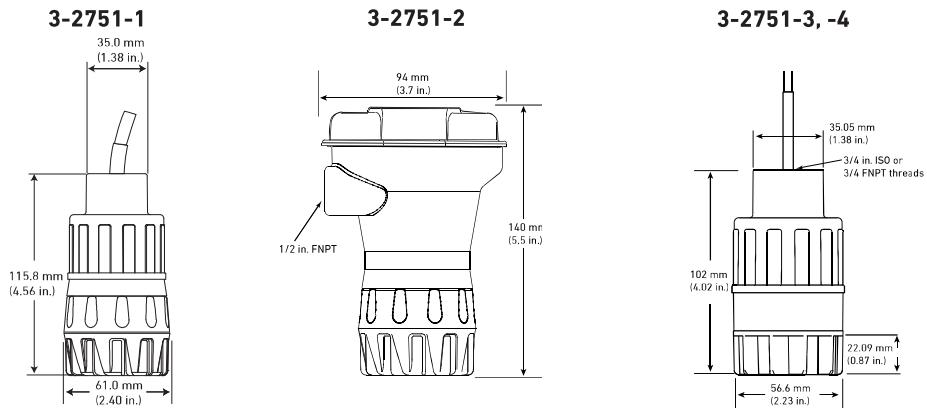
## Standards and Approvals

CE, FCC

RoHS compliant, China RoHS

Manufactured under ISO 9001, ISO 14001 and ISO 45001

## Dimensions



## 2751 Product Selection Guide

<b>1. Choose the Electrode</b>	2724-2726, 2734-2736  Can use Any 3-272X or 273X series electrode	2744-2747 Differential  3-2744-1 3-2744-2 3-2746-1 3-2746-2	2774-2777  ORP electrodes must have 10K ID resistor use: 3-2775, 3-2777  pH electrodes can be either the 1K or 3K use: 3-2774, 3-2774-1, 3-2776, 3-2776-1	2756 and 2757 Wet-Tap  Can use any Wet-Tap 275X series electrode
<b>2. Determine the mounting style:</b>	In-line  And  -In-line fitting  Or  Submersible			
<b>3. Junction Boxes</b>	3-8050-1: Use when extending the submersible cable over long distance. 3-8050-2: Use with the submersible 2751-3 or -4 and the in-line 2751-1 for best calibration results with the EasyCal function when using the blind 4 to 20 mA output.			
<b>4. Choose the output instrument</b>	Digital (S'L)  Or  4 to 20 mA		<b>OR</b>	
		9900 or 9950 Instruments, Profibus Concentrator		PLCs or Chart Recorders

# System Overview

## In-Line Installation

Panel Mount	Pipe, Tank, Wall Mount	4 to 20 mA Output	Automation System
GF Instruments 8900 9900 9950	GF Instruments 9900 and Rear Enclosure	GF 2751 Smart Sensor Electronics with - Customer Supplied Chart Recorder or Programmable Logic Controller or - Programmable Automation Controller	- 0486 Profibus Concentrator and - Customer Supplied Programmable Logic Controller or - Programmable Automation Controller
<b>GF 2751 Smart Sensor Electronics</b>	<b>GF 2751 Smart Sensor Electronics</b> with GF 3-8050-2 Universal Junction Box (EasyCal)	<b>GF 2751 Smart Sensor Electronics</b>	
GF Electrodes 2724-2726 2734-2736 2744-2747 2774-2777			

2724-2726 and 2734-2736 DryLoc Electrodes: Use GF fittings\* or customer supplied 3/4 in. NPT fittings  
2744-2747 and 2774-2777 DryLoc Electrodes: Use customer supplied 3/4 in. or 1 in. NPT fittings

All sold separately

## Submersible Installation

## Wet-Tap Installation

Panel Mount	Pipe, Tank, Wall Mount	4 to 20 mA Output	Automation System
GF Instruments 8900 9900 9950	GF Instruments 9900 and Rear Enclosure	GF 2751 Smart Sensor Electronics with - Customer Supplied Chart Recorder or Programmable Logic Controller or - Programmable Automation Controller	- 0486 Profibus Concentrator and - Customer Supplied Programmable Logic Controller or - Programmable Automation Controller
<b>GF 2751 Smart Sensor Electronics</b> with customer supplied pipe extension or conduit, 3/4 in. NPT or ISO 7/1-R 3/4 threads**	<b>GF 2751 Smart Sensor Electronics</b> with GF Wet-Tap Electrode 2756, 2757 and GF 3719 Wet-Tap		
GF Electrodes 2724-2726 2734-2736 2744-2747 2774-2777	GF Tees and Fittings see model 3719 for more info		

All sold separately

\* See fittings section for more information.

\*\*Refer to the Submersion Kit brochure (3-0000.707) located on our website for installation suggestions and options.

