Submittal Review Response

Project Name:	***Hilo WWTP Rehabilitation and Replacement Project Phase 1***
Submittal No.:	***15814-001.0***
Date:	***[Publish Date]***

Client:	County of Hawai'i	**Carollo Project No.:**	203975
Contractor:	Nan, Inc.		
Submittal Name:	Fiberglass Reinforced Plastic Ducts		
Reviewed By:	Khalil kairouz		

SUBMITTAL REVIEW		
Review is for general compliance with contract documents. No responsibility is assumed by Carollo for correctness of quantities, dimensions, and details. No deviation or variation is approved unless specifically addressed in these review comments. Refer to Section 01330 for additional requirements. The Contractor shall assume full responsibility for coordination with all other trades and deviations from contract requirements.		
Approved	☐	No Exceptions
	☐	Make Corrections Noted - See Comments
	☒	Make Corrections Noted - Confirm
Not Approved	☐	Correct and Resubmit
	☐	Rejected - See Remarks
Receipt Acknowledged	☐	Filed for Record
	☐	With Comments - Resubmit

Review Comments:

1. Drawing 00-C-06-503, section 1, Add 2" flange for the PD as shown on design drawing detail 1. Also add flange on the stack where the support si shown on the design drawing.
2. Drawing 02-M-01-103/104, verify the duct layout for the screening channel. It does not match the design drawings.
3. Verify elevations of the ductwork for all the areas.
4. The submitted layout drawings are difficult to follow and identify the related areas ductwork. Revise the drawings and identify each area ductwork for ease of identification and review. Engineer has already discussed with the duct supplier the difficulty in identifying the ductwork and duct supplier is aware of the requirements of the design engineer.
5. Contractor and duct supplier will need to field verify the ductwork layout and elevations according to the field installations as some ductwork submitted although they meet the intent of the design, there could be some refinement and adjusting of the duct routing and locations in order to properly installed the ductwork in the field. Therefore prior to manufacturing of the ductwork, contractor shall field verify the submitted ductwork layout to ensure proper installations.

CONTRACTOR SUBMITTAL TRANSMITTAL FORM REV. A

Owner:	County of Hawaii		
Contractor:	Nan, Inc.	**Project No.:**	WW-4705R
Project Name:	Hilo WWTP Phase 1	**Submittal Number:**	15814-001.0
Submittal Title:	Fiberglass Reinforced Plastic Ducts		
TO:	County		
From:	Nan Inc.		

Specification No. and Subject of Submittal / Equipment Supplier			
Spec: 15814	**Paragraph:** 1.01, 1.02, 1.03, 1.04, 2.01, 2.02, 2.03, 2.04, 2.06, 2.07, 2.08, 2.10, 2.11		
Authored By:	Daniel Company	**Date Submitted:**	08/11/2025

Submittal Certification	
Check Either (A) or (B):	
☑ (A)	We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings with no exceptions.
☐ (B)	We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings except for the deviations listed.
Certification Statement: By this submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and I have checked and coordinated each item with other applicable approved shop drawings and all Contract requirements.	
General Contractor's Reviewer's Signature:	Marshall Rucknagel — Digitally signed by Marshall Rucknagel DN: C=US, E=mrucknagel@nanhawaii.com, O="Nan, Inc.", CN=Marshall Rucknagel Date: 2025.08.07 13:36:35-10'00'
Printed Name and Title:	Marshall Rucknagel, Project Engineer
In the event, Contractor believes the Submittal response does or will cause a change to the requirements of the Contract, Contractor shall immediately give written notice stating that Contractor considers the response to be a Change Order.	
Firm:	**Signature:** **Date Returned:**

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

Nan, Inc

PROJECT: HILO WWTP REHABILITATION AND REPLACEMENT PROJECT - PHASE 1

JOB NO. WW-4705R

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

DATE RECEIVED 8/11/2025
SPECIFICATION SECTION # 15814
SPECIFICATION Fiberglass Reinforced Plas
PARAGRAPH SEE ABOVE
DRAWING SHOP DRAWING
SUBCONTRACTOR N/A
SUPPLIER DANIEL COMPANY
MANUFACTURER SAME

CERTIFIED BY CQCM or Designee : Matthew Chun

Digitally signed by Matthew Chun
DN: C=US, E=mchun@nanhawaii.com, O=Nan Inc., OU=Quality Control, CN=Matthew Chun
Reason: I am approving this document
Date: 2025.08.11 14:52:59-10'00'

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

PRODUCT SUBMITTAL

DUCTWORK AND ACCESSORIES
(SECTION 15580)

Revision 0

BY
Daniel Company
1939 W. 11th Street, Suite E
Upland, CA 91786

FOR
Nan, Inc.

JUNE 2025

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Resin: Interplastic CoRezyn CORVE 8401
Corrosion Liner Veil: C-Veil (Viledon T1777)
Spray-up Roving: Owens Corning OptiSpray F
Filament Winding Roving: Owens Corning 366 Roving
Chopped Strand Mat: CTG
Woven Roving: CTG (EWR800)
Unidirectional: Vectorply
Catalyst: NOROX MEKP-925H
Exterior Liner Veil: Schmelzer Industries Pearlveil (A-Veil)
UV Inhibitor: Cyasorb UV-9
Latex Coating (Indoors): PPG Speedhide Interior Fire Retardant Flat Latex (42-7 White)
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* * * *

SECTION 1

DANIEL COMPANY INFORMATION

DANIEL COMPANY

Fiberglass Air Pollution Control Systems

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

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

DANIEL COMPANY serves:

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

91st Avenue Wastewater Treatment Plant
Tolleson, Arizona

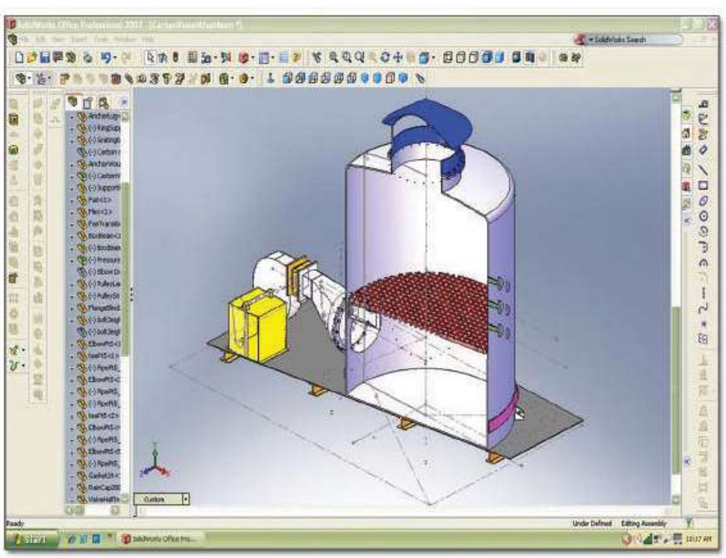
Product Line

AIR SCRUBBERS – DANIEL COMPANY provides three types of air scrubbing systems:

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

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

Northwest Water Reclamation Plant - Mesa, Arizona



Engineering and Design

ENGINEERING AND DESIGN –

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

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

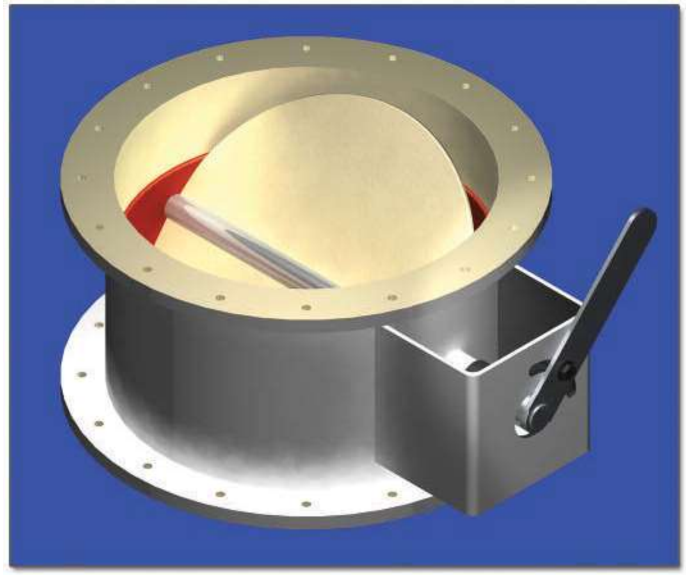
Daniel Company's extensive engineering team has been involved in the successful design of hundred's of air scrubbing systems currently in operation.

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

Fittings include round and rectangular elbows with long and short radii, transitions, flanges, end caps, tees, wyes, and laterals. Strict adherence to the accepted ASTM, RTP-1, NBS PS 15-69 dimensional and quality control standards guarantee the end user a superior product.

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

Nashville Central Wastewater Treatment Plant - Nashville, Tennessee



Dampers

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

CHEMICAL STORAGE TANKS –

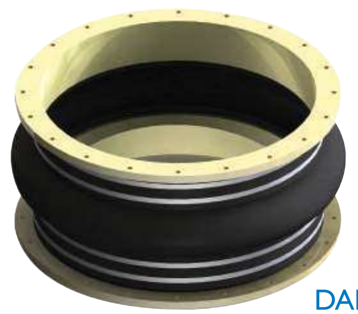
DANIEL COMPANY provides filament-wound fiberglass reinforced plastic corrosion-resistant tanks typically used for NaOCl and NaOH solution storage. All tanks are designed to be installed either above or below grade, and are built per RTP-1 and ASTM D 3299 industry-accepted standards. Access ports and fill/drain nozzles are standard features included in our tanks.

Hoods

ADDITIONAL APPLICATIONS –

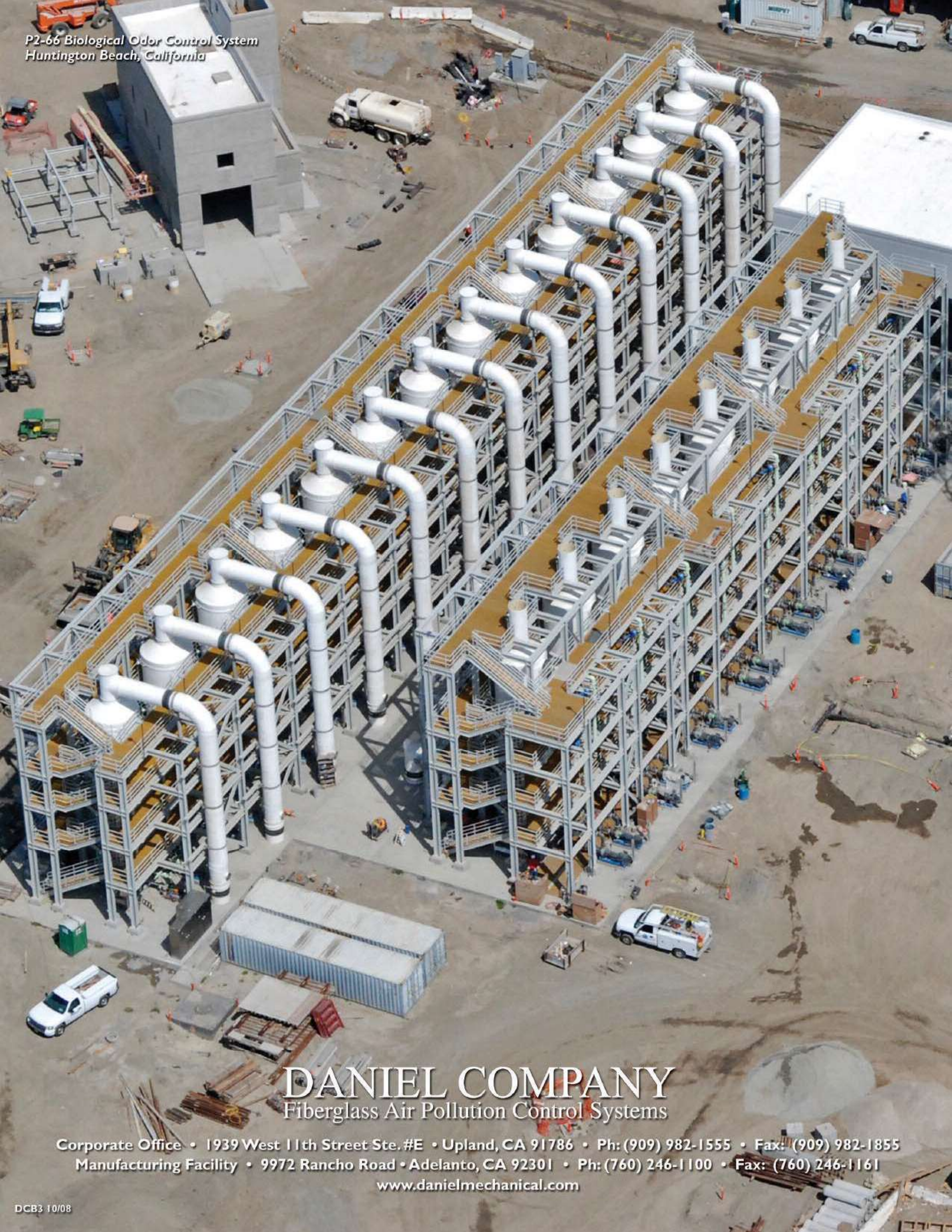
DANIEL COMPANY also manufactures other equipment and components used in corrosive environments typically found at water and wastewater treatment facilities. These include Decarbonators, Hoods, Launder Covers, Weirs and Baffles, Ladders, Platforms, Fan Inlet Boxes, and a myriad of other customized products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

Advanced Water Treatment Facility – Fountain Valley, California



FLEXIBLE CONNECTORS –

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


P2-66 Biological Odor Control System
Huntington Beach, California
DANIEL COMPANY
Fiberglass Air Pollution Control Systems
Corporate Office • 1939 West 11th Street Ste. #E • Upland, CA 91786 • Ph: (909) 982-1555 • Fax: (909) 982-1855
Manufacturing Facility • 9972 Rancho Road • Adelanto, CA 92301 • Ph: (760) 246-1100 • Fax: (760) 246-1161
www.danielmechanical.com
DCB3 10/08

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

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

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

SECTION 2

COMPLIANCE CHECKLIST FOR SPECIFICATION SECTION 15184

DANIEL COMPANY

Air & Water Pollution Control Systems

June 3, 2025

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

RE: Hilo WWTP Rehabilitation and Replacement Project Phase 1

Subject: Compliance Checklist for Specification Section 15184

To Whom It May Concern:

The following attachment is a compliance checklist that Daniel Company uses to mark off what is being fulfilled and complied with under specification Section 15184. A “√” means that Daniel Company acknowledges and fully adheres with the denoted paragraph of the specification. An “*” means that there is a deviation with attached explanation. A “C” means that, while Daniel Company intends to fully comply with the specification, this particular item is to be supplied by the Contractor and/or others. An “N/A” indicates that this item is not applicable.

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

Sincerely,

Shawn Garey

Shawn Garey
Project Manager

1939 W. 11th St., Ste. E, Upland, CA 91786 **Ph: (909) 982-1555, Fax: (909) 982-1855**

SECTION 15814

FIBERGLASS REINFORCED PLASTIC DUCTS

PART 1 GENERAL

1.01 SUMMARY

*

* Supports by others.

A. Section includes: Requirements for a Fiberglass reinforced plastic (FRP) ductwork system:
   1. Ducts and fittings.
   2. Flexible connections.
   3. Expansion joints.
   4. Supports.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. RTP-1 - Reinforced Thermoset Plastic Corrosion-Resistant Equipment.

B. American Water Works Association (AWWA):
   1. M45 - Fiberglass Pipe Design.

C. ASTM International (ASTM):
   1. C582 - Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
   2. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   3. D2105 - Standard Test Method for Longitudinal Tensile Properties of Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube.
   4. D2344 - Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates.
   5. D2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   6. D2992 - Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings.
   7. D2996 - Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
   8. D3982 - Standard Specification for Contact Molded “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Ducts.
   9. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

D. National Fire Protection Association (NFPA):
   1. 91 - Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids.

E. National Institute of Standards and Technology (NIST):
   1. PS 15 - Custom Contact-Molded Reinforced-Polyester Chemical Resistant Process Equipment.

F. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

1.03 SUBMITTALS

A. As specified in Sections 01330 - Submittal Procedures and Section 15500 - Common Work Results for HVAC.

* B. Shop drawings:

* Supports by others.

   1. Scaled ductwork layout:
      a. Size, joint types, horizontal dimensions, and elevations.
      b. Support locations.
      c. External stiffeners and expansion joints locations.
   2. Fabrication details.
   3. Support, flexible connections, and external stiffeners:
      a. Materials and configuration.

C. Calculations:
   1. Wall thickness calculations based upon design criteria.
   2. Stresses and reaction loads at supports.

X D. Direct burial procedure and details.

E. Manufacturer's installation instructions:
   1. Detailed instructions for field butt joints including lay-up sequence, width of each reinforcement layer, and total number of layers.

* F. Submit test results as specified in Section 06608 - Fiberglass Reinforced Plastic verifying that ductwork meets standards specified:

* Shall be submitted under a separate cover.

   1. Also, in accordance with Section 06608 - Fiberglass Reinforced Plastic as to the requirements of FRP manufacturing and standard testing.
   2. If there is a conflict between this Section and Section 06608 - Fiberglass Reinforced Plastic, the more stringent requirements shall govern:
      a. Test methods by the manufacturer shall be in accordance with ASTM 2996 and ASTM 2992 (buried pipe).

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

2.02 MANUFACTURERS

A. Fiberglass reinforced plastic ductwork:
   1. One of the following or equal:
      a. Daniel Mechanical.
      b. Engineered Composite Systems.
      c. Perry Fiberglass Products, Inc.
      d. NOV Fiber Glass Systems.
      e. Midwestern Fabricators.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Ducting for HVAC and ventilation systems:
   1. Minimum internal pressure: 10.0 inches water gauge.
   2. Minimum internal vacuum: 6.0 inches water gauge.

B. Ducting for odor control systems:
   1. Minimum internal pressure: 20.0 inches water gauge.
   2. Minimum internal vacuum: 20.0 inches water gauge.

C. Support spacing: As needed to comply with wall thicknesses calculations but not greater than the following:
   1. Contact-molded ductwork: Not greater than 5 foot centers.
   2. Filament-wound ducts: In accordance with SMACNA standards below:

Duct Inside Diameter (Inches)	Maximum Span (Feet)
3 to 19	10
20 to 29	15
30 to 35	20

D. Buried duct: Design ductwork for H-20 loading in accordance with AWWA M45:
   1. Duct pressure and vacuum conditions listed in this Section.
   2. Buried duct shall not deflect more than 5 percent in the installed condition and under loads.

E. Minimum flooding: Design ductwork for water accumulation as follows:
   1. Rectangular ductwork: 1-inch deep across bottom of duct.
   2. Round ductwork: 2 inches deep across bottom of duct.

F. Physical and mechanical properties: Duct shall meet the following standards for physical and mechanical properties:

Pipe Property	Standard	Design Properties	
		Hoop (PSI)	Axial (PSI)
Ultimate Flexural Stress Flexural Modulus	ASTM D2412	50,000 3.05×10^6	18,000 1.0×10^6
Ultimate Tensile Stress Tensile Modulus	ASTM D2105	52,000 1.5×10^6	7,485 1.56×10^6
Ultimate Shear Strength		Approximate Typical Values (PSI)	
Interlaminar Cross	ASTM D2344	2130-2730 15,000	
Density	ASTM D792	0.065-0.072 lb./In^3	

G. Design tensile stress:
1. Calculations for design of wall thickness assume a laminate ultimate tensile stress of 9,000 pounds per square inch maximum.
2. Decrease ultimate tensile stress as appropriate to the laminate design:
   a. Round ducting: The maximum allowable design tensile stress shall be the ultimate tensile stress divided by 5.
   b. Rectangular ducting: The maximum allowable design tensile stress shall be the ultimate tensile stress divided by 10.

H. Manufacturer shall provide design calculations for FRP ductwork design and construction. Calculations shall be signed and sealed by licensed engineer registered in the state of the project location

* 2.04 DUCTWORK MATERIALS

* See Section 3 for materials list.

