Department of Environmental Protection

2600 Blair Stone Road ♦ Tallahassee, Florida 32399-2400

DEP Form: 62-761.900(9)
Form Title: Storage Tank Equipment Registration Form
Effective Date: July 2019
Incorporated in Rule 62-761.850, F.A.C.

Storage Tank System Equipment Registration Form

Fill out completely

General Information

Company Name: Industrial Plastic Systems
Contact Name: Michael Brown
Company Address: 4225 Drane Field Road
City, State: Lakeland Fl. Zip: 33811
E-mail: mbrown@IPS-FRP.com
Contact Number: 863-646-8551
Product Name: 8000 gallon DW Tank Derakane 411 VE.
Model Number(s): 8000 DW FRP
Product Type: FRP

Rule(s) citation that registration is being requested within Chapter 62-761 (UST), and/or 62-762 (AST), ______

F.A.C.: Write a brief description of equipment registration request including product limitations:

8000 gallon FRP tank, Hydro tested At Factory. See Drawings + Submittals.

Information Checklist (Choose Yes, No, or N/A - Not Applicable):

		Yes	No	N/A
1.	Third-party Certification by a Nationally Recognized Testing Laboratory? (Required)	☐	☒	
2.	Documentation of third-party evaluation that the equipment meets DEP Rules?	☒	☐	☐
3.	Documents included about the qualifications of the Nationally Recognized Testing Laboratory?	☐	☒	☒
4.	Technical information and drawings included?	☒	☐	☐
5.	Installation instructions included?	☒	☐	☐
6.	Annual Operability Testing Requirements (Rules 62-761.500, 62-762.501, & 62-762.502 F.A.C.)?	☒	☐	☐
7.	Integrity Testing Requirements (Rules 62-761.700, 62-762.701, & 62-762.702, F.A.C.)?	☒	☐	☐
8.	Compatible with fuel blends containing >10% ethanol or >20% biodiesel?	☐	☐	☒
9.	Has the product been approved or registered in other countries or states? (If so provide list)	☐	☐	☒
10.	Any requirements for company-certified installers or trainers?	☐	☒	☐
11.	Was this product(s) previously approved or registered by the Department? If yes, EQ-______	☒	☐	☐
12.	Any changes or modifications to the equipment since the last submittal to DEP?	☒	☐	☐

Document Information: Provide supporting documents indicated as "Yes" above including this form via email to Tanknotify@floridadep.gov, or documents can be sent to FDEP, Division of Waste Management, 2600 Blair Stone Road, MS 4560, Tallahassee, FL 32399.

Write a brief description of equipment installation and performance in the U.S.:

Equipment Registration Certification:

To the best of my knowledge and belief, all information submitted on this form is true, accurate and complete.

Michael Brown, President — Printed Name and Title

[signature], President — Signature (right click to sign)

5-1-24 — Date

For Department Use Only:

Date Application Received: 05/06/2024 Application complete: Yes: ☒ No: ☐

EQ- 1009 Date of complete or incomplete letter sent: 05/28/2024 Date Equipment Requires Renewal: 05/28/2029

Storage tank system equipment requires renewal every 5 years in accordance with subsection 62-761.850(2), F.A.C.

CORCEL CORP.

SHOP DRAWING SUBMITTAL RESPONSE (1)

SECTION TP ATS 02-001
FIBERGLASS REINFORCED PLASTIC TANK

SUBMITTAL DATE:	November 23, 2021
SUBMITTAL NUMBER:	COO-IFB21-0116-07232021-01-r1
OWNER:	City of Orlando
PROJECT NAME:	Lake Dot Alum Treatment System Tank Replacement
PROJECT NO:	IFB21-0116
LOCATION:	100 Lake Dot Drive, Sanford, FL
CONTRACTOR:	Boromei Construction, Inc.

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The following datasheets are being submitted for review by Orlando Utilities Commission reviewers for approval with compliance to OUC Standards and Construction Specifications for the job in questions.

AN EQUIPMENT SUBMITTAL

FIBERGLASS REINFORCED PLASTIC TANK

Project: Lake DOT Treatment Plant

Sanford, Florida

Prepared for: Corcel Corp.
Altamonte Springs, Florida

Re-submittal: November, 2021

ips Industrial Plastic Systems

Prepared by
Michael Brown   Douglas Wolcott   Curtis Renberg

4225 Drane Field Road, Lakeland, Florida 33811
Ph 863.646.8551   Web: www.ips-frp.com

SECTION ONE

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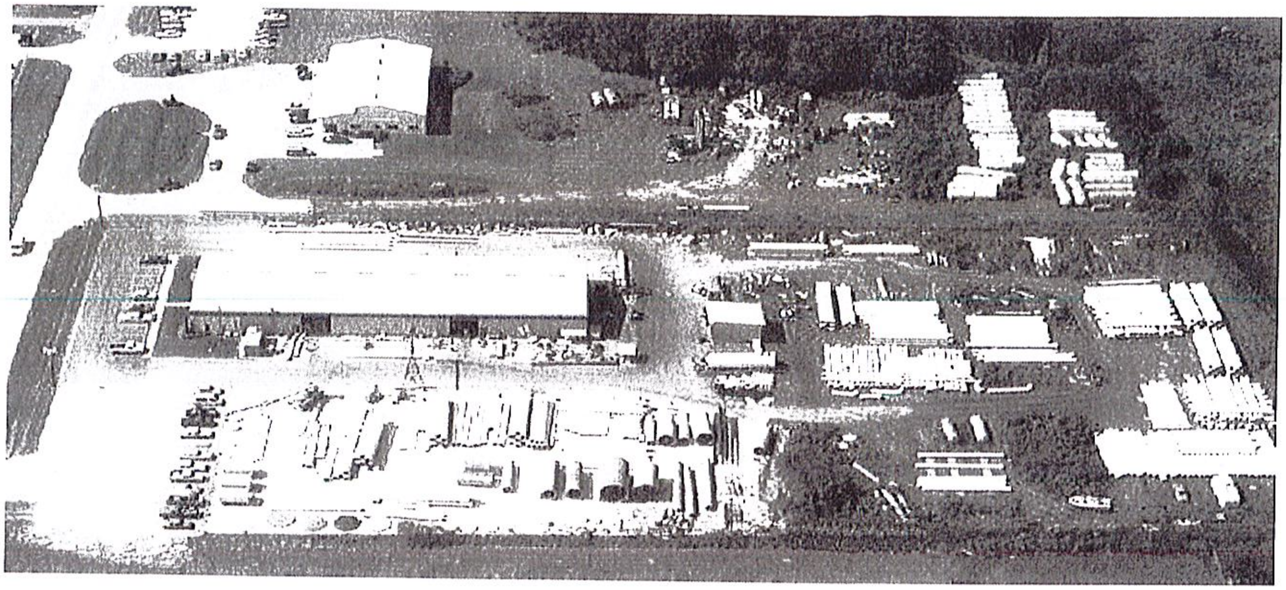
SECTION TWO

Manufacturer Qualifications & Case Histories

4225 Drane Field Road, Lakeland, Florida 33811
Ph 863.646.8551 Fax 863.644.1534

Industrial Plastic Systems, Inc. Profile



<u>INDUSTRIAL PLASTIC SYSTEMS (IPS)</u> has continued to be a leader in contact molded and filament wound FRP industrial equipment for over twenty years. In 1987, Burhans & Brown, Inc. a Lakeland, Florida manufacturer with similar capabilities, purchased IPS. Both operations, including personnel were merged and are operating today in Lakeland as Industrial Plastic Systems, Inc. IPS operates in a 25,000 sq. ft. facility. IPS offers complete industrial FRP manufacturing and fabrication capabilities.

<u>CORROSION RESISTANT</u> equipment is IPS's central theme. Coupled that with structural integrity, exacting tolerances and uniform quality creates superior product. To insure this end, our quality control department runs gel time tests on incoming resin, maintains control on mixing of resins, checks Barcol readings on cured products and visually checks for dimensional accuracy and visual defects.

<u>SHOP FABRICATION</u> is our main service. This service provides a cost effective alternative for many contractors. Our shop fabricators undergo extensive training before being allowed to work unsupervised on any product. The average experience time of our shop workers is over seven years

<u>ENGINEERING</u> is a major component in our ability to design and manufacture FRP equipment. Our design basis is supported by calculations to meet our customers' structural requirements. We maintain a professional engineer on staff and are able to respond quickly with production of drawings and design calculations.

<u>FIELD SERVICES</u> are a key ingredient in assuring customer satisfaction. Customers have "rush" needs, which must be met. We are equipped and prepared to react. Our field service group is able to respond on a 24-hour basis.

<u>PIPE AND DUCT</u> are available as loose components or in prefabricated assemblies to reduce installation costs. Detailed drawings assure dimensional accuracy. Joining systems include butt & strap welds, adhesive socket, flanges and our 200 psi "O" ring sealed bell and spigot.

<u>TANKS AND PROCESS VESSELS</u> are available as vertical or horizontal, single or double wall design configurations with capacity exceeding 50,000 gallons. They can be designed for below ground or above ground installation. Fittings include blade or conically gusseted flanged nozzles and threaded connections. Tank design considerations can include pressure, vacuum, temperature, flow, agitation, wind loading, seismic loading, live and static earth loading, soil modulus, flotation, chemical and abrasion conditions.

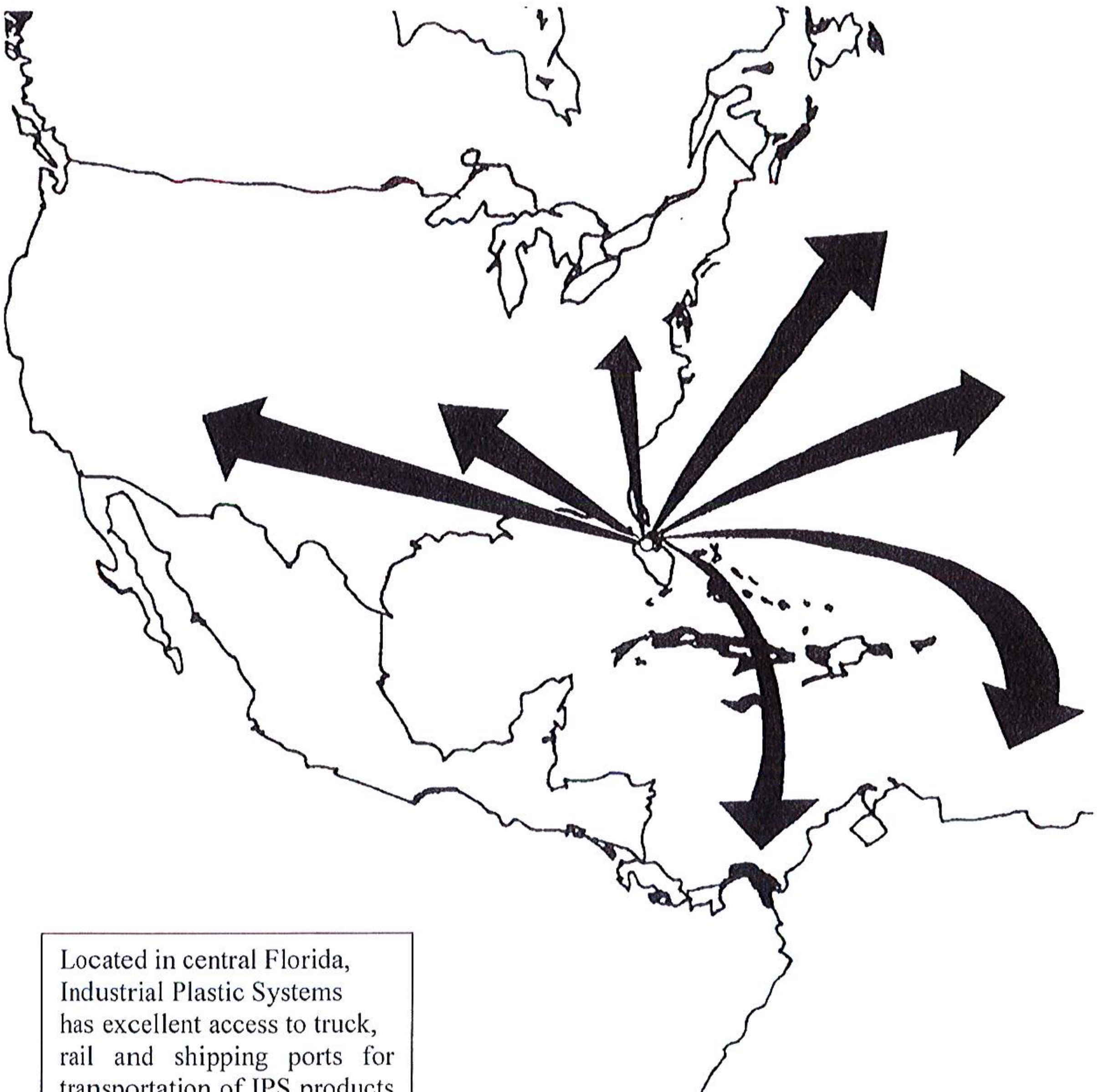
<u>SCRUBBERS AND STACKS</u> are designed to suit specific mechanical and chemical operating conditions, seismic, wind and equipment loading. We can also provide scrubber and stripper design, packing, components and start up assistance. Stacks are designed as either guyed or free standing units.

<u>DAMPERS AND BLAST GATES</u> are available in diameters from 6" thru 72". These can be simple "volume balancing" type or "complete closure" type. The standard BF damper or blast gate are available as a flanged unit or built into our duct as an a economical option.

<u>MISC. FABRICATIONS</u> include ladders, platforms and walkways for use with tanks, scrubbers and stacks. We also produce custom items to our customer's designs, such as contact molded launderers, baffles, hoods and housings.

PLANT FACILITIES AND LOCATION

The manufacturing and administrative facilities of Industrial Plastic Systems, Inc. are strategically located in Lakeland, Florida approximately 25 miles east of Tampa. Manufacturing facilities include over 25,000 sq. ft. of floor area. Product as large as 13'-6" in diameter is regularly produced, fabricated and handled within the plant. The facility includes five acres of improved storage area. Several major port locations including Tampa, Jacksonville and Miami make export shipments convenient. A rail siding is located close to the plant. IPS, Inc. is also located only 4 miles from Interstate 4 and 15 miles from Interstate 75. All of this coupled with our close working relationship with the area's trucking industry, makes freight charges a minor portion of total job cost.



Located in central Florida, Industrial Plastic Systems has excellent access to truck, rail and shipping ports for transportation of IPS products to all points in the world.

INDUSTRIAL PLASTIC SYSTEMS CUSTOMER LIST

POWER GENERATION INDUSTRY

Florida Power & Light	Palatka, Florida
Florida Power & Light	Sanford, Florida
Florida Power Corp.	Crystal River, Florida
Florida Power Corp., Anclote Plant	Tarpon Springs, Florida
TECO, Gannon Station	Tampa, Florida
TECO, Big Bend Station	Tampa, Florida
Lakeland Power, McIntosh Plant	Lakeland, Florida
Orlando Utilities, Statan Energy Center	Orlando, Florida
Orlando Utilities, Indian River Station	Orlando, Florida
St. Johns River Power Plant	Jacksonville, Florida
Jacksonville Electric Authority	Jacksonville, Florida
Georgia Power Co.	Noonan, Georgia
Southern Company Services	Birmingham, Alabama

MUNICIPALITIES

City of Delray Beach	Delray Beach, Florida
City of Ft. Pierce	Ft. Pierce, Florida
City of Miami	Miami, Florida
City of Lakeland	Lakeland, Florida
City of Gaffiley	Gaffney, South Carolina
City of Durham	Durham, North Carolina
County of Henrico	Richmond, Virginia
City of Indianapolis	Indianapolis, Indiana

CHEMICAL PLANTS

I.M.C.	Mulberry, Florida
C.F. Industries	Plant City, Florida
U.S. Agri-Chem	Ft. Meade, Florida
Seminole Fertilizer	Bartow, Florida
Albright-Wilson	Charleston, South Carolina
Corning, Inc.	Wilmington, North Carolina
Texas Gulf	Aurora, North Carolina
SCM Corp.	Ashtabula, Ohio
Fuji Film, Inc.	Greenville, South Carolina

PULP & PAPER INDUSTRY

Southeast Paper Mfg. Co.	Dublin, Georgia
Union Camp Corp.	Eastover, South Carolina
Weyerhaeuser Co.	Plymouth, North Carolina

INDUSTRIAL PLASTIC SYSTEMS CUSTOMER LIST

ENGINEERING I DESIGN FIRMS

Jacobs Engineering	Lakeland, Florida
Hazen Sawyer	Hollywood, Florida
Hazen Sawyer	Raleigh, North Carolina
Badger Engineering	Tampa, Florida
Black & Veatch	Kansas City, Missouri
Rust International	Birmingham, Alabama
CH2M & Hill	Montgomery, Alabama
CH2M & Hill	Gainesville, Florida
CRS Sirrine	Greenville, South Carolina

Recent Tank Orders

2008 Publix Super Markets, Lakeland, Florida (2) 8' Insulated Tanks

2008 City of Cape Coral, Florida (6) 12' Tanks

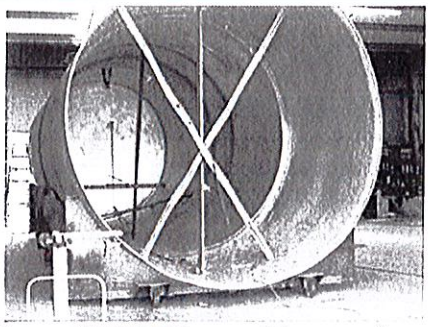
2009 Lockheed Martin (3E Consultants) Orlando, FL (2) 13'-6 Cone Bottom Tanks

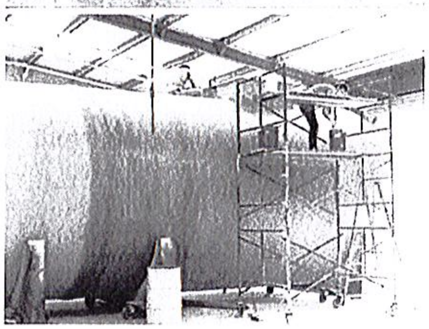
2010 Lockheed Martin (3E Consultants) Orlando, FL (3) 9'-0 Cone Bottom Tanks

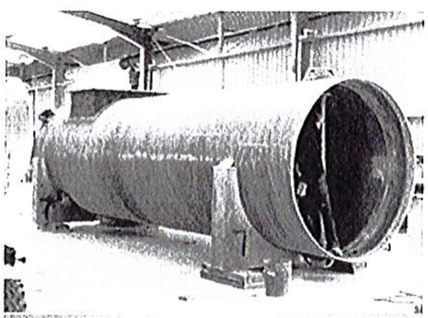
2011 Country Pure (Ludwig, Inc) Deland, FL (1) 12'-0 Tank, Dome Top & Bottom, Special Support

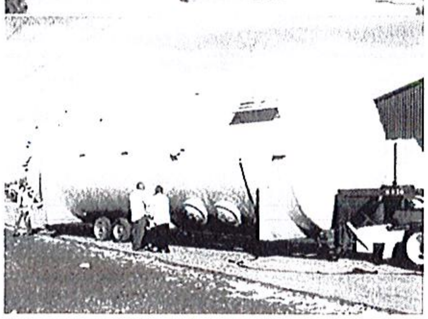
2012 Doosan Hydro Tech. Saudi Arabia (1) 9'-0 Tank, (1) 7'-0 Tank, (1) 5'-0 Tank, (2) 24" Tanks

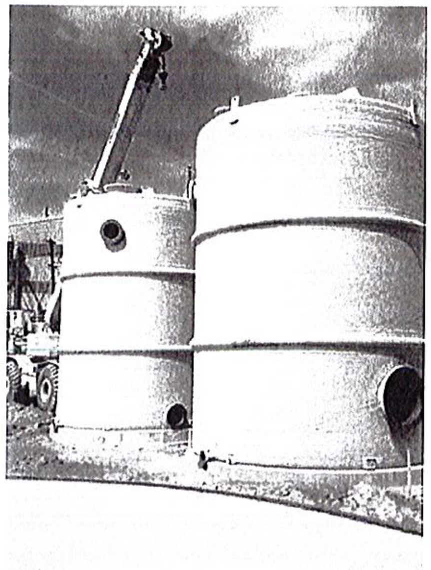
2014 Chevron Energy, Pompano Beach, FL (2) Special 12'-0 Filter Vessels