## Model 2751 Ordering Information

- 1) Model 2751 requires 12 to 24 VDC to function as a blind 4 to 20 mA output transmitter.
- 2) Order a 3-2751-2 or any other 2751 with a junction box 3-8050-2 if the EasyCal feature is desired.
- 3) Conduit and mounting brackets for submersion installation must always be used (customer supplied).
- 4) The 3-2759 System Tester must be ordered with the adapter cable 3-2759.391 for exclusive use with the 2751.
- 5) All sensor electronics, preamplifiers and connectors require a DryLoc electrode for full system installation.
- 6) The 2751 pH/ORP Smart Sensor Electronics is compatible with all GF 8900, 9900 and 9950 instruments. To take full advantage of the advanced features use the 9900 SmartPro Transmitters (Generation IV or greater), 9950 and 0486 Profibus Concentrator.

## Application Tips

- The EasyCal feature automatically recognizes standard 4.0, 7.0, and 10.0 pH buffer or ORP quinhydrone solutions of +87 and +264 mV or Light's Solution, +469 mV, and simplifies calibration. For EasyCal ORP only single point calibration is used.
- Frequency of calibration of electrodes is dependent upon the application.



### 9900 pH/ORP Calibrator ( 150 399 007)

The 9900 battery operated calibrator is built to enhance the user experience with the new line of 2751 Smart pH/ ORP sensor electronics. This unit can be kept in a lab or taken in to the field. The calibration storage capability of the pH/ORP electrodes when used with the 2751 Smart sensor electronics, allows the user the ability to rotate electrodes, meaning unplug an aged/dirty electrode replacing with a pre-calibrated electrode.

With larger installations, all collected dirty and uncalibrated electrodes can be taken to a central well organized location where proper cleaning and calibration can be performed. This improves efficiency of this process resulting more stable readings, higher sensitivity, faster response time, and overall more accurate readings. Runs on (8) AA Alkaline batteries (included).



## Ordering Information

Mfr. Part No.	Code	Description
In-line pH/ORP Smart Sensor Electronics (yellow body)		
3-2751-1	<b>159 001 804</b>	with 4.6 m (15 ft) cable, recommended for 9900 or 9950 instruments
3-2751-1-025	<b>159 070 110</b>	with 7.6 m (25 ft) cable, recommended for 9900 or 9950 instruments
3-2751-1-050	<b>159 070 111</b>	with 15.2 m (50 ft) cable, recommended for 9900 or 9950 instruments
3-2751-1-100	<b>159 070 112</b>	with 30.5 m (100 ft) cable, recommended for 9900 or 9950 instruments
3-2751-2	<b>159 001 805</b>	with junction box and EasyCal, recommended for 4 to 20 mA use
Submersible pH/ORP Smart Sensor Electronics (gray body)		
3-2751-3	<b>159 001 806</b>	with 4.6 m (15 ft) cable and ¾ in. NPT threads - when 4 to 20 mA is required use the 3-8050-2 junction box with EasyCal
3-2751-3-025	<b>159 070 113</b>	with 7.6 m (25 ft) cable and ¾ in. NPT threads - when 4 to 20 mA is required use the 3-8050-2 junction box with EasyCal
3-2751-3-050	<b>159 070 114</b>	with 15.2 m (50 ft) cable and ¾ in. NPT threads - when 4 to 20 mA is required use the 3-8050-2 junction box with EasyCal
3-2751-3-100	<b>159 070 115</b>	with 30.5 m (100 ft) cable and ¾ in. NPT threads - when 4 to 20 mA is required use the 3-8050-2 junction box with EasyCal
3-2751-4	<b>159 001 807</b>	with 4.6 m (15 ft) cable and ISO 7/1-R 3/4 threads - when 4 to 20 mA is required use the 3-8050-2 junction box with EasyCal

Sensor Electronics with preamplified signal and digital (S<sup>3</sup>L) output (for use with the SmartPro Instruments) or 4 to 20 mA output - power supplied to unit dictates output type.

**Note:**

The 2751 pH/ORP Smart Sensor Electronics is compatible with 8900, 9900 and 9950 SmartPro Transmitters, and GF 0486 Profibus Concentrator. To take full advantage of the 2751 features, use 9900 (Generation IV or later), 9950 or 0486 Profibus Concentrator.