A. As specified in applicable portions of Section 06608 - Fiberglass Reinforced Plastic.

B. Minimum corrosion liner:
1. Interior surfacing "C" or Nexus veil as specified for the service environment.
2. Exterior surfacing: “C” or “A” veil.
3. Remainder 1-1/2 ounce per square foot mat to total minimum thickness of 0.096 inches on surface exposed to the service environment.
4. Duct shall be resistant to the following in accordance with ASTM C582:

Sulfuric Acid	75 percent	At 100 degrees Fahrenheit
Nitric Acid	20 percent	At 100 degrees Fahrenheit
Sodium Hydroxide	50 percent	At 100 degrees Fahrenheit
Hydrofluoric Acid	20 percent	At 100 degrees Fahrenheit

* C. Ultraviolet stabilizer:

* See Section 3 for proposed Lilly-Ram gel coat for all exterior ductwork.

1. All exposed external surfaces of all FRP ductwork installed outdoors shall be provided with protection against ultraviolet degradation and weather erosion.
2. The duct shall carry the flame spread rating of 25 or less in accordance with ASTM E84 and a smoke contribution rating in excess of 1,000 in accordance with NPFA 91.
3. External duct protection shall be provided by an ultraviolet stabilizer added to the final coat or resin that also incorporates paraffin wax curing elements and color pigment.
4. An alternative system to polyurethane paint with color pigments may be used if approved by the Owners Designated Representative.

* D. Resin:

* See Section 3 for proposed Interplastic CORVE 8401 resin.

1. The external surface and structural layers of all FRP ductwork shall carry a flame spread rating of 25 or less in accordance with ASTM E84 and a smoke contribution of 50 or less in accordance with NFPA 91.
2. Premium vinyl ester as follows unless otherwise recommended by the resin manufacturer for the service environment:
   a. Resin for structural layers: Resin with sufficient antimony trioxide or pentoxide for Class I fire rating.
   b. Manufacturers: One of the following or equal:
      1) Ashland, Hetron 992FR.
      2) Reichhold Dion, VER 9300FR.

E. Color: Add pigment to the exterior surface resin coat such that the color of the duct will be similar to paint used for equipment, except that ducting for air conditioning systems which are concealed above suspended ceilings need not be pigmented. Color selected by Owner.

* Hardware and gaskets by others. *

F. Provide fasteners, field joints, expansion joints, and supports required for complete installation of a duct system:

1. Stainless steel nuts shall be finished with TRIPAC 2000 coating system to minimize galling and provide proper torque.

* G. Flanges:

* All flanges from Daniel Company will follow the "FRP Duct Flange Dimensions" table in Section 7.

1. All flanges shall be hand laid up to the thickness specified in accordance with ASTM D3982.
2. FRP flanges shall be made of the same materials as the FRP ductwork.
3. Flange bolt hold pattern as well as flange dimensions, shall be in accordance with NIST PS 15 Tables 2 and 5 for duct and pipe, respectively, except for thickness. Thickness of flange shall be a minimum of 1/2 inch.
4. Flanges shall be manufactured using the hand lay-up technique and shall be integral to the duct in accordance with ASME RTP-1. Filament-wound and/or random chopped methods of constructing flanges will not be acceptable:

Pipe Diameter, Inches	Minimum Flange Thickness, Inches
Less Than 12	1/2
12-24	1/2

Pipe Diameter, Inches	Minimum Flange Thickness, Inches
25-41	5/8
42-60	3/4

N/A

2.05 DOUBLE-WALL INSULATED FRP DUCT

A. Double-wall insulated FRP duct:
1. Inner and outer duct shall comply with requirements for FRP duct specified in this Section.
2. Insulation shall be closed cell polyurethane foam with a maximum thermal conductivity of 0.14 Btu-inch per hour per square foot per degree Fahrenheit at 75 degrees Fahrenheit. Insulation layer shall have a 1 inch thickness with an R-value no less than R6.0.
3. Double-wall insulated FRP outer wall dimensions as indicated on the Drawings.

2.06 DUCTWORK FABRICATION

* A. Hand lay-up or filament wound construction as specified in Section 06608 - Fiberglass Reinforced Plastic.

* Minimum wall thickness shall be per the PE-stamped design calculations in Section 4 of this submittal.

1. Provide wall thickness necessary to comply with design criteria but not less than the following minimum thicknesses.
2. Structural wall thicknesses shall not include the thickness of the interior corrosion barrier, inner surface, and interior layer:

Duct Size	Round Ducting (wall thickness, inches)	Rectangular Ducting (wall thickness, inches)	Buried Ducting (wall thickness, inches)
For 18 inch & smaller ducts	0.1875	0.25	0.34
20 to 36 inch ducts	0.25	0.375	0.42
42 to 54 inch ducts	0.375	0.500	0.60
60 to 72 inch ducts	0.438	0.625	0.625

B. Fittings:
1. Type: Hand lay-up contact molded.
2. Resin: Identical to and with same strength as resin used for FRP ductwork.
3. Wall thickness: At least equal to the thickness of the thickest adjacent ducting.
4. Internal diameter: Equal to the adjacent duct.
5. Tolerance:
   a. Angles for all fittings shall be within 1 degree for up to 30-inch diameter duct.
   b. Angles for all fittings shall be within 1/2 degree for over 30-inch diameter and above duct.
6. Round standard elbows:
   a. Standard elbow centerline radius shall be equal to 1-1/2 times the diameter unless otherwise indicated on the Drawings.

b. Standard elbows up to 24-inch diameter shall be smooth radius elbows. Standard elbows of 26-inch diameter and greater may be mitered sections as follows:
   1) 0 to 44 degree elbows shall contain 1 mitered joint and 2 sections.
   2) 45 to 80 degree elbows shall contain a minimum of 2 mitered joints and 3 sections.
   3) Elbows greater than 80 degrees shall contain a minimum of 4 mitered joints and 5 sections.

N/A c. Provide turning vanes in all round mitered elbows. Round elbow turning vanes shall be of FRP construction, solid or double wall construction with an airfoil shaped profile.

N/A 7. Rectangular elbows:
   a. Fittings shall be factory manufactured to meet the specified design criteria and in accordance with approved submittals. Factory install reinforcing ribs as required to meet the specified deflection requirements and to provide a system free from pulsing, warpage, sagging, and undue vibration.
   b. Provide turning vanes in all rectangular elbows. Rectangular elbow turning vanes shall be of FRP construction, solid or double wall construction with an airfoil shaped profile.

* C. Joints:

* Hardware and gaskets by others.

1. Flanged:
   a. Flanged in accordance with ASTM D3982 and bolt hold patterns in accordance with NIST PS 15, Table 2.
   b. Flanged joints shall be provided at the following locations:
      1) At each damper and each item of equipment to facilitate disassembly.
      2) At each change in material.
      3) Where indicated on the Drawings.
   c. Gaskets for flanged joints: 1/8-inch neoprene over full flange face.
   d. Bolt nuts and washers: Type 316 stainless steel.
2. Butt and strap welded:
   a. Field butt and strap welded joints shall be provided at the following locations:
      1) 12 inches from any increasing or decreasing cross-section of pipe.
      2) Where the pipe to be joined has the same diameter.
   b. Thickness of butt and strap joint overlays: At least equal to the thickness of the thickest adjacent duct.
   c. Field weld kits:
      1) All necessary fiberglass and reinforcing material shall be supplied pre-cut and individually packaged for each joint.
      2) Bulk Glass rolls will not be acceptable.

2.07 FLEXIBLE CONNECTIONS

A. Flexible connection shall be provided as indicated on the Drawings. When flexible connections are not shown, they shall be provided at all duct to rotating equipment connections.

* B. FL-3, Duct to Equipment Heavy Duty Flexible Connection:

* See Section 8 for proposed Holz 952/777 style flex connectors.

1. Materials: EPDM rubber vulcanized with minimum of 1 ply of reinforcing fabric; 3/16 inch thick.
2. Unit shall have minimum movement of:
   a. Axial compression: 2.25 inches.
   b. Axial extension: 1.25 inches.
   c. Lateral offset: 1.25 inches.
3. Provide 3/8-inch thick by 2-inch wide pre-drilled retaining rings/back-up bars to clamp the expansion joints into the ducting system.
4. The expansion joint shall be of fully molded construction. Splices will not be allowed in the body of the expansion joint.
5. Manufacturers: One of the following or equal:
   a. Proco Series 500, Style 530 Fabric Fan Connector.
   b. Holz Rubber Style 952 Arch Design Expansion Joint.

* 2.08 EXPANSION JOINTS

* See Section 8 for proposed Holz 952/777 style flex connectors.

A. Expansion joints shall be provided as indicated on the Drawings. When expansion joints are not shown, they shall be provided in above grade duct at maximum spacing of 40 foot centers.

B. Construction:
1. Body: EPDM.
2. Reinforcing: Multiple layers (2 minimum) of impregnated polyester or Kevlar tire cord fabric.
3. Flange rings: Type 316 stainless steel or minimum 3/4 inch thick FRP.
4. Hardware/Fasteners: Type 316 stainless steel.
5. Minimum pressure rating: 1 pounds per square inch.
6. Minimum vacuum rating: 1 pounds per square inch.
7. Minimum operating temperature: 175 degree Fahrenheit.
8. Connections: Flanged in accordance with NIST PS 15, Table 2.
9. Seamless construction built as on continuous piece. Wrapped, seamed, or spliced type expansion joints are not acceptable.
10. Provide Type 316 stainless steel control rods.

C. Minimum movement:
1. Axial compression: 2.25 inches.
2. Axial extension: 1.25 inches.
3. Lateral offset: 1 inch.

D. Manufacturers: One of the following or equal:
1. Daniel Co., DanFLEX Model 101.
2. Mercer Rubber Co., Model ME for Rectangular, Model MI-9 for Round.

2.09 DUCT SUPPORTS

A. Provide duct supports as indicated on the Drawings.

B. Protect the duct from clamping force of strap hangers with a 1/8-inch thick layer of neoprene pad.

C. When anchors are required, they shall be externally bonded to the duct. Drive screws or other penetrations of the duct linter are not permitted.

D. When duct supports are not indicated on the Drawings provide supports and seismic bracing in accordance with the SMACNA Design Manual.

* **2.10 SHOP INSPECTION**

* Daniel Company will comply with this specification if requested.

A. Each load of FRP duct or pipe shall be shop inspected during fabrication and prior to shipment:
   1. Inspection shall be conducted by qualified third-party inspectors that have extensive experience in the design, manufacture, testing, and installation of all FRP duct and pipe.
   2. The cost for third-party inspection shall be borne by the manufacturer.
   3. The name, resume, and qualifications of the third-party inspector shall be submitted to the Engineer for approval. Acceptable inspection engineers shall be one of the following or equal:
      a. Fiberglass Structural Engineers, Inc.
      b. Femech Engineering.

2.11 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

3.02 INSTALLATION

A. All ductwork shall be fabricated and erected where indicated on the Drawings or as specified in this Section. Ductwork shall be rigidly supported and secured in an approved manner.

A. Install ductwork parallel to walls and/or roof and vertically plumb.

B. Bracing and vibration isolators shall be installed, where necessary, to eliminate vibration, rattle and noise:
   1. Hangers shall be installed plumb and securely suspended from supplementary steel or inserts in concrete slabs.
   2. Lower ends of hanger rods shall be sufficiently threaded to allow for adequate vertical adjustment.
   3. Building siding and metal decking shall not be used to hang ductwork.

C. Contractor shall not install any equipment or materials until the Owners Designated Representative has approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

D. Wherever ducts are divided, the cross-sectional area shall be maintained. All such changes must be approved and installed as directed by the Owners Designated Representative or as approved on shop or erection drawings.

E. Do not remove or alter factory installed duct reinforcing ribs except as required to accommodate duct alterations due to unexpected field conditions:
   1. Notify the Owners Designated Representative prior to starting any field modifications involving ductwork structural reinforcing members.
   2. Submit additional design calculations to demonstrate structural design integrity of ductwork and fittings requiring reinforcing modifications in the field.

F. Direct buried duct:
   1. Grade trench so it will be 1.5 times wider than the diameter of the duct.
   2. Fill bottom of trench with a minimum of 6 inches of back fill (sand or pea gravel).
   3. Slope Trench with a 1/8 inch per foot pitch back to the start of the system.
   4. Backfill in 6 inches lift increments compacting 80 to 90 percent.
   5. A minimum of 4 inches of backfill overtop the duct system is required.
   6. Follow manufacturer's burial procedures.

G. No ductwork or components shall be shipped prior to complete resin cure.

H. Cover ductwork openings with tape, plastic, or sheet metal to reduce the amount of dust or debris which may collect in the system at each of the following times:
   1. At the time of rough installation.
   2. During storage on the construction site.
   3. Until final start-up of the heating and cooling equipment.

I. Before installation remove dust and debris from ducts.

J. Install products in accordance with shop drawings and manufacturer's instructions. Drawings indicate general routing only and shall be modified as necessary.

END OF SECTION

SECTION 3

FRP MATERIAL LIST AND TECHNICAL DATA SHEETS

DANIEL COMPANY
Fiberglass Air Pollution Control Systems

Project: 5013 Hilo
Date: 6/24/2025
Revision: 0

Fiberglass Reinforced Plastic Materials List

Resin: Interplastic CoRezyn CORVE 8401
Corrosion Liner Veil: C-Veil (Viledon T1777)
Spray-up Roving: Owens Corning OptiSpray F
Filament Winding Roving: Owens Corning 366 Roving
Chopped Strand Mat: CTG
Woven Roving: CTG (EWR800)
Unidirectional: Vectorply
Catalyst: NOROX MEKP-925H
Exterior Liner Veil: Schmelzer Industries Pearlveil (A-Veil)
UV Inhibitor: Cyasorb UV-9
Latex Coating (Indoors): PPG Speedhide Interior Fire Retardant Flat Latex (42-7 White)
Gel Coating (Outdoors): Gel Coat / Color: Lilly-Ram WHITE W-1 (unless directed otherwise)

* All materials shall be as specified above or equal.

1939 W. 11th St., Ste. E, Upland, CA 91786 Ph: (909) 982-1555

CORVE8401

Fire Retardant Vinyl Ester Resin

Technical Data Sheet

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

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

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

TYPICAL PROPERTIES

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

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

FLAME TEST PROPERTIES

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

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Revised: 5/15

Nonwovens for Fiber Reinforced Plastics **T 1777 C**
Vliesstoffe für faserverstärkte Kunststoffe

viledon®

Technical data / Technische Daten			
Fibre Faser		C-Glass C-Glas	
Binder system Bindesystem		chemical (soluble in styrene) chemisch (styrollöslich)	
Nonwoven structure Vliesstruktur		random wirr	
Weight Gewicht	ISO 9073-1	26 g/m²	
Thickness Dicke	ISO 9073-2	0.30 mm	
Max. tensile strength Höchstzugkraft	ISO 9073-3	25 N/50mm	machine direction längs
		18 N/50mm	cross direction quer
Elongation at max. tensile strength Höchszugkraftdehnung	ISO 9073-3	1 %	machine direction längs
		1 %	cross direction quer

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

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

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

Revision date: Rev. 08 - 12/2012

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Freudenberg

Owens Corning®

INNOVATIONS FOR LIVING™

PRODUCT INFORMATION

OptiSpray™ Solutions

OptiSpray™ F Roving

For Fast Wet out Spray-up in Complex Molds

PRODUCT DESCRIPTION

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

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

PRODUCT APPLICATIONS

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

FEATURES AND PRODUCT BENEFITS

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

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

*Other tex may be available upon request

PRODUCT AVAILABILITY (STANDARD REF.)

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

OptiSpray™ F Roving

For Fast Wet out Spray-up in Complex Molds

PACKAGING (standard ref.)

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

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

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

LABELING

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

STORAGE

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

Contact
MultiEndRovings@owenscorning.com

INNOVATIONS FOR LIVING™

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OWENS CORNING®
INNOVATIONS FOR LIVING™

PRODUCT INFORMATION

366 Roving

Single End Roving for Pultrusion and filament Winding Processes

PRODUCT DESCRIPTION

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

PRODUCT APPLICATION

366 roving is specifically designed for use in pultrusion and filament winding applications in polyester, vinylester and epoxy resin systems.
366 roving has also been successfully used in acrylic resin and polyurethane resin systems. 366 roving can be used in a variety of processes to manufacture pipes, tanks, ladder rails, pultruded structural shapes and grating systems.

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

FEATURES AND PRODUCT BENEFITS

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

366 Roving

Single End Roving for Pultrusion and filament Winding Processes

PRODUCT AVAILABILITY

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

MECHANICAL PROPERTIES

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

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

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

PACKAGING

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

STORAGE

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

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

INNOVATIONS FOR LIVING™

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SingleEndRovings_366_ww_11_2012_Rev 1

CTG

【Product Description】 (CHOPPED STRAND MAT)

Composed of E-glass chopped strands bounded with unsaturated polyester binder.
Application for hand lay-up.
Compatible with unsaturated polyester resins and vinyl resins for manufacture of panel, boat hulls and other FRP parts.

【Characteristics】

Thickness steady and optimum stiffness.
Excellent strands dispersion and outstanding bonding on double sides.
Easy impregnation, good air-releasing performance and less resins consumption.
Optimum wet out, excellent processibility, high abrasion and corrosion resistance
Good mechanical properties

【Technical data】

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

Notes:1. Individualized specification is available as per customer's request.
2. this data sheet herein above is provided for information purposes only and CTG reserves the right to modify it without prior notice.

【Packaging】

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

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

【Storage】

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

【Product description】 (WOVEN ROVING)

EWR800 woven roving from E-glass direct roving by weaving machines.
Applicable for hand lay-up process, mould pressing, machinery formation.
Compatible with unsaturated polyester resin and vinyl resin.

【Characteristics】

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

【Product code】

EWR800

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

【Technical data】

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

【Package】

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

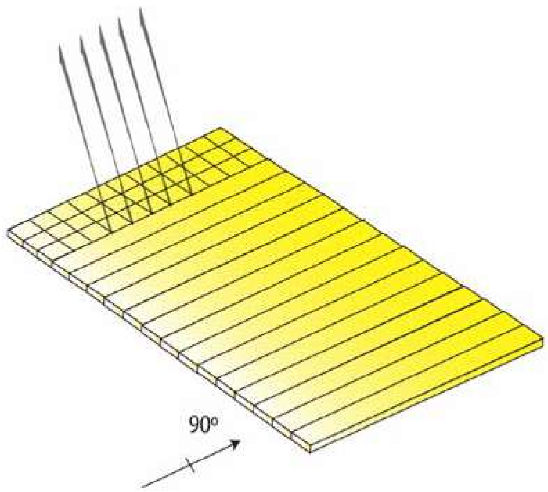
Roll width(mm)	roll weight(kg)	rolls/pallet	pallet size(mm)	weight per pallet(kg)
1270	50	16	1350*1120	800

【Storage】

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

VECTORPLY

Performance Composite Reinforcements



E-T 1600

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

Roll Specifications			**Fiber Architecture Data**	
Roll Width:	Roll Weight:	Roll Length:	0 ° :	n/a
50 in / 1270 mm	187 lb / 85 kg	138 yd / 126 m	45 ° :	n/a
			90 ° :	15.07 oz/sq.yd / 511 g/sq.m
			- 45 ° :	n/a
			Chopped Mat :	n/a

1: Packaging: box or bag.
2: Weights do not include polyester stitching.

Laminated Properties

	0 °	0 °
Laminate Weight		
(lb/sq.ft)	E-T 1600 Resin Infused	E-T 1600 Open Mold
Fiber	0.10	0.10
Resin	0.05	0.09
Total	0.15	0.19

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

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

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

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

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

Notes:

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

2: Open mold laminate made with polyester resin.

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

VECTORPLY CORPORATION

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

NOROX® MEKP-925H

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

Description

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

Technical Data

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

Application

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

PACKAGING, SHIPPING & AVAILABILITY

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

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

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

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

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

www.united-initiators.com

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

PEARLVEIL

For Flat Molding and Filament Winding

Product Description

Pearlveil is a non-woven, continuous strand glass fiber surfacing veil for relatively flat composite parts. Process applications include:

- Pre-form
- Compression Molding
- Continuous Lamination
- Electrical Flat Sheet
- RTM / Vacuum Infusion
- Filament Winding
- Glass Reinforced Gypsum (GFRG)

Binder Selection

Select the correct binder for any specific molding process or application from the SI Veils Binder Selection Data Sheet.

Appearance

SI Veils are white in color, highly uniform and substantially free of tears, holes, glass beads and tails or other foreign materials.

Width

Standard widths range from 40 inches (1.016 m) up to 120 inches (3.048 m). Narrower widths are available, a slitting charge and minimum quantity requirements may apply.