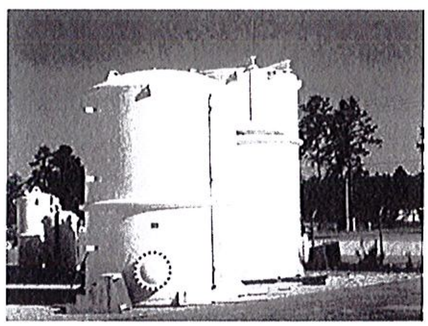


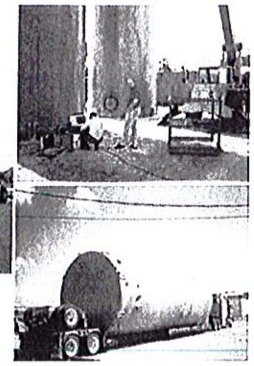


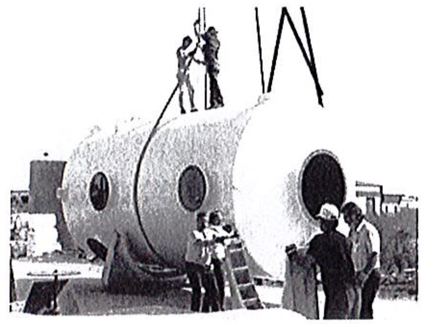


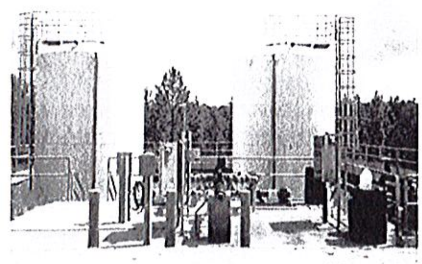


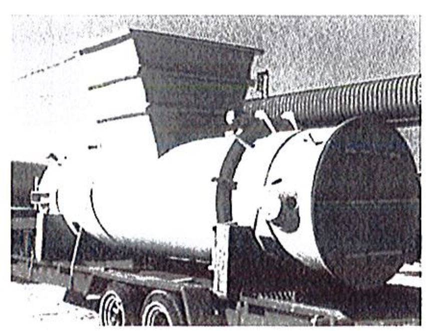
Miscellaneous
FRP
Tanks





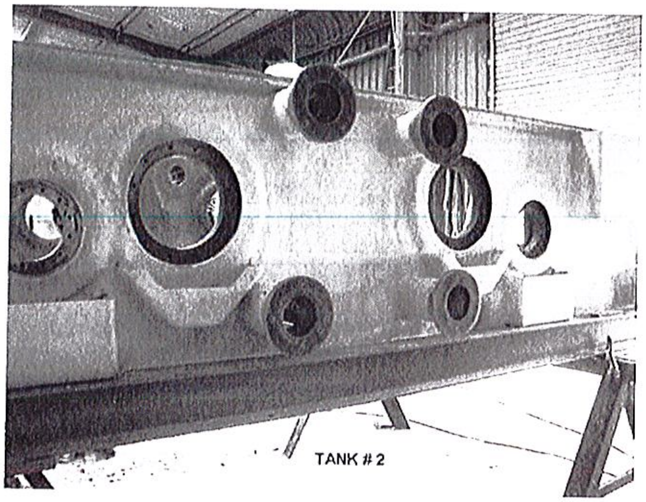


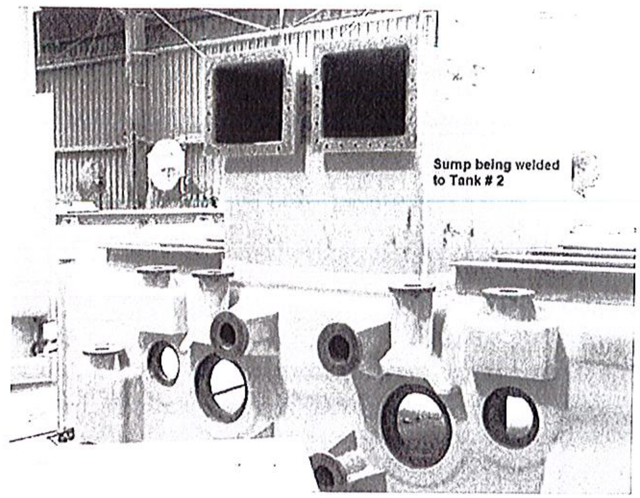


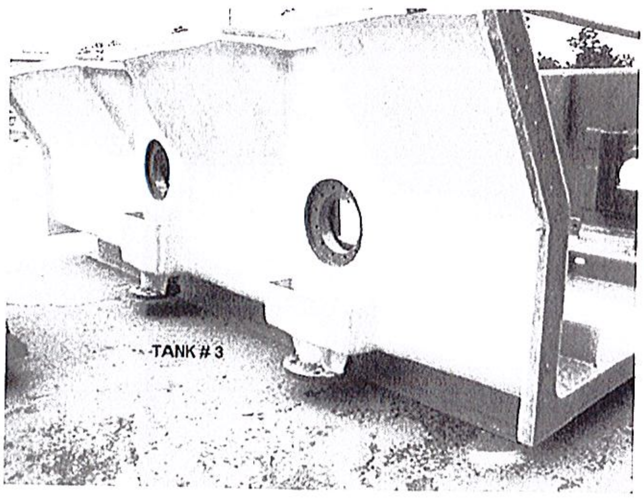


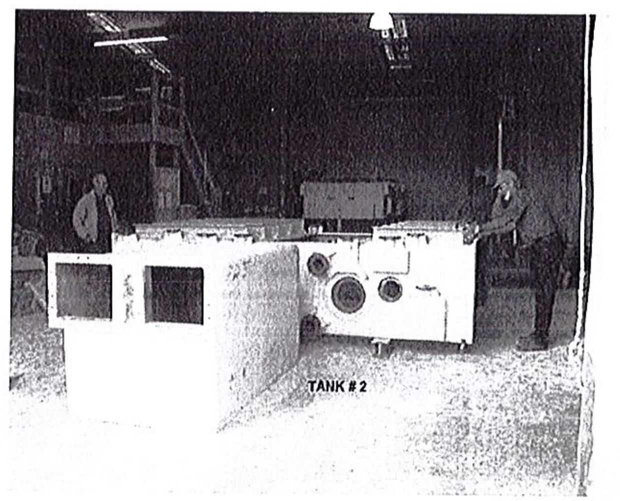
Special FRP Process Vessels

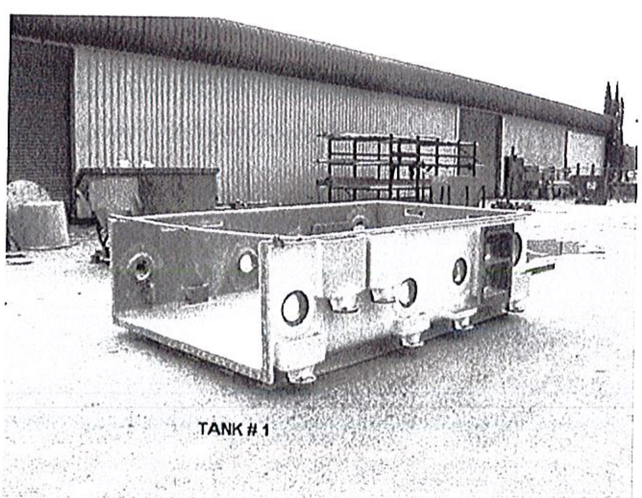
for a leading Photo Film Manufacturer

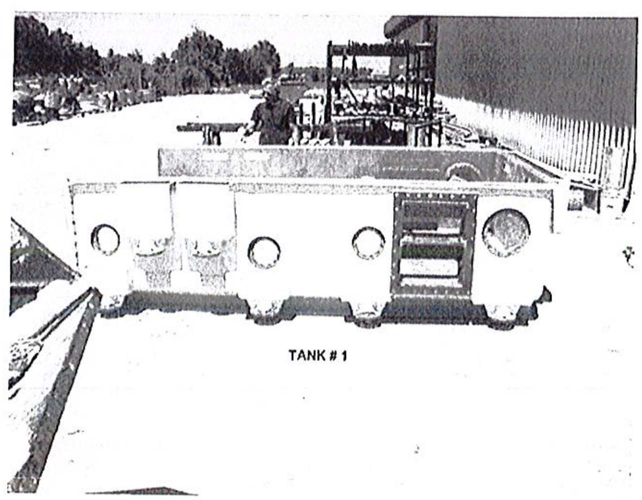












SECTION THREE

Tank Handling and Installation Guide

4225 Drane Field Road, Lakeland, Florida 33811
Ph 863.646.8551 Fax 863.644.1534

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1.0. INTRODUCTION

1.1. Proper tank handling and installation is extremely important for long-term corrosion resistance and low maintenance tank life. The following handling installation instructions are designed to assist customers install properly and efficiently.

1.2. Handling and installation instructions are only recommendations and do not relieve the purchaser/installer from full responsibility for proper inspection, handling and installation. Improper handling or installation, which results in damage or tank failure, is the sole responsibility of the customer. Failure by the customer to comply with these handling or installation instructions will void the vessel warranty. Unknown situations or conditions are also the burden of the customer/installer.

1.3. Please note while installing a tank, safety must be of the highest priority. This manual is not to be interpreted to create a situation of "safety" risk to the unloading and installing personnel. All OSHA regulations must be strictly adhered to during the installation process.

2.0. INSPECTION

2.1. At the time of delivery, the customer shall be responsible for the inspection for the damage in transit, both inside and outside of the tank. If damage has occurred it should be noted on delivery prior to signing acceptance. The customer accepts future responsibility for damaged tank if the procedures set forth are not allowed.

3.0. SHIPPING AND HANDLING

3.1. Never roll or slide a tank. Lift the tank using a crane or other approved method.

3.2. Operators of the hoist equipment must follow proper rigging procedures at all times. Never allow the tank to swing out of control.

3.3. Do not drop or allow hard impact from tools, spreader bars, etc. on the inside or the outside of the tank.

3.4. Avoid the use of equipment inside the tank that could scratch or damage the inner corrosion barrier.

3.5. Never use cables or chains around the tank. ALWAYS use nylon or canvas slings that are rated for appropriate loads. Use a guideline to keep the load under control.

3.6. NEVER lift the tank using anything other than the designed lifting lugs unless erecting a vertical tank that is in a horizontal position due to shipping and storing. When lifting a vessel, all lifting lugs must be used and spreader bars/cables must be utilized. **DO NOT LIFT THE TANK BY USING HOLD DOWN LUGS, NOZZLES, FITTINGS, ETC.**

3.7. If the tanks are being stored prior to installation, be sure to lay on a flat padded surface or in padded wooden saddles the tank was shipped in and tie down securely.

3.8. Tanks Shipped Horizontally:

3.8.1. Large tanks should be unloaded using two slings and an appropriate spreader bar. Smaller tanks may be unloaded using one sling to balance the load. Place the tank on the shipping saddles or soft, level ground before lifting to the vertical position.

3.8.2. For vertical tanks, the standard lifting lugs should not be used to unload a tank.

3.8.3. If open top tanks are shipped with cross bracing, it must not be removed until the tank is in the vertical position.

3.8.4. Be careful not to set the tank on lugs, nozzles, etc. protruding from the tank. When setting the tank on the ground, removing a few shovels of dirt can usually relieve these problems.

3.8.5. When setting the tank upright the sling should be positioned ⅔ to ¾ up the tank. A suitable protective pad of material should be placed under the pivot point of the tank so that, as the tank rises, the strain is taken out on the pad.

3.9. Tanks Shipped Vertically

3.9.1. Lifting lugs can be used to lift a tank vertically ONLY. If a spreader bar is not used in lifting vertically, the clearance between the shackle of the crane and the tank shall be at least 1 1/2 times the overall diameter of the tank.

3.9.2. All lifting lugs supplied with the tank must be used for lifting. This may require a 3-way or 4-way spreader bar. Tanks MUST be lifted using a spreader bar or spreader cables which are a minimum of three tank diameters long.

4.0. ABOVE GROUND INSTALLATION

4.1. Vertical tanks shall be fully supported on a level non-deflecting pad. If the tank has a flush or full drain, the pad shall be notched for sufficient clearance of the nozzle. The minimum width of notch shall be equal to the flange outside diameter plus three inches. The minimum depth of the notch shall be ½ the flange outside diameter plus 1½".

4.2. The pad should be clean and free of debris; nuts, bolts, welding rods, rocks, tools, etc.

4.3. Liquid grouting such as concrete, epoxy, etc. MUST NOT be used under tank bottoms. Use roofing felt as a buffer between tank bottom and tank support. When applying the roofing felt, be sure there are no overlaps or wrinkles causing ridges under the bottom.

4.4. All hold down lugs supplied must be utilized to secure the tank to its pad. The hold down lugs must not be over-tightened and must be shimmed. Because of the difficulty in maintaining exact dimensions on locations of the anchor holes, it is recommended that the holes for the foundation bolts be drilled after the tank is set. If the studs must be set when the foundation is poured, please consult with the tank manufacturer.

4.5. **Only full-face gaskets are to be used.** If the mating flange has a raised face, it should be machined flat or a filler ring of the proper thickness should be applied to provide a full flat surface for contact. Gasket material exceeding 70 durometer should not be used. Failure to use full-face gaskets or the use of raised face mating flanges will void the warranty.

4.6. After the tank is in place, nozzles must be adequately supported. Flexible pipe connections should be used whenever possible. **If rigid piping must be used, be certain it is self supporting.** Valves, instruments, etc. must also be supported independent of the tank. Nozzles must not be strained under any condition.

4.7. Ladders MUST be supported on the foundation so as to take the full vertical load of the ladder. The FRP or steel clips attaching the ladder to the tank are for horizontal loads only.

4.8. FRP and PVC couplings should be tightened very carefully. If over-tightened, the threads can be damaged and the coupling may break loose from the tank, causing a leak.

4.9. Bolting take-up torque should be applied uniformly as shown in the table below. Note some hairline cracks may be visible after the bolts have been tightened. These cracks are usually in the exterior paint coat only and are no cause for alarm.

NOZZLE BOLT TORQUES		
PIPE SIZE	BOLT SIZE/DIA.	TORQUE [FT-LB]
1"	5/8"	25
2"	5/8"	25
3"	5/8"	25
4"	¾"	25
6"	¾"	25
8"	7/8"	25
10"	7/8"	25
12"	7/8"	25
14"	1"	30
16"	1 1/8"	30
18"	1 1/8"	35
MANWAY	¾"	30

5.0. UNDERGROUND INSTALLATION

5.1. Buried tanks must be installed using appropriate trench width, depth to insure there is no chance of "floating" a tank if ground water is present in backfill. If groundwater is an installation issue, IPS recommends the installer contact IPS to confirm appropriate tank design.

5.2. TRENCH WIDTH AND TANK SPACING: Tank trench width shall be the tank OD plus 24" on each side of the tank in stable soils. A stable soil would be defined as when sheeting/shoring is not required to maintain vertical trench walls. Minimum spacing between tanks in a multi-tank trench should not be less than 24". There must be enough room between the tanks to compact the backfill during installation.

In unstable soils, IPS recommends a half of a tank diameter space on each side of the tank and a half diameter space between each tank in multiple tank trenchs. IPS recommends using trench shoring/sheeting for all underground installations. IPS requires sheeting for all unstable soil trench installation. Please note that the sheeting is to be removed from the trench as the tank is being buried. Trenches must be sloped or layered.

5.3. TRENCH DEPTH: Where ground water is present, rule of thumb for tank minimum burial depth is 40% of the tank diameter. If this depth is not possible then the tank must be anchored using deadmen or a reinforced concrete slab and over-straps. IPS recommends consulting our engineering department when tank anchorage is required due to groundwater.

If ground water is not an issue IPS recommends a minimum of 2' cover without live loads and 4' with live loads. If live loads are present and a minimum 4' of burial is not possible, IPS recommends the tank trench to be covered with a minimum of 6" of reinforced concrete after the tank is properly covered and compacted.

5.4. BACKFILL: Backfill must be pea gravel or crushed rock. It must be free flowing. Backfill diameter should range between 1/8" and ½". 95% of the crush rock must pass thru a No. 7 seive. 5% of the crushed rock should pass thru a No. 8 sieve.

5.5. BACKFILL INSTALLATION: Backfill should be pored in 12" lifts. Each lift must be fully compacted before the next lift is pored. If sheeting is being used it must be pulled out of the trench as the backfill is being pored. No gaps may be left on either side of the trench when sheeting is removed. Note the hauch zone compaction is essential to a quality installation.

6.0. VESSEL OPERATION

6.1. Chemical Service/Environment: Vessels must only store or operate using the chemicals the vessel's corrosion barrier was intended for. Contact IPS's engineering staff if the vessel's operational chemical parameters are to be changed to determine corrosion resistance acceptability. The chemical service parameter will be listed on the tank nametag.

6.2. Temperature and Pressure: Do not exceed the design operating temperature and pressures of the vessels. These parameters will be listed on the tank nametag.

6.3. Operating a vessel under conditions other than its intended its use will void its warranty.

6.4. IPS recommends only gravity filling tanks.

6.5. Heat Tracing:

6.5.1. Consult the heat panel manufacturer's operation manual for specific panel operation instructions.

6.5.2. Heat panels must NOT be operated while the tank is empty..

6.5.3. Under no circumstances are the panels to be operated above than 200° F.

7.0 MAINTENANCE

7.1. IPS recommends annual inspections of FRP tanks by personnel with no less than 5 years FRP tank manufacturing and inspection experience. During inspections, inspectors should look for signs of excessive corrosion, cracks, and discoloration as shown in ASTM 2563. Locations of special interest are the tank's interior corrosion barrier, tank's interior knuckle radius, hold down lugs, nozzles, manways and blind flanges.

Additionally, if possible, Barcol hardness tests on the tank's interior corrosion barrier should be performed per ASTM 2583. Test results should reflect a 90% value of the resin manufacturer's published data. Contact the tank manufacturer if they do not.

7.2. Failures: If the tank is shows signs of damage, excessive corrosion or is leaking, contact the tank manufacturer immediately.

SECTION FOUR

Quality Assurance Program

4225 Drane Field Road, Lakeland, Florida 33811
Ph 863.646.8551 Fax 863.644.1534

Quality Assurance Program

FRP Tanks & Vessels

I

P

S

* Pipe
* Tanks
* Hoods
* Duct
* Air strippers
* Stacks
* Scrubbers
* Custom Fabrications

Industrial Plastic Systems, Inc.
4225 Drane Field Road
Lakeland, Florida 33811
Ph 863-646-8551 Fax 863-644-1534
Corrosion Resistant Fiberglass Products
Ver. 2009.04

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INDUSTRIAL PLASTIC SYSTEMS, INC.
QUALITY ASSURANCE PROGRAM
Scope

The following documents are fabrication, inspection, testing and handling procedure standards set forth by Industrial Plastic Systems, Inc. management group in order to guarantee Industrial Plastic Systems' customers a FRP product of the highest quality and to insure the product will have a service life as expected.
Industrial Plastic Systems' management group has the intention to continually review, update and add to this quality assurance manual in order to keep pace with the highly accelerated FRP industry.

INDUSTRIAL PLASTIC SYSTEMS, INC·
QUALITY ASSURANCE PROGRAM

Vessel/Tower Fabrication

1.0 SCOPE

1.1.1 This specification covers techniques used by the manufacturer during fabrication of FRP chemical resistant equipment to insure the finished product meets industry standards and is of high quality.

1.2 Applicable Specifications: (Most Current Revision)

ASTM C 582	Contact Molded Reinforced Thermosetting Plastic Laminates for Corrosion Resistant Equipment
ASTM D 2563	Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts
ASTM D 3299	Filament Wound Glass Fiber Reinforced Thermoset Resin Chemical Resistant Tanks
ASTM D 4097	Contact Molded Glass Fiber Reinforced Thermoset Resin Chemical Resistant Tanks
ASME/ANSI RTP-1	Reinforced Thermoset Plastic Corrosion Resistant Equipment
ASME BOILER & PRESSURE VESSEL CODE; SECTION X	Fiber Reinforced Plastic Pressure Vessels

2.0 PRODUCTION FLOW - FABRICATION

2.1 A work order and 3 sets of drawings are issued to the Shop Manager when the manufacturer receives a written approval from the customer to begin fabrication. Generally, this is after the customer has reviewed the manufacturer's drawings (system or spool) and approves them as satisfactory.

2.2 One copy of the drawings is given to each group of shop fabricators. One set of shop drawings is kept in the Shop Manager's office.

2.3 Fabricators measure and mark vessel/tower pieces for cutting, drilling, etc. and obtain confirmation of correct dimensions from Shop Manager before proceeding. Upon approval from Shop Manager, fabrication will proceed.

2.4 After fabrication is complete, correct dimensions, angles, hole sizes, etc. are confirmed by QA Manager. A quality assurance report will be completed for the vessel/tower being fabricated.

2.5 If there is a discrepancy between the actual dimensions and the dimensions on the shop drawings that is above the manufacturer's standard tolerances, the Shop Manager will take the appropriate action to bring the vessel/tower within standard tolerances or the design engineer will determine if vessel/tower can still satisfy the required design conditions. If the vessel/tower cannot or it is impractical to bring the vessel/tower within tolerance or the vessel/tower cannot satisfy the required design conditions, it will be replaced.

3.0 Fabrication

3.1 All vessels/towers will be fabricated according to the customer's specifications, shop drawings, manufacturer's standards or quality and written agreement reached between the customer and the manufacturer.

3.2 Nominal Wall Thickness

3.2.1 The average wall thickness, based on at least six (6) measurements as outlined in RTP-1 section 6-920 shall not be less than the nominal wall thickness listed on the shop drawings, the wall thickness at any point on the vessel's circumference, top or bottom heads shall be in accordance with ASME RTP-1, Subpart 2C. The average wall thickness shall be measured in accordance with ASTM D 3567, para. 6 using a micrometer where possible.

3.2.2 During fabrication, the required vessel's cylinder body liner nominal thickness will be determined by measuring (at two locations minimum) the mandrel O.D. and the liner O.D. after it is applied to the mandrel. If the measured liner nominal wall thickness is less than the required liner nominal wall thickness listed on the shop drawings or customer specifications, additional layers of chopped 1-1/2 oz. mat will be added to the liner to achieve the required thickness.

3.2.3 The required structural nominal thickness for filament wound vessel's cylinder body will be defined as the pipe nominal wall thickness listed on the shop drawings minus the minimum nominal liner thickness listed on the shop drawing.

3.2.4 During fabrication, the structural nominal wall thickness for filament wound cylinders will be determined by measuring (at two locations minimum) the cured liner O.D. and the pipe O.D. after the filament winding process is complete. If the measured structural nominal wall thickness is less than the required structural nominal wall thickness listed on the shop drawings, additional layers of filament winding will be added to achieve the required thickness.

3.2.4 The nominal thickness of a top or bottom head shall be determined by measuring the thickness of all cutouts and the head edges using a micrometer in accordance with ASTM D3567 Para. 6.

3.3 Visual Defects

3.3.1 The vessel's interior surface shall conform to RTP-1, Level II unless stated on the shop drawings.

3.3.2 The vessel's exterior surface shall conform to RTP-1, Level II unless stated on the shop drawings.

3.3.3 When the vessel is inspected with a light, air bubbles should be less than ten per square foot. As detailed in RTP-1, section 6-950 Table 1, air bubbles in the liner shall not exceed 1/8" in diameter, and air bubbles in the structural laminate shall not exceed ¼" in diameter.