## Accessories and Replacement Parts

Mfr. Part No.	Code	Description
<b>Calibration</b>		
3-2700.395	<b>159 001 605</b>	Calibration Kit: includes 3 polypropylene cups, box used as cup stand, 1 pint pH 4.01, 1 pint pH 7.00
3822-7115	<b>159 001 606</b>	20 gm Bottle Quinhydrone for ORP calibration (must use pH 4.01 and/or pH 7.00 buffer solutions)
3-2759	<b>159 000 762</b>	pH/ORP System Tester (adapter cable sold separately)
3-2759.391	<b>159 000 764</b>	2759 Adapter Cable for use with 2751 DryLoc Sensor Electronics
3-0700.390	<b>198 864 403</b>	pH Buffer kit (1 each 4, 7, 10 pH buffer in powder form, makes 50 ml of each)
3822-7004	<b>159 001 581</b>	pH 4 Buffer Solution, 1 pint (473 ml) bottle
3822-7007	<b>159 001 582</b>	pH 7 Buffer Solution, 1 pint (473 ml) bottle
3822-7010	<b>159 001 583</b>	pH 10 Buffer Solution, 1 pint (473 ml) bottle
<b>Mounting</b>		
3-8050.390-3	<b>159 310 116</b>	Retaining Nut Replacement Kit, Black Polypropylene
3-8050-1	<b>159 000 753</b>	Universal Mount Junction Box
3-8050-2	<b>159 000 754</b>	Universal Mount Junction Box w/EasyCal (for submersible applications, use with 3-2751-3 and -4 where 4 to 20 mA is required)
3-9000.392-1	<b>159 000 839</b>	Liquid Tight Connector Kit, NPT (1 connector)
3-9000.392-2	<b>159 000 841</b>	Liquid Tight Connector Kit, PG 13.5 (1 connector)
<b>Other</b>		
5523-0322	<b>159 000 761</b>	Sensor Cable (per ft), 3-cond. plus shield, 22 AWG, black/red/white (for use with 2751)
P31515-0P200	<b>159 000 630</b>	Universal Pipe Adapter PVC
P31515-0C200	<b>159 000 631</b>	Universal Pipe Adapter CPVC
P31515-0V200	<b>159 000 459</b>	Universal Pipe Adapter PVDF
7310-1024	<b>159 873 004</b>	24 VDC Power Supply, 10W, 0.42 A
7310-2024	<b>159 873 005</b>	24 VDC Power Supply, 24W, 1.0 A
7310-4024	<b>159 873 006</b>	24 VDC Power Supply, 40W, 1.7 A
7310-6024	<b>159 873 007</b>	24 VDC Power Supply, 60W, 2.5 A
7310-7024	<b>159 873 008</b>	24 VDC Power Supply, 96W, 4.0 A
3-2700.398	<b>159 001 886</b>	O-ring Lubricant Kit (5 packs of Super Lube, 1cc each)

Member of the SmartPro® Family of Instruments



The 9950 Transmitter is a two channel controller that can support two sensors of same or different types in one instrument. The sensor types supported by the 9950 are Signet Flow, pH/ORP, Conductivity/Resistivity, Salinity, Temperature, Pressure, Level, Dissolved Oxygen, and devices that transmit a 4 to 20 mA signal with the use of the 8058 iGo® Signal Converter.

The 9950 includes advanced features such as derived functions, advanced multiple relay modes, and timer based relay functions. Derived functions allows for the control of a relay or current loop with the sum, delta (difference), or ratio of two measurements, for example delta pressure and delta temperature. Multiple relay modes allow up to three signals to be used for the control of a single relay. This can be any combination of analog and binary inputs. The timer relay modes allow relay to be activated on a repeating basis from every minute to once every 30 days. Weekday timer mode allows a relay to be turned on on a specific day or days of the week at a specific time.

The 3-9950.393-3 Relay Module includes the ability to interface up to four binary inputs. The binary inputs are compatible with either open collector or mechanical contacts. The binary inputs can supply power to the four inputs or accepts powered outputs from external devices. These inputs can be used with level switches, flow switches, pressure switches or other devices. The inputs can be used to directly control the relays of the 9950 or can be used in combination with the measurement readings for advanced control of your process.

The 9950 supports the following relay modules:

- Four Channel Mechanical Relay Module
- Two Mechanical and Two Solid State Relay Module
- Two Mechanical Relays and Four Binary Inputs Module

## Features

- One instrument for multiple sensor types
- Two different sensor types can be combined in one unit
- Configurable display
- Derived measurements
- Advanced boolean logic
- Optional modules can be added for additional capabilities
- USB Port for Field Upgrades using standard USB Flash Drive



## Applications

- Wastewater Treatment
- Reverse Osmosis
- Deionization
- Chemical Manufacturing / Addition
- Metal and Plastic Finishing
- Fume Scrubber
- Cooling Tower
- Media Filtration
- Chemical Dosing/ Injection
- Aquatic Life Support
- Pools & Fountains
- Rinse Tanks
- Chemical Neutralization

## Specifications

General		
Input Channels	Two frequency or S <sup>3</sup> L inputs	
Enclosure and Display		
Case Material	PBT	
Window	Shatter-resistant glass	
Keypad	4 buttons, injection-molded silicone rubber seal	
Display	Dot matrix, LCD	
Indicators	Two horizontal digital bar graphs, four LED relay status indicators	
Update Rate	1 s	
LCD Contrast	5 settings	
Size	1/4 DIN	
Mounting		
Panel	1/4 DIN, ribbed on four sides for panel mounting clip inside panel, silicon gasket included	
Wall	Large enclosure (sold as an accessory)	
Terminal Blocks		
Pluggable Screw Type	Use minimum 105 °C rated wire	
Torque Ratings		
	Power/Loop	0.49 Nm (4.4 lb-in.)
	Freq/S <sup>3</sup> L	0.49 Nm (4.4 lb-in.)
	Relay Module	0.49 Nm (4.4 lb-in.)
Connector Wire Gauge		
	Power, Loop	12 to 28 AWG
	Freq/S <sup>3</sup> L	16 to 28 AWG
Relay Module Connector Wire Gauge		
	Relay	12 to 28 AWG
Environmental		
Ambient Operating Temperature		
DC Power	-10 °C to 70 °C	14 °F to 158 °F
AC Power	-10 °C to 60 °C	14 °F to 140 °F
Storage Temp	-15 °C to 70 °C	5 °F to 158 °F
Relative Humidity	0 to 100% condensing for (front only); 0 to 95% non-condensing (rear panel)	
Maximum Altitude	4,000 m (13,123 ft)	
Enclosure Rating	NEMA 4X/IP65 (front face only)	
Performance Specifications		
System Accuracy	Primarily dependent upon the sensor	
System Response	Primarily dependent upon the sensor. Controller adds a maximum of 150 ms processing delay to the sensor electronics.	
	Minimum update period is 100 ms	
	System response is tempered by the display rate, output averaging and sensitivity feature	