Features

- Boron free glass fibers
- Outstanding surface finish results
- Light weight reinforcement
- Excellent resin wet-out
- Good electrical resistance properties
- Roll widths up to 120 inches wide
- Longer length rolls, thus reducing the number of rolls required to be put up while completing a project.
- Customer specified binder percentage
- Corrosion resistance under acidic conditions. See Corrosion Data Sheet
- Contamination free
- Consistent white color, transparent to the finished part
- Excellent punch-ability properties
- Easily sanded for improved post-finishing

Options

Pearlveil offers many configuration options which helps to ensure a perfect match with your composites process.

Some customer specified options include:

- Weight per square foot/square meter
- Roll width from 3 to 120 inches
- Binder percentage
- Fiber orientation
- Fiber diameter
- Custom cut pieces
- Custom packaging
- Other options – consult factory

Pearlveil Specifications

Other custom weights may be possible, consult factory for price and availability.

Pearlveil Specification	Thickness Inches (mm)	Ounces / Sq. Ft.	Grams / Sq. meter	Length - Feet (+/- 10 %)	Length m (+/- 10 %)	Roll Dia. Inches
3 mil	.003 (0.08)	0.05	15	1,750	530	12" - 15"
5 mil	.005 (0.13)	0.06	20	1,750	530	12" - 15"
7 mil	.007 (0.18)	0.09	30	1,750	530	14" - 17"
10 mil	.010 (0.25)	0.12	40	1,750	530	16" - 20"
15 mil	.015 (0.38)	0.18	55	1,750	530	20" - 24"
20 mil	.020 (0.51)	0.26	80	1,750	530	25" - 28"
30 mil	.030 (0.76)	0.34	105	1,400	430	25" - 28"
40 mil	.040 (1.02)	0.47	145	900	270	23" - 25"
1/2 Ounce	.043 (1.08)	0.50	155	900	270	23" - 25"

Note: Rolls 80 inches or wider may be cut to half-length to maintain reasonable roll weight.

Packaging

All veils are wound onto a heavy duty 3 inch I.D. cardboard core, immediately sealed against contamination in a polyethylene bag and identified with a unique, product specific label.

Based upon quantities, Pearlveil is shipped on wooden pallets, typically 9 rolls per pallet. Optional packaging is available.

All material is supplied in roll goods form with trimmed edges.

Quality

All Pearlveil products are manufactured in the United States and meet the demanding quality requirements within the composites industry.

Storage

For best results, Pearlveil should be stored indoors, with temperatures between 50° F (10° C) and 90° F (32° C) and relative humidity below 80%. It should remain upright, on a pallet and in the original packaging until ready to use.

Warranty

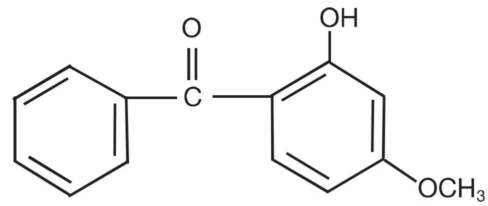
See Schmelzer Industries' Standard Terms and Conditions.

About Schmelzer Industries

Schmelzer Industries Inc., headquartered in Somerset, Ohio, is a glass fiber manufacturer, custom materials developer and supplier of quality veils and light weight reinforcements for the composites industry. We can be found on the internet at www.siveils.com

Rev: 16-Feb.-18

CYASORB® UV-9 light absorber



2-Hydroxy-4-methoxybenzophenone

CAS NUMBER 000131-57-7

TYPICAL PROPERTIES

Chemical Formula	$C_{14}H_{12}O_3$
Molecular Weight	228.2
Specific Gravity (25°C)	1.32
Melting Point, °C	62.0

SPECIFICATIONS

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

PERFORMANCE BENEFITS

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

HEALTH AND SAFETY

EFFECTS OF OVEREXPOSURE:

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

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

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

FDA STATUS

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

Shipping Classification:

Chemical NOI

Shipping Container:

32-gallon fiber drum, 100 lb net

PPG ecological Solutions from PPG™

SPEEDHIDE® 42-7

Architectural Coatings

SPEEDHIDE® Interior Fire Retardant Flat Latex

GENERAL DESCRIPTION

SPEEDHIDE® Interior Fire Retardant latex is formulated to meet the performance requirements of professional application. Recommended for the protection and decoration of combustible interior wall and ceiling surfaces. The paint film intumesces when exposed to flame or high temperatures. Coating expands and forms a thick char blanket (intumescence) which retards flame spread and minimizes smoke development.

CONFORMANCE STANDARDS

- VOC compliant in all regulated areas
- Meets MPI category #64, Interior Latex Fire Retardant Flat
- Meets Green Performance Standards (GPS-1 & GPS-2)
- Can help earn LEED 2009 credits
- Fulfills Class A rating established by the National Fire Protection Association
- Meets most local and state fire laws
- Passed ASTM E-84, NFPA 255, UL 723
- Meets Mine Safety and Health Administration regulations

RECOMMENDED SUBSTRATES

Cement Board
Gypsum Wallboard-Drywall
Wood

APPLICATION INFORMATION

Stir thoroughly before and occasionally during use. When using more than one can of the same color, intermix to ensure color uniformity. USE WITH ADEQUATE VENTILATION. KEEP OUT OF REACH OF CHILDREN. Read all label and Material Safety Data Sheet (MSDS) information prior to use. MSDS are available through our website or by calling 1-800-441-9695.

Application Equipment: Apply with a high quality brush, roller, paint pad, or by spray equipment. Where necessary, apply a second coat.

Airless Spray: Pressure 2400 psi, 60 mesh filter.

Spray equipment must be handled with due care and in accordance with manufacturer's recommendation. High-pressure injection of coatings into the skin by airless equipment may cause serious injury.

Brush: Polyester/Nylon Brush

Roller: 3/8" - 3/4" nap roller cover.

Thinning: No thinning is recommended. Up to 1/2 pint of water (237 mL) per U.S. gallon (3.78 L) may be added for brush/roller applications. For conventional spray, up to one pint (473 mL) of water per U.S. gallon (3.78 L) may be added.

Permissible temperatures during application:

Material:	50 to 90ºF	10 to 32ºC
Ambient:	50 to 90ºF	10 to 32ºC
Substrate:	50 to 90ºF	10 to 32ºC

TINTING AND BASE INFORMATION

Refer to the appropriate color formula book, automatic tinting equipment, and or computer color matching system for color formulas and tinting instructions.

42-7 White

Some colors, drastic color changes, or porous substrates may require more than one coat to achieve a uniform finish.

PRODUCT DATA

PRODUCT TYPE:	Modified Polyvinyl Acetate Latex
SHEEN:	Flat: 0 to 5 (60º and 85º Gloss Meter)
VOLUME SOLIDS:	50% +/- 2%
WEIGHT SOLIDS:	62% +/- 2%
VOC:	33 g/L (0.3 lbs./gal.)
WEIGHT/GALLON:	11.7 lbs. (5.3 kg) +/- 0.2 lbs. (91 g)

COVERAGE: 150 to 335 sq. ft./gal. (13 to 31 sq. m/3.78L)

Wet Film Thickness:	4.8 to 10.8 mils
Wet Microns:	122 to 274.3
Dry Film Thickness:	2.4 to 5.4 mils
Dry Microns:	61 to 137.2

Coverage figures do not include loss due to surface irregularities and porosity or material loss due to application method or mixing.

DRYING TIME: Dry time @ 77ºF (25ºC); 50% relative humidity.

To Touch:	30 minutes
To Handle:	4 hours
To Recoat:	4 hours
To Full Cure:	30 days

Drying times listed may vary depending on temperature, humidity, film build, color, and air movement.

WASHING INSTRUCTIONS: Wait at least 14 days after painting before cleaning the surface with a non-abrasive mild cleaner.

CLEANUP: Soap and water

DISPOSAL: Contact your local environmental regulatory agency for guidance on disposal of unused product. Do not pour down a drain or storm sewer.

FLASH POINT: Over 200ºF (93ºC)

FEATURES / BENEFITS

Features	**Benefits**
Intumescence	Retards flame spread and minimizes smoke development
Great hide and coverage	Hides surface imperfection
Applies like a conventional latex flat paint	May be applied by brush, roller or spray
Good scrubbability	Withstands repeated cleaning without loss of intumescence
Excellent adhesion and durability	Looks like new longer
<50 g/L VOC	Meets the most stringent environmental regulations nationwide
Can help earn LEED 2009 credits	Contributes to sustainable design
MPI approval in category #64, Interior Latex Fire Retardant Flat	Meets strict performance and aesthetic requirements

GENERAL SURFACE PREPARATION

Surface must be free of grease, dirt, rust, and loose or powdery paint. Water sensitive coatings including calcimine must be completely removed. Repair cracks and gouges with patching compound. Sand these smooth and remove all dust. Previously painted glossy or slick surfaces must be thoroughly cleaned with strong detergents to remove surface soils and contaminates. To promote adhesion, surface sheen should be removed or reduced by rubbing with sandpaper. To meet UL rating, SPEEDHIDE Interior Fire Retardant Flat Latex is self-priming on bare wood and cement board.

WARNING! If you scrape, sand, or remove old paint, you may release lead dust or fumes. LEAD IS TOXIC. EXPOSURE TO LEAD DUST OR FUMES CAN CAUSE SERIOUS ILLNESS, SUCH AS BRAIN DAMAGE, ESPECIALLY IN CHILDREN. PREGNANT WOMEN SHOULD ALSO AVOID EXPOSURE. Wear a properly fitted NIOSH-approved respirator and prevent skin contact to control lead exposure. Clean up carefully with a HEPA vacuum and a wet mop. Before you start, find out how to protect yourself and your family by contacting the USEPA National Lead Information Hotline at 1-800-424-LEAD or log on to www.epa.gov/lead. In Canada contact a regional Health Canada office. Follow these instructions to control exposure to other hazardous substances that may be released during surface preparation.

RECOMMENDED PRIMERS

Cement Board	Self-priming
Gypsum Wallboard-Drywall	Self-priming
Wood	Self-priming

PACKAGING

1-Gallon (3.78 L)
5-Gallon (18.9 L)

LIMITATIONS OF USE

FOR INTERIOR USE ONLY. Apply when air, surface and product temperatures are above 50ºF (10ºC). Not recommended for application over “foam” type insulations. Not recommended for use on floors. Do not use where continuous dampness exists.

PROTECT FROM FREEZING.

PPG Industries, Inc.
Architectural Coatings
One PPG Place
Pittsburgh, PA 15272
www.ppgpittsburghpaints.com
www.ppgporterpaints.com

Technical Services
1-800-441-9695
1-888-807-5123 fax

Architect/Specifier
1-888-PPG-IDEA

PPG Canada, Inc.
Architectural Coatings
4 Kenview Blvd
Brampton, ON L6T 5E4

A2.7 1/2012
Supersedes (11/2011)

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

Lilly-Ram Gel Coat

Technical Data Sheet

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

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

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

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

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

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

Our colors match the spectrum of your creativity.

Lilly RAM

★ WHITE W-1	YO WHITE W-33	50 WHITE W-52	LIGHT GRAY E-6
ANTIQUE WHITE W-41	IVORY W-5	TAN W-47	FAWNSKIN L-11
★ CANARY YELLOW L-27	YELLOW L-55	TANGERINE N-50	BURNT ORANGE N-23
LIME GREEN G-28	DEEP LIME GREEN G-43	TEAL G-19	GREEN G-20
AQUA A-18	LIGHT BLUE A-46	BLUE A-16	DARK BLUE A-17

PLATINUM E-48	MEDIUM GRAY E-7	CAFE L-49	CHARCOAL E-8
PALE YELLOW L-45	★ SPANISH GOLD L-10	★ OXIDE R-32	BUBBLE GUM R-24
★ ORANGE N-12	VIPER RED R-54	★ RED R-14	MAROON R-15
FOREST GREEN G-51	★ DARK GREEN G-35	PURPLE R-44	★ BURGUNDY R-31
★ MIDWATCH BLUE A-34	BOYSENBERRY R-26	DEEP PURPLE R-42	DARK PURPLE R-29

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

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

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

SECTION 4

FRP METHOD OF CONSTRUCTION AND DESIGN CALCULATIONS

Project: 5013 Hilo
Date: 6/24/2025
Revision: 0

Method of Construction - Ductwork

Method of Construction

Corrosion Liner:	Consisting of a resin rich inner veil being a minimum of 10 mils in thickness using a layer of C-veil saturated with Interplastic CORVE 8401 Epoxy Vinyl Ester resin followed by random chopped glass mat to form a corrosion barrier having a total thickness of 100 mils with approximately 75% resin and 25% glass by weight. This applies to filament wound as well as contact molded methods of construction.

Structural Lamination

Filament Wound:	The structural layer shall be fabricated with Interplastic CORVE 8401 Epoxy Vinyl Ester resin using a helical filament winding technique per ASTM D2996 with structural layer thickness never being less than what was denoted in our structural calculations. This method of constructing the structural wall is specific to the straight cylindrical pipe length only.
Hand Lay-Up:	The structural layer shall be alternate layers of 1.5 oz/sq.ft. mat, random chopped glass, and/or woven roving per the Hand Lay-Up Laminate Composition Table included in this submittal. Alternative structural layers shall be chopped, sprayed, and woven roving as described.
Exterior Coating:	Exterior shall consist of 10 mils of A veil followed by either paraffinated Gel Coat with UV inhibitor or fire retardant flat latex paint, depending upon install location of the duct.
Flanges:	Flanges will be hand lay-up, undrilled with dimensions in accordance with ASTM D 3982. Flange thickness will be ¾" minimum. Gaskets, nuts, bolts, and washers shall be provided by others.
Fittings:	All fittings such as elbows or reducers shall be manufactured to NBS PS 15-69. Dimensions using hand Lay-Up techniques. All lengths and dimensions of pipe and fittings to be field verified, approved on fabrication drawing, and released to fabricate by installer prior to manufacturing.

Design Calculations for Above Grade
Round FRP Duct

County of Hawaii
Hilo WWTP Rehabilitation and Replacement Project Phase 1

Specification 15814
Fiberglass Reinforced Plastic Ducts
Daniel Company Project Number: #5013

Prepared by: Bin Ngo, PE

6-5-25

BIN KHON NGO
LICENSED PROFESSIONAL ENGINEER
No. 18667-M
HAWAII U.S.A.

Expires: 4-30-26

Design Standard: ASTM D 3982

Design Conditions:

Density of Water:	$\rho_w := 0.0361$	pci
Design Pressure:	$P := 20 \cdot \rho_w = 0.722$	psi
Design Vacuum:	$P_e := 20 \cdot \rho_w = 0.722$	psi
Average Fiberglass Density:	$\rho_f := 0.065$	pci
Water Accumulation:	$w_l := 2$	in
Design Factor on Pressure:	$DF_p := 10$	
Design Factor on Vacuum:	$DF_e := 5$	
Design Factor on Tensile Stress:	$DF_t := 5$	
Ultimate Tensile Stress:	$\sigma_u := 9000$	psi per Specification
Design Temperature:	0 - 120 deg. F	
Number of Sizes:	$n := 16$	$i := 0 .. n - 1$

Allowable Stress & Strain:

Allowable Tensile Stress: $\sigma_{allow} := \dfrac{\sigma_u}{DF_t} = 1800$ psi where $\sigma_u = 9000$ psi

Maximum Allowable Strain: $\varepsilon_{allow} := .001$

$t_{cb} := 0.100$ in Corrosion Barrier

Duct I.D.: (in)	Duct Inner Radius: (in)	Structural Wall Thickness: (in)	Total Wall Thickness (in)

$$D := \begin{pmatrix} 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 24 \\ 26 \\ 30 \\ 36 \\ 42 \\ 42 \\ 42 \end{pmatrix} \qquad R_i := \overrightarrow{\frac{D}{2}} = \begin{pmatrix} 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 12 \\ 13 \\ 15 \\ 18 \\ 21 \\ 21 \\ 21 \end{pmatrix} \qquad t := \begin{pmatrix} 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.16 \\ 0.21 \\ 0.25 \\ 0.30 \\ 0.30 \\ 0.30 \end{pmatrix} \qquad t_t := t + t_{cb} = \begin{pmatrix} 0.250 \\ 0.250 \\ 0.250 \\ 0.250 \\ 0.250 \\ 0.250 \\ 0.250 \\ 0.250 \\ 0.250 \\ 0.250 \\ 0.260 \\ 0.310 \\ 0.350 \\ 0.400 \\ 0.400 \\ 0.400 \end{pmatrix}$$

Axial Modulus:	Hoop Modulus:	Hoop Flex. Modulus:	Diameter	Span	Structural Thickness
(psi)	(psi)	(psi)	(in)	(in)	(in)

$$E_{at} := \begin{pmatrix} 1.17 \\ 1.17 \\ 1.17 \\ 1.17 \\ 1.17 \\ 1.17 \\ 1.17 \\ 1.17 \\ 1.17 \\ 1.17 \\ 1.17 \\ 1.22 \\ 1.25 \\ 1.27 \\ 1.27 \\ 1.27 \end{pmatrix} 10^6 \quad E_h := \begin{pmatrix} 1.48 \\ 1.48 \\ 1.48 \\ 1.48 \\ 1.48 \\ 1.48 \\ 1.48 \\ 1.48 \\ 1.48 \\ 1.48 \\ 1.48 \\ 1.81 \\ 2.09 \\ 2.32 \\ 2.32 \\ 2.32 \end{pmatrix} \cdot 10^6 \quad E_{hf} := \begin{pmatrix} 1.32 \\ 1.32 \\ 1.32 \\ 1.32 \\ 1.32 \\ 1.32 \\ 1.32 \\ 1.32 \\ 1.32 \\ 1.32 \\ 1.32 \\ 1.43 \\ 1.61 \\ 1.79 \\ 1.79 \\ 1.79 \end{pmatrix} \cdot 10^6 \quad D = \begin{pmatrix} 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 24 \\ 26 \\ 30 \\ 36 \\ 42 \\ 42 \\ 42 \end{pmatrix} \quad Span := \begin{pmatrix} 7 \\ 8 \\ 9 \\ 10 \\ 10 \\ 10 \\ 10 \\ 10 \\ 15 \\ 15 \\ 15 \\ 20 \\ 20 \\ 25 \\ 25 \\ 25 \end{pmatrix} \quad t = \begin{pmatrix} 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.15 \\ 0.16 \\ 0.21 \\ 0.25 \\ 0.30 \\ 0.30 \\ 0.30 \end{pmatrix}$$

Outer Diameter: $D_o := \overrightarrow{(D + 2 \cdot t_t)}$

Duct Section Properties:

Second Moment of Area: $I := \overrightarrow{\left[\frac{\pi \cdot (R_i + t)^4}{4} - \frac{\pi \cdot (R_i)^4}{4}\right]}$ in^4

Weight of duct per foot: $W_{frp} := \overrightarrow{\left[\frac{\pi}{4} \cdot \left(D_o^{\,2} - D^2\right) \cdot \rho_f \cdot 12\right]}$ lb/ft

$w_{frp} := \frac{W_{frp}}{12}$ $\frac{lb}{in}$

Internal Pressure:

Required thickness:

$$t_p := \overrightarrow{\frac{P \cdot D}{2 \cdot \sigma_{allow}}} = \begin{pmatrix} 0.001 \\ 0.001 \\ 0.002 \\ 0.002 \\ 0.002 \\ 0.003 \\ 0.003 \\ 0.004 \\ 0.004 \\ 0.005 \\ 0.005 \\ 0.006 \\ 0.007 \\ 0.008 \\ 0.008 \\ 0.008 \end{pmatrix} \text{ in} \qquad \frac{t}{t_p} = \begin{pmatrix} 187 \\ 124.7 \\ 93.5 \\ 74.8 \\ 62.3 \\ 53.4 \\ 46.7 \\ 41.6 \\ 37.4 \\ 31.2 \\ 30.7 \\ 34.9 \\ 34.6 \\ 35.6 \\ 35.6 \\ 35.6 \end{pmatrix} \qquad \text{if}\left[\left(\frac{t}{t_p}\right)_i > 1, \text{"ok"}, \text{"bad"}\right] = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

Assuming thin-walled, check for hoop stress thickness using allowable strain:

$$t_h := \overrightarrow{\frac{DF_p \cdot P \cdot D}{2 \cdot \varepsilon_{allow} \cdot E_h}} = \begin{pmatrix} 0.01 \\ 0.015 \\ 0.02 \\ 0.024 \\ 0.029 \\ 0.034 \\ 0.039 \\ 0.044 \\ 0.049 \\ 0.059 \\ 0.063 \\ 0.06 \\ 0.062 \\ 0.065 \\ 0.065 \\ 0.065 \end{pmatrix} \text{ in} \qquad \frac{t}{t_h} = \begin{pmatrix} 15.4 \\ 10.2 \\ 7.7 \\ 6.1 \\ 5.1 \\ 4.4 \\ 3.8 \\ 3.4 \\ 3.1 \\ 2.6 \\ 2.5 \\ 3.5 \\ 4 \\ 4.6 \\ 4.6 \\ 4.6 \end{pmatrix} \qquad \text{if}\left[\left(\frac{t}{t_h}\right)_i > 1, \text{"ok"}, \text{"bad"}\right] = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

Assuming thin-walled, check for axial stress thickness using allowable axial strength:

$$t_a := \overrightarrow{\frac{P \cdot D}{4\sigma_{allow}}} = \begin{pmatrix} 0 \\ 0.001 \\ 0.001 \\ 0.001 \\ 0.001 \\ 0.001 \\ 0.002 \\ 0.002 \\ 0.002 \\ 0.002 \\ 0.003 \\ 0.003 \\ 0.004 \\ 0.004 \\ 0.004 \\ 0.004 \end{pmatrix} \text{in} \qquad \frac{t}{t_a} = \begin{pmatrix} 374 \\ 249.3 \\ 187 \\ 149.6 \\ 124.7 \\ 106.8 \\ 93.5 \\ 83.1 \\ 74.8 \\ 62.3 \\ 61.4 \\ 69.8 \\ 69.3 \\ 71.2 \\ 71.2 \\ 71.2 \end{pmatrix} \qquad \text{if}\left[\left(\frac{t}{t_a}\right)_i > 1, \text{"ok"}, \text{"bad"}\right] = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\sigma_{press} := \frac{DF_p \cdot P \cdot D}{2t}$$

$$\sigma_{press}^T = (96 \;\; 144 \;\; 193 \;\; 241 \;\; 289 \;\; 337 \;\; 385 \;\; 433 \;\; 481 \;\; 578 \;\; 587 \;\; 516 \;\; 520 \;\; 505 \;\; 505 \;\; 505) \quad \text{psi}$$

$$DF_{press} := \frac{\sigma_{allow}}{\sigma_{press}}$$

$$DF_{press}^T = (18.7 \;\; 12.5 \;\; 9.3 \;\; 7.5 \;\; 6.2 \;\; 5.3 \;\; 4.7 \;\; 4.2 \;\; 3.7 \;\; 3.1 \;\; 3.1 \;\; 3.5 \;\; 3.5 \;\; 3.6 \;\; 3.6 \;\; 3.6) \quad > 1 \text{ OK}$$

Wind Loading:

$V_{wind} := 145$ mph Exposure C

$G := 0.85$ Gust Factor

$K_z := 0.98$ Velocity pressure exposure coeff. for
Exp. C: at 25' is 0.94; 30' is 0.98; at 40' is 1.04. For exposure B at 50', K.z= 0.81.
Exp. D at 25' is 1.12; 30' is 1.16; at 40' is 1.22.