3.4 Dimensions

3.4.1 All dimensions to be as shown on the shop drawings. If there is a discrepancy, the design engineer shall be informed before fabrication may proceed. The design engineer shall change the

dimensions

as deemed appropriate and inform the customer of the change or contact the customer of the need to make a dimensional change for their approval.

3.4.2 Dimension tolerances shall be as listed in the engineering drawings or as required by the customer's specification.

3.5 If the vessel /tower does not meet any of the above requirements, it shall be brought within tolerance or repaired. A description of the discrepancy shall be listed on a quality assurance report and the action taken to correct the pipe.

4.0 FITTINGS

4.1 All fittings shall be fabricated per the same requirements as the vessel/tower where applicable or unless stated on shop drawings or if agreed upon between the customer and the manufacturer.

4.2 Flanged Nozzles

4.2.1 The flange nozzle thickness shall not less than as listed per RTP-1 for 25 psi or as listed on the shop drawings for the vessel's design pressure for all flanges in hydrostatic or pressure service. All other flanged nozzle thickness shall be a shown on the shop drawings. There is no tolerance on flange thickness. Dimensions are minimum thickness.

4.2.2 Flange face shall be perpendicular to the axis of the pipe within 1/2° and be flat to ± 1/16" for all pipe sizes.

4.2.3 All flanges will be spot faced on the back side for standard washers unless stated on the shop drawings or agreed upon between the customer and the manufacturer. The hole size, bolt circle and flange O.D. must be correct.

4.2.4 Flange faces shall have a chemical resistant surface identical to the vessel's/tower's liner.

4.2.5 Flanged nozzle projection shall be 5" from the vessel's inner surface or as listed on the shop drawings.

4.2.6 All flanged nozzles 6" and smaller will either be conically or plate gusseted where ever possible.

4.2.7 All flanged nozzles 6" and smaller to penetrate into the vessel/tower 2" to 2 1/2' inches unless deemed unacceptable by the customers specification.

4.2.8 All flanged nozzles large than 6" shall be installed flush with the vessel's/tower's inside diameter where ever possible.

4.3 Couplings

4.3.1 All threaded couplings will have NPT threads or be of an adhesive slip type coupling.

4.3.2 Coupling nozzle projection shall be 2" from the vessel's inner surface or as listed on the shop drawings.

4.3.2 Half couplings shall be installed flush with the vessel's/tower's inside diameter where ever possible.

4.4 Welds

4.4.1 All nominal butt weld thickness and lengths shall be as shown on the shop drawing.

4.4.2 Nominal weld thickness shall be determined by measuring the vessel O.D. and the O.D. of the finished weld. If the measured weld thickness is less than the required nominal weld thickness, additional layers of fiberglass will be added to the joint.

4.4.3 The minimum weld thickness at any point along the welded joint's circumference shall not be less than 95% of the required nominal weld thickness. If there is a point below this tolerance, additional layers of fiberglass will be added to bring the weld within tolerance.

4.4.5 The total weld length shall be as described in 4.5.1. plus a minimum of (3) times the weld thickness added to each side of a butt weld or nozzle weld diameter. This is the area where the vessel's O.D. becomes the required weld's O.D.

4.5 Top & Bottom Heads

4.5.1 The ends of heads must be trimmed as close as practically possible before installation or shipment. The heads must be squared to ± 1/8".

4.5.2 Heads shall have no humps, depressions or large wrinkles. Trimmed and sanded edges of all heads will be brush coated with resin. Heads shall be of even thickness on the edges.

4.5.3 Flat bottom heads, where ever possible, shall have a 1 1/2" radius at the horizontal/vertical junction and the thickness of the radius area shall not be less than the combined thickness of the bottom and vessel's cylinder or as shown on the shop drawings.

4.5.4 Where alignment bells are not used, top and bottom head edges are to have the same/matching thickness as the vessel's/tower's cylinder.

4.6 Cutout Reinforcement

4.6.1 All nozzles larger than 6" located in a pressure vessel, below a storage tank's liquid level or below a tower's packing column's lower half shall have the vessel/tower shell reinforced with a FRP pad.

4.6.2 All reinforcement pads shall be of the thickness and width or diameter as shown on the shop drawing. If shop drawings do not show a reinforcement pad, the shop manager shall inquire to the engineer for the specific reason for not having a reinforcement pad if the nozzle is within the requirements set forth in 4.6.1.

(END SECTION)

INDUSTRIAL PLASTIC SYSTEMS, INC.
QUALITY ASSURANCE PROGRAM
General Inspection Procedures

1.0 SCOPE

1.1 This specification covers acceptance criteria for visual and physical inspection of glass fiber reinforced plastic (FRP) equipment made by filament winding or contact molding FRP.

1.2 Applicable Codes: (Most current revision)

<u>Pipe/Duct:</u>	
ANSI/AWWA C950	Standard for Fiberglass Pressure Pipe
ASTM D 2996	Filament Wound Glass Fiber Reinforced Thermoset Resin Chemical Resistant Pipe
<u>Vessels:</u>	
ASTM D 3299	Filament Wound Glass Fiber Reinforced Thermoset Resin Chemical Resistant Tanks
ASTM D 4097	Contact Molded Glass Fiber Reinforced Thermoset Resin Chemical Resistant Tanks
ASME/ASTM RTP-1	Reinforced Thermoset Plastic Corrosion Resistant Equipment
ASME BOILER & PRESSURE VESSEL CODE; SECTION X	Fiber Reinforced Plastic Pressure Vessels
<u>Both:</u>	
ASTM C-582	Contact Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment
ASTM D-883	Standard Definition of Terms Relating to Plastics
ASTM D-2563	Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts

2.0 <u>STANDARDS AND DRAWINGS</u>

2.1 Fabrication shall conform to applicable specifications, customer drawings and customer approved shop drawings.

2.2 The manufacturer shall verify that fabrication conforms to applicable specifications and drawings.

3.0 <u>DIMENSIONS AND TOLERANCES</u>

3.1 All equipment shall be inspected for conformance with the dimensions and tolerance specified on the applicable drawings and specifications.

4.0 MATERIAL

4.1 The resin, surfacing veil and fiberglass reinforcement are to comply with the requirements of the purchase order and/or the applicable specification.

4.2 The manufacturer shall verify that the specified material has been used.

5.0 INSPECTION RESPONSIBILITY

5.1 The manufacturer is fully responsible for the inspection necessary to meet the requirements of the customer and applicable specifications, prior to customer's final acceptance inspection.

5.2 Where practical, the manufacturer should confer with the customer prior the start of construction to discuss any special requirements specified in the purchase order.

6.0 INSPECTION OF LAMINATE

6.1 Reinforced plastic laminates should be of a high quality. No areas that are excessively resin rich or poorly wetted out should be present. The laminate should be dense, without dry spots cracked or crazed surfaces. Even in a good laminate, small air bubbles may be found. They must be less than 10 per sq. ft. and should be evenly distributed, size in accordance with RTP-1, Table 6-1.

6.2 The inner surface of the equipment should be smooth, glossy and resin rich with no exposed glass.

6.3 The outer surface of the laminate should also be smooth and free of exposed glass fibers. All reinforcing glass exposed by cross cutting thorough a section of the laminate must be resin coated.

6.4 Each part shall be checked visually without magnification. Visual examination of a laminate should be made prior to the addition of any colorants or pigments. Inspection should be made by placing a light behind the wall or section of the vessel to permit the detection of air bubbles, dry spots, internal cracking or other defects in the laminate.

6.5 The edges of cut-outs from nozzle locations should be inspected to determine the total laminate thickness and the corrosion barrier thickness. The cross-section also will show the bond between the layers of laminate and the degree of wet-out of glass reinforcement.

6.6 The manufacturer shall inspect the ends of the lay-up and the edges of the cut-outs for possible delamination and use of suitable reinforcement before any exterior pigment.coat is applied.

6.7 The hardness of the interior corrosion resistant surface shall be determined by using a Barcol impressor, Model No. GYZJ-934-1. The manufacturer shall verify that the impressor is properly calibrated using the "hard" and "soft" aluminum disks supplied with the instrument and that the test results meet minimum hardness requirements.

6.8 For exterior surfaces and locations where it is impractical to use the Barcol hardness impressor, the degree of resin cure can be checked by an acetone test. For this test, remove mold release, air inhibited resin and wax from a small area on the laminate surface. Apply a few drops of acetone to an area 1 to 2 inches square on the laminated surface and rub lightly with a clean cotton rag until the acetone evaporates. If the laminate surface softens or becomes tacky, it is under-cured and unacceptable.

6.9 Allowable defects are those which by nature, content or frequency do not affect serviceability of the laminate. The type, size, number, extent and spacing of such defects must not exceed the limits given in Table 1 of ASTM D-2563, Level II.

6.10 Defects in excess of these listed in Table 1 or as specifically permitted by the customer will be cause for rejection of the fabrication involved, unless required in accordance with 6.11.

6.11 Defects shall be repaired by sanding or grinding to remove defective areas followed by layers of resin and glass reinforcement. The area to be repaired will be built up until the surface is at least flush and the original thickness is regained. Repairs to the interior wall must be finished with a layer of surfacing veil and a coating of resin coating paraffin was (5% by wt.).

7.0 ASSEMBLY

7.1 For assemblies consisting of multiple parts, the manufacturer shall check to see that adjoining sections are match marked and that all pieces are labeled or otherwise identified to facilitate field assembly.

7.2 For inspection purposes, the fabricated equipment parts are to be completely assembled by the manufacturer, except where otherwise agreed upon.

8.0 TESTING

8.1 If called for by the customer in the purchase order, the manufacturer will conduct the specified tests or have the tests conducted by a testing laboratory that the customer and manufacturer agree upon. If the tests are performed by the manufacturer, the customer may request to be present to witness the tests.

(END SECTION)

INDUSTRIAL PLASTIC SYSTEMS, INC.
QUALITY ASSURANCE PROGRAM
General Testing Procedures

1.0 SCOPE

1.1 This specification covers the test procedures performed by Industrial Plastic Systems, Inc. in order to comply with the Quality Control Program material acceptance criteria. This specification is not intended to set acceptance criteria.

1.2 Applicable Specifications: (Most current revision)

ASTM D 2583	Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts
ASTM D 2584	Ignition Loss of Cured Reinforced Resins
ASTM C 582	Contact Molded Reinforced Thermosetting Plastic Laminates for Corrosion Resistant Equipment

2.0 BARCOL HARDNESS TEST PER ASTM D 2583

2.1 BASIC PROCEDURE:

1. Confirm calibration of instrument (BARCOL IMPRESSOR MODEL 934-1) by using standard calibration aluminum disc(s).
2. Take and record 10 readings inside surface of pipe tank, etc. (using proper procedure per ASTM D 2583-87).
3. Eliminate the lower 2 and higher 2 readings and average the remaining 6 readings.
4. Acceptable average readings are within 90% of manufacturer's Barcol Hardness Performance data results.

3.0 DETERMINATION OF PER CENT FIBERGLASS IN A GLASS/RESIN MATRIX PER ASTM D 2584

3.1 BASIC PROCEDURE:

1. Cut cured sample of glass/resin matrix such that sample will fit in 3" crucible (~40 gr.).
2. Obtain and record the weight of crucible to nearest 0.1 gr.
3. Obtain and record weight of sample and crucible.
4. Place crucible with sample in blue M muffle furnace and heat for ~ 600 C.
5. After cooling, obtain and record crucible weight with remaining glass (resin has ignited and flashed off).
6. Calculate % of glass as follows:

$$\% \text{ glass} = \frac{\text{weight of sample after heating}}{\text{weight of sample before heating}} \times 100$$

7. To obtain % glass of structural sections, separate structural section from liner section and repeat burn off procedure.

4.0 ACETONE SENSITIVITY TEST PER ASTM C 582

4.1 To determine if resin/glass parts are cured properly, the following test procedure is followed:

4.2 Part should have 24 hours cure time before being tested.

4.3 **BASIC PROCEDURE:**

1. **Pour clean acetone on a rag and wipe on a ~ 6" square area of the inner and outer surface.**
2. **Allow the acetone to totally evaporate, then feel of the treated surface. If part is properly cured, there will be no tackiness or softness.**
3. **Check at least 5 places for each major part. (40' long pipe, tank shell, tank top, etc.)**

(END SECTION)

QUALITY ASSURANCE PROGRAM

Vessel Hydrostatic and Pressure Test Procedures

1.0 SCOPE

1.1 This specification covers the procedural steps for hydrostatic/pressure testing FRP storage tanks.

1.2 Applicable Codes: (Most current revision)

ASTM D 3299	Filament Wound Glass-Fiber-Reinforced Thermoset Resin Chemical Resistant Tanks
ASTM D 4097	Contact Mold Glass-Fiber-Reinforced Thermoset Resin Chemical Resistant Tanks
ASME/ANSI RTP-1	Reinforced Thermoset Plastic Corrosion Resistant Equipment
ASME Pressure Vessel	Fiber Reinforced Plastic Pressure Vessels Code; Section X

2.0 STORAGE TANKS

2.1 Upon customer's request, vessels operating at atmospheric pressure shall be filled with water to the vessel's designated liquid capacity, regardless of specific gravity of the material being contained, before shipment to the customer.

2.2 The vessel shall remain full for no less than 2 hours. During the test, vessel shall be supported similar to service conditions.

2.3 For double wall tanks, if the customer desires to have the tank's void space hydrostatically tested, the inner tank must be filled to the tanks designed capacity before the void space is filled. After the inner space is filled, the void space can then be tested. Fill void space to same hydrostatic level as the inner tank and leave for no less than 2 hours.

3.0 PRESSURE VESSELS

3.1 A minimum of 5% of all pressure vessels per project being fabricated by Industrial Plastics System, Inc. will be pressure tested. A higher percentage of vessels will be tested at the customer's request.

3.2 Water is introduced to the vessel's full capacity. Water should be introduced into the vessel at the lowest nozzle on the vessel when possible. Air shall be bled off through a partially open valve or flange at the highest possible point.

3.3 After vessel is full, slowly close the valve and bring the vessel to 1.5 times the required operating pressure. Pressurization shall not exceed a rate of 2% of the maximum test pressure per minute (50 minutes to pressurize all vessels).

3.4 The test duration shall not be less than 2 hours and the test temperature shall be ambient.

4.0 ACCEPTANCE

4.1 During testing, no leaking shall occur.

4.2 The inspector shall witness all tests, verify the results and record the results on the test report.

5.0 OTHER TESTING

5.1 Upon customer's request, Industrial Plastic Systems Inc. can perform strain gage tests and acoustic emissions tests during hydrostatic and pressure testing.

(END SECTION)

SECTION FIVE

Material Data

Resin – Derakane 411-350
Glass – Veil, Mat, Woven, Winding, Chop
External Coating – Resin, Wax, UV Additive

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DERAKANE 411-350 Epoxy Vinyl Ester Resin

November 2004

The Industry Standard for Epoxy Vinyl Ester Resin

DERAKANE 411-350 epoxy vinyl ester resin is based on bisphenol-A epoxy resin and has become an "industry standard" due to its wide range of end-use applications and ability to be used in a wide range of fabrication techniques. DERAKANE 411-350 resin provides resistance to a wide range of acids, alkalis, bleaches, and organic compounds for use in many chemical processing industry applications.

Typical Liquid Resin Properties

Property[1]	Value
Density, 25°C/77°F	1.046 g/mL
Dynamic Viscosity, 25°C/77°F	370 mPa·s
Kinematic Viscosity	350 cSt
Styrene Content	45%
Shelf Life[2], Dark, 25°C/77°F	7 months

(1) Typical property values only, not to be construed as specifications.
(2) Unopened drum with no additives, promoters, accelerators, etc. added. Shelf life specified from date of manufacture.

Applications and Fabrication Techniques

- FRP storage tanks, vessels, ducts, and on-site maintenance projects, particularly in chemical processing and pulp and paper operations.
- The resin is designed for ease of fabrication using hand lay-up, spray-up, filament winding, compression molding and resin transfer molding techniques, pultrusion and molded grating applications.
- An alternate viscosity, optimized for some vacuum infusion processes, is available as DERAKANE MOMENTUM™ 411-100 resin.
- An alternate for low styrene (HAP) content is available as DERAKANE 441-400 resin.

Benefits

- Provides resistance to wide range of acids, alkalis, bleaches, and solvents. This resin holds up in corrosive environments, postponing the need for equipment replacement.
- Tolerates heavy design loads without causing failure due to resin damage. This facilitates working with large weight-bearing equipment with confidence.
- Superior elongation and toughness provides FRP equipment with better impact resistance and less cracking due to cyclic temperature, pressure fluctuations, and mechanical shocks providing a safety factor against damage during process upsets or during shipping installation.
- When properly formulated and cured, complies with FDA regulation 21 CFR 177.2420, covering materials intended for repeated use in contact with food.

Gel Time Formulations

The following table provides typical gel times for MEKP. "Starting point" formulations for MEKP, non-foaming MEKP alternatives, and BPO peroxides are available in separate product bulletins. These and other information are available at www.derakane.com.

MEKP Gel Time Table

Typical Gel Times[3] Using NOROX[4] MEKP-925H[5] and Cobalt Napthenate-6%[6]

Temperature	15 +/-5 Minutes	30 +/-10 Minutes	60 +/-15 Minutes
15°C/59°F	1.5 phr[7] MEKP 0.30 phr CoNap6% 0.20 phr DMA	1.5 phr MEKP 0.30 phr CoNap6% 0.05 phr DMA	1.25 phr MEKP 0.30 phr CoNap6% 0.05 phr DMA 0.04 phr 2,4-P
20°C/68°F	1.5 phr MEKP 0.30 phr CoNap6% 0.10 phr DMA	1.5 phr MEKP 0.30 phr CoNap6% 0.05 phr DMA 0.03 phr 2,4-P	1.5 phr MEKP 0.30 phr CoNap6% 0.05 phr DMA 0.06 phr 2,4-P
25°C/77°F	1.25 phr MEKP 0.20 phr CoNap6% 0.05 phr DMA	1.25 phr MEKP 0.20 phr CoNap6% 0.02 phr 2,4-P	1.5 phr MEKP 0.20 phr CoNap6% 0.05 phr 2,4-P
30°C/86°F	1.0 phr MEKP 0.20 phr CoNap6% 0.02 phr DMA	1.25 phr MEKP 0.20 phr CoNap6% 0.04 phr 2,4-P	1.25 phr MEKP 0.20 phr CoNap6% 0.06 phr 2,4-P
35°C/95°F	1.0 phr MEKP 0.20 phr CoNap6% 0.02 phr 2,4-P	1.0 phr MEKP 0.20 phr CoNap6% 0.05 phr 2,4-P	1.0 phr MEKP 0.20 phr CoNap6% 0.08 phr 2,4-P

(3) Thoroughly test any other materials in your application before full-scale use. Gel times may vary due to the reactive nature of these products. Always test a small quantity before formulating large quantities.
(4) Registered trademark of Norac Inc.
(5) Materials: NOROX MEKP-925H Methylethylketone peroxide (MEKP) or equivalent low hydrogen peroxide content MEKP, Cobalt Napthenate-6% (CoNap6%), Dimethylaniline (DMA), and 2,4-Pentanedione (2,4-P). Use of other MEKP or other additives may result in different gel time results.
(6) Use of cobalt octoate, especially in combination with 2,4-P can result in 20-30% slower gel times.
(7) Phr=parts per hundred resin molding compound

Casting Properties

Typical Properties[1] of Postcured[8] Resin Clear Casting

Property	SI	US Standard	Test Method
Tensile Strength	86 MPa	12,000 psi	ASTM D-638/ISO 527
Tensile Modulus	3.2 GPa	4.6 x 10^5 psi	ASTM D-638/ISO 527
Tensile Elongation, Yield	5-6%	5-6%	ASTM D-638/ISO 527
Flexural Strength	150 MPa	22,000 psi	ASTM D-790/ISO 178
Flexural Modulus	3.4 GPa	4.9 x 10^5 psi	ASTM D-790/ISO 178
Density	1.14 g/cm3		ASTM D-792/ISO1183
Volume Shrinkage	7.8%	7.8%	
Heat Distortion Temperature[9]	105°C	220°F	ASTM D-648 Method A/ISO 75
Glass Transition Temperature, Tg2	120°C	250°F	ASTM D-3419/ISO 11359-2
Barcol Hardness	35	35	ASTM D-2583/EN59

(1) Typical property values only, not to be construed as specifications. SI values reported to two significant figures; US standard values based on conversion.
(8) Cure schedule: 24 hours at room temperature; 2 hours at 120°C (250°F)
(9) Maximum stress: 1.8 MPa (264 psi)

Laminate Properties

Typical Properties[1] of Postcured[10] 6 mm (1/4") Laminate[11]

Property	SI	US Standard	Test Method
Tensile Strength	150 MPa	22,000 psi	ASTM D-3039/ISO 527
Tensile Modulus	12 GPa	1.7×10^6 psi	ASTM D-3039/ISO 527
Flexural Strength	210 MPa	30,000	ASTM D-790/ISO 178
Flexural Modulus	8.1 GPa	1.2×10^6 psi	ASTM D-790/ISO 178
Glass Content	40%	40%	ASTM D-2584/ISO 1172

(1) Typical property values only, not to be construed as specifications. SI values reported to two significant figures; US standard values based on conv ersion.
(10) Cure schedule: 24 hours at room temperature; 6 hours at 80°C (175°F)
(11) 6 mm (1/4") Construction – V/M/M/Wr/M/Wr/M
V = Continuous veil glass; M = Chopped strand mat; 450 g/m^2 (1.5 oz/ft^2);
Wr = Woven roving, 800 g/m^2 (24 oz/yd^2)

Safety and Handling Consideration

This resin contains ingredients which could be harmful if mishandled. Contact with skin and eyes should be avoided and necessary protective equipment and clothing should be worn.