## Specifications (continued)

Electrical Requirements	
Power to Sensors	
Voltage	+4.9 to 5.5 VDC @ 25 °C, regulated
Current	30 mA Maximum
Short Circuit	Protected
Isolation	Low voltage (< 48 V AC/DC)
Power Requirements	
DC (3-9950-1, 3-9950-2)	24 VDC nominal (10.8 to 35.2 VDC regulated)
AC (3-9950-2)	100 to 240 VAC, 50 to 60 Hz, 24 VA
Maximum current	200 mA (without optional relay module)*
	500 mA (with optional relay module)*
*The current draw of the other modules and the sensors are minimal	
Current Loop	10.8 to 35.2 VDC 4 to 20 mA (30 mA max.)
Overvoltage protection	48 Volt Transient Protection Device (for DC ONLY)
Current limiting for circuit protection	
Reverse-Voltage protection	
Input Types	
Digital (S <sup>3</sup> L) or AC frequency	
4 to 20 mA input via the 8058	
Open collector	
pH/ORP input via the Digital (S <sup>3</sup> L) output from the 2750 pH/ORP Sensor Electronics	
Conductivity/Resistivity via the Digital (S <sup>3</sup> L) output from the 2850 Conductivity/Resistivity Sensor Electronics	
Sensor Types	Flow, pH/ORP, Conductivity/Resistivity, Pressure, Temperature, Level/Volume, Salinity, Dissolved Oxygen, Other (4 to 20 mA)
Sensor Input Specifications	
Digital (S <sup>3</sup> L)	Serial ASCII, TTL level, 9600 bps
Frequency Flow Sensors	0.5 to 1500 Hz
Sensitivity (for coil type sensors)	80 mV @ 5 Hz, gradually increasing with frequency to 2.5 V
Freq. Range (for square wave type sensors)	0.5 Hz to 1500 Hz @ TTL level input or open collector
K-Factor Range	0.0001 to 9999999
Accuracy	± 0.5% of reading max error @ 25 °C
Resolution	1 µs
Repeatability	± 0.2% of reading
Power Supply	
Rejection	No Effect ± 1 µA per volt
Short Circuit	Protected
Reverse Polarity	Protected
Update Rate	(1/frequency) + 100 ms

## Specifications (continued)

### Binary Input (3-9950.393-3)

Input Voltage Range (without damage)	-5 VDC to 30 VDC (No operation below 0 VDC)		
Max. Current Rating	6.0 mA		
Max. Voltage Rating	30 VDC		
Maximum Input Voltage for signal "Off" (low or "0")	3.0 VDC		
Minimum Input Voltage for signal "On" (high or "1")	4.8 VDC		
Maximum Current Draw for Signal "0" (low)	$\leq 500 \mu\text{A}$ DC		
Minimum Current Draw for Signal "1" (high)	750 $\mu\text{A}$		
Typical Current Draw for Signal "1" (high)	6.0 mA at 30 VDC, 4.8 mA at 24 VDC, 2.4 mA at 12 VDC, 1.0 mA at 5 VDC		

### Current Loop Specifications

Current Loop Out	ANSI-ISA 50.00.01 Class H (Passive, external voltage required)		
Voltage	10.8 to 35.2 VDC		
Max. Impedance	250 $\Omega$ @ 12 VDC	500 $\Omega$ @ 18 VDC	750 $\Omega$ @ 24 VDC
Span	3.8 to 21 mA		
Accuracy	$\pm 32 \mu\text{A}$ max. error @ 25 °C @ 24 VDC		
Resolution	6 $\mu\text{A}$ or better		
Temp. Drift	$\pm 1 \mu\text{A}$ per °C		
Isolation	Low voltage (< 48 VAC/DC)		
Update Rate	100 mS nominal		
Zero	4.0 mA factory set; user programmable from 3.8 to 5.0 mA		
Full Scale	20.0 mA factory set; user programmable from 19.0 to 21.0 mA		
Power Supply Rejection	$\pm 1 \mu\text{A}$ per V		

Actual Update Rate Determined by Sensor Type

Short Circuit and Reverse Polarity Protected

Adjustable Span, Reversible

Error Condition	Selectable error condition 3.6 or 22 mA or None
Test Mode	Increment to desired current (range 3.8 to 21.00 mA)
Analog Outputs	2 Passive 4 to 20 mA Outputs in Base Unit

### Relay Specifications

#### Dry-Contact Relays (3-9950.393-1, 3-9950.393-2, and 3-9950.393-3)

Type	SPDT
Form	C
Max. Voltage Rating	30 VDC or 250 VAC
Max. Current Rating	5 A resistive