$K_{zt} := 1.0$ Topographic Factor

$K_d := 1.0$ Wind directionality factor

$K_e := 1.0$

Force coefficient $C_f := 0.8$

$q_z := \frac{0.00256}{144} \cdot K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V_{wind}^2$ $q_z = 0.366$ psi $q_{z\_psf} := q_z \cdot 144 = 52.7$

$p_{w\_psi} := q_z \cdot G \cdot C_f$ $p_{w\_psi} = 0.249$ psi

$p_{w\_psf} := p_{w\_psi} \cdot 144 = 35.9$

$A_w := D_o \cdot 12$ Projected Area per foot

$w_{wind} := p_{w\_psi} \cdot D_o$

$w_{wind}^T = (1.1 \;\; 1.6 \;\; 2.1 \;\; 2.6 \;\; 3.1 \;\; 3.6 \;\; 4.1 \;\; 4.6 \;\; 5.1 \;\; 6.1 \;\; 6.6 \;\; 7.6 \;\; 9.1 \;\; 10.7 \;\; 10.7 \;\; 10.7)$ lb/in

$W_{wind} := 12 \cdot p_{w\_psi} \cdot D_o$

$W_{wind}^T = (13.5 \;\; 19.4 \;\; 25.4 \;\; 31.4 \;\; 37.4 \;\; 43.3 \;\; 49.3 \;\; 55.3 \;\; 61.3 \;\; 73.2 \;\; 79.3 \;\; 91.5 \;\; 109.7 \;\; 127.9 \;\; 127.9 \;\; 127.9)$

lb/ft

Moment due to wind load:

Using, $Coef_{12} := 12$

$M_{wind} := \overrightarrow{\frac{(w_{wind}) \cdot (12Span)^2}{Coef_{12}}}$ lb in

Weight of water in duct:

Water accumulates to specified level above the bottom of the duct. This water will fill a sector of the circle to an angle:

$w_l = 2$ in

$\theta := \overrightarrow{\left(2\,acos\left(\frac{R_i - w_l}{R_i}\right)\right)}$

Weight of water in duct:

$w_{h2oin} := \overrightarrow{\left[\frac{R_i^2}{2} \cdot (\theta - \sin(\theta)) \cdot \rho_w\right]}$

$w_{h2oin}^T = (0.23 \;\; 0.3 \;\; 0.35 \;\; 0.4 \;\; 0.45 \;\; 0.49 \;\; 0.52 \;\; 0.56 \;\; 0.59 \;\; 0.65 \;\; 0.68 \;\; 0.73 \;\; 0.8 \;\; 0.87 \;\; 0.87 \;\; 0.87)$

$W_{wPerFt} := w_{h2oin} \cdot 12$ lb/in

$W_{wPerFt}^T = (2.7\ \ 3.6\ \ 4.3\ \ 4.8\ \ 5.4\ \ 5.8\ \ 6.3\ \ 6.7\ \ 7.1\ \ 7.8\ \ 8.1\ \ 8.8\ \ 9.6\ \ 10.4\ \ 10.4\ \ 10.4)$ lb/ft

Snow Load:

$Snow_{psf1} := 0$ psf

$Ce := 0.9$ $\quad Ct := 1.2$ $\quad I_{snow} := 1.0$

$P_f := 0.7 \cdot Ce \cdot Ct \cdot I_{snow} \cdot Snow_{psf1}$

$Snow_{psi} := (P_f \div 144) = 0$ psi

$w_{snow} := Snow_{psi} \cdot D_o$

$w_{snow}^T = (0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0)$ lb/in

Moment due to dead loads:

$Coef_{12} = 12$ $\quad M_{DL} := \overrightarrow{\frac{144(w_{frp} + w_{h2oin} + w_{snow}) \cdot Span^2}{Coef_{12}}}$ lb in

Moment due to wind:

Taking the larger moment: $M_{max_i} := \overrightarrow{\max(M_{DL_i}, M_{wind_i})}$

Maximum Bending Stress (Axial): $\sigma_{max} := \overrightarrow{\frac{M_{max} \cdot (R_i + t)}{I}}$

$\sigma_{max}^T = (336\ \ 286\ \ 268\ \ 262\ \ 217\ \ 186\ \ 162\ \ 144\ \ 290\ \ 241\ \ 209\ \ 245\ \ 171\ \ 191\ \ 191\ \ 191)$ psi

$\left(\frac{\sigma_{allow}}{\sigma_{max}}\right)^T = (5.4\ \ 6.3\ \ 6.7\ \ 6.9\ \ 8.3\ \ 9.7\ \ 11.1\ \ 12.5\ \ 6.2\ \ 7.5\ \ 8.6\ \ 7.4\ \ 10.5\ \ 9.4\ \ 9.4\ \ 9.4)$

$check1_i := \text{if}\left(\overrightarrow{\frac{\sigma_{allow}}{\sigma_{max_i}}} > 1, \text{"ok"}, \text{"bad"}\right)$

$check1^T = (\text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}$

Deflection:

Dead load:

$w_{DL} := w_{frp} + w_{h2oin} + w_{snow}$

$$w_{DL}^T = (0.44\ \ 0.62\ \ 0.78\ \ 0.93\ \ 1.07\ \ 1.21\ \ 1.35\ \ 1.49\ \ 1.62\ \ 1.89\ \ 2.07\ \ 2.65\ \ 3.40\ \ 4.33\ \ 4.33\ \ 4.33)$$

lb/in

Wind load:

$$w_{wind}^T = (1.12\ \ 1.62\ \ 2.12\ \ 2.62\ \ 3.11\ \ 3.61\ \ 4.11\ \ 4.61\ \ 5.11\ \ 6.10\ \ 6.61\ \ 7.63\ \ 9.14\ \ 10.66\ \ 10.66\ \ 10.66)$$

Taking the larger load: $Load_{max_i} := \overrightarrow{\max\left(w_{DL_i}, w_{wind_i}\right)}$ lb/in

$$Load_{max}^T = (1.12\ \ 1.62\ \ 2.12\ \ 2.62\ \ 3.11\ \ 3.61\ \ 4.11\ \ 4.61\ \ 5.11\ \ 6.1\ \ 6.61\ \ 7.63\ \ 9.14\ \ 10.66\ \ 10.66\ \ 10.66)$$

lb/in

$$\Delta_{max} := \overrightarrow{\frac{12^4 \cdot 3 \cdot (Load_{max}) \cdot Span^4}{384 \cdot E_{at} \cdot I}}$$

$$\Delta_{max}^T = (0.09\ \ 0.07\ \ 0.06\ \ 0.06\ \ 0.04\ \ 0.03\ \ 0.02\ \ 0.02\ \ 0.07\ \ 0.05\ \ 0.04\ \ 0.07\ \ 0.04\ \ 0.06\ \ 0.06\ \ 0.06)$$

in

Design factor based on 0.5" maximum allowable deflection:

$$\frac{0.5}{\Delta_{max}}^T = (5.7\ \ 7.5\ \ 8.3\ \ 8.5\ \ 12.3\ \ 16.7\ \ 21.8\ \ 27.6\ \ 6.7\ \ 9.7\ \ 12.1\ \ 7\ \ 12.3\ \ 8.4\ \ 8.4\ \ 8.4)$$ > 1 OKAY

External Pressure per ASTM D3982:

Critical Length:

$$L_c := \overrightarrow{\left[1.73 \cdot \left(\frac{D_o}{t_t}\right)^{0.5} \cdot D_o\right]}$$

Infinite Tube Critical External Pressure:

$$P_{e1} := \overrightarrow{\left[\frac{2.2 \cdot E_{hf}}{DF_e} \cdot \left(\frac{t_t}{D_o}\right)^3\right]}$$

Finite Tube Critical External Pressure (Stiffened or Supported at Span):

$$P_{e2} := \overrightarrow{\frac{\frac{2.6 \cdot E_{hf}}{DF_e} \cdot \left(\frac{t_t}{D_o}\right)^{2.5}}{\frac{12Span}{D_o} - 0.45 \cdot \left(\frac{t_t}{D_o}\right)^{0.5}}}$$

$P_e + p_{w\_psi} = 0.97$ psi

$P_{ale_i} := \text{if}\left(L_{c_i} < 12\,Span_i, P_{e1_i}, P_{e2_i}\right)$

$P_{ale}^T = (\,99.59 \;\; 33.05 \;\; 14.78 \;\; 7.84 \;\; 4.07 \;\; 3.26 \;\; 2.69 \;\; 2.26 \;\; 1.29 \;\; 0.99 \;\; 0.97 \;\; 0.98 \;\; 1.14 \;\; 1.13 \;\; 1.13 \;\; 1.13\,)$ psi

$SF_{vac} := \dfrac{P_{ale}}{P_e + p_{w\_psi}}$

$SF_{vac}^T = (\,102.6 \;\; 34.0 \;\; 15.2 \;\; 8.1 \;\; 4.2 \;\; 3.4 \;\; 2.8 \;\; 2.3 \;\; 1.3 \;\; 1.0 \;\; 1.0 \;\; 1.0 \;\; 1.2 \;\; 1.2 \;\; 1.2 \;\; 1.2\,)$

$check2_i := \text{if}\left(\dfrac{P_{ale_i}}{P_e} > 1, \text{"ok"}, \text{"bad"}\right)$

$check2^T = (\,\text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"} \;\; \text{"ok"}\,)$

Bending Stress Due to Seismic Loading:

$S_{DS} \equiv 1.20$

$R_P := 3.0$ (Table 13.6-1, Ductwork made of non-ductile plastics)

$I_p := 1.5$

$a_p := 2.5$ (Table 13.6-1, Ductwork made of non-ductile plastics)

Let $zDivH := 1$

$F_{pmax} := 1.6 \cdot S_{DS} \cdot I_p = 2.88$

$F_{pcalc} := \dfrac{0.4 \cdot a_p \cdot S_{DS}}{\left(\dfrac{R_P}{I_p}\right)} \cdot (1 + 2 \cdot zDivH) = 1.8$

$F_{pmin} := 0.3 \cdot S_{DS} \cdot I_p = 0.54$

$F_p := \text{if}\left(F_{pcalc} \ge F_{pmax}, F_{pmax}, \text{if}\left(F_{pcalc} \le F_{pmin}, F_{pmin}, F_{pcalc}\right)\right)$

$F_p = 1.8$

Seismic Induced Stress:

Moment due to seismic load: $M_{sDL} := \overrightarrow{\dfrac{144 F_p \cdot w_{DL} \cdot Span^2}{12}}$

Bending Stress (Axial):

$$\sigma_{sDL} := \overrightarrow{\frac{M_{sDL} \cdot (R_i + t)}{I}}$$

$\sigma_{sDL}^T = (240\ \ 196\ \ 177\ \ 167\ \ 135\ \ 112\ \ 96\ \ 84\ \ 166\ \ 134\ \ 118\ \ 153\ \ 115\ \ 140\ \ 140\ \ 140)$ psi

Design Factor:

$$\left(\overrightarrow{\frac{\sigma_{allow}}{\sigma_{sDL}}}\right)^T = (7.5\ \ 9.2\ \ 10.2\ \ 10.8\ \ 13.3\ \ 16\ \ 18.7\ \ 21.5\ \ 10.8\ \ 13.4\ \ 15.3\ \ 11.8\ \ 15.7\ \ 12.9\ \ 12.9\ \ 12.9)$$

$$check3_i := if\left(\frac{\sigma_{allow}}{\sigma_{sDL_i}} > 1, \text{"ok"}, \text{"Not Ok"}\right)$$

$check3^T = (\text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}\ \ \text{"ok"}$

Deflection from seismic load:

$$\Delta_s := \overrightarrow{\frac{12^4 \cdot 3 \cdot (F_p) \cdot w_{DL} \cdot Span^4}{384 \cdot E_{at} \cdot I}}$$

$\Delta_s^T = (0.06\ \ 0.05\ \ 0.04\ \ 0.04\ \ 0.03\ \ 0.02\ \ 0.01\ \ 0.01\ \ 0.04\ \ 0.03\ \ 0.02\ \ 0.04\ \ 0.03\ \ 0.04\ \ 0.04\ \ 0.04)$ in

Check for design factor at 0.5" allowable deflection:

$\dfrac{0.5}{\Delta_s}^T = (8\ \ 11\ \ 13\ \ 13\ \ 20\ \ 28\ \ 37\ \ 47\ \ 12\ \ 17\ \ 22\ \ 11\ \ 18\ \ 11\ \ 11\ \ 11)$ > 1 OK

Notes: Support reactions due to the loads are provided below as a courtesy. Contractor is responsible for this information and the design of the supports.

Reaction due to dead loads: $R_{dl} := \overrightarrow{\left[(w_{frp} + w_{h2oin} + w_{snow}) \cdot 12Span\right]}$ lb

$R_{dl}^T = (37\ \ 59\ \ 84\ \ 111\ \ 129\ \ 146\ \ 162\ \ 179\ \ 292\ \ 340\ \ 373\ \ 636\ \ 816\ \ 1300\ \ 1300\ \ 1300)$ lb

Reaction due to wind loads: $R_{wl} := \overrightarrow{(p_{w\_psi} \cdot D_o 12Span)}$

$R_{wl}^T = (94\ \ 155\ \ 229\ \ 314\ \ 374\ \ 433\ \ 493\ \ 553\ \ 919\ \ 1098\ \ 1189\ \ 1830\ \ 2194\ \ 3198\ \ 3198\ \ 3198)$ lb

Reaction due to seismic loads: $R_{sl} := \overrightarrow{\left[F_p \cdot (w_{frp} + w_{h2oin} + w_{snow}) \cdot 12Span\right]}$

$R_{sl}^T = (67\ \ 107\ \ 151\ \ 200\ \ 232\ \ 262\ \ 292\ \ 322\ \ 526\ \ 612\ \ 671\ \ 1144\ \ 1469\ \ 2340\ \ 2340\ \ 2340)$ lb

Design Summary

Duct I.D.: (in)	Minimum Total Wall Thickness: (in)	Minimum Weight: (lb/ft)	Support Span: (ft)
D	t_t	W_{frp}	$Span$
4	0.25	2.6	7
6	0.25	3.8	8
8	0.25	5.1	9
10	0.25	6.3	10
12	0.25	7.5	10
14	0.25	8.7	10
16	0.25	10	10
18	0.25	11.2	10
20	0.25	12.4	15
24	0.25	14.9	15
26	0.26	16.7	15
30	0.31	23	20
36	0.35	31.2	20
42	0.40	41.6	25
42	0.40	41.6	25
42	0.40	41.6	25

Laminate sequence: 100 mils corrosion barrier, 65 deg. filament winding, no uni-directional fabric

Typical Modulus of Elasticity of Filament Wound Pipe at 65° Winding Angle

t	Axial Mod E(a)	Hoop Mod E(h)	Hoop Flex Mod E(hf)	Laminate Sequence
(in)	10^6 (psi)	10^6 (psi)	10^6 (psi)	65° Winding Angle
0.15	1.17	1.48	1.32	VMM, FW
0.20	1.22	1.81	1.43	VMM, 2(FW)
0.25	1.25	2.09	1.61	VMM, 3(FW)
0.30	1.27	2.32	1.79	VMM, 4(FW)
0.35	1.29	2.50	1.94	VMM, 5(FW)
0.40	1.30	2.63	2.08	VMM, 6(FW)
0.45	1.31	2.73	2.19	VMM, 7(FW)
0.50	1.31	2.81	2.29	VMM, 8(FW)
0.55	1.32	2.88	2.38	VMM, 9(FW)
0.60	1.32	2.93	2.45	VMM, 10(FW)
0.65	1.33	2.97	2.51	VMM, 11(FW)
0.70	1.33	3.01	2.57	VMM, 12(FW)
0.75	1.33	3.04	2.62	VMM, 13(FW)
0.80	1.34	3.07	2.66	VMM, 14(FW)
0.85	1.35	3.09	2.68	VMM, 15(FW)

Design Calculations for Above Ground "Odor Control" Rectangular FRP Ducts

Hilo WWTP Rehabilitation and Replacement Project Phase 1
Job No. WW-4705R

6-18-25

BIN KHON NGO
LICENSED PROFESSIONAL ENGINEER
No. 18667-M
HAWAII U.S.A.