Ashland maintains Material Safety Data Sheets on all of its products. Material Safety Data Sheets contain health and safety information for your development of appropriate product handling procedures to protect your employees and customers.

Our Material Safety Data Sheets should be read and understood by all of your supervisory personnel and employees before using Ashland's products in your facilities.

Recommended Storage:
Drums - Store at temperatures below 27°C/80°F. Storage life decreases with increasing storage temperature. Avoid exposure to heat sources such as direct sunlight or steam pipes. To avoid contamination of product with water, do not store outdoors. Keep sealed to prevent moisture pick-up and monomer loss. Rotate stock.

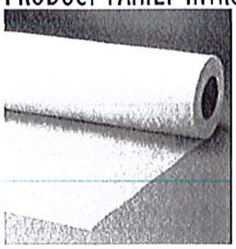
Bulk - See Ashland's Bulk Storage and Handling Manual for Polyesters and Vinyl Esters. A copy of this may be obtained from Composite Polymers at 1.614.790.3333.

INNOVATIONS FOR LIVING™

PRODUCT INFORMATION

OC® SURFACING VEILS

PRODUCT FAMILY INTRODUCTION



OC® Surfacing Veils are designed to give surface enhancement to composite laminates. They are designed to add reinforcement at the surface of a laminate and provide a smooth, resin-rich, durable surface. The surface layer is an aesthetic enhancement and a corrosion resistant barrier for the finished part. The wide range of products means that the user may select one that satisfies both process and end-use performance requirements.

VEIL TYPES

OC Surfacing Veils are available in two types, Dry Process C Veils and Wet Laid ECR Veils. Each is manufactured through a process that is suitable for many composite processes.

OWENS CORNING C VEILS

OC® C Veils provide corrosion resistance and surface enhancements in many composite manufacturing processes. OC C Veils contain C Glass, which is a chemically resistant glass that withstands acid and alkaline environments. OC C Veils are typically utilized in applications that specify the use of C Glass and when the processing of conformable continuous fibers is preferred.

OWENS CORNING ECR VEILS

OC® ECR Veils are uniform and can be used in a variety of composite manufacturing processes. OC ECR Veils are made with Advantex® glass fiber reinforcements, which combine the electrical and mechanical properties of E Glass with the corrosion resistance of ECR glass.

BINDERS

OC Surfacing Veils are available with high, low and non-soluble binders. Low solubility binders provide superior wet strength and resist fiber washing, yet maintain rapid wet-out. High solubility binders dissolve in styrene based resin systems and offer very fast wet-out and conformability to complex part curvatures as the binder is dissolved. Non-soluble binders give maximum wet strength but have less conformability. All binders are compatible with polyester, vinyl ester and epoxy resins.

GLOBAL QUALITY

Owens Corning continues to meet ongoing customer demands for higher productivity, higher value products and excellent support. OC Surfacing Veils are high-quality products produced with a multi-regional process that helps to ensure consistent products in many regions of the world while meeting performance and cost requirements. The Owens Corning worldwide technical and marketing network provides our customers with products and services that continue to meet evolving needs. OC Surfacing Veils are appropriate for applications with global or regional specifications, and are optimized to meet customer's cost and performance needs. They conform to DIN 12111, Hydrolytic Class III.

OC® SURFACING VEIL PRODUCT SELECTION

Thickness

OC® Surfacing Veils are generally selected first based on thickness in the composite part. The standard for corrosion resistance and surface enhancement is 13 mil (0.32 mm). Thicker veils are selected for enhanced surface print blocking or added corrosion protection through a thicker resin-rich surface layer. Generally the thinnest layer that gives sufficient surface properties is chosen. For closed molding and infusion process with higher glass content in the laminate, thicker veils are often required to mask the substrate reinforcements.

Solubility and Binder Selection

The selection of the appropriate binder is based on the composite process and matrix resin chemistry. For open molding and complex curvatures, a soluble binder is preferred. The soluble binder chemistry wets out the fastest and can also be used in dry winding processes where wet strength is not required. The Low Solubility binder systems are chosen when wet strength is required, or in cases where high tensile strength is preferred. Epoxy resins are not styrene based and do not quickly dissolve the soluble binder, so non-soluble binder is typically used.

FEATURES	PRODUCT BENEFITS
• CORROSION RESISTANCE	• PROVIDES RESIN-RICH SURFACE LAYER TO RESIST CHEMICAL ATTACK • ALL *OC SURFACING VEILS* ARE SUITABLE IN ACID, ALKALI AND HIGH MOISTURE ENVIRONMENTS
• DRY LAID CONTINUOUS C GLASS FIBERS	• PROVIDES CONFORMABILITY TO COMPLEX MOLD SHAPES • FAMILIAR HANDLING AND PROVEN PERFORMANCE
• WET LAID ADVANTEX® VEILS	• OUTSTANDING UNIFORMITY OF FIBER DISTRIBUTION • CONSISTENT VEIL STRENGTH AND PROCESSIBILITY
• LOW SOLUBILITY BINDERS	• EXCELLENT WET-OUT • PROVIDE HIGH WET-STRENGTH • GIVE CONSISTENTLY STRONG PROCESSING IN WINDING PROCESSES
• STYRENE SOLUBLE BINDERS	• USED IN OPEN MOLDING AND "DRY" PROCESS FILAMENT WINDING • VERY FAST WET-OUT WITH STYRENE BASED RESINS
• NON-SOLUBLE BINDERS	• MAXIMUM WET STRENGTH • SUITABLE FOR SIMPLY SHAPED PULTRUDED PARTS

OC® SURFACING VEILS

INNOVATIONS FOR LIVING™

AVAILABLE PRODUCTS - NORTH AMERICA

WET PROCESS ADVANTEX® VEILS	THICKNESS MILS	THICKNESS CM	BASIS WEIGHT G/M²	STYRENE SOLUBILITY	WIDTH INCHES	WIDTH CM	STANDARD WIDTHS STOCKED IN NORTH AMERICA
ECR25A	10	0.5	25	Low	1.5 - 83	3.5 - 210	10" (25cm), 39" (1m), 50" (127cm)
ECR50A	19	1.0	50	Low	1.5 - 83	3.5 - 210	39" (1m)
ECR70A	27	1.4	70	Low	1.5 - 83	3.5 - 210	39" (1m)
ECR30S	12	0.6	30	High	2 - 83	5 - 210	39" (1m)
DRY PROCESS "C VEILS"							
C64	11	0.29	30	High	2 - 72	5 - 200	39.4" (1m), 50" (127cm)
C33	12	0.32	33	Low	2 - 72	5 - 200	39.4" (1m), 50" (127cm)

AVAILABLE PRODUCTS - EUROPE/NORTH AFRICA/MIDDLE EAST

WET PROCESS ADVANTEX® VEILS	THICKNESS MILS	THICKNESS CM	BASIS WEIGHT G/M²	STYRENE SOLUBILITY	WIDTH LIMITS INCHES	WIDTH LIMITS CM	PROCESS
ECR25A	10	0.27	25	Low	2 - 83	5 - 210	Filament Winding
ECR30A	13	0.33	30	Low	1.5 - 83	3.5 - 210	Filament Winding
ECR50A/3	19	0.48	50	Low	1.5 - 83	3.5 - 210	Filament Winding
ECR70A/3	25	0.63	70	Low	1.5 - 83	3.5 - 210	Filament Winding
ECR30S	13	0.33	30	High	2 - 83	5 - 210	Open Molding, Dry Filament Winding
ECR30H/3	13	0.33	30	High	2 - 83	5 - 210	Pultrusion, Laminates
DRY PROCESS "C VEILS"							
C64	12	0.29	30	Low	2 - 72	5 - 200	Hand Lay Up, Filament Winding
C114	12	0.29	30	High	2 - 72	5 - 200	Hand Lay Up
C33	13	0.32	33	Non	2 - 72	5 - 200	Hand Lay Up, Pultrusion
C50	19	0.50	50	Low	2 - 72	5 - 200	Hand Lay Up, Filament Winding

Wet Process Advantex® vs. Dry Process "C-Veil"

OC C-Veils are a standard for the corrosion and open molding industries. The familiarity in handling these combined with a fiber architecture that allows easy wet-out, make these preferred products of many molders. The long fibers in OC C Veils can give more conformability in complex parts. Advantex® OC ECR Veils are a newer product with advantages in some applications. The Wet Process used to produce these OC ECR Veils makes a product with very high small-area weight uniformity. The binders applied can give a high and uniform tensile strength to the OC ECR Veil for processes such as filament winding. Both OC Surfacing Veil product types offer excellent corrosion resistance.

Owens Corning manufactures a very broad range of OC Surfacing Veil products and has many other binders and veil products to meet special needs. Contact your Owens Corning representative for special product needs.

PACKAGING

OC Surfacing Veils are wound on 3" (72mm) cardboard tubes of the same length as the veil width. The rolls are wrapped in polyethylene film and packed in cartons or large boxes.

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81.3.5733.1671

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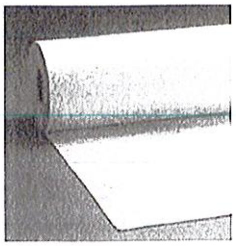
OWENS CORNING
INNOVATIONS FOR LIVING™

PRODUCT INFORMATION

OC® CHOPPED STRAND MATS

ESSENTIAL PRODUCTS WITH UNCOMMON PERFORMANCE



When Owens Corning made the world's first chopped glass fibers, the company's researchers had chopped strand mat in mind. They were trying to develop materials that would make plastics stronger and more durable. Their success is history but the product form they developed continues to be a basic building block of the composite industry.

PRODUCT FAMILY DESCRIPTION

OC® Chopped Strand Mats are composed of chopped glass fiber strands that are bonded together into mats, either with an emulsion binder or with a small amount of highly soluble polyester powder. OC Chopped Strand Mats are designed to be compatible in resins such as unsaturated polyester (UP), vinyl ester (VE) and dicyclopentadiene (DCPD) systems, and are used as gel-coat backups and standard laminate reinforcements for most contact molding (hand lay-up) applications, including boats, surfboard panels, tanks and other applications. Their many excellent product characteristics have been used for decades to provide superior performance in a broad range of end-use markets such as marine, transportation, recreation, construction, consumer and anti-corrosion.

GLOBAL QUALITY

Owens Corning continues to meet ongoing customer demands for higher productivity, higher value products and excellent support. OC Chopped Strand Mats provide high-quality products produced with a global process, which ensures consistent products in all regions of the world while meeting performance and cost requirements. The Owens Corning worldwide technical and marketing network provides our customers with products and services that continue to meet their evolving needs. To help ensure the quality of our products, Owens Corning produces OC Chopped Strand Mats globally with the most advanced equipment, innovative surface chemistry and a major commitment to statistical process control. OC Chopped Strand Mats are appropriate for applications with global or regional specifications, and are optimized to meet your cost and performance needs.

ADVANTEX® AND OC CHOPPED STRAND MATS

In recent years, Owens Corning began making OC Chopped Strand Mats with the company's Advantex® glass fiber reinforcements. *Advantex* glass fiber reinforcements combine the electrical and mechanical properties of traditional E glass with the acid corrosion resistance of E-CR glass. *Advantex* glass fiber reinforcements are compatible with all of the most widely used resin systems. Processability and production characteristics of *Advantex* glass fiber reinforcements are comparable to traditional E glass and E-CR glass formulations.

FEATURES	PRODUCT BENEFITS
• QUICK WETTING AND RAPID AIR RELEASE	• MAXIMUM MOLDING PRODUCTIVITY AND REDUCED COST
• EXCELLENT WEIGHT UNIFORMITY	• CONSISTENT CUSTOMER PART QUALITY
• FINE STRAND AND SUPERIOR CHEMISTRY (POWDER MAT)	• MINIMIZES PRINT-THROUGH, RESULTING IN ATTRACTIVE SURFACE FINISHES WITH EXCELLENT LAMINATE CLARITY
• SUPERB DRY MAT INTEGRITY	• ENHANCES PRODUCTIVITY AND REDUCES MATERIAL LOSSES DURING UNROLLING, CUTTING AND PIECE HANDLING
• SMALL DIAMETER, VERY DENSE ROLLS (POWDER MAT)	• SAFER AND MORE EFFICIENT MATERIALS HANDLING

INNOVATIONS FOR LIVING™

OC® CHOPPED STRAND MATS

AVAILABLE PRODUCTS - NORTH AMERICA

PRODUCT	WEIGHT GR/SM	WEIGHT OZ/SQ. FT.	RESIN COMPATIBILITY	PROCESS
Powder				
M723	225, 300, 450, 600, 900	0.75, 1.0, 1.5, 2.0, 3.0	UP, VE	Standard Open Mold Processes
M723A	225, 300, 450, 600, 900	0.75, 1.0, 1.5, 2.0, 3.0	UP, VE, DCPD	Hand Lay-up
CM1091	450, 600	1.5, 2.0	UP, VE	Standard Open Mold Processes

Information on current widths for this and other mat products is available upon request. Non-standard weights may be available with the prior approval of the product engineer.

AVAILABLE PRODUCTS - LATIN AMERICA

PRODUCT	WEIGHT	RESIN COMPATIBILITY	PROCESS
M810B	450		Vacuum, S-RIM
M821B	300, 400, 450		Vacuum, RTM, S-RIM, Press Molding
M830B	300, 450		Press Molding, Pultrusion
M710B	225, 300, 375, 450, 600		Hand Lay-Up
CM1090	450, 600		Hand Lay-Up

AVAILABLE PRODUCTS - EUROPE/NORTH AFRICA/MIDDLE EAST

PRODUCT	WEIGHT	RESIN COMPATIBILITY	PROCESS
M705	300, 375, 450, 600, 900	UP, PN, PU	Hand Lay-Up
MK12	450, 600	UP, PN	Hand Lay-Up
M505	300, 450, 600	UP	Hand Lay-Up
M723A	225, 300, 450, 600, 900	UP,VE, DCPD	Hand Lay-Up
CM 1092	450, 600	UP,VE	Hand Lay-Up

AVAILABLE PRODUCTS - ASIA PACIFIC

PRODUCT	WEIGHT	RESIN COMPATIBILITY	PROCESS
M705	300, 375, 600, 900	UP,VE	Hand Lay-Up
M705	450	UP,VE, PU	Hand Lay-Up
M705 Wide	225, 250	UP,VE	Hand Lay-Up
M705X12	225	UP,VE	Hand Lay-Up
705	225, 300, 450, 600	UP,VE	Hand Lay-Up
505	300, 450	UP	Hand Lay-Up
MK12-450	450, 600	UP	Hand Lay-Up
M723*	300, 450, 600	UP,VE, DCPD	Hand Lay-Up
M723**	225, 300, 380, 450, 600	UP,VE, DCPD	Hand Lay-Up

*Taloja Plant
**Kimchon Plant.

PACKAGING

OC Chopped Strand Mats are wound into a roll on a cardboard inner tube. Each roll is wrapped in stretch-wrap and placed vertically on a pallet or polybagged, boxed, palletized and shrink-wrapped.

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81.3.5733.1671

Pub No. 44861-B March 2006

Product Information

300 Gun Roving

Designed for Spray-Up Operations

Product Description

300 Gun Roving is developed for customers who require a basic gun roving requiring minimal Sales or Technical support.
300 Gun Roving is designed for use in a variety of spray-up operations in a wide range of end use applications in the marine, construction, consumer-recreation and transportation markets.

300 Gun Roving is compatible with polyester and vinyl ester resin systems. The final selection of any roving for molding processes is dependent upon the performance characteristics required of the finished product and the process techniques used. Each roving, therefore, should be evaluated for its own specific characteristics and cost/performance benefits, which dictate where and when the product is most applicable.

Visual Characteristics

Roving doffs are square-edged, cylindrical packages which are firmly and evenly wound and have a constant traverse length. The packages are designed to provide a smooth run out, and their geometry is controlled to maintain the run out performance.

Performance Characteristics

300 Gun Roving is designed to meet basic runnability, choppability, wet out and roll out characteristics. If premium performance is required, please contact your Owens Corning distributor for recommendations regarding Owens Corning's high performance gun rovings.

Available Product

Identification	Yield (Nom. yd/lb)	Linear Density (Nom. TEX)	% LOI (Nom.)
300 Gun Roving	207	2400	0.84-1.25

Packaging

For packaging, wrapping, packing and palletization, see the packaging information below:

Package Information

Package height, cm (in)	26	(10.25)
Package weight, kg (lb)	23	(50)
Package diameter, cm (in)	30	(12)
Packages per layer	12	
Packages per pallet	48	

Tack-Pak® Creel-Pak® and Bulk-Pak® Packaging

Pallet Information

Pallet height, cm (in)	120	(47)
Pallet length, cm (in)	95	(38)
Pallet width, cm (in)	130	(51)
Number of layers	4	
Pallet weight, kg (lb)	1088	(2400)

Other Information

Creel-Pak* packaging is a shipping pallet consisting of two carton tubes. Each tube contains 24 packages, four doffs high and three doffs wide. Two sets of 12 roving packages in each cell are tied together to allow continuous running, minimizing down time required for package changes.

Bulk-Pak** packaging is a shipping pallet consisting of 48 unlinked rovings arranged in four layers of 12 rovings. Layers are separated by cardboard layer pads and the whole pallet is film wrapped for protection and stability.

Tack-Pak is a film that wraps rovings individually to assist roving run-out and roving-to-roving transfer.

Storage Conditions

Unless otherwise specified, it is recommended to store glass fiber products in a cool dry area. Temperature should not exceed 35°C (95°F) and the relative humidity should be kept below 75%. Glass fiber products must remain in their original packaging material until just prior to its use.

If these recommendations are followed, the glass fiber products should not undergo significant changes when stored for extended periods of time.

Stacking Information

The packaging is designed to allow stacking of two pallets. When stacking two pallets high, care should be taken to correctly and smoothly place the top pallet. Owens Corning is not responsible for any damage resulting from stacking pallets higher than two.

* *Creel-Pak* packaging is only available in North America.
** *Bulk-Pak* packaging is only available in Europe.

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COMPOSITES

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Product Information

158B Type 30® Roving

Roving for Filament Winding and Pultrusion

Introduction

158B Type 30® roving is specifically designed for use in filament winding and pultrusion applications with epoxy resin systems.

Type 30 is a family of reinforcement products designed and manufactured by Owens Corning. The 158B *Type 30* product is manufactured using state-of-the-art technology in conjunction with statistical process control.

Description

Type 30 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 assures an excellent resin-to-glass binding through uniform distribution of the binding agent.

The *Type 30* roving process represents the optimum in glass forming technology and results in maximum strand integrity.

Packaging

Number of packaging configurations product is available in:

Pallet Dimensions	
Height, cm (in)	124 (49)
Pallet length, cm (in)	116 (45.5)
Pallet width, cm (in)	116 (45.5)
Number of layers	4
Pallet weight, kg (lb)	1225-1361 (2700-3000)
Carton Doff Information	
Doff height, cm (in)	27 (11)
Doff weight, kg (lb)	20.4 (45)
Doff diameter, cm (in)	27-29 (11-11.25)
Doffs per layer	16
Doffs per pallet	64

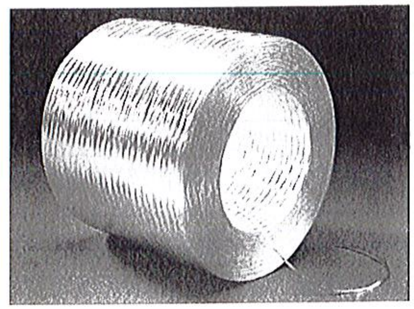
All packages are wrapped with Tack-Pak® film for protection and to facilitate doff-to-doff transfer.

Other Information

All pallets are stretch wrapped for load stability.

Storage

Unless otherwise specified, it is recommended to store glass fiber products in a cool, dry area. The packaging is not waterproof. Be sure to protect from the



weather and other sources of water. The glass fiber products must remain in their original packaging material just prior to their use. If these conditions are maintained, the glass fiber product should not undergo significant changes when stored for extended periods of time. It is recommended to bring the glass to room temperature 24 hours prior to use to allow the glass to equilibrate to room temperature.

Stacking

To ensure safety and avoid damage to the product, pallets should be stacked no more than two high. When stacking two pallets high, care should be taken to correctly and smoothly place the top pallet.
Owens Corning is not responsible for any damage resulting from stacking pallets higher than two.

Features	**Customer Benefits**
• Excellent Processing	• 158B *Type 30* roving has no catenary, which means smooth runout throughout the package. In addition, 158B 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.
• Fast Wet Out	• The 158B sizing allows fast, uniform wet out of the strand in epoxy resin systems. Fast wet out should allow you to optimize the amount of time to make a part, increasing productivity and improving your competitive position in the market.
• Optimum Package and Pallet Weight	• The 158B packages are designed to weigh approximately 20.4 kg (45 lb). Competitive products typically weigh between 16-18 kg (35-40 lb). The larger 158B packages result in less time needed for creeling and less splices going into the part. The heavier pallet weights of 1225-1361 kg (2700-3000 lb) mean less storage room is required and less pallet changes are needed. A side benefit of the heavier pallets is less packaging material to dispose of.
• Superior Burst Strength	• The 158B *Type 30* typically provides 15 percent higher burst pressure in pipe when compared to other high performance, epoxy compatible filament winding products.
• Increased Cycles-to-Failure	• The 158B *Type 30* typically provides three times the cycles-to-failure when compared to other high performance and epoxy compatible rovings.