#### Solid-State Relays (3-9950.393-2)

Type	SPDT
Form	C
Max. Voltage Rating	30 VDC or 30 VAC
Max. Current Rating	0.050 A resistive

Hysteresis

Adjustable (absolute in Engineering Units)

On Delay

9999.9 seconds (max)

Cycle Delay

99999 seconds (max)

Test Mode

Set On or Off

Maximum Pulse Rate (PLC and Counters)

300 pulses/minute

Proportional Pulse (Metering Pumps)

300 pulses/minute

Volumetric Pulse Width

0.1 to 3200 s

PWM Period (Solenoid Valves)

0.1 to 320 s

## Specifications (continued)

### Display Ranges

pH	-1.00 to 15.00 pH	
pH Temp.	-99 °C to 350 °C	-146 °F to 662 °F
ORP	-1999 to +1999.9 mV	
Flow Rate	-9999 to 99999 units per second, minute, hour or day	
Totalizer	0.00 to 99999999 units	
Conductivity	0.0000 to 99999 µS, mS, PPM and PPB (TDS), kΩ, MΩ	
Cond. Temp.	-99 °C to +350 °C	-146 °F to 662 °F
Temperature	-99 °C to +350 °C	-146 °F to 662 °F
Pressure	-40 to 1000 psi	
Level	-9999 to +99999 m, cm, ft, in, %	
Volume	0 to 99999 cm <sup>3</sup> , m <sup>3</sup> , in <sup>3</sup> , ft <sup>3</sup> , gal, L, lb, kg, %	
Salinity	0 to 100 PPT	
Dissolved Oxygen	0 to 50 mg/L, 0 to 200%	