Expires: 4-30-26

Specification 15814
Fiberglass Reinforced Plastic Ducts

Daniel Company Project Number: 5013

Prepared by: Bin Ngo, PE

Density of Water:	$\rho_w := 0.0361$	lb/in^3
Density of Fiberglass:	$\rho_{frp} := 0.065$	lb/in^3
Condensation Load:	$h_{liq} := 1$	in
Pressure:	$P := 20\rho_w = 0.722$	psi
Vacuum:	$P_v := 20\rho_w = 0.722$	psi
Number of Duct Sizes:	$n := 10$	

$\text{Snow} := 0$ psf $\quad \text{Snow}_{psi} := \frac{\text{Snow}}{144} = 0$ psi

Snow exposure factor: $C_e := 1$

Design Factor1: $DF10 := 10$

Design Factor2: $DF5 := 5$

$Coef3 := 3 \quad Coef5 := 5 \quad Coef8 := 8 \quad Coef12 := 12$

corrosion barrier thickness: $t_{cb} := 0.100$ in

Wind Pressure:

Wind Importance Factor	$I_w := 1.0$		
Basic Wind Speed:	$v := 0$	mph	INTERIOR DUCTS
Velocity Pressure Exposure Coeff.	$K_z := 0.98$		
Topographic Factor	$K_{zt} := 1.0$		

$P_{w\_psf} := .00256 \cdot K_z \cdot K_{zt} \cdot v^2 \cdot I_w = 0$ lb/ft^2

$P_{w\_psi} := \frac{P_{w\_psf}}{144} = 0$ psi

$P_{int} := P + h_{liq} \cdot \rho_w = 0.758$ Pressure due to internal pressure

$P_{ext} := P_v + P_{w\_psi} = 0.722$ Pressure due to external pressure

$P_{max} := \max(P_{int}, P_{ext})$

$P_{max} = 0.758$ psi $Snow_{psi} = 0$ psi

Duct Governing Data

Duct Height: $h := (20\ \ 24\ \ 24\ \ 18\ \ 12\ \ 20\ \ 10\ \ 10\ \ 10\ \ 10)^T$ in

Duct Base: $b := (30\ \ 36\ \ 24\ \ 24\ \ 24\ \ 26\ \ 16\ \ 16\ \ 16\ \ 16)^T$ in

Duct Thickness: $t := (0.33\ \ 0.38\ \ 0.28\ \ 0.28\ \ 0.276\ \ 0.3\ \ 0.22\ \ 0.22\ \ 0.22\ \ 0.22)^T$ in

Duct Span: $Span := (8\ \ 8\ \ 8\ \ 8\ \ 8\ \ 8\ \ 8\ \ 8\ \ 8\ \ 8)^T$ ft

$i := 0 .. n - 1$

$bh_{max_i} := \max(b_i, h_i)$

$bh_{max}^T = (30\ \ 36\ \ 24\ \ 24\ \ 24\ \ 26\ \ 16\ \ 16\ \ 16\ \ 16)$ in

$\delta_{allow} := bh_{max} \cdot 0.01$ in

$\delta_{allow}^T = (0.300\ \ 0.360\ \ 0.240\ \ 0.240\ \ 0.240\ \ 0.260\ \ 0.160\ \ 0.160\ \ 0.160\ \ 0.160)$ in

Duct Flex Modulus (RTP-1-2011 Table 2A-3 & ASTM D3299-2010 :

$$E_f(t) := \begin{cases} (1.0 \cdot 10^6) & \text{if } (t \geq 0.37) \\ (0.90 \cdot 10^6) & \text{if } (t \leq 0.369 \wedge t \geq 0.290) \\ (0.80 \cdot 10^6) & \text{if } t \leq 0.289 \end{cases}$$

Duct Tensile Modulus (RTP-1-2011 Table 2A-3 & ASTM D3299-2010):

$$E_a(t) := \begin{cases} (1.5 \cdot 10^6) & \text{if } (t \geq 0.37) \\ (1.4 \cdot 10^6) & \text{if } (t \leq 0.369 \wedge t \geq 0.290) \\ (1.3 \cdot 10^6) & \text{if } t \leq 0.289 \end{cases}$$

$\left(\overrightarrow{E_f(t)}\right)^T = (900000\ \ 1000000\ \ 800000\ \ 800000\ \ 800000\ \ 900000\ \ 800000\ \ 800000\ \ 800000\ \ 800000)$ psi

$\left(\overrightarrow{E_a(t)}\right)^T = (1400000\ \ 1500000\ \ 1300000\ \ 1300000\ \ 1300000\ \ 1400000\ \ 1300000\ \ 1300000\ \ 1300000\ \ 130000($

psi

Flexural Strength:

$$S_f(t) := \begin{cases} (22\cdot 10^3) & \text{if } (t \ge 0.37) \\ (20\cdot 10^3) & \text{if } (t \le 0.369 \wedge t \ge 0.290) \\ (19\cdot 10^3) & \text{if } t \le 0.289 \end{cases}$$

$$\left(\overrightarrow{S_f(t)}\right)^T = (20000 \quad 22000 \quad 19000 \quad 19000 \quad 19000 \quad 20000 \quad 19000 \quad 19000 \quad 19000 \quad 19000) \qquad \text{psi}$$

Axial Strength:

$$S_a(t) := \begin{cases} (9000 \div 10) & \text{if } (t \ge 0.37) \\ (9000 \div 10) & \text{if } (t \le 0.369 \wedge t \ge 0.290) \\ (9000 \div 10) & \text{if } t \le 0.289 \end{cases}$$

$$\left(\overrightarrow{S_a(t)}\right)^T = (900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900) \qquad \text{psi}$$

Pressure Loading:

Reference: Roark's Formulas for Stress and Strain Assuming Rectangular Plates with Large Deflection

$$\pi_1 := \overrightarrow{\frac{P_{max}\cdot bh_{max}{}^4}{E_f(t)\cdot t^4}} \qquad \pi_1{}^T = (57.53 \quad 61.07 \quad 51.15 \quad 51.15 \quad 54.18 \quad 47.52 \quad 26.51 \quad 26.51 \quad 26.51 \quad 26.51)$$

$$F_1 := (0 \quad 12.5 \quad 25 \quad 50 \quad 75 \quad 100 \quad 125 \quad 150 \quad 175 \quad 200 \quad 250)$$

$$F_2 := (0 \quad 0.28 \quad 0.51 \quad 0.825 \quad 1.07 \quad 1.24 \quad 1.4 \quad 1.5 \quad 1.63 \quad 1.72 \quad 1.86)$$

$$F_3 := (0 \quad 0.2 \quad 0.66 \quad 1.90 \quad 3.20 \quad 4.35 \quad 5.4 \quad 6.5 \quad 7.5 \quad 8.5 \quad 10.3)$$

$$F_4 := (0 \quad 5.75 \quad 11.12 \quad 20.3 \quad 27.8 \quad 35 \quad 41 \quad 47 \quad 52.5 \quad 57.60 \quad 67.00)$$

$$\pi_2 := \overrightarrow{\text{linterp}\left(F_1{}^T, F_2{}^T, \pi_1\right)} \quad \pi_3 := \overrightarrow{\text{linterp}\left(F_1{}^T, F_3{}^T, \pi_1\right)} \quad \pi_4 := \overrightarrow{\text{linterp}\left(F_1{}^T, F_4{}^T, \pi_1\right)}$$

Max Deflection: $\delta_{max} := \overrightarrow{(\pi_2\cdot t)}$

$$\delta_{max}{}^T = (0.297 \quad 0.355 \quad 0.234 \quad 0.234 \quad 0.239 \quad 0.238 \quad 0.116 \quad 0.116 \quad 0.116 \quad 0.116)\text{in}$$

$$\delta_{allow} = \begin{pmatrix} 0.30 \\ 0.36 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.26 \\ 0.16 \\ 0.16 \\ 0.16 \\ 0.16 \end{pmatrix} \text{ in}$$

Check Deflections: $\overrightarrow{\frac{\delta_{allow}}{\delta_{max}}} = \begin{pmatrix} 1.0114 \\ 1.0149 \\ 1.0250 \\ 1.0250 \\ 1.0041 \\ 1.0918 \\ 1.3747 \\ 1.3747 \\ 1.3747 \\ 1.3747 \end{pmatrix}$ > 1 OK

Membrane Stress: $\sigma_m := \left(\overrightarrow{\frac{\pi_3 \cdot E_f(t) \cdot t^2}{bh_{max}^{\;2}}}\right)^T = (250 \quad 276 \quad 213 \quad 213 \quad 224 \quad 213 \quad 111 \quad 111 \quad 111 \quad 111)$ psi

Maximum Stress: $\sigma_{max} := \left(\overrightarrow{\frac{\pi_4 \cdot E_f(t) \cdot t^2}{bh_{max}^{\;2}}}\right)^T = (2457 \quad 2632 \quad 2248 \quad 2248 \quad 2280 \quad 2323 \quad 1766 \quad 1766 \quad 1766 \quad 1766)$ psi

Check Stress: $\overrightarrow{\frac{S_f(t)^T}{DF5 \cdot \sigma_m}} = (16.0 \quad 16.0 \quad 17.8 \quad 17.8 \quad 17.0 \quad 18.8 \quad 34.2 \quad 34.2 \quad 34.2 \quad 34.2)$

$\overrightarrow{\frac{S_f(t)^T}{DF5 \cdot \sigma_{max}}} = (1.63 \quad 1.67 \quad 1.69 \quad 1.69 \quad 1.67 \quad 1.72 \quad 2.15 \quad 2.15 \quad 2.15 \quad 2.15)$

$\text{if}\left(\min\left(\frac{\delta_{allow}}{\delta_{max}}\right) \geq 1, \text{"ok"}, \text{"not ok"}\right) = \text{"ok"}$ $\quad$ $\text{if}\left[\min\left[\overrightarrow{\frac{\left(S_f(t)^T\right)}{DF5 \cdot \sigma_{max}}}\right] \geq 1, \text{"ok"}, \text{"not ok"}\right] = \text{"ok"}$

Weight of Duct:

Cross Section Properties:

$$I_{duct} := \overrightarrow{\frac{\left[(b+2\cdot t)\cdot(h+2\cdot t)^3\right]-b\cdot h^3}{12}}$$

$$Z_{duct} := \overrightarrow{\frac{I_{duct}}{\left(\frac{h+2t}{2}\right)}}$$

$$I_{duct}^T = (2531 \quad 5027 \quad 2672 \quad 1421 \quad 590 \quad 2044 \quad 226 \quad 226 \quad 226 \quad 226) \qquad in^4$$

$$Z_{duct}^T = (245 \quad 406.1 \quad 217.6 \quad 153.1 \quad 94 \quad 198.5 \quad 43.2 \quad 43.2 \quad 43.2 \quad 43.2) \qquad in^3$$

Fiberglass Weight per Foot:

$$W_{frp} := \overrightarrow{\left[\left[2(b+h)\cdot\left(t+t_{cb}\right)\right]\cdot 12\rho_{frp}\right]}$$

$$\left(\overrightarrow{W_{frp}}\right)^T = (33.5 \quad 44.9 \quad 28.5 \quad 24.9 \quad 21.1 \quad 28.7 \quad 13 \quad 13 \quad 13 \quad 13) \qquad lb/ft$$

Water Weight per Foot:

$$W_{water} := \overrightarrow{\left(h_{liq}\cdot\rho_w\cdot b\cdot 12\right)} \qquad lb/ft$$

$$W_{water}^T = (12.996 \quad 15.595 \quad 10.397 \quad 10.397 \quad 10.397 \quad 11.263 \quad 6.931 \quad 6.931 \quad 6.931 \quad 6.931) \qquad lb/ft$$

Snow Load:

$Snow = 0$ psf $\qquad Snow_{psi} = 0$ psi

$C_e = 1$

$$W_{snow} := C_e\cdot Snow\cdot\frac{b}{12} \qquad W_{snow}^T = (0.00 \quad 0.00 \quad 0.00 \quad 0.00 \quad 0.00 \quad 0.00 \quad 0.00 \quad 0.00 \quad 0.00 \quad 0.00) \qquad lb/ft$$

Dead Load per Foot:

$$W_{DL} := \overrightarrow{\left(W_{frp}+W_{water}+W_{snow}\right)} \qquad lb/ft$$

$$W_{DL}^T = (46.5 \quad 60.5 \quad 38.9 \quad 35.3 \quad 31.5 \quad 40 \quad 19.9 \quad 19.9 \quad 19.9 \quad 19.9) \qquad lb/ft$$

Moment due to dead load:

$$M_{DL} := \overrightarrow{\frac{12W_{DL}\cdot(Span)^2}{Coef12}}$$

Moment due to wind:

$$M_{wind} := \overrightarrow{\frac{144\cdot P_{w\_psi}\cdot h\cdot Span^2}{Coef12}}$$

$$M_{DL} = \begin{pmatrix} 2.978 \times 10^3 \\ 3.873 \times 10^3 \\ 2.486 \times 10^3 \\ 2.259 \times 10^3 \\ 2.017 \times 10^3 \\ 2.558 \times 10^3 \\ 1.274 \times 10^3 \\ 1.274 \times 10^3 \\ 1.274 \times 10^3 \\ 1.274 \times 10^3 \end{pmatrix} \text{ lb in} \qquad M_{wind} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \text{ lb in}$$

Taking the larger moment: $M_{max_i} := \overrightarrow{\max\left(M_{DL_i}, M_{wind_i}\right)}$

$$M_{max} = \begin{pmatrix} 2.978 \times 10^3 \\ 3.873 \times 10^3 \\ 2.486 \times 10^3 \\ 2.259 \times 10^3 \\ 2.017 \times 10^3 \\ 2.558 \times 10^3 \\ 1.274 \times 10^3 \\ 1.274 \times 10^3 \\ 1.274 \times 10^3 \\ 1.274 \times 10^3 \end{pmatrix} \text{ in lb}$$

Maximum stress due bending:

$$\sigma_{max\_b} := \frac{M_{max}}{Z_{duct}} \text{ psi} \qquad \sigma_{max\_b} = \begin{pmatrix} 12.155 \\ 9.539 \\ 11.426 \\ 14.749 \\ 21.447 \\ 12.887 \\ 29.487 \\ 29.487 \\ 29.487 \\ 29.487 \end{pmatrix} \text{ psi}$$

$$\left(\overrightarrow{\frac{S_a(t)}{\sigma_{max\_b}}}\right)^T = (74.0 \quad 94.4 \quad 78.8 \quad 61.0 \quad 42.0 \quad 69.8 \quad 30.5 \quad 30.5 \quad 30.5 \quad 30.5) \quad > 1 \text{ OK}$$

Design Factor: $\text{if}\left(\min\left(\overrightarrow{\frac{S_a(t)}{\sigma_{max\_b}}}\right) > 1, \text{"ok"}, \text{"bad"}\right) = \text{"ok"}$

Wind loading per unit length: $W_{wind\_ppi} := P_{w\_psi} \cdot h$

$$W_{wind\_ppi} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \frac{lb}{in} \qquad W_{DL} = \begin{pmatrix} 46.54 \\ 60.52 \\ 38.85 \\ 35.29 \\ 31.51 \\ 39.97 \\ 19.91 \\ 19.91 \\ 19.91 \\ 19.91 \end{pmatrix} \frac{lb}{ft} \qquad W_{DL\_ppi} := \frac{W_{DL}}{12} = \begin{pmatrix} 3.88 \\ 5.04 \\ 3.24 \\ 2.94 \\ 2.63 \\ 3.33 \\ 1.66 \\ 1.66 \\ 1.66 \\ 1.66 \end{pmatrix} \frac{lb}{in}$$

Taking the large loading:

$$W_{max_i} := \overrightarrow{\max\left(W_{wind\_ppi_i}, W_{DL\_ppi_i}\right)} \qquad W_{max} = \begin{pmatrix} 3.878 \\ 5.044 \\ 3.238 \\ 2.941 \\ 2.626 \\ 3.331 \\ 1.659 \\ 1.659 \\ 1.659 \\ 1.659 \end{pmatrix} \frac{lb}{in}$$

Maximum deflection:

$$\Delta_{max} := \overrightarrow{\frac{(12)^4 \cdot \mathrm{Coef3}\left(W_{max}\right) \cdot Span^4}{384 \cdot E_f(t) \cdot I_{duct}}} \quad in$$

$$\Delta_{max}^{T} = (0.0011 \quad 0.0007 \quad 0.0010 \quad 0.0017 \quad 0.0037 \quad 0.0012 \quad 0.0061 \quad 0.0061 \quad 0.0061 \quad 0.0061) \quad in$$

Maximum allowable beam deflection:

$$\delta_{beam\_span} := \frac{12 \cdot Span}{360}$$

$$\delta_{beam\_span} = \begin{pmatrix} 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \end{pmatrix} \text{ in}$$

$$\delta_{beam\_all_i} := \min\left(\delta_{beam\_span_i}, 0.5\right)$$

$$\delta_{beam\_all} = \begin{pmatrix} 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \end{pmatrix} \text{ in}$$

$$\frac{\delta_{beam\_all}}{\Delta_{max}} = \begin{pmatrix} 236.1 \\ 400.6 \\ 265.4 \\ 155.4 \\ 72.3 \\ 222.0 \\ 43.7 \\ 43.7 \\ 43.7 \\ 43.7 \end{pmatrix}$$

> 1 OK

Bending Stress Due to Seismic Loading:

Spectral Response Acceleration at Short Period: $S_{DS} := 1.2$

Component Response Factor: $R_P := 3.0$ (Table 13.6-1, Ductwork made of non-ductile plastics)

Component Importance Factor: $I_p := 1.25$

Component Amplification Factor: $a_p := 2.5$ (Table 13.6-1, Ductwork made of non-ductile plastics)

Let: $zDivh := 1$

Code Max Seismic Force: $F_{pmax} := \overrightarrow{\left(1.6 \cdot S_{DS} \cdot I_p\right)}$

$F_{pmax} = 2.4$

Code Calculated Seismic Force: $F_{pcalc} := \overrightarrow{\left[\frac{0.4 \cdot a_p \cdot S_{DS}}{\left(\frac{R_P}{I_p}\right)} \cdot (1 + 2 \cdot zDivh)\right]}$

$F_{pcalc} = 1.5$

Code Minimum Seismic Force: $F_{pmin} := \overrightarrow{\left(0.3 \cdot S_{DS} \cdot I_p\right)}$

$F_{pmin} = 0.45$

Check calculated force is between minimum and maximum:

$F_p := \text{if}\left(F_{pcalc} \ge F_{pmax}, F_{pmax}, \text{if}\left(F_{pcalc} \le F_{pmin}, F_{pmin}, F_{pcalc}\right)\right)$

$F_p = 1.5$

Stress from Seismic Load:

Moment due to Seismic Loads:

$$M_{s\_DL} := \overrightarrow{\frac{12F_p \cdot W_{DL} Span^2}{Coef12}} \quad \text{lb in}$$

$M_{s\_DL}^{T} = (4467 \quad 5810 \quad 3730 \quad 3388 \quad 3025 \quad 3837 \quad 1911 \quad 1911 \quad 1911 \quad 1911)$ lb in

Stress due to Seismic Loads: $\sigma_s := \frac{M_{s\_DL}}{Z_{duct}}$ psi

$\sigma_s^{T} = (18.23 \quad 14.31 \quad 17.14 \quad 22.12 \quad 32.17 \quad 19.33 \quad 44.23 \quad 44.23 \quad 44.23 \quad 44.23)$ psi

$\left(\overrightarrow{S_a(t)}\right)^{T} = (900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900)$ psi

$\left(\overrightarrow{\frac{S_a(t)}{\sigma_s}}\right)^{T} = (49.4 \quad 62.9 \quad 52.5 \quad 40.7 \quad 28.0 \quad 46.6 \quad 20.3 \quad 20.3 \quad 20.3 \quad 20.3)$ > 1 OK

Factor of Safety: $\text{if}\left(\min\left(\overrightarrow{\frac{S_a(t)}{\sigma_s}}\right) > 1, \text{"ok"}, \text{"bad"}\right) = \text{"ok"}$

Deflection from Seismic Load:

Deflection due to Seismic Loads:

$$\delta_{maxs} := \overrightarrow{\frac{12^4 \cdot Coef3\left(F_p\right) \cdot W_{DL\_ppi} Span^4}{384 \cdot E_f(t) \cdot I_{duct}}} \quad \text{in}$$

Deflection (in) | Allowable Beam Deflection (in) | Design factor

$$\delta_{maxs} = \begin{pmatrix} 0.00169 \\ 0.00100 \\ 0.00151 \\ 0.00257 \\ 0.00554 \\ 0.00180 \\ 0.00915 \\ 0.00915 \\ 0.00915 \\ 0.00915 \end{pmatrix} \quad \delta_{beam\_all} = \begin{pmatrix} 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \end{pmatrix} \quad \frac{\delta_{beam\_all}}{\delta_{maxs}} = \begin{pmatrix} 157 \\ 267 \\ 177 \\ 104 \\ 48 \\ 148 \\ 29 \\ 29 \\ 29 \\ 29 \end{pmatrix} \quad > 1 \ \text{OK}$$

Support Reactions:

The following equations are provided as a courtesy. The contractor is responsible for the following equations and the design of the duct supports.