158B Type 30® Roving

Typical Physical Properties*

Product Data

Identification Number	Nominal Yield (yds/lb)	Equivalent (TEX)	Nominal % Solids After Drying
158B-AA-675	671	735	0.55
158B-AB-450	447	1100	0.67
158B-AC-250	248	2000	0.74

Glass Fiber Data

Identification Number	Filament Type	Nominal Filament Diameter (in)	(microns)	Approx. Number of Filaments
158B-AA-675	K	0.00053	13.4	2000
158B-AB-450	M	0.00065	16.4	2000
158B-AC-250	M	0.00061	15.6	4000

Nominal specific gravity: 2.58 grams/cc (ASTM C 693)
Coefficient of linear expansion: 3 x 10^{6}/°F (ASTM D 696)

Cyclic Pressure Repression Performance*

Pipe pressure regression testing (ASTM D 2992, procedure A, Free-Ended). 54.75 degree winding angle. 73 °F (22.7 °C) test temperature. No liner, 2 in (5.08 cm) diameter pipe. All pipe was oven cured.

Laminate Properties*

The following data was generated using production material.

Tensile Strength Properties

Tested per ASTM D 2343 with resin impregnation done by a submerged resin bath. Resin: Epon 828 Epoxy Anhydride.

Identification Number	Average Tensile Strength Ksi	(GPa)	Tensile Strength Range of Data Ksi	(GPa)
158B-AA-675	373	(2.57)	341-404	(2.35-2.79)
158B-AB-450	349	(2.41)	319-391	(2.20-2.70)
158B-AC-250	355	(2.45)	321-391	(2.21-2.70)

Nominal Tensile Modulus

10.5 x 10^{6} psi (72.4 Gpa)

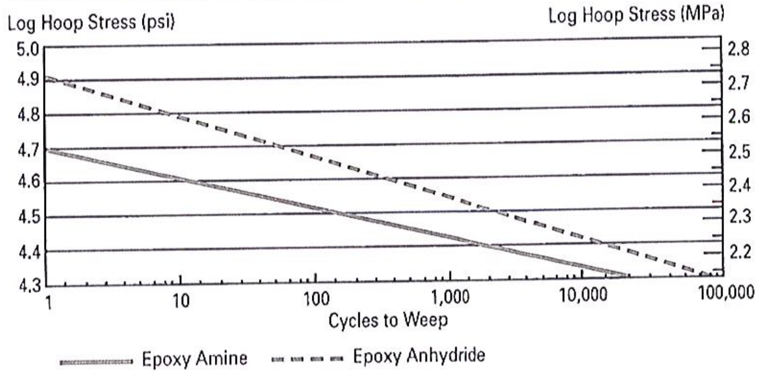
Apparent Interlaminar Sheer Strength

Tested per ASTM D 2344 with resin impregnation done by a submerged resin bath. Resin: Epon 828 Epoxy Anhydride.

Identification Number	Average Shear Strength (Dry) psi	(Dry) (MPa)	(72 Hr boil) psi	(72 Hr boil) (MPa)	% Retention
158B-AA-675	11261	(77.7)	10061	(69.4)	89.3
158B-AB-450	10123	(69.8)	9626	(66.4)	95.2
158B-AC-250	9908	(68.3)	9220	(63.6)	93.0

Laminate Data*

Pipe Cyclic Regression on 158B-AA-675



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Product Information

OWENS CORNING®

Knytex® Reinforcement Fabric

Woven Roving (Bi-Ply) (0°, 90°)

Systems Solutions for proven performance in demanding fabric reinforcement applications.

Resin Compatibility

All Knytex® fabrics are manufactured with multi-compatible glass reinforcing material. Sizings can be customized to meet particular application specifications, if required.

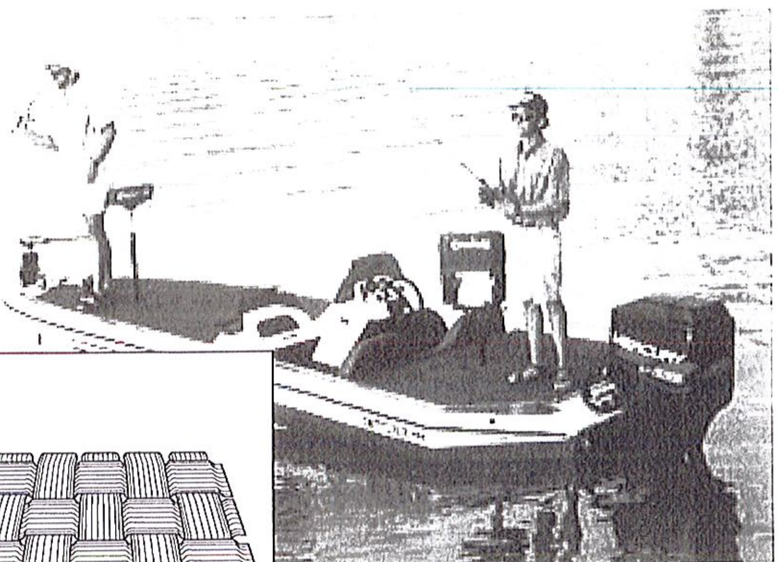
Processes

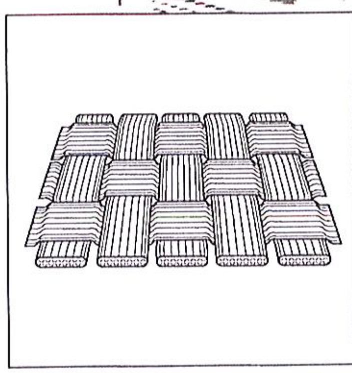
- Hand lay-up
- RTM/VARTM
- Chop hoop winding
- Centrifugal casting
- Vacuum bag
- Compression molding

Typical Applications

Multi-purpose *Knytex* Woven Roving fabrics are designed to be used in marine, transportation and industrial applications such as:

- Boat hulls and decks
- Barge covers
- Truck trailer panels
- Water tower blades
- Shipping containers
- Underground utility vaults
- Blast mitigation
- Storage tanks
- Tooling
- Pipes and tubing





Economical *Knytex* Woven Roving fabrics are the standard in the marine industry for large, cost-sensitive applications.

High-strength Solutions for Your Toughest Fabric Reinforcement Challenges

Knytex fabrics are specifically designed to meet your most demanding performance, processing and cost requirements. Owens Corning's global network of facilities and people – including specialists with in-depth knowledge and experience in composite fabrication and part construction – stands ready to help you develop innovative solutions to your most difficult fabric reinforcement challenges.

Fabrics Engineered for Optimal Composite Performance

Knytex fabrics deliver a unique combination of properties. They offer one of the highest strength-to-weight ratios possible for reinforced plastics. Plus, through careful selection and placement of fabrics, designers can put that strength exactly where it's needed, making optimum use of the fiber strength. Cost-efficient *Knytex* fabrics also reduce resin usage and fabrication time and offer excellent processability.

Woven Roving fabrics provide the most economical solution for raising glass content of laminates and increasing laminate stiffness and impact resistance without adding thickness, weight or other non-reinforcing materials. The economical fabric delivers cost-effective solutions to your cost competitive fabric reinforcement challenges, particularly large parts such as boat hulls and high-durability laminates such as underground utility boxes.

Fabric Description and Construction

Knytex Woven Roving fabrics, constructed by weaving single-end rovings on a loom, offer bi-directional (0°/90°), continuous fiber strength. Woven Roving Fabrics, made from high-quality glass fibers, are available in several weights and weave patterns to meet your particular application requirements. They are available with mats for improved handling and faster laminate build-up.

System Thinking

COMPOSITES

Knytex® Reinforcement Fabric

Woven Roving Fabric (Bi-Ply) (0°, 90°)

Benefits	Features
Lower finished part cost	Economical, low-cost and multi-use fabric
Enhanced physical performance from thinner, lighter laminates	Improved strength without adding thickness at comparable impact resistance and stiffness
Improved productivity	Fabric retains excellent conformability even when soaked with resin for fast, efficient laminate build-up; wets out quickly
Design flexibility enables engineers to achieve optimal composite performance and cost benefits	Can be stitchbonded with various mats to meet particular application requirements
Offers solutions for a wide range of applications	Available in a variety of widths, weights and weaves
Consistent, predictable and reliable high-quality performance	Made with high-purity fibers in leading-edge, ISO-registered facilities

"Standard" Products in the Woven Roving Family

Specs to include:

- Fabric weight in ounces/yard and grams/meter
- Fabric thickness in inches and mm
- Fabric layers (plies)
- Fabric ply and mat weights in ounces and grams
- Fabric physical and mechanical properties

Storage

Keep all fabrics dry and cool. Some sizings do not age well, leading to excessive stiffness, fuzz and a slowing of wet-out speed. Keeping the fabrics cool slows down the aging process. Always rotate stocks so the oldest material is used first.

Product Available

All *Knytex* fabrics are available with a stitchbonded mat. Available mats include: veils, chopped strand mat, direct chop (binderless) chopped strand mat, continuous filament mat and wet formed mats.

SYSTEM THINKING
Makes the Difference™

OWENS CORNING WORLD HEADQUARTERS
ONE OWENS CORNING PARKWAY
TOLEDO, OHIO 43659
USA 1.800.438.7465

OWENS CORNING FABRICS
1851 S. SEGUIN STREET
NEW BRAUNFELS, TEXAS 78130

OWENS CORNING FABRICS ESPANA S.A.
CARRETERA C-1411, KM 20
E-08295
SANT VICENÇ DE CASTELLET

For more information, visit our Internet site at http://www.owenscorning.com

COMPOSITES

Disclaimer of Liability

This data 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 liability arising out of its use or performance. The user, by accepting the products described herein, 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.

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Pub. No. XXXXXXXXX Printed in USA, January 1999

BASF
The Chemical Company

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Tinuvin® 328

Benzotriazole UV Absorber

Characterization

Tinuvin 328 is an ultraviolet light absorber (UVA) of the hydroxyphenyl benzotriazole class, which imparts outstanding light stability to plastics and other organic substrates.

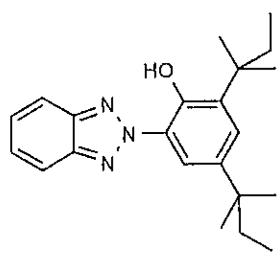
Chemical name

Phenol, 2-(2H-benzotriazol-2-yl)-4,6-bis(1,1-dimethylpropyl)

CAS number

25973-55-1

Chemical formula



Molecular weight

352 g/mol

Applications

Tinuvin 328 is a highly effective light stabilizer for a variety of plastics and other organic substrates. Its use is recommended for the stabilization of styrene homo- and copolymers, acrylic polymers, unsaturated polyesters, polyvinyl chloride, polyolefins, polyurethanes, polyacetals, polyvinyl butyral, elastomers, and adhesives.

Features/benefits

Tinuvin 328 features strong UV absorption, low initial color, excellent compatibility in a wide vari-ety of substrates, good solubility in plasticizers and monomers, and moderately low volatility. It protects polymers as well as organic pigments from UV radiation, helping to preserve the original appearance and physical integrity of molded articles, films, sheets, and fibers during outdoor weathering.

Product forms

Tinuvin 328	Slightly yellow powder
Tinuvin 328 FF	Slightly yellow, free-flowing granules

Guidelines for use

The use levels of Tinuvin 328 range between 0.1 and 1.0%, depending on substrate and performance requirements of the final application. Tinuvin 328 can be used alone or in combination with other functional additives such as antioxidants (hindered phenols, phosphites) and HALS light stabilizers, where often a synergistic performance is observed. Performance data for Tinuvin 328 alone and in combination with other additives are available in a variety of substrates.

Physical Properties

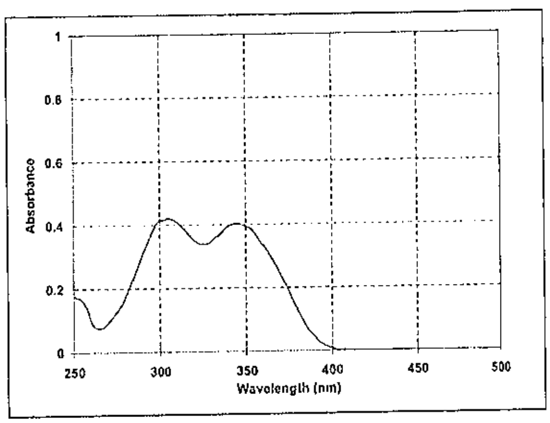
Melting Range	80–88 °C
Flashpoint	229 °C
Specific Gravity (20 °C)	1.17 g/ml
Vapor Pressure (20 °C)	4.7 E-6 Pa

Solubility (20 °C)	**g/100 g solution**
Acetone	6
Benzene	39
Chloroform	44
Cyclohexane	15
Ethyl acetate	16
n-Hexane	16
Methanol	0.4
Water	<0.01

Volatitility (pure substance; TGA, heating rate 20 °C/min in air)

Weight Loss %	Temperature °C
1.0	183
2.0	202
5.0	223

Absorbance spectrum
(10 mg/l, Chloroform)



Tinuvin 328 exhibits high absor-bance in the 300-400 nm region and minimal absorbance in the visible region (>400 nm) of the spectrum. The absorption maxima are at 306 nm and 347 nm (ε =14'760 l/mol · cm) in chloro-form solution.

Handling & Safety

Tinuvin 328 exhibits a very low order of oral toxicity and does not present any abnormal problems in its handling or general use.

Detailed information on handling and any precautions to be observed in the use of the product(s) described in this leaflet can be found in our relevant health and safety information sheet.

Note

The descriptions, designs, data and information contained herein are presented in good faith, and are based on BASF's current knowledge and experience. They are provided for guidance only, and do not constitute the agreed contractual quality of the product or a part of BASF's terms and conditions of sale. Because many factors may affect processing or application/use of the product, BASF recommends that the reader carry out its own investigations and tests to determine the suitability of a product for its particular purpose prior to use. It is the responsibility of the recipient of product to ensure that any proprietary rights and existing laws and legislation are observed. No warranties of any kind, either expressed or implied, including, but not limited to, warranties of merchantability or fitness for a particular purpose, are made regarding products described or designs, data or information set forth herein, or that the products, descriptions, designs, data or information may be used without infringing the intellectual property rights of others. Any descriptions, designs, data and information given in this publication may change without prior information. The descriptions, designs, data and information furnished by BASF hereunder are given gratis and BASF assumes no obligation or liability for the descriptions, designs, data or information given or results obtained, all such being given and accepted at the reader's risk.

August 2010

BASF Schweiz AG
Performance Chemicals/Plastic Additives
Klybeckstrasse 141
4057 Basel, Switzerland

SECTION SIX

FRP Tank Fabrication Drawings & Details

13658-FN01 Rev B

13658-LY01 Rev B

13658-SP01 Rev B

13658-SP02 Rev B

Industrial Plastic Systems

4225 Drane Field Road, Lakeland, Florida 33811
Ph 863.646.8551 Web: www.ips-frp.com

FABRICATION NOTES:

1.0. DESIGN CRITERIA
- 1.1. DESCRIPTION: Ø90"xØ96" DOUBLE WALL FRP TANK
- 1.2. DESIGN PRESSURE RATING: ATMOSPHERIC
- 1.3. TEMPERATURE: 40-120°F
- 1.4. SPECIFIC GRAVITY: 1.4
- 1.5. SERVICE: ALUM
- 1.6. WIND DESIGN: N/A
- 1.7. SEISMIC DESIGN: N/A
- 1.8. TANK DESIGN: PER ASTM D3299 & NBS PS 15-69 SPECIFICATIONS.

2.0. CONSTRUCTION/FABRICATION:
- 2.1. DIMENSIONS: INDUSTRIAL PLASTIC SYSTEMS IS NOT RESPONSIBLE FOR THE ACCURACY OF CONSTRUCTION SITE DIMENSIONS. ALL DIMENSIONS MUST BE CONFIRMED BY THE CUSTOMER OR THE CUSTOMER'S REPRESENTATIVE BEFORE FABRICATION MAY PROCEED. ALL DRAWINGS MUST BE APPROVED, SIGNED AND RELEASED FOR PRODUCTION BY CUSTOMER.
- 2.2. CORROSION BARRIER/LINER LAYERS:
  - 2.2.1. RESIN SYSTEM: DERAKANE 411 EPOXY VINYL ESTER RESIN OR EQUAL.
  - 2.2.2. CURE SYSTEM: MEKP CURED
  - 2.2.3. RESIN ADDITIVES: NONE
  - 2.2.4. STRUCTURAL REINFORCEMENT:
    - 2.2.4.1. CORROSION BARRIER: (1) PLY "C" VEIL
    - 2.2.4.2. LINER REINFORCEMENT: 1.5 OZ. PER SQ. FT. CHOPPED MAT "E" / "ECR" GLASS CLOTH OR SPRAY/CHOPPER GUN APPLIED:
      - INNER SHELL: (2) 43 MIL PLIES
      - OUTER SHELL: (1) 43 MIL PLIE
  - 2.2.5. NOM. THICKNESS:
    - INNER SHELL: 0.100"
    - OUTER SHELL: 0.050"
- 2.3. STRUCTURAL LAYERS:
  - 2.3.1. RESIN SYSTEM: DERAKANE 411 EPOXY VINYL ESTER RESIN OR EQUAL
  - 2.3.2. CURE SYSTEM: MEKP CURED
  - 2.3.3. RESIN ADDITIVES: NONE
  - 2.3.4. STRUCTURAL REINFORCEMENT:
    - 2.3.4.1. FILAMENT WOUND FRP CYLINDER PER ASTM D3299 STD: 250 YIELD "E" / "ECR" GLASS FILAMENT W/A SILANE FINISH APPLIED AT A 62-68° WIND ANGLE.
    - 2.3.4.2. CONTACT MOLDED FRP FITTINGS:
      - 2.3.4.2.1. 1.5 OZ. PER SQ. FT. CHOPPED MAT "E" OR "ECR" GLASS CLOTH OR SPRAY / CHOPPER GUN APPLIED.
      - 2.3.4.2.2. 24 OZ. PER SQ. YD. 0°/90° "E"/"ECR" GLASS WOVEN ROVING CLOTH
  - 2.3.5. NOMINAL STRUCTURAL THICKNESS: AS NOTED ON THE DRAWINGS.
- 2.4. FIRE RETARDANCY RATING: N/A
- 2.5. SMOKE RETARDANCY RATING: N/A
- 2.6. EXTERIOR PROTECTION: "UV" INHIBITOR.
- 2.7. MARKINGS: LAMINATED LABEL UNLESS NOTED ON THE DRAWINGS

3.0. FITTINGS: WELDS, FLANGES, NOZZLES, REDUCERS & TRANSITIONS DETAILS
- 3.1 CONSTRUCTION: CONTACT MOLDED PER NBS PS 15-69 & ASME RTP-1 TYPE-II LAMINATE UNLESS NOTED ON THE DRAWINGS.
- 3.2. WELDING LAMINATE SEQUENCES: ASME RTP-1 TYPE-II LAMINATE UNLESS NOTED ON THE DRAWINGS.
- 3.3. FLANGES:
  - 3.3.1 FLANGES ARE OF TYPE II CONSTRUCTION, MAT PLUS ALTERNATING LAYERS OF 1.5 OZ. MAT AND 24 OZ. WOVEN ROVING PER ASME RTP-1 TABLE 2A2 AND ASTM D-5421.
  - 3.3.2. FLANGES ARE FABRICATED IN ACCORDANCE WITH THE FLANGE TABLE UNLESS NOTED ON THE DWGS. FLANGES ARE SPOT FACED FOR NARROW TYPE FLAT WASHERS.
  - 3.3.3. ORIENTATION: ALWAYS STRADDLE NATURAL ℄ UNLESS NOTED ON DWGS.
  - 3.3.4. ALL FLANGES AND GASKETS THAT MATE WITH IPS SUPPLIED FLANGES MUST BE FULL FACE. RAISED FACE FLANGES MAY BE USED ALONG WITH WAFER SPACERS OR IF THE FLANGE FACE IS GROOVED TO RECEIVE THE RAISED PORTION OF THE MATING FLANGE. ALL GASKETS MUST BE 50-60 DUROMETER & ⅛ THK. CONTACT IPS WHEN FLANGES ARE NOT FULL FACE.
- 3.4. FLANGED NOZZLE GUSSETS:
  - 3.4.1. UP TO AND INCLUDING Ø4": PLATE GUSSETS, UNLESS NOTED ON THE DRAWINGS.
  - 3.4.2. Ø6" AND ABOVE: NONE, UNLESS NOTED ON THE DRAWINGS.
- 3.5. NOZZLE PROJECTIONS:
  - 3.5.1 TYPICAL NOZZLE PROJECTION IS 6" MEASURED FROM THE SHELL OR TOP O.D. UNLESS NOTED ON THE DRAWINGS.

4.0. QUALITY ASSURANCE/CONTROL:
- 4.1. RESIN CURE: BARCOL HARDNESS TEST PER ASTM D-2583. A MINIMUM OF TEN (10) HARDNESS READING SHALL BE TAKEN WITH AN AVERAGE READING OF 35 (MIN.).
- 4.2. VISUAL DEFECTS: ASTM D2563 LEVEL II ON THE INTERIOR AND LEVEL III ON THE EXTERIOR.
- 4.3. TOLERANCES: N.B.S. PRODUCT STANDARD 15-69
- 4.4. HYDRO TEST: N/A
- 4.5. RESIN AND GLASS CONTENT: DETERMINE RESIN / GLASS CONTENT PER ASTM D-2584.
- 4.6. ACETONE SENSITIVITY: DETERMINE RESIN IS PROPERLY CURED PER ASTM C-582.

5.0. HANDLING & INSTALLATION:
- 5.1. REVIEW THE INDUSTRIAL PLASTIC SYSTEMS HANDLING AND INSTALLATION MANUALS BEFORE HANDLING AND INSTALLING ALL FRP EQUIPMENT SUPPLIED BY IPS.
- 5.2. SEE DETAIL A, DRAWING LY01 FOR LIFTING AND ANCHORING LOCATIONS.
- 5.3. ALL DEADMAN, CONCRETE ANCHORS, HOLD DOWN STRAPS, CLIPS AND OTHER MATERIAL REQUIRED FOR INSTALLATION ARE PROVIDED BY OTHERS.