### Shipping Weights

Base Unit	0.63 kg	1.38 lb
Relay Module	0.19 kg	0.41 lb

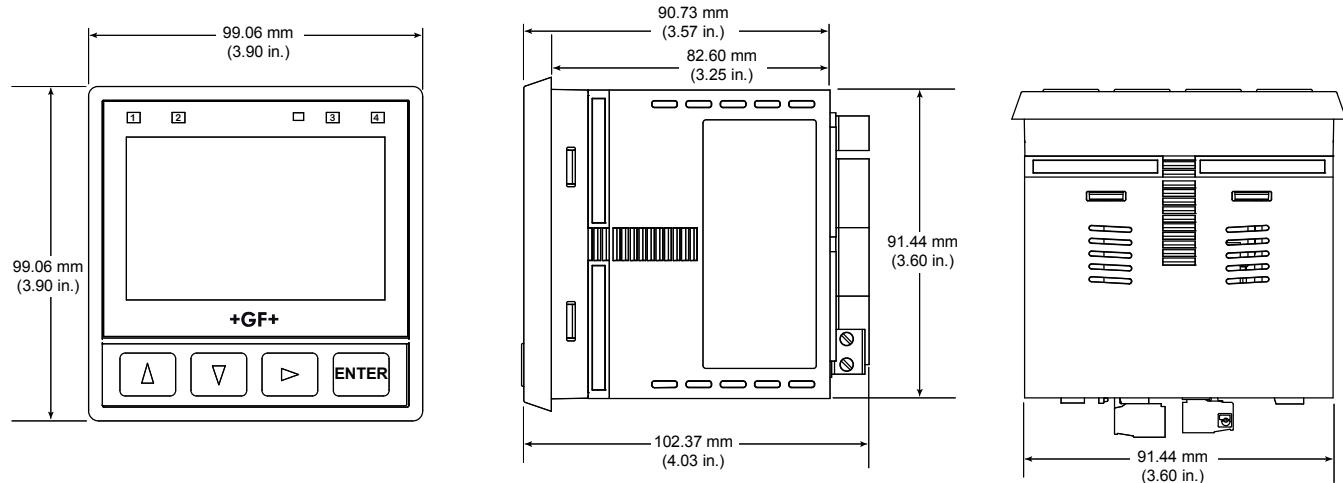
### Standards and Approvals

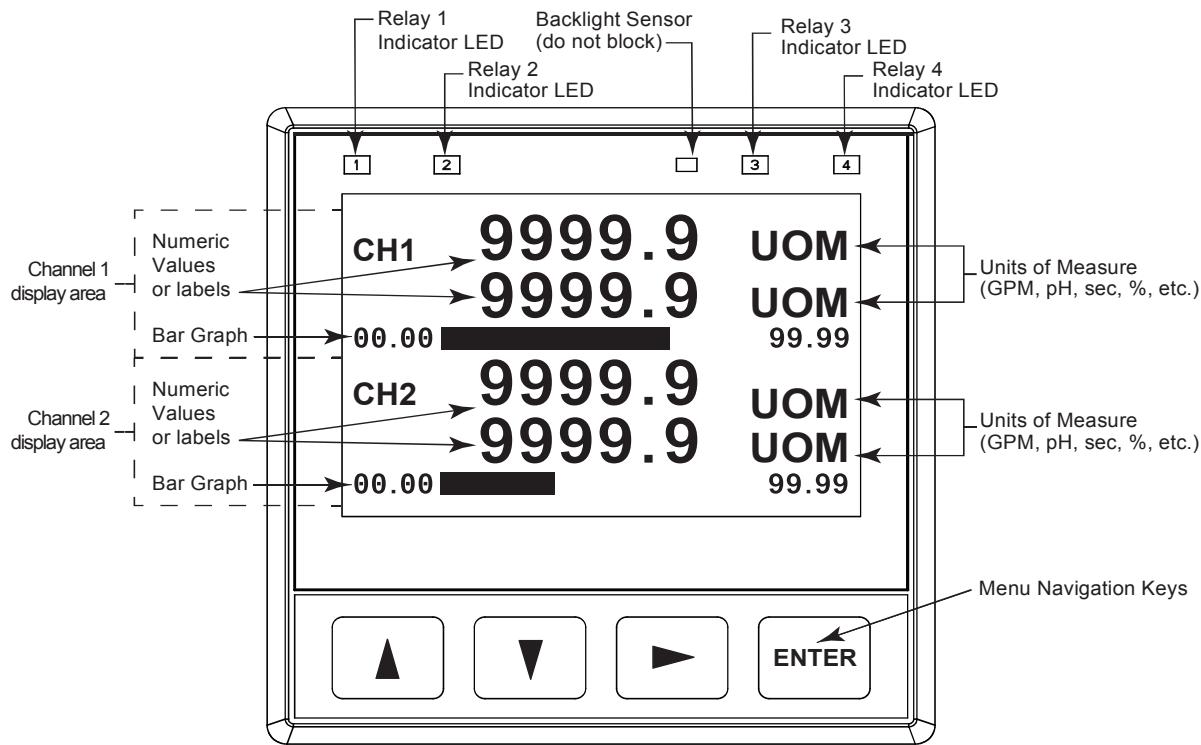
CE, UL, CUL, FCC

RoHS Compliant, China RoHS

Manufactured under ISO 9001 and ISO 14001 for Environmental Management and OHSAS 18001 for Occupational Health and Safety

## Dimensions





The 9950 is compatible with all GF Signet products listed in the column to the right.

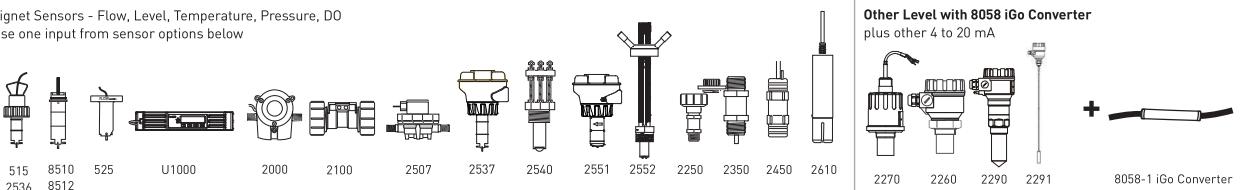
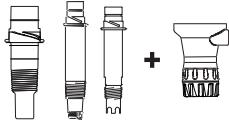
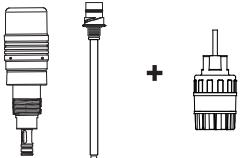
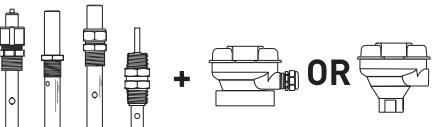
- pH and ORP electrodes require the Signet 2750 DryLoc® Sensor Electronics (sold separately).
- Conductivity/Resistivity or measurement requires the Signet 2850 Conductivity/Resistivity sensor electronics (sold separately).

Sensor Model	Freq Output	Digital (S <sup>3</sup> L) Output	Requires 8058
515/8510	X		
525	X		
2000	X		
2100	X		
2250		X	
2350		X	
2450		X	
2507	X		
2536/8512	X		
2537-5		X	
2540	X		
2551	X	X	
2552	X	X	
U1000	X		X
U3000	X		X
U4000	X		X
2260			X
2270			X
2290			X
2291			X
2610-41		X	
2724-2726		X	
2734-2736		X	
2750		X	
2756-2757		X	
2764-2767		X	
2774-2777		X	
2819-2823		X	
2839-2842		X	
2850		X	

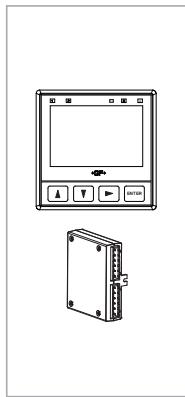
Binary Input compatible sensors. For use with  
3-9950.393-3 Relay Module

Sensor Model	Binary Input
2280	X
2281	X
2282	X
2284	X
2285	X

## System Overview

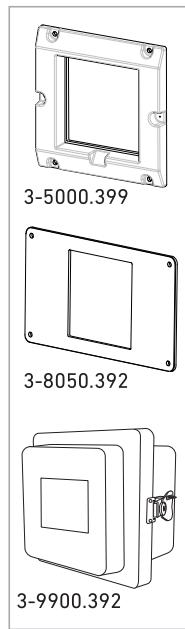
Panel or Wall Mount	
<b>Signet Model 9950 Transmitter</b> (Includes mounting bracket and panel gasket)	
Signet Sensors - Flow, Level, Temperature, Pressure, DO Use one input from sensor options below	
Signet Sensors - pH/ORP Use one input from sensor options below with 2750 Sensor Electronics	Signet Wet-Tap Electrode Model 2756, 2757 and 3719 Wet-Tap with 2750 Sensor Electronics
	