Reaction due to dead loads: $R_{dl} := \overrightarrow{\left[\left(W_{frp} + W_{water}\right) \cdot Span\right]}$

$R_{dl}{}^{T} = (372 \quad 484 \quad 311 \quad 282 \quad 252 \quad 320 \quad 159 \quad 159 \quad 159 \quad 159)$ lb

Reaction due to wind loads: $R_{wl} := \overrightarrow{\left[12 P_{w\_psi} \cdot \left(h + 2 \cdot t + 2 \cdot t_{cb}\right) \cdot Span\right]}$

Reaction due to seismic loads: $R_{sl} := \overrightarrow{\left[F_p \cdot \left(W_{frp} + W_{water}\right) \cdot Span\right]}$

Design Summary

Duct Width: I.D. (in)	Duct Height: I.D. (in)	Wall Thickness: (in)	Minimum Weight of Duct (lb/ft)	Span (ft)

$$b = \begin{pmatrix} 30 \\ 36 \\ 24 \\ 24 \\ 24 \\ 26 \\ 16 \\ 16 \\ 16 \\ 16 \end{pmatrix} \quad h = \begin{pmatrix} 20 \\ 24 \\ 24 \\ 18 \\ 12 \\ 20 \\ 10 \\ 10 \\ 10 \\ 10 \end{pmatrix} \quad t + t_{cb} = \begin{pmatrix} 0.430 \\ 0.480 \\ 0.380 \\ 0.380 \\ 0.376 \\ 0.400 \\ 0.320 \\ 0.320 \\ 0.320 \\ 0.320 \end{pmatrix} \quad W_{frp2} = \begin{pmatrix} 34.1 \\ 45.6 \\ 28.9 \\ 25.3 \\ 21.6 \\ 29.2 \\ 13.3 \\ 13.3 \\ 13.3 \\ 13.3 \end{pmatrix} \quad Span = \begin{pmatrix} 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \end{pmatrix} \text{ ft}$$

Use ASME RTP-1 laminate composition Type II

Design Calculations for Above Ground "HVAC" Rectangular FRP Ducts (PART 1)

Hilo WWTP Rehabilitation and Replacement Project Phase 1
Job No. WW-4705R

Specification 15814
Fiberglass Reinforced Plastic Ducts

6-19-25

BIN KHON NGO
LICENSED PROFESSIONAL ENGINEER
No. 18667-M
HAWAII U.S.A.

Expires: 4-30-26

Daniel Company Project Number: 5013

Prepared by: Bin Ngo, PE

Density of Water:	$\rho_w := 0.0361$	lb/in^3
Density of Fiberglass:	$\rho_{frp} := 0.065$	lb/in^3
Condensation Load:	$h_{liq} := 1$	in
Pressure:	$P := 10\rho_w = 0.361$	psi
Vacuum:	$P_v := 6\rho_w = 0.217$	psi
Number of Duct Sizes:	$n := 10$	

$Snow := 0$ psf $\quad Snow_{psi} := \frac{Snow}{144} = 0$ psi

Snow exposure factor: $C_e := 1$

Design Factor1: $DF10 := 10$

Design Factor2: $DF5 := 5$

$Coef3 := 3 \quad Coef5 := 5 \quad Coef8 := 8 \quad Coef12 := 12$

corrosion barrier thickness: $t_{cb} := 0.100$ in

Wind Pressure:

Wind Importance Factor	$I_w := 1.0$		
Basic Wind Speed:	$v := 0$	mph	INTERIOR DUCTS
Velocity Pressure Exposure Coeff.	$K_z := 0.98$		
Topographic Factor	$K_{zt} := 1.0$		

$P_{w\_psf} := .00256 \cdot K_z \cdot K_{zt} \cdot v^2 \cdot I_w = 0$ lb/ft^2

$$P_{w\_psi} := \frac{P_{w\_psf}}{144} = 0 \quad \text{psi}$$

$P_{int} := P + h_{liq} \cdot \rho_w = 0.397$ Pressure due to internal pressure

$P_{ext} := P_v + P_{w\_psi} = 0.217$ Pressure due to external pressure

$P_{max} := \max(P_{int}, P_{ext})$

$P_{max} = 0.397$ psi Snow$_{psi} = 0$ psi

Duct Governing Data

Duct Height: $h := (6 \quad 8 \quad 10 \quad 12 \quad 14 \quad 16 \quad 18 \quad 20 \quad 22 \quad 24)^T$ in

Duct Base: $b := (6 \quad 8 \quad 10 \quad 12 \quad 14 \quad 16 \quad 18 \quad 20 \quad 22 \quad 24)^T$ in

Duct Thickness: $t := (0.16 \quad 0.16 \quad 0.16 \quad 0.16 \quad 0.16 \quad 0.16 \quad 0.16 \quad 0.275 \quad 0.275 \quad 0.275)^T$ in

Duct Span: $Span := (6 \quad 6 \quad 7 \quad 8 \quad 8 \quad 8 \quad 8 \quad 8 \quad 8 \quad 8)^T$ ft

$i := 0 .. n - 1$

$bh_{max_i} := \max(b_i, h_i)$

$bh_{max}^T = (6 \quad 8 \quad 10 \quad 12 \quad 14 \quad 16 \quad 18 \quad 20 \quad 22 \quad 24)$ in

$\delta_{allow} := bh_{max} \cdot 0.01$ in

$\delta_{allow}^T = (0.060 \quad 0.080 \quad 0.100 \quad 0.120 \quad 0.140 \quad 0.160 \quad 0.180 \quad 0.200 \quad 0.220 \quad 0.240)$ in

Duct Flex Modulus (RTP-1-2011 Table 2A-3 & ASTM D3299-2010 :

$$E_f(t) := \begin{vmatrix} (1.0 \cdot 10^6) & \text{if } (t \geq 0.37) \\ (0.90 \cdot 10^6) & \text{if } (t \leq 0.369 \wedge t \geq 0.290) \\ (0.80 \cdot 10^6) & \text{if } t \leq 0.289 \end{vmatrix}$$

Duct Tensile Modulus (RTP-1-2011 Table 2A-3 & ASTM D3299-2010):

$$E_a(t) := \begin{vmatrix} (1.5 \cdot 10^6) & \text{if } (t \geq 0.37) \\ (1.4 \cdot 10^6) & \text{if } (t \leq 0.369 \wedge t \geq 0.290) \\ (1.3 \cdot 10^6) & \text{if } t \leq 0.289 \end{vmatrix}$$

$\left(\overrightarrow{E_f(t)}\right)^T = (800000 \quad 800000 \quad 800000 \quad 800000 \quad 800000 \quad 800000 \quad 800000 \quad 800000 \quad 800000 \quad 800000)$ psi

$\left(\overrightarrow{E_a(t)}\right)^T = (1300000 \quad 1300000 \quad 1300000 \quad 1300000 \quad 1300000 \quad 1300000 \quad 1300000 \quad 1300000 \quad 1300000 \quad 130000($

psi

Flexural Strength:

$$S_f(t) := \begin{cases} (22 \cdot 10^3) & \text{if } (t \geq 0.37) \\ (20 \cdot 10^3) & \text{if } (t \leq 0.369 \wedge t \geq 0.290) \\ (19 \cdot 10^3) & \text{if } t \leq 0.289 \end{cases}$$

$$\left(\overrightarrow{S_f(t)}\right)^T = (19000 \quad 19000 \quad 19000 \quad 19000 \quad 19000 \quad 19000 \quad 19000 \quad 19000 \quad 19000 \quad 19000) \qquad \text{psi}$$

Axial Strength:

$$S_a(t) := \begin{cases} (9000 \div 10) & \text{if } (t \geq 0.37) \\ (9000 \div 10) & \text{if } (t \leq 0.369 \wedge t \geq 0.290) \\ (9000 \div 10) & \text{if } t \leq 0.289 \end{cases}$$

$$\left(\overrightarrow{S_a(t)}\right)^T = (900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900) \qquad \text{psi}$$

Pressure Loading:

Reference: Roark's Formulas for Stress and Strain Assuming Rectangular Plates with Large Deflection

$$\pi_1 := \overrightarrow{\frac{P_{max} \cdot bh_{max}^{\ 4}}{E_f(t) \cdot t^4}} \qquad \pi_1^{\ T} = (0.98 \quad 3.1 \quad 7.57 \quad 15.71 \quad 29.1 \quad 49.64 \quad 79.51 \quad 13.89 \quad 20.33 \quad 28.8)$$

$$F_1 := (0 \quad 12.5 \quad 25 \quad 50 \quad 75 \quad 100 \quad 125 \quad 150 \quad 175 \quad 200 \quad 250)$$

$$F_2 := (0 \quad 0.28 \quad 0.51 \quad 0.825 \quad 1.07 \quad 1.24 \quad 1.4 \quad 1.5 \quad 1.63 \quad 1.72 \quad 1.86)$$

$$F_3 := (0 \quad 0.2 \quad 0.66 \quad 1.90 \quad 3.20 \quad 4.35 \quad 5.4 \quad 6.5 \quad 7.5 \quad 8.5 \quad 10.3)$$

$$F_4 := (0 \quad 5.75 \quad 11.12 \quad 20.3 \quad 27.8 \quad 35 \quad 41 \quad 47 \quad 52.5 \quad 57.60 \quad 67.00)$$

$$\pi_2 := \overrightarrow{\text{linterp}\left(F_1^{\ T}, F_2^{\ T}, \pi_1\right)} \quad \pi_3 := \overrightarrow{\text{linterp}\left(F_1^{\ T}, F_3^{\ T}, \pi_1\right)} \quad \pi_4 := \overrightarrow{\text{linterp}\left(F_1^{\ T}, F_4^{\ T}, \pi_1\right)}$$

Max Deflection: $\delta_{max} := \overrightarrow{(\pi_2 \cdot t)}$

$$\delta_{max}^{\ T} = (0.004 \quad 0.011 \quad 0.027 \quad 0.054 \quad 0.09 \quad 0.131 \quad 0.176 \quad 0.084 \quad 0.117 \quad 0.153) \qquad \text{in}$$

$$\delta_{allow} = \begin{pmatrix} 0.06 \\ 0.08 \\ 0.10 \\ 0.12 \\ 0.14 \\ 0.16 \\ 0.18 \\ 0.20 \\ 0.22 \\ 0.24 \end{pmatrix} \text{ in}$$

Check Deflections: $\overrightarrow{\frac{\delta_{allow}}{\delta_{max}}} = \begin{pmatrix} 17.0549 \\ 7.1950 \\ 3.6839 \\ 2.2125 \\ 1.5580 \\ 1.2189 \\ 1.0221 \\ 2.3805 \\ 1.8863 \\ 1.5645 \end{pmatrix}$ > 1 OK

Membrane Stress: $\sigma_m := \left(\overrightarrow{\frac{\pi_3 \cdot E_f(t) \cdot t^2}{bh_{max}^{\ 2}}}\right)^T = (9 \quad 16 \quad 25 \quad 45 \quad 90 \quad 151 \quad 215 \quad 38 \quad 61 \quad 89)$ psi

Maximum Stress: $\sigma_{max} := \left(\overrightarrow{\frac{\pi_4 \cdot E_f(t) \cdot t^2}{bh_{max}^{\ 2}}}\right)^T = (257 \quad 457 \quad 714 \quad 1014 \quad 1319 \quad 1613 \quad 1839 \quad 960 \quad 1139 \quad 1314)$ psi

Check Stress: $\overrightarrow{\frac{S_f(t)^T}{DF5 \cdot \sigma_m}} = (425.3 \quad 239.2 \quad 153.1 \quad 84.0 \quad 42.1 \quad 25.2 \quad 17.6 \quad 100.1 \quad 62.3 \quad 42.7)$

$$\overrightarrow{\frac{S_f(t)^T}{DF5 \cdot \sigma_{max}}} = (14.79 \quad 8.32 \quad 5.33 \quad 3.75 \quad 2.88 \quad 2.36 \quad 2.07 \quad 3.96 \quad 3.34 \quad 2.89)$$

$\text{if}\left(\min\left(\frac{\delta_{allow}}{\delta_{max}}\right) \ge 1, \text{"ok"}, \text{"not ok"}\right) = \text{"ok"}$ $\qquad$ $\text{if}\left[\min\left[\frac{\overrightarrow{\left(S_f(t)^T\right)}}{DF5 \cdot \sigma_{max}}\right] \ge 1, \text{"ok"}, \text{"not ok"}\right] = \text{"ok"}$

Weight of Duct:

Cross Section Properties:

$$I_{duct} := \overrightarrow{\frac{\left[(b+2\cdot t)\cdot(h+2\cdot t)^3\right] - b\cdot h^3}{12}}$$

$$Z_{duct} := \overrightarrow{\frac{I_{duct}}{\left(\frac{h+2t}{2}\right)}}$$

$$I_{duct}^{T} = (25\quad 58\quad 112\quad 192\quad 303\quad 450\quad 639\quad 1528\quad 2027\quad 2623) \qquad in^4$$

$$Z_{duct}^{T} = (7.9\quad 13.9\quad 21.7\quad 31.1\quad 42.3\quad 55.2\quad 69.7\quad 148.7\quad 179.7\quad 213.7) \qquad in^3$$

Fiberglass Weight per Foot:
$$W_{frp} := \overrightarrow{\left[\left[2(b+h)\cdot\left(t+t_{cb}\right)\right]\cdot 12\rho_{frp}\right]}$$

$$\left(\overrightarrow{W_{frp}}\right)^{T} = (4.9\quad 6.5\quad 8.1\quad 9.7\quad 11.4\quad 13\quad 14.6\quad 23.4\quad 25.7\quad 28.1) \qquad lb/ft$$

Water Weight per Foot:
$$W_{water} := \overrightarrow{\left(h_{liq}\cdot\rho_w\cdot b\cdot 12\right)} \qquad lb/ft$$

$$W_{water}^{T} = (2.599\quad 3.466\quad 4.332\quad 5.198\quad 6.065\quad 6.931\quad 7.798\quad 8.664\quad 9.53\quad 10.397) \qquad lb/ft$$

Snow Load:

$Snow = 0$ psf $\qquad Snow_{psi} = 0$ psi

$C_e = 1$

$$W_{snow} := C_e\cdot Snow\cdot\frac{b}{12} \qquad W_{snow}^{T} = (0.00\quad 0.00\quad 0.00\quad 0.00\quad 0.00\quad 0.00\quad 0.00\quad 0.00\quad 0.00\quad 0.00) \quad lb/ft$$

Dead Load per Foot:
$$W_{DL} := \overrightarrow{\left(W_{frp} + W_{water} + W_{snow}\right)} \qquad lb/ft$$

$$W_{DL}^{T} = (7.5\quad 10\quad 12.4\quad 14.9\quad 17.4\quad 19.9\quad 22.4\quad 32.1\quad 35.3\quad 38.5) \qquad lb/ft$$

Moment due to dead load:

$$M_{DL} := \overrightarrow{\frac{12W_{DL}\cdot(Span)^2}{Coef12}}$$

Moment due to wind:

$$M_{wind} := \overrightarrow{\frac{144\cdot P_{w\_psi}\cdot h\cdot Span^2}{Coef12}}$$

$$M_{DL} = \begin{pmatrix} 268.79 \\ 358.387 \\ 609.756 \\ 955.699 \\ 1.115 \times 10^3 \\ 1.274 \times 10^3 \\ 1.434 \times 10^3 \\ 2.052 \times 10^3 \\ 2.257 \times 10^3 \\ 2.463 \times 10^3 \end{pmatrix} \text{ lb in} \qquad M_{wind} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \text{ lb in}$$

Taking the larger moment: $M_{max_i} := \overrightarrow{\max\left(M_{DL_i}, M_{wind_i}\right)}$

$$M_{max} = \begin{pmatrix} 268.79 \\ 358.387 \\ 609.756 \\ 955.699 \\ 1.115 \times 10^3 \\ 1.274 \times 10^3 \\ 1.434 \times 10^3 \\ 2.052 \times 10^3 \\ 2.257 \times 10^3 \\ 2.463 \times 10^3 \end{pmatrix} \text{ in lb}$$

Maximum stress due bending:

$$\sigma_{max\_b} := \frac{M_{max}}{Z_{duct}} \text{ psi} \qquad \sigma_{max\_b} = \begin{pmatrix} 34.044 \\ 25.715 \\ 28.118 \\ 30.69 \\ 26.358 \\ 23.097 \\ 20.554 \\ 13.797 \\ 12.559 \\ 11.525 \end{pmatrix} \text{ psi}$$

$$\left(\overrightarrow{\frac{S_a(t)}{\sigma_{max\_b}}}\right)^T = (26.4 \quad 35.0 \quad 32.0 \quad 29.3 \quad 34.1 \quad 39.0 \quad 43.8 \quad 65.2 \quad 71.7 \quad 78.1) \quad > 1 \text{ OK}$$

Design Factor: $\text{if}\left(\min\left(\overrightarrow{\frac{S_a(t)}{\sigma_{max\_b}}}\right) > 1, \text{"ok"}, \text{"bad"}\right) = \text{"ok"}$

Wind loading per unit length: $W_{wind\_ppi} := P_{w\_psi} \cdot h$

$$W_{wind\_ppi} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \frac{lb}{in} \qquad W_{DL} = \begin{pmatrix} 7.47 \\ 9.96 \\ 12.44 \\ 14.93 \\ 17.42 \\ 19.91 \\ 22.4 \\ 32.06 \\ 35.27 \\ 38.48 \end{pmatrix} \frac{lb}{ft} \qquad W_{DL\_ppi} := \frac{W_{DL}}{12} = \begin{pmatrix} 0.62 \\ 0.83 \\ 1.04 \\ 1.24 \\ 1.45 \\ 1.66 \\ 1.87 \\ 2.67 \\ 2.94 \\ 3.21 \end{pmatrix} \frac{lb}{in}$$

Taking the large loading:

$$W_{max_i} := \overrightarrow{\max\left(W_{wind\_ppi_i}, W_{DL\_ppi_i}\right)} \qquad W_{max} = \begin{pmatrix} 0.622 \\ 0.83 \\ 1.037 \\ 1.244 \\ 1.452 \\ 1.659 \\ 1.867 \\ 2.672 \\ 2.939 \\ 3.206 \end{pmatrix} \frac{lb}{in}$$

Maximum deflection:

$$\Delta_{max} := \overrightarrow{\frac{(12)^4 \cdot \text{Coef3}(W_{max}) \cdot Span^4}{384 \cdot E_f(t) \cdot I_{duct}}} \quad in$$

$$\Delta_{max}^{T} = (0.0065 \quad 0.0038 \quad 0.0045 \quad 0.0054 \quad 0.0040 \quad 0.0031 \quad 0.0024 \quad 0.0015 \quad 0.0012 \quad 0.0010) \quad in$$

Maximum allowable beam deflection:

$$\delta_{beam\_span} := \frac{12 \cdot Span}{360}$$

$$\delta_{beam\_span} = \begin{pmatrix} 0.200 \\ 0.200 \\ 0.233 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \end{pmatrix} \text{in}$$

$$\delta_{beam\_all_i} := \min\left(\delta_{beam\_span_i}, 0.5\right)$$

$$\delta_{beam\_all} = \begin{pmatrix} 0.200 \\ 0.200 \\ 0.233 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \end{pmatrix} \text{in} \qquad \frac{\delta_{beam\_all}}{\Delta_{max}} = \begin{pmatrix} 30.6 \\ 53.3 \\ 51.8 \\ 49.6 \\ 67.1 \\ 87.2 \\ 110.0 \\ 183.9 \\ 221.7 \\ 263.0 \end{pmatrix} \quad > 1 \text{ OK}$$

Bending Stress Due to Seismic Loading:

Spectral Response Acceleration at Short Period: $S_{DS} := 1.2$

Component Response Factor: $R_P := 3.0$ (Table 13.6-1, Ductwork made of non-ductile plastics)

Component Importance Factor: $I_p := 1.25$

Component Amplification Factor: $a_p := 2.5$ (Table 13.6-1, Ductwork made of non-ductile plastics)

Let: $zDivh := 1$

Code Max Seismic Force: $F_{pmax} := \overrightarrow{\left(1.6 \cdot S_{DS} \cdot I_p\right)}$

$F_{pmax} = 2.4$

Code Calculated Seismic Force: $F_{pcalc} := \overrightarrow{\left[\frac{0.4 \cdot a_p \cdot S_{DS}}{\left(\frac{R_P}{I_p}\right)} \cdot (1 + 2 \cdot zDivh)\right]}$

$F_{pcalc} = 1.5$

Code Minimum Seismic Force: $F_{pmin} := \overrightarrow{\left(0.3 \cdot S_{DS} \cdot I_p\right)}$

$F_{pmin} = 0.45$

Check calculated force is between minimum and maximum:

$F_p := \text{if}\left(F_{pcalc} \geq F_{pmax}, F_{pmax}, \text{if}\left(F_{pcalc} \leq F_{pmin}, F_{pmin}, F_{pcalc}\right)\right)$

$F_p = 1.5$

Stress from Seismic Load:

Moment due to Seismic Loads:

$$M_{s\_DL} := \overrightarrow{\frac{12F_p \cdot W_{DL} Span^2}{Coef12}} \quad \text{lb in}$$

$M_{s\_DL}^T = (403 \quad 538 \quad 915 \quad 1434 \quad 1672 \quad 1911 \quad 2150 \quad 3078 \quad 3386 \quad 3694)$ lb in

Stress due to Seismic Loads: $\sigma_s := \frac{M_{s\_DL}}{Z_{duct}}$ psi

$\sigma_s^T = (51.07 \quad 38.57 \quad 42.18 \quad 46.04 \quad 39.54 \quad 34.65 \quad 30.83 \quad 20.7 \quad 18.84 \quad 17.29)$ psi

$\left(\overrightarrow{S_a(t)}\right)^T = (900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900)$ psi

$\left(\frac{\overrightarrow{S_a(t)}}{\sigma_s}\right)^T = (17.6 \quad 23.3 \quad 21.3 \quad 19.6 \quad 22.8 \quad 26.0 \quad 29.2 \quad 43.5 \quad 47.8 \quad 52.1) > 1$ OK

Factor of Safety: $\text{if}\left(\min\left(\frac{\overrightarrow{S_a(t)}}{\sigma_s}\right) > 1, \text{"ok"}, \text{"bad"}\right) = \text{"ok"}$

Deflection from Seismic Load:

Deflection due to Seismic Loads:

$$\delta_{maxs} := \overrightarrow{\frac{12^4 \cdot Coef3\left(F_p\right) \cdot W_{DL\_ppi} Span^4}{384 \cdot E_f(t) \cdot I_{duct}}} \quad \text{in}$$

Deflection (in)	Allowable Beam Deflection (in)	Design factor

$$\delta_{maxs} = \begin{pmatrix} 0.00982 \\ 0.00563 \\ 0.00676 \\ 0.00807 \\ 0.00596 \\ 0.00459 \\ 0.00364 \\ 0.00218 \\ 0.00180 \\ 0.00152 \end{pmatrix} \quad \delta_{beam\_all} = \begin{pmatrix} 0.200 \\ 0.200 \\ 0.233 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \end{pmatrix} \quad \frac{\delta_{beam\_all}}{\delta_{maxs}} = \begin{pmatrix} 20 \\ 36 \\ 35 \\ 33 \\ 45 \\ 58 \\ 73 \\ 123 \\ 148 \\ 175 \end{pmatrix} \quad > 1 \;\; \text{OK}$$

Support Reactions:

The following equations are provided as a courtesy. The contractor is responsible for the following equations and the design of the duct supports.