6.0. ADDITIONAL ITEMS SUPPLIED:
- 6.1. ALL FASTENERS SHALL BE STAINLESS STEEL, GRADE 316 UNLESS NOTED. (20) Ø ⅝"x3¼" HEX BOLT, NUT & (2) FLAT WASHERS
- 6.2. ALL GASKETS TO BE ⅛" EPDM: (1) 24"Ø FULL FACE GASKETS (SEE FLANGE DRILLING TABLE)

DESIGN / MATERIAL DESCRIPTION

INNER TANK SHELL, Ø90"	
INTERNAL LINER	100 MILS (1) "C" VEIL, (2) MAT
STRUCTURAL WALL	0.27" (6) COVER F/W
EXTERNAL LINER	NONE
TOTAL SHELL THICKNESS	0.37"
INNER TANK SEMI-ELLIP DISH END	0.56" - VMM, 3(MR)M, 2(MR)M
WELD FOR ABOVE	0.56" - VMM, 3(MR)M, 2(MR)M
BODY WELD FOR ABOVE	0.56" - VMM, 3(MR)M, 2(MR)M
OUTER TANK SHELL, Ø96"	
INTERNAL LINER	50 MILS (1) "C" VEIL, (1) MAT
STRUCTURAL WALL	0.27" (6) COVER F/W
EXTERNAL LINER	NONE
TOTAL SHELL THICKNESS	0.32"
OUTER TANK F&D DISH END	0.56" - VM, 3(MR)M, 2(MR)MM
WELD FOR ABOVE	0.56" - VM, 3(MR)M, 2(MR)MM
BODY WELD FOR ABOVE	0.56" - VM, 3(MR)M, 2(MR)MM
NOZZLES : 3"Ø ('A') & 2"Ø ('B' & 'C')	
INNER TANK WELD FOR ABOVE	0.18" - V, 4M
OUTER TANK WELD FOR ABOVE	0.25" - VM, 6M
NOZZLES 'D': 1"Ø	
INNER TANK WELD FOR ABOVE	0.18" - V, 4M
OUTER TANK WELD FOR ABOVE	0.18" - V, 4M
NOZZLES 'E' & 'F': 1"Ø	
OUTER TANK WELD FOR ABOVE	0.23" - VM, 4M
MANWAY 'G': 24"Ø	
INNER TANK WELD FOR ABOVE	0.37" - VMM, 3(MR)M
OUTER TANK WELD FOR ABOVE	0.27" - 3(MR)M
EXTERIOR COATING	"UV" INHIBITOR

FLANGE DRILLING

DIA.	O.D.	B.C.	B.H.	BOLT DIA.	SPOT FACE DIA	NO. HOLES	THK.
1"	4 1/4"	3 1/8"	5/8"	1/2"	1 1/2"	4	5/8"
2"	6"	4 3/4"	3/4"	5/8"	1 1/2"	4	11/16"
3"	7 1/2"	6"	3/4"	5/8"	1 1/2"	4	13/16"
24"	32"	29 1/2"	3/4"	5/8"	1 1/2"	20	1"

REVISION STATUS

DWG	REV	DWG	REV
FN01	B	SP01	B
LY01	B	SP02	B

REVISIONS RECORD

REV	CHK.	DRAWN	DATE	DESCRIPTION
B	DLW	CSR	11/18/21	RELOCATED NOZ. 'C', 'E' & 'F', APPROVAL PENDING
A	DLW	CSR	07/21/21	APPROVAL PENDING

DIMENSIONAL TOLERANCE UNLESS OTHERWISE SPECIFIED
FRACTIONALS PS 15-69 OR ± 1/8" — ANGLES ± 1° — PERPENDICULARITY ± 1° — PARALLELISM ± 1°

DRAWING NOT TO SCALE

LAST UPDATED SCHEDULE

	NAME	DATE
DRAWN BY	CSR	07/19/21
CHECKED BY	DLW	07/19/21
APPV'D BY	CUSTOMER	N.A.

ALWAYS CHECK IF APPRV. FOR FAB.

STATUS: APPROVAL PENDING

PROPRIETARY AND CONFIDENTIAL

DISCIPLINE: MECHANICAL ENGINEERING

IPS JOB NO.: 21-13658

PROJECT NAME: LAKE DOT ALUM TREATMENT PLANT

SIZE: LD — DRAWING No.: 13658-FN01 — REV: B

DESIGN: - — QUANTITY: 1

CUSTOMER / P.O. NUMBER: CORCEL CORPORATION P.O.: BCI 49-3220-1

DRAWING TITLE: 90"/96"ø DOUBLE WALL TANK FABRICATION NOTES

ALL DIMENSIONS IN FEET & INCHES

ips Industrial Plastic Systems
4725 DRANE FIELD RD. LAKELAND, FL 33811
PHONE: (863) 646-8551
FAX: (863) 644-1534
www.ips-frp.com

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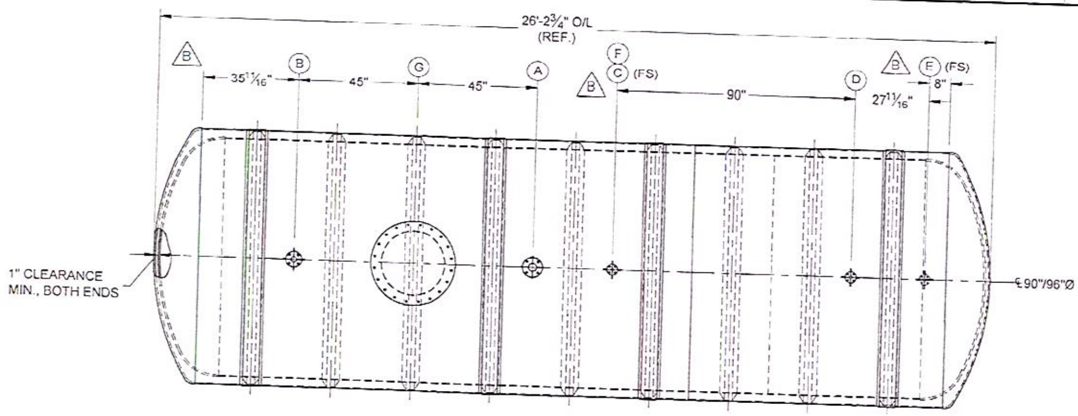
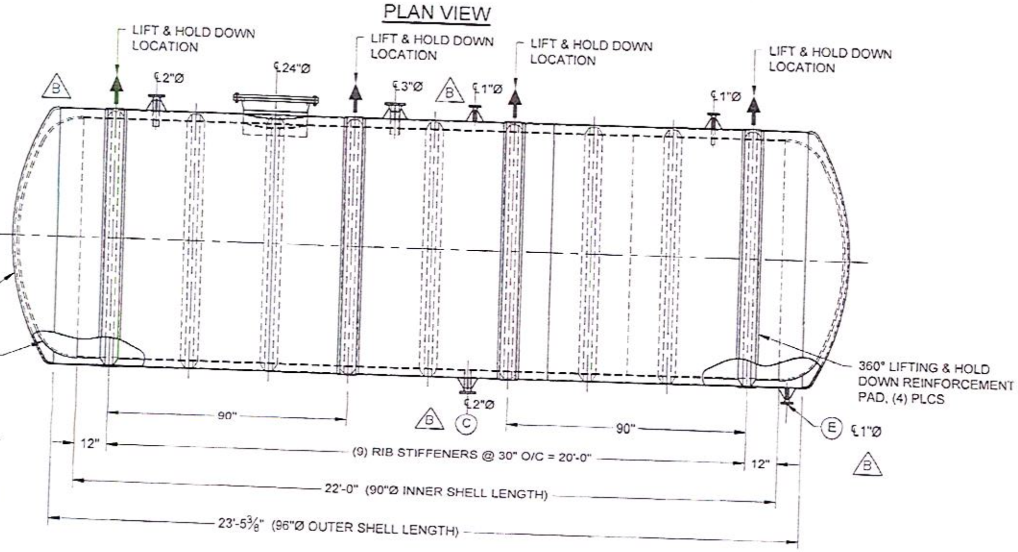
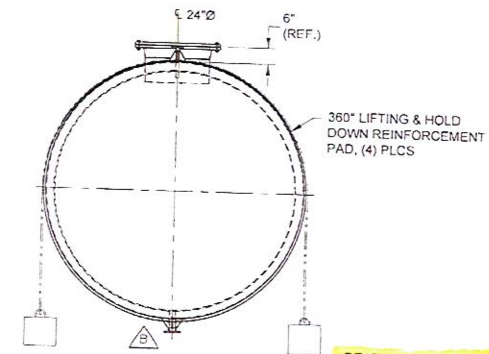


PLAN VIEW



ELEVATION VIEW



END VIEW

DEADMAN ANCHORS
(4) 12"x12"x12'-0" LONG ANCHORS, (2) PER SIDE. EACH ANCHOR TO INCLUDE (2) EMBEDDED LOOPS/HOOKS ON 7'-6" CENTERS. ANCHORS, BANDS AND HARDWARE BY OTHERS.

VESSEL SCHEDULE

ITEM	SIZE	DESCRIPTION
A	3"Ø	FLANGED NOZZLE, ANSI CL150 - VENT
B	2"Ø	FLANGED NOZZLE, ANSI CL150 - FILL
C	2"Ø	FLANGED NOZZLE, ANSI CL150 - DISCHARGE
D	1"Ø	FLANGED NOZZLE, ANSI CL150 - RETURN
E	1"Ø	FLANGED NOZZLE, ANSI CL150 - INTERSTITIAL SENSOR
F	1"Ø	FLANGED NOZZLE, ANSI CL150 - INTERSTITIAL VENT
G	24"Ø	MANWAY W/COVER, FASTENERS & GASKET

NOTE:
1) FOR FABRICATION NOTES & MATERIAL DESCRIPTIONS SEE DWG FN01.
2) TANKS MUST BE LIFTED ONLY AT INDICATED LOCATIONS.
3) ALL LIFTING AND HOLD DOWN POINTS MUST BE USED FOR LIFTING AND HOLD DOWN. LIFT WITH NYLON STRAPS AND SPREADER BARS.
4) DO NOT JERK TANK WHILE LIFTING.

REVISIONS RECORD

REV.	CHK.	DRAWN	DATE	DESCRIPTION
B	DLW	CSR	11/18/21	RELOCATED NOZ 'C', 'E' & 'F'; APPROVAL PENDING
A	DLW	CSR	07/21/21	APPROVAL PENDING

DIMENSIONAL TOLERANCE
UNLESS OTHERWISE SPECIFIED

FRACTIONALS PS 15-69 OR ± 1/8"
ANGLES ± 1°
PERPENDICULARITY ± 1°
PARALLELISM ± 1°

DRAWING NOT TO SCALE

LAST UPDATED SCHEDULE

	NAME	DATE
DRAWN BY	CSR	07/19/21
CHECKED BY	DLW	07/19/21
APPV'D BY	CUSTOMER	N.A.

ALWAYS CHECK IF APPRV. FOR FAB.

STATUS
APPROVAL PENDING

PROPRIETARY AND CONFIDENTIAL
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DISCIPLINE
MECHANICAL ENGINEERING

IPS JOB NO. 21-13658

PROJECT NAME
LAKE DOT ALUM TREATMENT PLANT

SIZE: LD
DRAWING No.: 13658-LY01
REV: B
DESIGN: -
QUANTITY: 1

CUSTOMER / P.O. NUMBER
CORCEL CORPORATION
P.O.: BCI 49-3220-1

FILENAME: [illegible]

DRAWING TITLE
90"/96"ø DOUBLE WALL TANK
GENERAL ARRANGEMENT

ALL DIMENSIONS IN FEET & INCHES

IPS Industrial Plastic Systems
4225 DRANE FIELD RD. LAKELAND, FL 33811
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FAX (863) 644-1534
www.ips-frp.com

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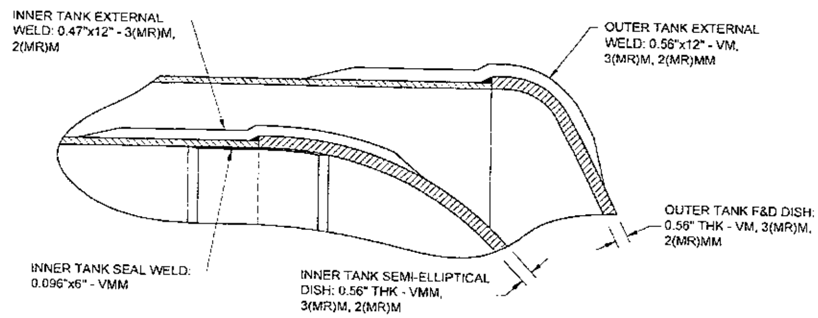
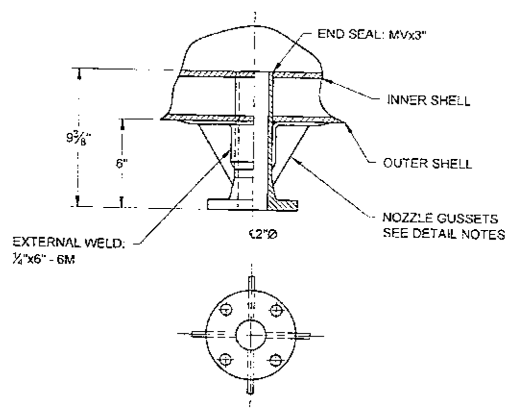
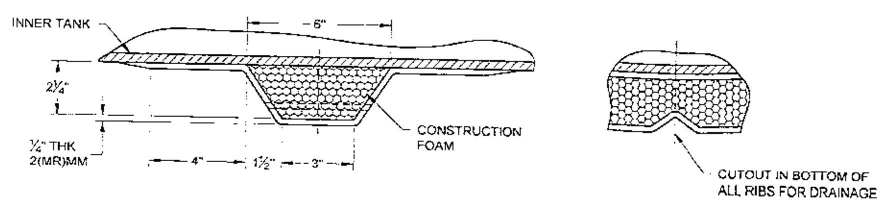
DETAIL NOTES:
1) FOR FABRICATION NOTES, MATERIAL AND FLANGE DESCRIPTIONS SEE DRAWING FN01.
2) SEAL ALL EXPOSED AND CUT EDGES WITH RESIN.
3) ALL NOZZLES Ø4" AND SMALLER SHALL HAVE (4) GUSSETS UNLESS NOTED OTHERWISE.
GUSSET PLATES: ½" - (6)M
OVERLAY: ⅛" - (3)M x 3" BOTH SIDES



1A / LY01 DETAIL - END CAP & SHELL ASSY
(TYP. BOTH ENDS)



B 1B / LY01 DETAIL - NOZZLE 'C'
(1) REQD - DISCHARGE



1B / LY01 DETAIL - INNER TANK RIB STIFFENER
(9) REQD

REV.	CHK.	DRAWN	DATE	DESCRIPTION
B	DLW	CSR	11/18/21	DELETED: DISCH HOSE DTL 1B; APPROVAL PENDING
A	DLW	CSR	07/21/21	APPROVAL PENDING

REVISIONS RECORD

DIMENSIONAL TOLERANCE UNLESS OTHERWISE SPECIFIED
FRACTIONALS PS 15-69 OR ± 1/8" — ANGLES ± 1° — PERPENDICULARITY ± 1° — PARALLELISM ± 1°
DRAWING NOT TO SCALE

LAST UPDATED SCHEDULE

	NAME	DATE
DRAWN BY	CSR	07/19/21
CHECKED BY	DLW	07/19/21
APPV'D BY	CUSTOMER	N.A.

ALWAYS CHECK IF APPRV. FOR FAB.

STATUS: APPROVAL PENDING

PROPRIETARY AND CONFIDENTIAL

DISCIPLINE: MECHANICAL ENGINEERING

IPS JOB NO.: 21-13658
PROJECT NAME: LAKE DOT ALUM TREATMENT PLANT
SIZE: LD — DRAWING No.: 13658-SP01 — REV: B
DESIGN: - — QUANTITY: 1

CUSTOMER / P.O. NUMBER: CORCEL CORPORATION P.O.: BCI 49-3220-1
FILENAME:
DRAWING TITLE: 90"/96"ø DOUBLE WALL TANK DETAILS AND SECTIONS
ALL DIMENSIONS IN FEET & INCHES

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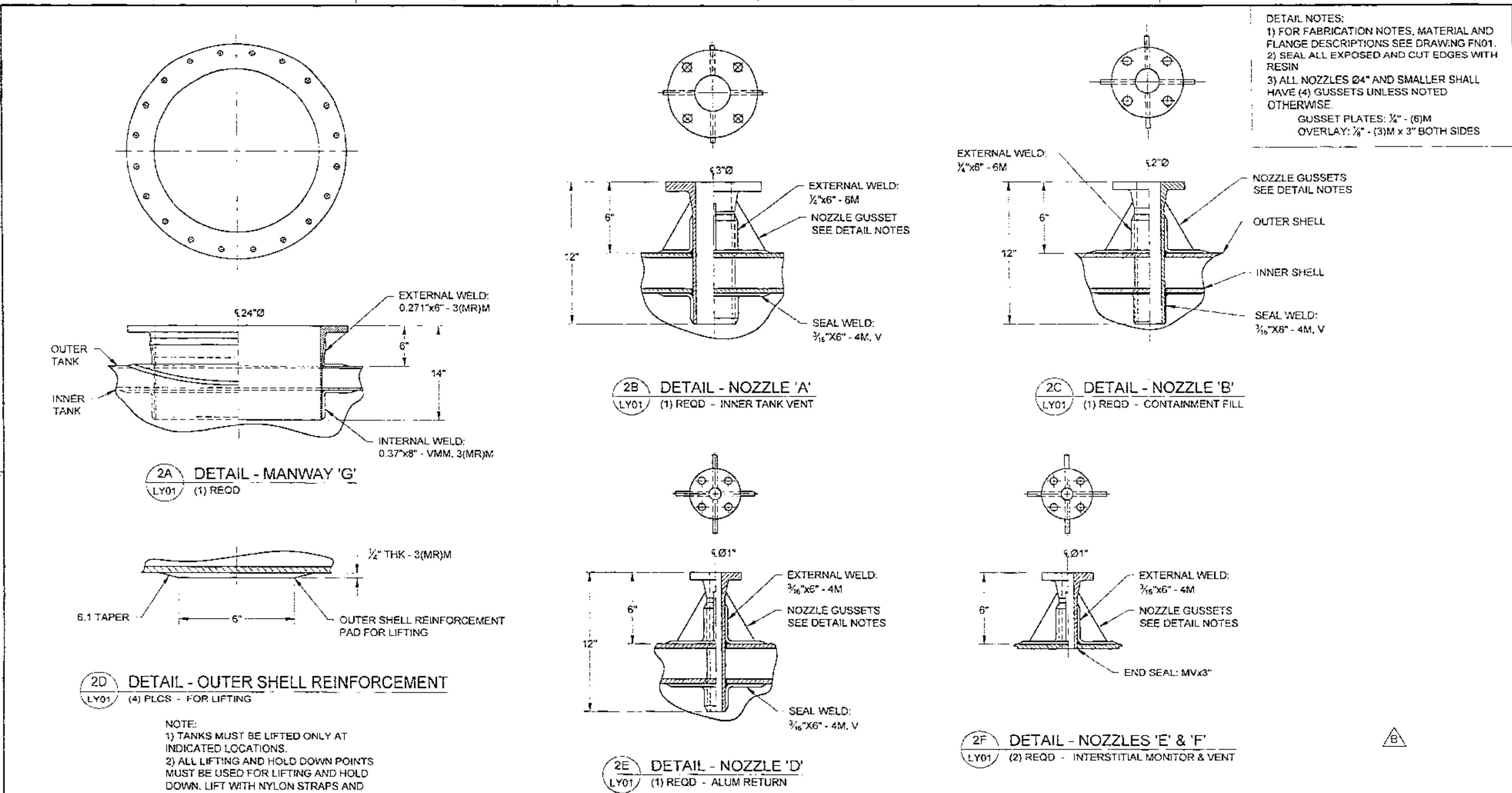

NOTE:
1) TANKS MUST BE LIFTED ONLY AT INDICATED LOCATIONS.
2) ALL LIFTING AND HOLD DOWN POINTS MUST BE USED FOR LIFTING AND HOLD DOWN. LIFT WITH NYLON STRAPS AND SPREADER BARS.
3) DO NOT JERK TANK WHILE LIFTING.

REVISIONS RECORD

REV.	CHK.	DRAWN	DATE	DESCRIPTION
B	DLW	CSR	11/18/21	DELETED: DETAIL 2G; APPROVAL PENDING
A	DLW	CSR	07/21/21	APPROVAL PENDING

DIMENSIONAL TOLERANCE UNLESS OTHERWISE SPECIFIED
FRACTIONALS PS 15-69 OR ± 1/8"
ANGLES ± 1°
PERPENDICULARITY ± 1°
PARALLELISM ± 1°
DRAWING NOT TO SCALE

LAST UPDATED SCHEDULE

	NAME	DATE
DRAWN BY	CSR	07/19/21
CHECKED BY	DLW	07/19/21
APPV'D BY	CUSTOMER	N.A.

ALWAYS CHECK IF APPRV. FOR FAB.

STATUS: APPROVAL PENDING

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DISCIPLINE: MECHANICAL ENGINEERING

IPS JOB NO.: 21-13658

PROJECT NAME: LAKE DOT ALUM TREATMENT PLANT

SIZE: LD | DRAWING No.: 13658-SP02 | REV: B

DESIGN: - | QUANTITY: 1

CUSTOMER / P.O. NUMBER: CORCEL CORPORATION P.O.: BCI 49-3220-1

DRAWING TITLE: 90"/96"ø DOUBLE WALL TANK DETAILS AND SECTIONS

ALL DIMENSIONS IN FEET & INCHES

IPS Industrial Plastic Systems
4225 DRANE FIELD RD LAKELAND, FL 33811
PHONE (863) 645-8551
FAX (863) 644-1534
www.ips-frp.com

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SECTION SEVEN

FRP Tank Design Calculations

90" dia. Underground Horizontal FRP Tank (Inner Tank) R-1

96" dia. Underground Horizontal FRP Tank (Outer Tank) R-1

4225 Drane Field Road, Lakeland, Florida 33811
Ph 863.646.8551 Web: www.ips-frp.com

BURIED HORIZONTAL SINGLE / DOUBLE WALL TANK DESIGN ANALYSIS:

This tank design analysis follows AWWA C950-88 specification for buried pipe in regards to tank buckling due to a NON H-20 loading and predicts allowable External pressure per equations from ASME/ASTM RTP-1. For design checks, (1) denotes sufficient design and (0) denotes insufficient design.