Signet Sensors - Conductivity/Resistivity and Salinity Electrodes Use one input from electrode options below with Conductivity Module or 2850 Sensor Electronics	
Signet Fittings - See individual sensor data sheets	All sold separately

## Ordering Information



Mfr. Part No	Code	Description
9950 Base Unit - Dual Channel, Multi-Parameter, AC Power and DC Power		
3-9950-1	<b>159 001 841</b>	9950 Base Unit – Two Channel Multi-Parameter Inputs, Two 4 to 20 mA Outputs, Panel Mount, DC Power
3-9950-2	<b>159 001 842</b>	9950 Base Unit – Two Channel Multi-Parameter Inputs, Two 4 to 20 mA Outputs, Panel Mount, AC or DC Power
<b>Optional Accessory Modules</b>		
3-9950.393-1	<b>159 310 268</b>	Relay Module with 4 Mechanical Relays
3-9950.393-2	<b>159 310 269</b>	Relay Module with 2 Mechanical and 2 Solid State Relays
3-9950.393-3	<b>159 310 270</b>	Relay Module with 2 Mechanical Relays and 4 Binary Inputs

## Accessories and Replacement Parts



Mfr. Part No	Code	Description
7310-1024	<b>159 873 004</b>	24 VDC Power Supply, 10 W, 0.42 A
7310-2024	<b>159 873 005</b>	24 VDC Power Supply, 24 W, 1.0 A
7310-4024	<b>159 873 006</b>	24 VDC Power Supply, 40 W, 1.7 A
7310-6024	<b>159 873 007</b>	24 VDC Power Supply, 60 W, 2.5 A
7310-7024	<b>159 873 008</b>	24 VDC Power Supply, 96 W, 4.0 A
3-5000.399	<b>198 840 224</b>	5 x 5 inch Retrofit Adapter
3-8050.392	<b>159 000 640</b>	CR200 ¼ DIN Retrofit Adapter
3-8050.396	<b>159 000 617</b>	RC Filter Kit (for relay use), 2 per kit
3-8058-1	<b>159 000 966</b>	i-Go® Signal Converter, wire-mount
3-9950.391	<b>159 310 278</b>	Connector Kit, In-Line, 9950 Transmitter
3-9950.392	<b>159 310 279</b>	Relay Module Connector Kit, 9950 Transmitter
3-9900.392	<b>159 001 700</b>	Wall Mount Enclosure Kit
3-9000.392-1	<b>159 000 839</b>	Liquid Tight Connector Kit, NPT (1 pc.)

# Metering Pumps

## EJ Series

The EJ Series provide precise chemical injection at an economical price.

Universal voltage capability enables operation from 100 - 240 VAC in virtually all countries.

The EJ Series are compact, simple to operate and have outputs to 1.3 GPH (4.8 LPH) and a maximum pressure of 175 PSI (1.2 MPa).



### Summary of Key Benefits

#### ➤ High Speed Performance

The EJ Series operate at 360 strokes-per-minute, providing high resolution chemical feed and high turndown capability. Most competitive products operate at slower speeds, resulting in slug feeding, accelerated diaphragm wear and poor feed control.

#### ➤ Universal Voltage

The Universal Voltage Function enables the EJ Series to operate at any AC voltage. The EJ Series also conform to global standards.

#### ➤ External Control

The EJ Series have both digital input and Stop/Start inputs built into the pump, enabling either proportional or On/Off control.

#### ➤ IP65 Equivalent Protection

A robust housing protects the pump from normal wear. Mounting the Digital Display and Key Pad control within the drive housing creates a highly water resistant design. A clear cover further protects the pump from liquids.

# Specifications

## Pump

Model	B09*	B11	B16	B21
Max. capacity (mL/min)	0.3 (19)	0.5 (30)	0.8 (50)	1.3 (80)
Max. discharge pressure (MPa)	175 (1.2)	150 (1.0)	90 (0.6)	45 (0.3)
Stroke rate	spm	1 to 360		
Power consumption	W	12		
Current (Input)	A	0.8		
Shipping Weight	lbs (kg)	8.0 (3.6)		

- The above information is based on pumping clean water at rated voltage and ambient temperature.
- Flow rates were collected at the maximum discharge pressure and 360spm. Degassing option derates capacity by approximately 20%.
- \*B09 size is available in PVC liquid ends only
- Flow rate increases as discharge pressure decreases.
- Allowable ambient temperature: 0 to 104°F (0 to 40°C)
- Allowable liquid temperature: 32° to 104°F (0 to 40°C)
- Allowable power voltage deviation: ±10% of the rated voltage
- Noise level: 65dB at 10 ft. (A scale)
- E90495 (field-wireable connector) or IX0018 (connector with 5 ft. cable) required for Inputs.