Reaction due to dead loads: $R_{dl} := \overrightarrow{\left[\left(W_{frp} + W_{water}\right)\cdot Span\right]}$

$R_{dl}^{T} = (45 \quad 60 \quad 87 \quad 119 \quad 139 \quad 159 \quad 179 \quad 257 \quad 282 \quad 308)$ lb

Reaction due to wind loads: $R_{wl} := \overrightarrow{\left[12P_{w\_psi}\cdot\left(h + 2\cdot t + 2\cdot t_{cb}\right)\cdot Span\right]}$

Reaction due to seismic loads: $R_{sl} := \overrightarrow{\left[F_p\cdot\left(W_{frp} + W_{water}\right)\cdot Span\right]}$

Design Summary

Duct Width: I.D. (in)	Duct Height: I.D. (in)	Wall Thickness: (in)	Span (ft)

$$b = \begin{pmatrix} 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \end{pmatrix} \quad h = \begin{pmatrix} 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \end{pmatrix} \quad t + t_{cb} = \begin{pmatrix} 0.260 \\ 0.260 \\ 0.260 \\ 0.260 \\ 0.260 \\ 0.260 \\ 0.260 \\ 0.375 \\ 0.375 \\ 0.375 \end{pmatrix} \quad Span = \begin{pmatrix} 6 \\ 6 \\ 7 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \end{pmatrix} \text{ ft}$$

Use ASME RTP-1 laminate composition Type II

Design Calculations for Above Ground "HVAC" Rectangular FRP Ducts (PART 2)

Hilo WWTP Rehabilitation and Replacement Project Phase 1
Job No. WW-4705R

Specification 15814
Fiberglass Reinforced Plastic Ducts

6-19-25

BIN KHON NGO
LICENSED PROFESSIONAL ENGINEER
No. 18667-M
HAWAII U.S.A.

Expires: 4-30-26

Daniel Company Project Number: 5013

Prepared by: Bin Ngo, PE

Density of Water: $\rho_w := 0.0361$ lb/in^3

Density of Fiberglass: $\rho_{frp} := 0.065$ lb/in^3

Condensation Load: $h_{liq} := 1$ in

Pressure: $P := 10\rho_w = 0.361$ psi

Vacuum: $P_v := 6\rho_w = 0.217$ psi

Number of Duct Sizes: $n := 10$

$Snow := 0$ psf $\quad Snow_{psi} := \frac{Snow}{144} = 0$ psi

Snow exposure factor: $C_e := 1$

Design Factor1: $DF10 := 10$

Design Factor2: $DF5 := 5$

$Coef3 := 3 \quad Coef5 := 5 \quad Coef8 := 8 \quad Coef12 := 12$

corrosion barrier thickness: $t_{cb} := 0.100$ in

Wind Pressure:

Wind Importance Factor $I_w := 1.0$

Basic Wind Speed: $v := 0$ mph INTERIOR DUCTS

Velocity Pressure Exposure Coeff. $K_z := 0.98$

Topographic Factor $K_{zt} := 1.0$

$$P_{w\_psf} := .00256 \cdot K_z \cdot K_{zt} \cdot v^2 \cdot I_w = 0 \quad \text{lb/ft^2}$$

$$P_{w\_psi} := \frac{P_{w\_psf}}{144} = 0 \qquad \text{psi}$$

$P_{int} := P + h_{liq} \cdot \rho_w = 0.397$ Pressure due to internal pressure

$P_{ext} := P_v + P_{w\_psi} = 0.217$ Pressure due to external pressure

$P_{max} := \max(P_{int}, P_{ext})$

$P_{max} = 0.397$ psi $\quad Snow_{psi} = 0$ psi

Duct Governing Data

Duct Height: $h := (26 \ \ 30 \ \ 32 \ \ 36 \ \ 38 \ \ 40 \ \ 48 \ \ 50 \ \ 50 \ \ 50)^T$ in

Duct Base: $b := (26 \ \ 30 \ \ 32 \ \ 36 \ \ 38 \ \ 40 \ \ 48 \ \ 50 \ \ 50 \ \ 50)^T$ in

Duct Thickness: $t := (0.27 \ \ 0.28 \ \ 0.28 \ \ 0.30 \ \ 0.33 \ \ 0.35 \ \ 0.46 \ \ 0.47 \ \ 0.47 \ \ 0.47)^T$ in

Duct Span: $Span := (8 \ \ 8 \ \ 8 \ \ 8 \ \ 8 \ \ 8 \ \ 8 \ \ 8 \ \ 8 \ \ 8)^T$ ft

$i := 0 .. n - 1$

$bh_{max_i} := \max(b_i, h_i)$

$bh_{max}^T = (26 \ \ 30 \ \ 32 \ \ 36 \ \ 38 \ \ 40 \ \ 48 \ \ 50 \ \ 50 \ \ 50)$ in

$\delta_{allow} := bh_{max} \cdot 0.01$ in

$\delta_{allow}^T = (0.260 \ \ 0.300 \ \ 0.320 \ \ 0.360 \ \ 0.380 \ \ 0.400 \ \ 0.480 \ \ 0.500 \ \ 0.500 \ \ 0.500)$ in

Duct Flex Modulus (RTP-1-2011 Table 2A-3 & ASTM D3299-2010 :

$$E_f(t) := \begin{vmatrix} (1.0 \cdot 10^6) & \text{if } (t \ge 0.37) \\ (0.90 \cdot 10^6) & \text{if } (t \le 0.369 \wedge t \ge 0.290) \\ (0.80 \cdot 10^6) & \text{if } t \le 0.289 \end{vmatrix}$$

Duct Tensile Modulus (RTP-1-2011 Table 2A-3 & ASTM D3299-2010):

$$E_a(t) := \begin{vmatrix} (1.5 \cdot 10^6) & \text{if } (t \ge 0.37) \\ (1.4 \cdot 10^6) & \text{if } (t \le 0.369 \wedge t \ge 0.290) \\ (1.3 \cdot 10^6) & \text{if } t \le 0.289 \end{vmatrix}$$

$$\left(\overrightarrow{E_f(t)}\right)^T = (800000 \ \ 800000 \ \ 800000 \ \ 900000 \ \ 900000 \ \ 900000 \ \ 1000000 \ \ 1000000 \ \ 1000000 \ \ 10000 \ \text{psi}$$

$$\left(\overrightarrow{E_a(t)}\right)^T = (1300000 \ \ 1300000 \ \ 1300000 \ \ 1400000 \ \ 1400000 \ \ 1400000 \ \ 1500000 \ \ 1500000 \ \ 1500000 \ \ 150000($$

psi

Flexural Strength:

$$S_f(t) := \begin{cases} (22\cdot 10^3) & \text{if } (t \ge 0.37) \\ (20\cdot 10^3) & \text{if } (t \le 0.369 \wedge t \ge 0.290) \\ (19\cdot 10^3) & \text{if } t \le 0.289 \end{cases}$$

$$\left(\overrightarrow{S_f(t)}\right)^T = (19000 \quad 19000 \quad 19000 \quad 20000 \quad 20000 \quad 20000 \quad 22000 \quad 22000 \quad 22000 \quad 22000) \qquad \text{psi}$$

Axial Strength:

$$S_a(t) := \begin{cases} (9000 \div 10) & \text{if } (t \ge 0.37) \\ (9000 \div 10) & \text{if } (t \le 0.369 \wedge t \ge 0.290) \\ (9000 \div 10) & \text{if } t \le 0.289 \end{cases}$$

$$\left(\overrightarrow{S_a(t)}\right)^T = (900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900) \qquad \text{psi}$$

Pressure Loading:

Reference: Roark's Formulas for Stress and Strain Assuming Rectangular Plates with Large Deflection

$$\pi_1 := \overrightarrow{\frac{P_{max}\cdot bh_{max}{}^4}{E_f(t)\cdot t^4}} \qquad \pi_1{}^T = (43 \quad 65 \quad 85 \quad 91 \quad 78 \quad 75 \quad 47 \quad 51 \quad 51 \quad 51)$$

$$F_1 := (0 \quad 12.5 \quad 25 \quad 50 \quad 75 \quad 100 \quad 125 \quad 150 \quad 175 \quad 200 \quad 250)$$

$$F_2 := (0 \quad 0.28 \quad 0.51 \quad 0.825 \quad 1.07 \quad 1.24 \quad 1.4 \quad 1.5 \quad 1.63 \quad 1.72 \quad 1.86)$$

$$F_3 := (0 \quad 0.2 \quad 0.66 \quad 1.90 \quad 3.20 \quad 4.35 \quad 5.4 \quad 6.5 \quad 7.5 \quad 8.5 \quad 10.3)$$

$$F_4 := (0 \quad 5.75 \quad 11.12 \quad 20.3 \quad 27.8 \quad 35 \quad 41 \quad 47 \quad 52.5 \quad 57.60 \quad 67.00)$$

$$\pi_2 := \overrightarrow{\text{linterp}\left(F_1{}^T, F_2{}^T, \pi_1\right)} \quad \pi_3 := \overrightarrow{\text{linterp}\left(F_1{}^T, F_3{}^T, \pi_1\right)} \quad \pi_4 := \overrightarrow{\text{linterp}\left(F_1{}^T, F_4{}^T, \pi_1\right)}$$

Max Deflection: $\delta_{max} := \overrightarrow{(\pi_2\cdot t)}$

$$\delta_{max}{}^T = (0.198 \quad 0.273 \quad 0.318 \quad 0.355 \quad 0.359 \quad 0.375 \quad 0.363 \quad 0.392 \quad 0.392 \quad 0.392) \qquad \text{in}$$

$$\delta_{allow} = \begin{pmatrix} 0.26 \\ 0.30 \\ 0.32 \\ 0.36 \\ 0.38 \\ 0.40 \\ 0.48 \\ 0.50 \\ 0.50 \\ 0.50 \end{pmatrix} \text{ in}$$

Check Deflections:

$$\overrightarrow{\frac{\delta_{allow}}{\delta_{max}}} = \begin{pmatrix} 1.3141 \\ 1.0977 \\ 1.0062 \\ 1.0151 \\ 1.0588 \\ 1.0663 \\ 1.3239 \\ 1.2764 \\ 1.2764 \\ 1.2764 \end{pmatrix} \quad > 1 \text{ OK}$$

Membrane Stress: $$\sigma_m := \left(\overrightarrow{\frac{\pi_3 \cdot E_f(t) \cdot t^2}{bh_{max}^{\ 2}}}\right)^T = (133 \quad 188 \quad 223 \quad 247 \quad 225 \quad 221 \quad 161 \quad 172 \quad 172 \quad 172) \text{ psi}$$

Maximum Stress: $$\sigma_{max} := \left(\overrightarrow{\frac{\pi_4 \cdot E_f(t) \cdot t^2}{bh_{max}^{\ 2}}}\right)^T = (1520 \quad 1737 \quad 1873 \quad 2034 \quad 1937 \quad 1921 \quad 1766 \quad 1817 \quad 1817 \quad 1817) \text{ psi}$$

Check Stress: $$\overrightarrow{\frac{S_f(t)^T}{DF5 \cdot \sigma_m}} = (28.7 \quad 20.2 \quad 17.0 \quad 16.2 \quad 17.8 \quad 18.1 \quad 27.3 \quad 25.6 \quad 25.6 \quad 25.6)$$

$$\overrightarrow{\frac{S_f(t)^T}{DF5 \cdot \sigma_{max}}} = (2.50 \quad 2.19 \quad 2.03 \quad 1.97 \quad 2.06 \quad 2.08 \quad 2.49 \quad 2.42 \quad 2.42 \quad 2.42)$$

$$\text{if}\left(\min\left(\frac{\delta_{allow}}{\delta_{max}}\right) \ge 1, \text{"ok"}, \text{"not ok"}\right) = \text{"ok"} \qquad \text{if}\left[\min\left[\overrightarrow{\frac{\left(S_f(t)^T\right)}{DF5 \cdot \sigma_{max}}}\right] \ge 1, \text{"ok"}, \text{"not ok"}\right] = \text{"ok"}$$

Weight of Duct:

Cross Section Properties:

$$I_{duct} := \overrightarrow{\frac{\left[(b+2\cdot t)\cdot(h+2\cdot t)^3\right]-b\cdot h^3}{12}}$$

$$Z_{duct} := \overrightarrow{\frac{I_{duct}}{\left(\frac{h+2t}{2}\right)}}$$

$I_{duct}{}^T = (3264\ \ 5183\ \ 6279\ \ 9567\ \ 12390\ \ 15330\ \ 34902\ \ 40285\ \ 40285\ \ 40285)$ in^4

$Z_{duct}{}^T = \left(245.9\ \ 339.2\ \ 385.7\ \ 522.8\ \ 641\ \ 753.3\ \ 1.4\times10^3\ \ 1.6\times10^3\ \ 1.6\times10^3\ \ 1.6\times10^3\right)$ in^3

Fiberglass Weight per Foot: $W_{frp} := \overrightarrow{\left[\left[2(b+h)\cdot\left(t+t_{cb}\right)\right]\cdot 12\rho_{frp}\right]}$

$\left(\overrightarrow{W_{frp}}\right)^T = (30\ \ 35.6\ \ 37.9\ \ 44.9\ \ 51\ \ 56.2\ \ 83.9\ \ 88.9\ \ 88.9\ \ 88.9)$ lb/ft

Water Weight per Foot: $W_{water} := \overrightarrow{\left(h_{liq}\cdot\rho_w\cdot b\cdot 12\right)}$ lb/ft

$W_{water}{}^T = (11.263\ \ 12.996\ \ 13.862\ \ 15.595\ \ 16.462\ \ 17.328\ \ 20.794\ \ 21.66\ \ 21.66\ \ 21.66)$ lb/ft

Snow Load:

$Snow = 0$ psf $Snow_{psi} = 0$ psi

$C_e = 1$

$W_{snow} := C_e\cdot Snow\cdot\frac{b}{12}$ $W_{snow}{}^T = (0.00\ \ 0.00\ \ 0.00\ \ 0.00\ \ 0.00\ \ 0.00\ \ 0.00\ \ 0.00\ \ 0.00\ \ 0.00)$ lb/ft

Dead Load per Foot: $W_{DL} := \overrightarrow{\left(W_{frp}+W_{water}+W_{snow}\right)}$ lb/ft

$W_{DL}{}^T = (41.3\ \ 48.6\ \ 51.8\ \ 60.5\ \ 67.4\ \ 73.5\ \ 104.7\ \ 110.6\ \ 110.6\ \ 110.6)$ lb/ft

Moment due to dead load:

$$M_{DL} := \overrightarrow{\frac{12W_{DL}\cdot(Span)^2}{Coef12}}$$

Moment due to wind:

$$M_{wind} := \overrightarrow{\frac{144\cdot P_{w\_psi}\cdot h\cdot Span^2}{Coef12}}$$

$$M_{DL} = \begin{pmatrix} 2.642\times10^3 \\ 3.108\times10^3 \\ 3.315\times10^3 \\ 3.873\times10^3 \\ 4.316\times10^3 \\ 4.703\times10^3 \\ 6.698\times10^3 \\ 7.077\times10^3 \\ 7.077\times10^3 \\ 7.077\times10^3 \end{pmatrix} \text{ lb in} \qquad M_{wind} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \text{ lb in}$$

Taking the larger moment: $M_{max_i} := \overrightarrow{\max\left(M_{DL_i}, M_{wind_i}\right)}$

$$M_{max} = \begin{pmatrix} 2.642\times10^3 \\ 3.108\times10^3 \\ 3.315\times10^3 \\ 3.873\times10^3 \\ 4.316\times10^3 \\ 4.703\times10^3 \\ 6.698\times10^3 \\ 7.077\times10^3 \\ 7.077\times10^3 \\ 7.077\times10^3 \end{pmatrix} \text{ in lb}$$

Maximum stress due bending:

$$\sigma_{max\_b} := \frac{M_{max}}{Z_{duct}} \text{ psi} \qquad \sigma_{max\_b} = \begin{pmatrix} 10.742 \\ 9.163 \\ 8.596 \\ 7.409 \\ 6.734 \\ 6.243 \\ 4.694 \\ 4.474 \\ 4.474 \\ 4.474 \end{pmatrix} \text{ psi}$$

$$\left(\overrightarrow{\frac{S_a(t)}{\sigma_{max\_b}}}\right)^T = (83.8 \quad 98.2 \quad 104.7 \quad 121.5 \quad 133.7 \quad 144.2 \quad 191.7 \quad 201.1 \quad 201.1 \quad 201.1) \quad > 1 \text{ OK}$$

Design Factor: $\text{if}\left(\min\left(\overrightarrow{\frac{S_a(t)}{\sigma_{max\_b}}}\right) > 1, \text{"ok"}, \text{"bad"}\right) = \text{"ok"}$

Wind loading per unit length: $W_{wind\_ppi} := P_{w\_psi} \cdot h$

$$W_{wind\_ppi} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \frac{lb}{in} \qquad W_{DL} = \begin{pmatrix} 41.28 \\ 48.56 \\ 51.8 \\ 60.52 \\ 67.44 \\ 73.49 \\ 104.66 \\ 110.58 \\ 110.58 \\ 110.58 \end{pmatrix} \frac{lb}{ft} \qquad W_{DL\_ppi} := \frac{W_{DL}}{12} = \begin{pmatrix} 3.44 \\ 4.05 \\ 4.32 \\ 5.04 \\ 5.62 \\ 6.12 \\ 8.72 \\ 9.21 \\ 9.21 \\ 9.21 \end{pmatrix} \frac{lb}{in}$$

Taking the large loading:

$$W_{max_i} := \overrightarrow{\max\left(W_{wind\_ppi_i}, W_{DL\_ppi_i}\right)} \qquad W_{max} = \begin{pmatrix} 3.44 \\ 4.047 \\ 4.317 \\ 5.044 \\ 5.62 \\ 6.124 \\ 8.722 \\ 9.215 \\ 9.215 \\ 9.215 \end{pmatrix} \frac{lb}{in}$$