DESIGN CONDITIONS:

Tank Pressure: $P_T := 1.0 \cdot psi$

Tank Inside Diameter: $D := 7.5 \cdot ft$ Dish Head Radius: $R_O := 81 in$

Extension: $Ex := 2 \cdot ft$

Design Operating Internal Pressure: $P_O := P_T + (D + Ex) \cdot 12 \cdot \frac{in\_wc}{ft}$ $P_O = 5.12 \cdot psi$

Design Test Internal Pressure:
(P.TO=1.0XP.O for Storage Tanks
P.TO=1.5XP.O for Press Vessels) ALUM = SG 1.40 $P_{TO} := 1.4 \cdot P_O$ $P_{TO} = 7.16 \cdot psi$

Design Test External Pressure: $P_{TD} := 2.61 \cdot psi$

Height of Cover (Depth of Burial): $H := 2.0 \cdot ft$

Estimated Earth Load: $\gamma_S := 125 \cdot \frac{lbf}{ft^3}$

Liner Thickness: $t_L := 0.100 \cdot in$

No. of FW Layers: $NL := 6$

FW Layer Thickness: $LT := 0.045 \cdot in$

Structural Wall Thickness: $t := NL \cdot LT$ $t = 0.27 \cdot in$

Total Wall Nominal Thickness: $t_T := t + t_L$ $t_T = 0.37 \cdot in$

Dished Head Nominal Thickness: $t_d := 0.56 \cdot in$

FRP MATERIAL PROPERTIES:

Allowable Working Hoop and Longitudinal Strain: $\varepsilon_{HW} := .0010 \cdot \frac{in}{in}$

Allowable Strain for Combined Load: $\varepsilon_{HC} := \frac{2 \cdot \varepsilon_{HW}}{2.5}$ $\varepsilon_{HC} = 0.0008 \cdot \frac{in}{in}$

Filament Wound FRP Helix Angle: (usually 68) $\theta_h := 68 \cdot deg$

$E_A := 1.80 \cdot 10^6 \cdot psi - 60000 \cdot \frac{psi}{deg} \cdot (\theta_h - 55 \cdot deg)$ $E_H := 3.0 \cdot 10^6 \cdot psi + 70000 \cdot \frac{psi}{deg} \cdot (\theta_h - 55 \cdot deg)$

Filament Wound FRP Hoop Modulus of Elasticity: $E_H = 3.91 \times 10^6 \cdot psi$

Filament Wound FRP Axial Modulus of Elasticity: $E_A = 1.02 \times 10^6 \cdot psi$

Liner Modulus of Elasticity: $E_L := 1.00 \cdot 10^6 \cdot psi$

Contact Molded FRP Modulus of Elasticity: $E_{CM} := 1.5000 \cdot 10^6 \cdot psi$

FRP Tank Hoop Modulus of Elasticity per ASTM D-3299:

$$E_{PH} := \frac{t}{t_T} \cdot E_H + \frac{t_L}{t_T} \cdot E_L \qquad E_{PH} = 3.12 \times 10^6 \cdot psi$$

FRP Tank Axial Modulus of Elasticity per ASTM D-3299:

$$E_{PA} := \frac{t}{t_T} \cdot E_A + \frac{t_L}{t_T} \cdot E_L \qquad E_{PA} = 1.01 \times 10^6 \cdot psi$$

Ultimate Hoop Tensile Stress: $S_h := 50000 \cdot psi$

Ultimate Hand Lay-up Tensile Stress: $S_{hlt} := 15000 \cdot psi$

Design Operating Safety Factor: $SF := 10$

Design Test Safety Factor: $SF_T := 10$

Design Test External Safety Factor: $SF_X := 5$

Poisson's Ratio, applied hoop load/stress: $\nu_{hl} := 0.45$

Poisson's Ratio, applied axial stress: $\nu_{lh} := 0.15$

STEP1:

Determine actual and allowable tensile stresses in the inner tank wall and dished heads due to hydrostatic pressure. Hydrostatic pressure is defined by the maximum liquid depth for a horizontal storage tank.

Predicted Hydrostatic Hoop Stress: $\sigma_{hh} := \frac{P_O \cdot D}{2 \cdot t}$ $\qquad \sigma_{hh} = 853 \cdot psi$

Allowable Hydrostatic Hoop Stress: $\sigma_{ahh} := (E_H \cdot \varepsilon_{HW})$ $\qquad \sigma_{ahh} = 3910 \cdot psi$

Predicted Test Hoop Stress: $\sigma_{th} := \frac{P_{TO} \cdot D}{2 \cdot t}$ $\qquad \sigma_{th} = 1194 \cdot psi$

Allowable Test Hoop Stress: $\sigma_{ath} := (E_H \cdot \varepsilon_{HW})$ $\qquad \sigma_{ath} = 3910 \cdot psi$

Predicted Dished Head Hydrostatic Tensile Stress: $\sigma_{dht} := \frac{0.885 \cdot (P_O \cdot R_O)}{t_d}$ $\qquad \sigma_{dht} = 655 \cdot psi$

Allowable Dished Head Hydrostatic Tensile Stress:: $\sigma_{adt} := \frac{S_{hlt}}{SF}$ $\qquad \sigma_{adt} = 1500 \cdot psi$

Predicted Dished Head Test Tensile Stress: $\sigma_{dtt} := \dfrac{0.885 \cdot (P_{TO} \cdot R_O)}{t_d}$ $\sigma_{dtt} = 917 \cdot psi$

Allowable Dished Head Test Tensile Stress:: $\sigma_{att} := \dfrac{S_{hlt}}{SF_T}$ $\sigma_{att} = 1500 \cdot psi$

Internal Pressure Hoop Stress Design Check: $CK1 := if\left[\left(\sigma_{hh} < \sigma_{ahh}\right) \cdot \left(\sigma_{dht} < \sigma_{adt}\right), 1, 0\right]$ $CK1 = 1$

Minimum Dish Head Thickness: $th_{min} := \dfrac{0.885 \cdot (P_O \cdot R_O)}{\dfrac{S_{hlt}}{SF}}$ $th_{min} = 0.24 \cdot in$

Minimum Dish Head Thickness for Torispherical Heads Design Check $CK1b := if\left(th_{min} < t_d, 1, 0\right)$ $CK1b = 1$

STEP2:

Check Tank Shell's Pipe Stiffness and determine AWWA C950 Shape Factor from Table A1:

Pipe Structural Mean Diameter: $D_M := D + 2 \cdot t_L + t$ $D_M = 90.47 \cdot in$

Pipe Mean Structural Radius: $r := \dfrac{D_M}{2}$ $r = 45.23 \cdot in$

Tank Stiffener Rib Moment of Inertia (See Appendix A):
(input value from appendix A manually!!! $I_{rib} := 0.21 \cdot \dfrac{in^4}{in}$

Predicted Tank Shell Stiffness: $PS1 := \left(\dfrac{E_{PH}}{0.149 \cdot r^3} \cdot \dfrac{t_T^{\,3}}{12}\right) + \left(\dfrac{E_L}{0.149 \cdot r^3} \cdot I_{rib}\right)$ $PS1 = 16.2 \cdot psi$

Design Tank Shell Stiffness: $PS := if\left[(PS1 < 72 \cdot psi) \cdot (PS1 > 9 \cdot psi), PS1, if\left[(PS1 < 9 \cdot psi), 9 \cdot psi, 72 \cdot psi\right]\right]$

$PS = 16.2 \cdot psi$

SHAPE FACTORS: Table A.1 from AWWA C950-1989.

Enter burial parameters and soil type:

Choose Soil and Burial Parameters: $B := 3$

1 - Gravel: Dumped to Slight Compaction
2 - Gravel: Moderate to High Compaction
3 - Sand: Dumped to Slight Compaction
4 - Sand: Moderate to High Compaction

Pipe Stiffness *psi*	Gravel* Dumped to Slight	Gravel* Moderate to High	Sand+ Dumped to Slight	Sand+ Moderate to High

$$PS' := \begin{pmatrix} 9\cdot psi \\ 18\cdot psi \\ 36\cdot psi \\ 72\cdot psi \end{pmatrix} \quad D'_{f1} := \begin{pmatrix} 5.5 \\ 4.5 \\ 3.8 \\ 3.3 \end{pmatrix} \quad D'_{f2} := \begin{pmatrix} 7.0 \\ 5.5 \\ 4.5 \\ 3.8 \end{pmatrix} \quad D'_{f3} := \begin{pmatrix} 6.0 \\ 5.0 \\ 4.0 \\ 3.5 \end{pmatrix} \quad D'_{f4} := \begin{pmatrix} 8.0 \\ 6.5 \\ 5.5 \\ 4.5 \end{pmatrix}$$

Shape Factor Chart: $D'_f := if(B = 1, D'_{f1}, if(B = 2, D'_{f2}, if(B = 3, D'_{f3}, D'_{f4})))$

Shape Factor (linearly interpolated): $D_f := linterp(PS', D'_f, PS)$ $D_f = 5.2$

STEP3:

Calculate the allowable deflection D_{ya} from ring bending.

Deflection Factor: (Fixed) $DF := 0.05$

Allowable Deflections No. 1: $\Delta y1_a := DF\cdot D$ $\Delta y1_a = 4.5\cdot in$

Tank Structural Mean Diameter: $D_M = 90.47\cdot in$

Tank Structural Mean Radius: $r = 45.23\cdot in$

Shape Factor : $D_f = 5.2$

Allowable Deflection Two: $\Delta y2_a := \dfrac{\varepsilon_{HW}\cdot D_M^{\ 2}}{D_f\cdot t}$ $\Delta y2_a = 5.828\cdot in$

Allowable Deflection: $\Delta y_a := if(\Delta y1_a < \Delta y2_a, \Delta y1_a, \Delta y2_a)$ $\Delta y_a = 4.5\cdot in$

STEP4.

Determine external soil and live truck loads.

SOIL LOAD:

Tank Outside Diameter: $D_o := D + 2\cdot t_T$ $D_o = 90.74\cdot in$

Weight of Earth cover above the tank per inch of length: $W_c := \gamma_S\cdot D_o\cdot H$ $W_c = 157.5\cdot\dfrac{lbf}{in}$

LIVE LOAD:

Impact Factor for Live Loads: $I_f := 0.766 - 0.133 \cdot \frac{H}{ft}$ $\quad I_f := if(I_f < 0, 0, if(I_f > .5, .5, I_f))$ $\quad I_f = 0.5$

Live Load Coefficient for H20 Single Wheel Loading: $C_L := 0.236$ See Table A.3.

Wheel Load at Grade Surface (Standard for H-20 Loading): $P := 000 \cdot lbf$

Live Load due to H2O Truck Loading per inch of length: $W_L := C_L \cdot P \cdot \frac{1 + I_f}{ft}$ $\quad W_L = 0 \cdot \frac{lbf}{in}$

STEP5.

Check actual deflection prediction.

Stiffness Factor: $EI := E_{PH} \cdot \frac{t_T^3}{12} + E_L \cdot I_{rib}$ $\quad EI = 223185 \cdot psi \cdot \frac{in^4}{in}$

Deflection Coefficient: $K_X := 0.083$ See Table A.2.

Modulus of Soil Reaction: $E' := 1000 \cdot psi$ See Table A.5 - (Coarse grained soils w/ fines; moderate compaction)

2000 psi makes soil stiffer and helps in our design

Deflection coefficient for installations with 16' of cover or less to provide 95% probability that actual deflection will be less than the calculated value.

$K_A := if(H < 16 \cdot ft, 0.75, 1)$ $\quad K_A = 0.75$

Deflection Lag Factor: $D_l := 1.5$ See paragraph A.3.4.2.1.

Deflection Prediction: $\Delta y := \frac{(D_l \cdot W_c + W_L) \cdot K_X \cdot r^3}{EI + .061 \cdot K_A \cdot E' \cdot r^3}$ $\quad \Delta y = 0.407 \cdot in$

Allowable Deflection: $\Delta y_a = 4.5 \cdot in$

Deflection Design Check: $CK2 := if(\Delta y < \Delta y_a, 1, 0)$ $\quad CK2 = 1$

STEP6:

Check combined hydrostatic pressure and H-20 loading strain.

Shape Factor: $D_f = 5.2$ See Table A.1

Rerounding Coefficient: $r_c := 1 - \frac{P_O}{435 \cdot psi}$ $r_c = 0.988$

Combined Strain: $\varepsilon_c := D_f \cdot r_c \cdot \frac{\Delta y}{D_M} \cdot \frac{t_T}{D_M} + \frac{P_O \cdot D}{2 \cdot E_H \cdot t}$ $\varepsilon_c = 0.000313 \cdot \frac{in}{in}$

Allowable Combined Strain: $\varepsilon_{HC} = 0.0008 \cdot \frac{in}{in}$

Combined Strain Design Check: $CK3 := if(\varepsilon_c < \varepsilon_{HC}, 1, 0)$ $CK3 = 1$

STEP7:

Check buckling due to above soil load.

Rib Stiffener Spacing: $L_v := 30.0 \cdot in$

No. of Lobes Formed at Buckling: $n := 2$

Height of Water Surface Above Top of Pipe: $h_w := 24.0 \cdot in$

Water Buoyancy Factor: $R_w := 1 - 0.33 \cdot \frac{h_w}{H}$ $R_w = 0.67$

Empirical Coefficient of Elastic Support: $B' := \frac{1}{1 + 4 \cdot exp\left(-\frac{0.065}{ft} \cdot H\right)}$ $B' = 0.222$

Modulus of Soil Reaction: $E' = 1000 \cdot psi$

Predicted Buckling Pressure 1: $q_{b1} := \left(0.0361 \cdot \frac{lbf}{in^3}\right) \cdot h_w + R_w \cdot \frac{W_c}{D_M}$ $q_{b1} = 2.03 \cdot psi$

Predicted Buckling Pressure 2:
(With Live Load) $q_{b2} := \left(0.0361 \cdot \frac{lbf}{in^3}\right) \cdot h_w + R_w \cdot \frac{W_c}{D_M} + \frac{W_L}{D_M}$ $q_{b2} = 2.03 \cdot psi$

Allowable Buckling Pressure No.1: $q_{ab1} := \frac{1}{SF_T} \cdot \left(32 \cdot R_w \cdot B' \cdot E' \cdot \frac{EI}{{D_M}^3}\right)^{\frac{1}{2}}$ $q_{ab1} = 3.78 \cdot psi$

Buckling Constants: $K := \frac{(2 \cdot n \cdot L_v)^2}{(\pi \cdot D_M)^2}$ $K = 0.18$

Allowable Buckling Pressure No. 2:

$$q_{ab2} := \frac{1}{SF_T}\cdot\left[\frac{2\cdot E_{PH}\cdot t_T}{D_M\cdot\left(n^2-1\right)\cdot(1+K)^2}+\left[n^2-1+\left(\frac{2\cdot n^2-1-\nu_{hl}}{1+K}\right)\right]\cdot\left[\frac{8\cdot EI}{D_M{}^3\cdot\left(1-\nu_{hl}\cdot\nu_{lh}\right)}\right]\right] \qquad q_{ab2} = 615.65\cdot psi$$

Allowable Buckling Pressures:	$q_{ab} := if\left(H \ge 4\cdot ft, q_{ab1}, q_{ab2}\right)$	$q_{ab} = 615.65\cdot psi$
Buckling Pressure Design Check: (with external loads)	$CK4a := if\left(q_{b1} < q_{ab}, 1, 0\right)$	$CK4a = 1$
Buckling Pressure Design Check: (with live load)	$CK4b := if\left(q_{b2} < q_{ab}, 1, 0\right)$	$CK4b = 1$

STEP8:

Check the tank wall for buckling due to test extrenal pressure per specification ANSI/ASME RTP-1-1992 equations. Equations on Page 21

Safety Factor: $SF_T = 10$

Pressure Coefficients: $A' := 1.73\cdot\left(\frac{D+2\cdot t_T}{t_T}\right)^{.5}$ $\qquad B' := \frac{L_v}{D+2\cdot t_T}$

$A' = 27.09 \qquad B' = 0.33$

Allowable Tank Wall External Pressure One:	$P_1 := 2.6\cdot\frac{E_{PA}}{SF_T}\cdot\frac{D_o}{L_v}\cdot\left(\frac{t_T}{D_o}\right)^{2.5}$	$P_1 = 0.8\cdot psi$
Allowable Tank Wall External Pressure Two:	$P_2 := \frac{2.6\cdot\frac{E_{PA}}{SF_T}\cdot\left(\frac{t_T}{D_o}\right)^{2.5}\cdot\left(\frac{D_o}{L_v}\right)}{\left(\frac{L_v}{D_o}\right)-0.45\cdot\left(\frac{t_T}{D_o}\right)^{.5}}$	$P_2 = 2.81\cdot psi$
Allowable Tank Wall External Pressure:	$P_{tall} := if\left(A' < B', P_1, P_2\right)$	$P_{tall} = 2.8\cdot psi$
Required Test External Pressure:	$P_{TD} = 2.61\cdot psi$	$P_{TD} = 2.61\cdot psi$
Tank Wall External Pressure Design Check:	$CK5 := if\left(P_{TD} < P_{tall}, 1, 0\right)$	$\boxed{CK5 = 1}$

STEP9:

Check the dished head for buckling due to test External per specification ANSI/ASME RTP-1-1992 equations. Standard F&D dished heads are used for the tank ends. F&D heads have a working radius equal to the tank's diameter.

Allowable Dished Head External Pressure: $P_{dall} := 0.36 \cdot \left(\frac{E_{CM}}{SF_X}\right) \cdot \left(\frac{t_d}{R_O}\right)^2$ $P_{dall} = 5.16 \cdot psi$

Required Test External Pressure: $P_{TD} = 2.61 \cdot psi$

Dished Head External Pressure Design Check: $CK6 := if(P_{TD} < P_{dall}, 1, 0)$ $CK6 = 1$

DESIGN CHECKS ((1) denotes sufficient design; (0) denotes insufficient design):

Internal Pressure Hoop Stress Design Check: $CK1 = 1$

Dish Head Thickness Design Check: $CK1b = 1$

Deflection Design Check: $CK2 = 1$

Combined Strain Design Check: $CK3 = 1$

Buckling Pressure Design Check: $CK4a = 1$

Buckling Pressure Design Check: $CK4b = 1$

Tank Wall External Test Pressure Design Check: $CK5 = 1$

Dished Head External Test Pressure Design Check: $CK6 = 1$

Complete Design Check:

$$CK_{com} := if[(CK1 = 1)(CK1b = 1) \cdot (CK2 = 1) \cdot (CK3 = 1) \cdot (CK4a = 1) \cdot (CK4b = 1) \cdot (CK5 = 1) \cdot (CK6 = 1), 1, 0]$$

$CK_{com} = 1$

Tank Inside Diameter: $D = 90 \cdot in$

Required Tank Wall Thickness: $t_T = 0.37 \cdot in$

Required Dished Head Thickness: $t_d = 0.56 \cdot in$

APPENDIX A: RIB MOMENT OF INERTIA

This design analysis determines the moment of inertia for a trapezoidal rib stiffener for external collapse of a FRP storage tank from the tanks outer wall.

RIB STIFFENER:

Description: 6" wide x 4" wide x 1.5" high foam w/ 1/4" thick FRP structural cover. Foam is assumed to have no struct aspects. Rib also has a 4" x 1/4" leg on the tank outer wall for bonding the rib to the tank shell both sides of the rib.

LARGE TRAPEZOID:

Bottom Width: $b_{L1} := 6.5 \cdot in$

Top Width: $b_{L2} := 3.5 \cdot in$

Height: $h_L := 2.25 \cdot in$

Moment of Inertia: $I_L := \left[\dfrac{h_L^{\,3} \cdot (b_{L1} + 3 \cdot b_{L2})}{12}\right]$ $\qquad I_L = 16.1 \cdot in^4$

SMALL(FOAM) TRAPEZOID:

Bottom Width: $b_{S1} := 6.0 \cdot in$

Top Width: $b_{S2} := 3.0 \cdot in$

Height: $h_S := 2.0 \cdot in$

Moment of Inertia: $I_S := \left[\dfrac{h_S^{\,3} \cdot (b_{S1} + 3 \cdot b_{S2})}{12}\right]$ $\qquad I_S = 10 \cdot in^4$

RIB BONDING LEGS:

Thickness: $b_{BL} := 6 \cdot in$

$h_{BL} := 0.25 \cdot in$

Moment of Inertia: $I_{BL} := 2 \cdot \left(\dfrac{b_{BL} \cdot h_{BL}^{\,3}}{3}\right)$ $\qquad I_{BL} = 0.0625 \cdot in^4$

RIB COMBINED MOMENT OF INERTIA:

Rib Spacing: $L_v = 30 \cdot in$

Rib Moment of Inertia: $I_{rib} := (I_L + I_{BL}) - I_S$ $\qquad I_{rib} = 6.2 \cdot in^4$

Rib Moment of Inertia per Linear Foot of Tank Wall between Rib Supports:

I.RIB VALUE MUST BE INPUT MANUALLY IN CALCULATIONS IN STEP 2 ON PAGE 3

$$I_{rib} := \frac{(I_L + I_{BL}) - I_S}{L_v} \qquad I_{rib} = 0.21 \cdot \frac{in^4}{in}$$

$bar \equiv 100000 \cdot Pa$

$N \equiv newton$

$in\_wc \equiv .0361 \cdot psi$

BURIED HORIZONTAL SINGLE / DOUBLE WALL TANK DESIGN ANALYSIS:

This tank design analysis follows AWWA C950-88 specification for buried pipe in regards to tank buckling due to a NON H-20 loading and predicts allowable External pressure per equations from ASME/ASTM RTP-1. For design checks, (1) denotes sufficient design and (0) denotes insufficient design.