## Controller

Operation mode	Mode	Manual
		EXT
	Mode selection	Key operation
Stroke rate	Setting range	1 to 360spm
	SPM programming	UP key
STOP function	Input signal	No-voltage contact or open collector <sup>Note 1</sup>
EXT mode	Maximum spm	360spm
	Pump behavior	1 shots per signal <sup>Note 2</sup>
	Input signal	No-voltage contact or open collector <sup>Note 1</sup>
Monitors	LCD	7x3 LCD with three status codes
	LED	Green LEDx1 (blinks at each shot)
Buffer		Non-volatile memory
Power voltage <sup>Note 3</sup>		100 to 240VAC 50/60Hz

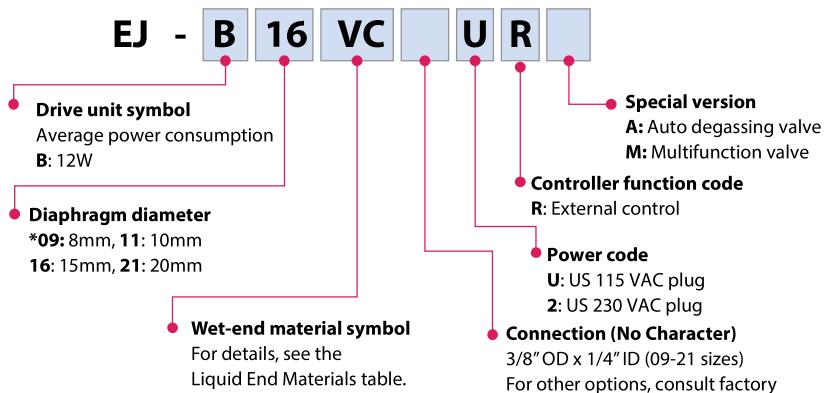
- The max voltage from the EJ to an external contact is 15V at 3mA. When using a mechanical relay, the minimum load should be 3mA or below.
- When the external pulse signal is over the max spm, the extra pulses are ignored.
- The allowable voltage range is 90 to 264VAC. Outside of this range, failure may result.

## Safety Certifications

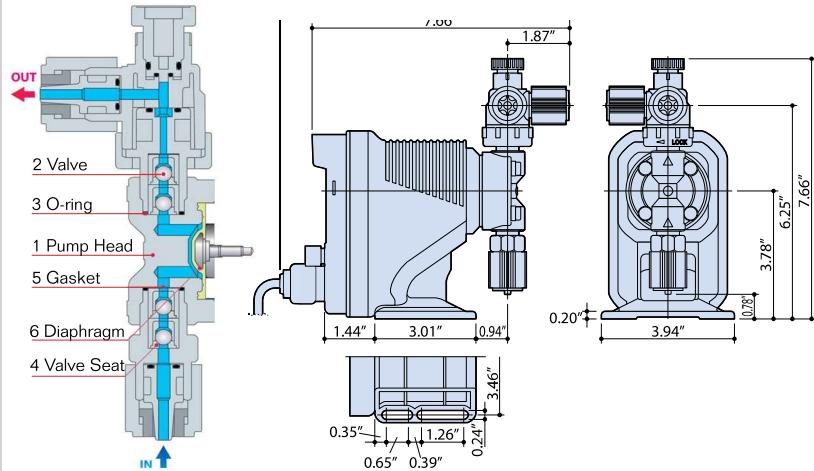
The EJ series metering pumps\* are WQA tested and certified to NSF/ANSI Standard 50 and Standard 61.

\* See [www.wqa.org](http://www.wqa.org) for specific chemicals and certification parameters.

The EJ series metering pumps are tested by Intertek to UL and CSA standards.



## Dimensions



## Liquid End Materials

Material	1	2	3	4	5	6
	Pump head	Valve	O-Ring	Valve seat	Gasket	Diaphragm
VC	PVC	CE	FKM	FKM	PTFE	
VE	PVC	CE	EPDM	EPDM	PTFE	
VF	PVC	PTFE	EPDM	EPDM	PTFE	
TC	PVDF	CE	FKM	FKM	PTFE	
PC	GFRPP	CE	FKM	FKM	PTFE	
PE	GFRPP	CE	EPDM	EPDM	PTFE	
FC	PVDF	CE	PTFE	PCTFE	PTFE	
TA	PVDF	CE	AFLAS®	PCTFE	PTFE	
PA	GFRPP	CE	AFLAS®	PCTFE	PTFE	
SHN	316SS	316SS	---	316SS	PTFE	
CE	Alumina ceramic		EPDM	Ethylene propylene diene monomer		
FKM	Fluoroelastomer		GFRPP	Glass fiber reinforced polypropylene		
PTFE	Polytetrafluoroethylene		PVC	Polyvinylchloride (translucent)		
PCTFE	Polychlorotrifluoroethylene		PVDF	Polyvinylidenefluoride		
AFLAS®	Tetrafluoroethylene-Propylene					
PTFE + EPDM backer						

CE Alumina ceramic  
 FKM Fluoroelastomer  
 PTFE Polytetrafluoroethylene  
 PCTFE Polychlorotrifluoroethylene  
 AFLAS® Tetrafluoroethylene-Propylene