DESIGN CONDITIONS:

Tank Pressure: $P_T := 1.0 \cdot psi$

Tank Inside Diameter: $D := 8.0 \cdot ft$ Dish Head Radius: $R_O := 92in$

Extension: $Ex := 2 \cdot ft$

Design Operating Internal Pressure: $P_O := P_T + (D + Ex) \cdot 12 \cdot \frac{in\_wc}{ft}$ $P_O = 5.33 \cdot psi$

Design Test Internal Pressure:
(P.TO=1.0XP.O for Storage Tanks
P.TO=1.5XP.O for Press Vessels) ALUM = SG 1.40 $P_{TO} := 1.4 \cdot P_O$ $P_{TO} = 7.46 \cdot psi$

Design Test External Pressure: $P_{TD} := 2.61 \cdot psi$

Height of Cover (Depth of Burial): $H := 2.0 \cdot ft$

Estimated Earth Load: $\gamma_S := 125 \cdot \frac{lbf}{ft^3}$

Liner Thickness: $t_L := 0.100 \cdot in$

No. of FW Layers: $NL := 6$

FW Layer Thickness: $LT := 0.045 \cdot in$

Structural Wall Thickness: $t := NL \cdot LT$ $t = 0.27 \cdot in$

Total Wall Nominal Thickness: $t_T := t + t_L$ $t_T = 0.37 \cdot in$

Dished Head Nominal Thickness: $t_d := 0.56 \cdot in$

FRP MATERIAL PROPERTIES:

Allowable Working Hoop and Longitudinal Strain: $\varepsilon_{HW} := .0010 \cdot \frac{in}{in}$

Allowable Strain for Combined Load: $\varepsilon_{HC} := \frac{2 \cdot \varepsilon_{HW}}{2.5}$ $\varepsilon_{HC} = 0.0008 \cdot \frac{in}{in}$

Filament Wound FRP Helix Angle: (usually 68) $\theta_h := 68 \cdot deg$

$$E_A := 1.80 \cdot 10^6 \cdot psi - 60000 \cdot \frac{psi}{deg} \cdot (\theta_h - 55 \cdot deg) \qquad E_H := 3.0 \cdot 10^6 \cdot psi + 70000 \cdot \frac{psi}{deg} \cdot (\theta_h - 55 \cdot deg)$$

Filament Wound FRP Hoop Modulus of Elasticity: $E_H = 3.91 \times 10^6 \cdot psi$

Filament Wound FRP Axial Modulus of Elasticity: $E_A = 1.02 \times 10^6 \cdot psi$

Liner Modulus of Elasticity: $E_L := 1.00 \cdot 10^6 \cdot psi$

Contact Molded FRP Modulus of Elasticity: $E_{CM} := 1.5000 \cdot 10^6 \cdot psi$

FRP Tank Hoop Modulus of Elasticity per ASTM D-3299:

$$E_{PH} := \frac{t}{t_T} \cdot E_H + \frac{t_L}{t_T} \cdot E_L \qquad E_{PH} = 3.12 \times 10^6 \cdot psi$$

FRP Tank Axial Modulus of Elasticity per ASTM D-3299:

$$E_{PA} := \frac{t}{t_T} \cdot E_A + \frac{t_L}{t_T} \cdot E_L \qquad E_{PA} = 1.01 \times 10^6 \cdot psi$$

Ultimate Hoop Tensile Stress: $S_h := 50000 \cdot psi$

Ultimate Hand Lay-up Tensile Stress: $S_{hlt} := 15000 \cdot psi$

Design Operating Safety Factor: $SF := 10$

Design Test Safety Factor: $SF_T := 10$

Design Test External Safety Factor: $SF_X := 5$

Poisson's Ratio, applied hoop load/stress: $\nu_{hl} := 0.45$

Poisson's Ratio, applied axial stress: $\nu_{lh} := 0.15$

STEP 1:

Determine actual and allowable tensile stresses in the inner tank wall and dished heads due to hydrostatic pressure. Hydrostatic pressure is defined by the maximum liquid depth for a horizontal storage tank.

Predicted Hydrostatic Hoop Stress: $$\sigma_{hh} := \frac{P_O \cdot D}{2 \cdot t} \qquad \sigma_{hh} = 948 \cdot psi$$

Allowable Hydrostatic Hoop Stress: $$\sigma_{ahh} := \left(E_H \cdot \varepsilon_{HW}\right) \qquad \sigma_{ahh} = 3910 \cdot psi$$

Predicted Test Hoop Stress: $$\sigma_{th} := \frac{P_{TO} \cdot D}{2 \cdot t} \qquad \sigma_{th} = 1327 \cdot psi$$

Allowable Test Hoop Stress: $$\sigma_{ath} := \left(E_H \cdot \varepsilon_{HW}\right) \qquad \sigma_{ath} = 3910 \cdot psi$$

Predicted Dished Head Hydrostatic Tensile Stress: $$\sigma_{dht} := \frac{0.885 \cdot \left(P_O \cdot R_O\right)}{t_d} \qquad \sigma_{dht} = 775 \cdot psi$$

Allowable Dished Head Hydrostatic Tensile Stress:: $$\sigma_{adt} := \frac{S_{hlt}}{SF} \qquad \sigma_{adt} = 1500 \cdot psi$$

Predicted Dished Head Test Tensile Stress: $\sigma_{dtt} := \frac{0.885 \cdot (P_{TO} \cdot R_O)}{t_d}$ $\sigma_{dtt} = 1085 \cdot psi$

Allowable Dished Head Test Tensile Stress:: $\sigma_{att} := \frac{S_{hlt}}{SF_T}$ $\sigma_{att} = 1500 \cdot psi$

Internal Pressure Hoop Stress Design Check: $CK1 := if[(\sigma_{hh} < \sigma_{ahh}) \cdot (\sigma_{dht} < \sigma_{adt}), 1, 0]$ $CK1 = 1$

Minimum Dish Head Thickness: $th_{min} := \frac{0.885 \cdot (P_O \cdot R_O)}{\frac{S_{hlt}}{SF}}$ $th_{min} = 0.29 \cdot in$

Minimum Dish Head Thickness for Torispherical Heads Design Check $CK1b := if(th_{min} < t_d, 1, 0)$ $CK1b = 1$

STEP2:

Check Tank Shell's Pipe Stiffness and determine AWWA C950 Shape Factor from Table A1:

Pipe Structural Mean Diameter: $D_M := D + 2 \cdot t_L + t$ $D_M = 96.47 \cdot in$

Pipe Mean Structural Radius: $r := \frac{D_M}{2}$ $r = 48.23 \cdot in$

Tank Stiffener Rib Moment of Inertia (See Appendix A):
(input value from appendix A manually!!! $I_{rib} := 0.21 \cdot \frac{in^4}{in}$

Predicted Tank Shell Stiffness: $PS1 := \left(\frac{E_{PH}}{0.149 \cdot r^3} \cdot \frac{t_T^3}{12}\right) + \left(\frac{E_L}{0.149 \cdot r^3} \cdot I_{rib}\right)$ $PS1 = 13.3 \cdot psi$

Design Tank Shell Stiffness: $PS := if[(PS1 < 72 \cdot psi) \cdot (PS1 > 9 \cdot psi), PS1, if[(PS1 < 9 \cdot psi), 9 \cdot psi, 72 \cdot psi]]$

$PS = 13.3 \cdot psi$

SHAPE FACTORS: Table A.1 from AWWA C950-1989.

Enter burial parameters and soil type:

Choose Soil and Burial Parameters: $B := 3$

1 - Gravel: Dumped to Slight Compaction
2 - Gravel: Moderate to High Compaction
3 - Sand: Dumped to Slight Compaction
4 - Sand: Moderate to High Compaction

	Gravel*		Sand+	
Pipe Stiffness *psi*	Dumped to Slight	Moderate to High	Dumped to Slight	Moderate to High

$$PS' := \begin{pmatrix} 9\cdot psi \\ 18\cdot psi \\ 36\cdot psi \\ 72\cdot psi \end{pmatrix} \quad D'_{f1} := \begin{pmatrix} 5.5 \\ 4.5 \\ 3.8 \\ 3.3 \end{pmatrix} \quad D'_{f2} := \begin{pmatrix} 7.0 \\ 5.5 \\ 4.5 \\ 3.8 \end{pmatrix} \quad D'_{f3} := \begin{pmatrix} 6.0 \\ 5.0 \\ 4.0 \\ 3.5 \end{pmatrix} \quad D'_{f4} := \begin{pmatrix} 8.0 \\ 6.5 \\ 5.5 \\ 4.5 \end{pmatrix}$$

Shape Factor Chart: $D'_f := \text{if}(B = 1, D'_{f1}, \text{if}(B = 2, D'_{f2}, \text{if}(B = 3, D'_{f3}, D'_{f4})))$

Shape Factor (linearly interpolated): $D_f := \text{linterp}(PS', D'_f, PS)$ $\quad D_f = 5.52$

STEP3:

Calculate the allowable deflection D_{ya} from ring bending.

Deflection Factor: (Fixed) $\quad DF := 0.05$

Allowable Deflections No. 1: $\quad \Delta y1_a := DF\cdot D$ $\quad \Delta y1_a = 4.8\cdot in$

Tank Structural Mean Diameter: $\quad D_M = 96.47\cdot in$

Tank Structural Mean Radius: $\quad r = 48.23\cdot in$

Shape Factor : $\quad D_f = 5.52$

Allowable Deflection Two: $\quad \Delta y2_a := \dfrac{\varepsilon_{HW}\cdot D_M^{\ 2}}{D_f\cdot t}$ $\quad \Delta y2_a = 6.248\cdot in$

Allowable Deflection: $\quad \Delta y_a := \text{if}(\Delta y1_a < \Delta y2_a, \Delta y1_a, \Delta y2_a)$ $\quad \Delta y_a = 4.8\cdot in$

STEP4.

Determine external soil and live truck loads.

SOIL LOAD:

Tank Outside Diameter: $\quad D_o := D + 2\cdot t_T$ $\quad D_o = 96.74\cdot in$

Weight of Earth cover above the tank per inch of length: $\quad W_c := \gamma_S\cdot D_o\cdot H$ $\quad W_c = 168\cdot\dfrac{lbf}{in}$

LIVE LOAD:

Impact Factor for Live Loads: $I_f := 0.766 - 0.133 \cdot \frac{H}{ft}$ $\quad I_f := if(I_f < 0, 0, if(I_f > .5, .5, I_f))$ $\quad I_f = 0.5$

Live Load Coefficient for H20 Single Wheel Loading: $C_L := 0.236$ See Table A.3.

Wheel Load at Grade Surface (Standard for H-20 Loading): $P := 000 \cdot lbf$

Live Load due to H2O Truck Loading per inch of length: $W_L := C_L \cdot P \cdot \frac{1 + I_f}{ft}$ $\quad W_L = 0 \cdot \frac{lbf}{in}$

STEP5.

Check actual deflection prediction.

Stiffness Factor: $EI := E_{PH} \cdot \frac{t_T^{\,3}}{12} + E_L \cdot I_{rib}$ $\quad EI = 223185 \cdot psi \cdot \frac{in^4}{in}$

Deflection Coefficient: $K_X := 0.083$ See Table A.2.

Modulus of Soil Reaction: $E' := 1000 \cdot psi$ See Table A.5 - (Coarse grained soils w/ fines; moderate compaction)

2000 psi makes soil stiffer and helps in our design

Deflection coefficient for installations with 16' of cover or less to provide 95% probability that actual deflection will be less than the calculated value.

$K_A := if(H < 16 \cdot ft, 0.75, 1)$ $\quad K_A = 0.75$

Deflection Lag Factor: $D_l := 1.5$ See paragraph A.3.4.2.1.

Deflection Prediction: $$\Delta y := \frac{(D_l \cdot W_c + W_L) \cdot K_X \cdot r^3}{EI + .061 \cdot K_A \cdot E' \cdot r^3}$$ $\Delta y = 0.438 \cdot in$

Allowable Deflection: $\Delta y_a = 4.8 \cdot in$

Deflection Design Check: $CK2 := if(\Delta y < \Delta y_a, 1, 0)$ $\quad CK2 = 1$

STEP6:

Check combined hydrostatic pressure and H-20 loading strain.

Shape Factor: $D_f = 5.52$ See Table A.1

Rerounding Coefficient: $r_c := 1 - \frac{P_O}{435 \cdot psi}$ $r_c = 0.988$

Combined Strain: $\varepsilon_c := D_f \cdot r_c \cdot \frac{\Delta y}{D_M} \cdot \frac{t_T}{D_M} + \frac{P_O \cdot D}{2 \cdot E_H \cdot t}$ $\varepsilon_c = 0.000337 \cdot \frac{in}{in}$

Allowable Combined Strain: $\varepsilon_{HC} = 0.0008 \cdot \frac{in}{in}$

Combined Strain Design Check: $CK3 := if(\varepsilon_c < \varepsilon_{HC}, 1, 0)$ $CK3 = 1$

STEP7:

Check buckling due to above soil load.

Rib Stiffener Spacing: $L_v := 30.0 \cdot in$

No. of Lobes Formed at Buckling: $n := 2$

Height of Water Surface Above Top of Pipe: $h_w := 24.0 \cdot in$

Water Buoyancy Factor: $R_w := 1 - 0.33 \cdot \frac{h_w}{H}$ $R_w = 0.67$

Empirical Coefficient of Elastic Support: $B' := \frac{1}{1 + 4 \cdot \exp\left(-\frac{0.065}{ft} \cdot H\right)}$ $B' = 0.222$

Modulus of Soil Reaction: $E' = 1000 \cdot psi$

Predicted Buckling Pressure 1: $q_{b1} := \left(0.0361 \cdot \frac{lbf}{in^3}\right) \cdot h_w + R_w \cdot \frac{W_c}{D_M}$ $q_{b1} = 2.03 \cdot psi$

Predicted Buckling Pressure 2: (With Live Load) $q_{b2} := \left(0.0361 \cdot \frac{lbf}{in^3}\right) \cdot h_w + R_w \cdot \frac{W_c}{D_M} + \frac{W_L}{D_M}$ $q_{b2} = 2.03 \cdot psi$

Allowable Buckling Pressure No.1: $q_{ab1} := \frac{1}{SF_T} \cdot \left(32 \cdot R_w \cdot B' \cdot E' \cdot \frac{EI}{D_M^{\ 3}}\right)^{\frac{1}{2}}$ $q_{ab1} = 3.44 \cdot psi$

Buckling Constants: $K := \frac{(2 \cdot n \cdot L_v)^2}{(\pi \cdot D_M)^2}$ $K = 0.16$

Allowable Buckling Pressure No. 2:

$$q_{ab2} := \frac{1}{SF_T}\cdot\left[\frac{2\cdot E_{PH}\cdot t_T}{D_M\cdot\left(n^2-1\right)\cdot(1+K)^2}+\left[n^2-1+\left(\frac{2\cdot n^2-1-\nu_{hl}}{1+K}\right)\right]\cdot\left[\frac{8\cdot EI}{D_M{}^3\cdot\left(1-\nu_{hl}\cdot\nu_{lh}\right)}\right]\right] \qquad q_{ab2} = 598.69\cdot psi$$

Allowable Buckling Pressures: $q_{ab} := \text{if}\left(H \ge 4\cdot ft, q_{ab1}, q_{ab2}\right)$ $\quad q_{ab} = 598.69\cdot psi$

Buckling Pressure Design Check: (with external loads) $CK4a := \text{if}\left(q_{b1} < q_{ab}, 1, 0\right)$ $\quad CK4a = 1$

Buckling Pressure Design Check: (with live load) $CK4b := \text{if}\left(q_{b2} < q_{ab}, 1, 0\right)$ $\quad CK4b = 1$

STEP 8:

Check the tank wall for buckling due to test extrenal pressure per specification ANSI/ASME RTP-1-1992 equations. Equations on Page 21

Safety Factor: $SF_T = 10$

Pressure Coefficients: $A' := 1.73\cdot\left(\frac{D+2\cdot t_T}{t_T}\right)^{.5}$ $\quad B' := \frac{L_v}{D+2\cdot t_T}$

$A' = 27.97$ $\quad B' = 0.31$

Allowable Tank Wall External Pressure One: $P_1 := 2.6\cdot\frac{E_{PA}}{SF_T}\cdot\frac{D_o}{L_v}\cdot\left(\frac{t_T}{D_o}\right)^{2.5}$ $\quad P_1 = 0.8\cdot psi$

Allowable Tank Wall External Pressure Two:

$$P_2 := \frac{2.6\cdot\frac{E_{PA}}{SF_T}\cdot\left(\frac{t_T}{D_o}\right)^{2.5}\cdot\left(\frac{D_o}{L_v}\right)}{\left(\frac{L_v}{D_o}\right)-0.45\cdot\left(\frac{t_T}{D_o}\right)^{.5}} \qquad P_2 = 2.73\cdot psi$$

Allowable Tank Wall External Pressure: $P_{tall} := \text{if}\left(A' < B', P_1, P_2\right)$ $\quad P_{tall} = 2.7\cdot psi$

Required Test External Pressure: $P_{TD} = 2.61\cdot psi$ $\quad P_{TD} = 2.61\cdot psi$

Tank Wall External Pressure Design Check: $CK5 := \text{if}\left(P_{TD} < P_{tall}, 1, 0\right)$ $\quad CK5 = 1$

STEP9:

Check the dished head for buckling due to test External per specification ANSI/ASME RTP-1-1992 equations. Standard F&D dished heads are used for the tank ends. F&D heads have a working radius equal to the tank's diameter.

Allowable Dished Head External Pressure: $P_{dall} := 0.36 \cdot \left(\frac{E_{CM}}{SF_X}\right) \cdot \left(\frac{t_d}{R_O}\right)^2$ $P_{dall} = 4 \cdot psi$

Required Test External Pressure: $P_{TD} = 2.61 \cdot psi$

Dished Head External Pressure Design Check: $CK6 := if(P_{TD} < P_{dall}, 1, 0)$ $CK6 = 1$

DESIGN CHECKS ((1) denotes sufficient design; (0) denotes insufficient design):

Internal Pressure Hoop Stress Design Check: $CK1 = 1$

Dish Head Thickness Design Check: $CK1b = 1$

Deflection Design Check: $CK2 = 1$

Combined Strain Design Check: $CK3 = 1$

Buckling Pressure Design Check: $CK4a = 1$

Buckling Pressure Design Check: $CK4b = 1$

Tank Wall External Test Pressure Design Check: $CK5 = 1$

Dished Head External Test Pressure Design Check: $CK6 = 1$

Complete Design Check:

$CK_{com} := if[(CK1 = 1)(CK1b = 1) \cdot (CK2 = 1) \cdot (CK3 = 1) \cdot (CK4a = 1) \cdot (CK4b = 1) \cdot (CK5 = 1) \cdot (CK6 = 1), 1, 0]$

$CK_{com} = 1$

Tank Inside Diameter: $D = 96 \cdot in$

Required Tank Wall Thickness: $t_T = 0.37 \cdot in$

Required Dished Head Thickness: $t_d = 0.56 \cdot in$

APPENDIX A: RIB MOMENT OF INERTIA

This design analysis determines the moment of inertia for a trapezoidal rib stiffener for external collapse of a FRP storage tank from the tanks outer wall.

RIB STIFFENER:

Description: 6" wide x 4" wide x 1.5" high foam w/ 1/4" thick FRP structural cover. Foam is assumed to have no struct aspects. Rib also has a 4" x 1/4" leg on the tank outer wall for bonding the rib to the tank shell both sides of the rib.

LARGE TRAPEZOID:

Bottom Width: $b_{L1} := 6.5 \cdot in$

Top Width: $b_{L2} := 3.5 \cdot in$

Height: $h_L := 2.25 \cdot in$

Moment of Inertia: $I_L := \left[\frac{h_L^3 \cdot (b_{L1} + 3 \cdot b_{L2})}{12} \right]$ $\qquad I_L = 16.1 \cdot in^4$

SMALL(FOAM) TRAPEZOID:

Bottom Width: $b_{S1} := 6.0 \cdot in$

Top Width: $b_{S2} := 3.0 \cdot in$

Height: $h_S := 2.0 \cdot in$

Moment of Inertia: $I_S := \left[\frac{h_S^3 \cdot (b_{S1} + 3 \cdot b_{S2})}{12} \right]$ $\qquad I_S = 10 \cdot in^4$

RIB BONDING LEGS:

Thickness: $b_{BL} := 6 \cdot in$

$h_{BL} := 0.25 \cdot in$

Moment of Inertia: $I_{BL} := 2 \cdot \left(\frac{b_{BL} \cdot h_{BL}^3}{3} \right)$ $\qquad I_{BL} = 0.0625 \cdot in^4$

RIB COMBINED MOMENT OF INERTIA:

Rib Spacing: $L_v = 30 \cdot in$

Rib Moment of Inertia: $I_{rib} := (I_L + I_{BL}) - I_S$ $\qquad I_{rib} = 6.2 \cdot in^4$

Rib Moment of Inertia per Linear Foot of Tank Wall between Rib Supports:

I.RIB VALUE MUST BE INPUT MANUALLY IN CALCULATIONS IN STEP 2 ON PAGE 3

$$I_{rib} := \frac{(I_L + I_{BL}) - I_S}{L_v} \qquad I_{rib} = 0.21 \cdot \frac{in^4}{in}$$

$bar \equiv 100000 \cdot Pa$

$N \equiv newton$

$in\_wc \equiv .0361 \cdot psi$