Maximum deflection:

$$\Delta_{max} := \overrightarrow{\frac{(12)^4 \cdot \mathrm{Coef3}\left(W_{max}\right) \cdot Span^4}{384 \cdot E_f(t) \cdot I_{duct}}} \quad in$$

$$\Delta_{max}^{T} = \begin{pmatrix} 0.0009 & 0.0006 & 0.0006 & 0.0004 & 0.0003 & 0.0003 & 0.0002 & 0.0002 & 0.0002 & 0.0002 \end{pmatrix} \quad in$$

Maximum allowable beam deflection:

$$\delta_{beam\_span} := \frac{12 \cdot Span}{360}$$

$$\delta_{beam\_span} = \begin{pmatrix} 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \end{pmatrix} \text{ in}$$

$$\delta_{beam\_all_i} := \min\left(\delta_{beam\_span_i}, 0.5\right)$$

$$\delta_{beam\_all} = \begin{pmatrix} 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \end{pmatrix} \text{ in}$$

$$\frac{\delta_{beam\_all}}{\Delta_{max}} = \begin{pmatrix} 305.0 \\ 411.7 \\ 467.7 \\ 686.1 \\ 797.4 \\ 905.4 \\ 1608.2 \\ 1756.9 \\ 1756.9 \\ 1756.9 \end{pmatrix}$$

> 1 OK

Bending Stress Due to Seismic Loading:

Spectral Response Acceleration at Short Period: $S_{DS} := 1.2$

Component Response Factor: $R_P := 3.0$ (Table 13.6-1, Ductwork made of non-ductile plastics)

Component Importance Factor: $I_p := 1.25$

Component Amplification Factor: $a_p := 2.5$ (Table 13.6-1, Ductwork made of non-ductile plastics)

Let: $zDivh := 1$

Code Max Seismic Force: $F_{pmax} := \overrightarrow{\left(1.6 \cdot S_{DS} \cdot I_p\right)}$

$F_{pmax} = 2.4$

Code Calculated Seismic Force: $F_{pcalc} := \overrightarrow{\left[\frac{0.4 \cdot a_p \cdot S_{DS}}{\left(\frac{R_P}{I_p}\right)} \cdot (1 + 2 \cdot zDivh)\right]}$

$F_{pcalc} = 1.5$

Code Minimum Seismic Force: $F_{pmin} := \overrightarrow{\left(0.3 \cdot S_{DS} \cdot I_p\right)}$

$F_{pmin} = 0.45$

Check calculated force is between minimum and maximum:

$F_p := \text{if}\left(F_{pcalc} \geq F_{pmax}, F_{pmax}, \text{if}\left(F_{pcalc} \leq F_{pmin}, F_{pmin}, F_{pcalc}\right)\right)$

$F_p = 1.5$

Stress from Seismic Load:

Moment due to Seismic Loads:

$$M_{s\_DL} := \overrightarrow{\frac{12F_p \cdot W_{DL} Span^2}{Coef12}} \quad \text{lb in}$$

$M_{s\_DL}^T = (3963 \quad 4662 \quad 4973 \quad 5810 \quad 6474 \quad 7055 \quad 10047 \quad 10616 \quad 10616 \quad 10616)$ lb in

Stress due to Seismic Loads: $\sigma_s := \frac{M_{s\_DL}}{Z_{duct}}$ psi

$\sigma_s^T = (16.11 \quad 13.74 \quad 12.89 \quad 11.11 \quad 10.1 \quad 9.37 \quad 7.04 \quad 6.71 \quad 6.71 \quad 6.71)$ psi

$\left(\overrightarrow{S_a(t)}\right)^T = (900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900 \quad 900)$ psi

$\left(\overrightarrow{\frac{S_a(t)}{\sigma_s}}\right)^T = (55.9 \quad 65.5 \quad 69.8 \quad 81.0 \quad 89.1 \quad 96.1 \quad 127.8 \quad 134.1 \quad 134.1 \quad 134.1)$ > 1 OK

Factor of Safety: $\text{if}\left(\min\left(\overrightarrow{\frac{S_a(t)}{\sigma_s}}\right) > 1, \text{"ok"}, \text{"bad"}\right) = \text{"ok"}$

Deflection from Seismic Load:

Deflection due to Seismic Loads:

$$\delta_{maxs} := \overrightarrow{\frac{12^4 \cdot Coef3\left(F_p\right) \cdot W_{DL\_ppi} Span^4}{384 \cdot E_f(t) \cdot I_{duct}}} \quad \text{in}$$

Deflection (in) | Allowable Beam Deflection (in) | Design factor

$$\delta_{maxs} = \begin{pmatrix} 0.00131 \\ 0.00097 \\ 0.00086 \\ 0.00058 \\ 0.00050 \\ 0.00044 \\ 0.00025 \\ 0.00023 \\ 0.00023 \\ 0.00023 \end{pmatrix} \quad \delta_{beam\_all} = \begin{pmatrix} 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \\ 0.267 \end{pmatrix} \quad \frac{\delta_{beam\_all}}{\delta_{maxs}} = \begin{pmatrix} 203 \\ 274 \\ 312 \\ 457 \\ 532 \\ 604 \\ 1072 \\ 1171 \\ 1171 \\ 1171 \end{pmatrix} \quad > 1 \text{ OK}$$

Support Reactions:

The following equations are provided as a courtesy. The contractor is responsible for the following equations and the design of the duct supports.

Reaction due to dead loads: $R_{dl} := \overrightarrow{\left[\left(W_{frp} + W_{water}\right) \cdot Span\right]}$

$R_{dl}^{T} = (330 \quad 389 \quad 414 \quad 484 \quad 540 \quad 588 \quad 837 \quad 885 \quad 885 \quad 885)$ lb

Reaction due to wind loads: $R_{wl} := \overrightarrow{\left[12P_{w\_psi} \cdot \left(h + 2 \cdot t + 2 \cdot t_{cb}\right) \cdot Span\right]}$

Reaction due to seismic loads: $R_{sl} := \overrightarrow{\left[F_p \cdot \left(W_{frp} + W_{water}\right) \cdot Span\right]}$

Design Summary

Duct Width: I.D. (in)	Duct Height: I.D. (in)	Wall Thickness: (in)	Span (ft)

$$b = \begin{pmatrix} 26 \\ 30 \\ 32 \\ 36 \\ 38 \\ 40 \\ 48 \\ 50 \\ 50 \\ 50 \end{pmatrix} \quad h = \begin{pmatrix} 26 \\ 30 \\ 32 \\ 36 \\ 38 \\ 40 \\ 48 \\ 50 \\ 50 \\ 50 \end{pmatrix} \quad t + t_{cb} = \begin{pmatrix} 0.370 \\ 0.380 \\ 0.380 \\ 0.400 \\ 0.430 \\ 0.450 \\ 0.560 \\ 0.570 \\ 0.570 \\ 0.570 \end{pmatrix} \quad \mathrm{Span} = \begin{pmatrix} 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \end{pmatrix} \mathrm{ft}$$

Use ASME RTP-1 laminate composition Type II

Design Calculations for Buried FRP Pipe

County of Hawaii
Hilo WWTP Rehabilitation and Replacement Project
Phase 1

6-16-25

BIN KHON NGO
LICENSED PROFESSIONAL ENGINEER
No. 18667-M
HAWAII U.S.A.

Expires: 4-30-26

Specification 15814
Fiberglass Reinforced Plastic Ducts
Daniel Company Project Number: #5013

Prepared by: Bin Ngo, PE

DESIGN CONDITIONS

Design Pressure - $p := 20 \cdot 0.0361$ psi $p = 0.722$ psi

Design Vaccum - $p_e := 20 \cdot 0.0361$ psi $p_e = 0.722$ psi

Design Temperature - $20\ °F$ to $120\ °F$

Design Deflection: 5%

Design for H-20 -Traffic Loading

Minimum Burial Depth - $h := 3$ ft

Maximum Burial Depth - $H := 12$ ft

Minimum soil modulus: $M_s := 1000$ psi

Corrosion barrier thickness - $cb := 0.10$ in

Configuration: Cylindrical, Buried

Note: FRP pipe must be backfilled in keeping with AWWA C950 & M-45

Input Data

Design Internal Pressure (psi) . . . . $p = 0.72$ psi

Design Vacuum (psi) . . . . $p_e = 0.72$ psi

Density of Water . . . . $\rho_w := 0.0361$ pci

Allowable Strain (in/in) . . . . $\varepsilon := 0.001$

Design Factor for Internal Pressure . . . . $D_f := 10$

Design Factor for External Pressure . . . . $D_{fe} := 5$

Specific Weight of Soil . . . . $\gamma_s := 120$ lb/ft^3

Modulus of Soil Reaction . . . . $M_s = 1000$ psi

Bedding Coefficient . . . . $K_x := 0.1$

Deflection Lag Factor . . . . $D_L := 1.5$

Factor to account for live load distribution . . . . $LLDF := 1$

Length of tire footprint . . . . $t_l := 10$ in

Width of tire footprint . . . . $t_w := 20$ in

Multiple presence factor . . . . $M_p := 1.2$

Wheel Load . . . . $P := 16000$ lbf

Minimum Burial depth . . . . $h = 3$ ft

Maximum Burial Depth . . . . $H = 12.0$ ft

$S_{a1} := 9000 \div 5 = 1800$ psi Allowable tensile stress

Diameter (in)	Thicknesses (in)	Hoop Moduli (psi)	Axial Strength (psi)
$D \equiv \begin{pmatrix} 4 \\ 8 \\ 12 \\ 16 \\ 20 \\ 24 \\ 30 \\ 30 \\ 30 \end{pmatrix}$	$t := \begin{pmatrix} 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.32 \\ 0.32 \\ 0.32 \\ 0.32 \\ 0.32 \end{pmatrix}$	$E_h := \begin{pmatrix} 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \end{pmatrix} \cdot 10^6$	$S_a := \begin{pmatrix} 1800 \\ 1800 \\ 1800 \\ 1800 \\ 1800 \\ 1800 \\ 1800 \\ 1800 \\ 1800 \end{pmatrix}$

$j := 0 .. \mathrm{last}(D)$

Check Pipe for Internal Pressure

Reference: ASME RTP-1 3A-210

Wall thickness required by hoop stress . . . . $tshh := \overrightarrow{\left(p \cdot \frac{D}{2 \cdot \varepsilon \cdot E_h}\right)}$

Wall thickness required by axial stress . . . . $tsha := \overrightarrow{\left(p \cdot \frac{D \cdot D_f}{4 \cdot S_a}\right)}$

Select the thicker of the two values

$$t_{shs_j} := \mathrm{if}\left[\left(tshh_j > tsha_j\right), tshh_j, tsha_j\right]$$

Required Thickness (in)

$$t_{shs} = \begin{pmatrix} 0.004 \\ 0.008 \\ 0.012 \\ 0.016 \\ 0.020 \\ 0.024 \\ 0.030 \\ 0.030 \\ 0.030 \end{pmatrix}$$

Check Thickness

$$\overrightarrow{\left(\frac{t}{t_{shs}}\right)} = \begin{pmatrix} 59.83 \\ 29.92 \\ 19.94 \\ 14.96 \\ 15.96 \\ 13.30 \\ 10.64 \\ 10.64 \\ 10.64 \end{pmatrix}$$

>= 1.0 OK

$$Check1_j := \mathrm{if}\left(\frac{t_j}{t_{shs_j}} > 1, \text{"Ok"}, \text{"Failed"}\right)$$

$$Check1^T = (\text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"})$$

Check Pipe for Above grade Vacuum

Use Standard Formulation for infinite Tubes - - No Stiffeners

Maximum Allowable External Pressure

$$p_c := \overrightarrow{\left[\frac{2.2 \cdot E_{hf}}{D_{fe}} \cdot \left(\frac{t}{D}\right)^3\right]}$$

Hoop Flex Moduli (psi) | Max External Pressure (psi) | Compared to Design

$$E_{hf} \equiv \begin{pmatrix} 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \\ 3.3 \end{pmatrix} \cdot 10^6 \qquad p_c = \begin{pmatrix} 313.6 \\ 39.2 \\ 11.6 \\ 4.9 \\ 5.9 \\ 3.4 \\ 1.8 \\ 1.8 \\ 1.8 \end{pmatrix} \text{psi} \qquad \frac{p_{c_j}}{p_e} = \begin{pmatrix} 434.39 \\ 54.30 \\ 16.09 \\ 6.79 \\ 8.24 \\ 4.77 \\ 2.44 \\ 2.44 \\ 2.44 \end{pmatrix}$$

>= 1.0 OK

$$\text{Check2}_j := \text{if}\left(\overrightarrow{\frac{p_{c_j}}{p_e} > 1, \text{"Ok"}, \text{"Failed"}}\right)$$

$$\text{Check2}^T = (\text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"})$$

Burial and Traffic Loading

Reference: AWWA M45 5.7.3

Design Deflection . . . . $\Delta y_{allow} := 0.05D$

Calculate the Moment of Inertia $I := \frac{t^3}{12}$ $\quad D_m := (D + t)$ $\quad r := \frac{D}{2}$ $\quad R := r$

Calculate the Pipe Stiffness

$$PS_j := \frac{E_{hf_j} \cdot I_j}{0.149 \cdot \left(r_j + \frac{\Delta y_{allow_j}}{2}\right)^3}$$

$$PS^T = (2755.0 \quad 344.4 \quad 102.0 \quad 43.0 \quad 52.2 \quad 30.2 \quad 15.5 \quad 15.5 \quad 15.5) \quad \text{psi}$$

Check at Maximum Burial Depth

Calculate the Vertical Soil Load on the Pipe

$$W_c := \frac{\gamma_s \cdot H}{144} \qquad W_c = 10.00 \ \text{psi}$$

Impact Factor $\quad I_f := \max\left[1.0, 1 + 0.33 \frac{(96 - H \cdot 12)}{96}\right] \qquad I_f = 1.00$

Calculate depth at which load from wheel interacts $\quad h_{int} := \frac{72 - t_w}{LLDF} \qquad h_{int} = 52 \quad$ in

$t_w = 20 \quad$ in

$h_{int\_ft\_max} := \frac{h_{int}}{12} = 4.33 \quad$ ft

$L_1 := t_l + LLDF \cdot H \cdot 12 \quad$ in $\qquad L_1 = 154 \quad$ in

$L_{1\_ft\_max} := L_1 \div 12 = 12.8 \quad$ ft

$$L_2 := \text{if}\left(12H > h_{int}, \frac{t_w + 72 + LLDF \cdot 12 \cdot H}{2}, t_w + LLDF \cdot H \cdot 12\right) \qquad L_2 = 118 \quad \text{in}$$

$L_{2\_ft\_max} := L_2 \div 12 = 9.8 \quad$ ft

Live load on pipe $\quad W_L := \frac{M_p \cdot P \cdot I_f}{L_1 \cdot L_2} \qquad W_L = 1.057 \quad$ psi

Calculate the Shape Factor

$D_{fd} := (7 \quad 5.5 \quad 4.5 \quad 3.8) \qquad \mu_i := (9 \quad 18 \quad 36 \quad 72) \quad$ psi

$D_{fs} := \text{linterp}\left(\mu_i^T, D_{fd}^T, PS\right) \qquad j := 0 .. \text{last}(D_{fs})$

$D_{fs}^T = (-48.37 \quad -1.50 \quad 3.22 \quad 4.36 \quad 4.18 \quad 4.82 \quad 5.92 \quad 5.92 \quad 5.92)$

$D_{fs_j} := \text{if}\left(D_{fs_j} < 3.8, 3.8, D_{fs_j}\right)$

Calculate the Percentage Deflection Using the Spangler Equation

$$\Delta y := \frac{(D_L \cdot W_c \cdot K_x + W_L \cdot K_x) \cdot D}{0.149PS + 0.061M_s}$$

Deflection of Duct (in)

Deflection Percent of Diameter

$$\Delta y = \begin{pmatrix} 0.01 \\ 0.11 \\ 0.25 \\ 0.38 \\ 0.47 \\ 0.59 \\ 0.76 \\ 0.76 \\ 0.76 \end{pmatrix} \qquad \frac{\Delta y}{D} \cdot 100 = \begin{pmatrix} 0.34 \\ 1.43 \\ 2.11 \\ 2.38 \\ 2.33 \\ 2.45 \\ 2.54 \\ 2.54 \\ 2.54 \end{pmatrix}$$

< 5% OK

Check for Ring Bending

Design Strain . . . . $\varepsilon_D := 0.002$

Ring Bending Strain (in/in) . . . . $\varepsilon_B := \overrightarrow{\left[D_{fs} \cdot \frac{\Delta y}{D} \cdot \frac{(t)}{D}\right]}$

$$\varepsilon_B = \begin{pmatrix} 0.0008 \\ 0.0016 \\ 0.0016 \\ 0.0016 \\ 0.0016 \\ 0.0016 \\ 0.0016 \\ 0.0016 \\ 0.0016 \end{pmatrix} \qquad \overrightarrow{\frac{\varepsilon_D}{\varepsilon_B}} = \begin{pmatrix} 2.576 \\ 1.227 \\ 1.249 \\ 1.283 \\ 1.28 \\ 1.269 \\ 1.249 \\ 1.249 \\ 1.249 \end{pmatrix}$$

$$Check3_j := if\left(\frac{\varepsilon_D}{\varepsilon_{B_j}} > 1, \text{"Ok"}, \text{"Failed"}\right)$$

$$Check3^T = (\text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"})$$

Check at Minimum Burial Depth

Calculate the Vertical Soil Load on the Duct

$$W_{cm} := \frac{\gamma_s \cdot h}{144} \qquad W_{cm} = 2.50 \quad \text{psi}$$

Impact Factor $$I_{fm} := \max\left[1.0, \left[1 + 0.33\,\frac{(96 - h\cdot 12)}{96}\right]\right] \qquad I_{fm} = 1.21$$

Depth at which load from wheel interacts $$h_{int} = 52 \quad \text{in} \qquad h_{int\_ft} := \frac{h_{int}}{12} = 4.33$$

$$L_{1min} := t_l + LLDF\cdot h\cdot 12 \quad \text{in} \qquad L_{1min} = 46 \quad \text{in} \qquad L_{1min\_ft} := L_{1min} \div 12 = 3.8 \quad \text{ft}$$

$$L_{2min} := \mathrm{if}\left(12h > h_{int}, \frac{t_w + 72 + LLDF\cdot 12\cdot h}{2}, t_w + LLDF\cdot h\cdot 12\right) \qquad L_{2min} = 56 \quad \text{in}$$

$$L_{2min\_ft} := L_{2min} \div 12 = 4.7 \quad \text{ft}$$

$$12\cdot h = 36 \quad \text{in} \qquad h_{int} = 52 \quad \text{in}$$

Live load on pipe $$W_{Lm} := \frac{M_p\cdot P\cdot I_{fm}}{L_{1min}\cdot L_{2min}} \qquad W_{Lm} = 8.991 \quad \text{psi}$$

Calculate the Percentage Deflection Using the Spangler Equation

$$\Delta ym := \frac{\left(D_L\cdot W_{cm}\cdot K_x + W_{Lm}\cdot K_x\right)\cdot D}{0.149PS + 0.061M_s}$$

Deflection of Duct

Deflection Percent of Diameter

$$\Delta ym = \begin{pmatrix} 0.01 \\ 0.09 \\ 0.20 \\ 0.30 \\ 0.37 \\ 0.47 \\ 0.60 \\ 0.60 \\ 0.60 \end{pmatrix} \text{in} \qquad \frac{\Delta ym}{D}\cdot 100 = \begin{pmatrix} 0.27 \\ 1.13 \\ 1.67 \\ 1.89 \\ 1.85 \\ 1.95 \\ 2.01 \\ 2.01 \\ 2.01 \end{pmatrix}$$

< 5% OK

Check Ring Bending

Design Strain . . . . $\varepsilon_D = 0.002$

Ring Bending Strain (in/in) . . . . $\varepsilon_{Bm} := \overrightarrow{\left(D_{fs}\cdot\frac{\Delta ym}{D}\cdot\frac{t}{D}\right)}$

$$\varepsilon_{Bm} = \begin{pmatrix} 0.0006 \\ 0.0013 \\ 0.0013 \\ 0.0012 \\ 0.0012 \\ 0.0013 \\ 0.0013 \\ 0.0013 \\ 0.0013 \end{pmatrix} \qquad \frac{\varepsilon_D}{\varepsilon_{Bm}} = \begin{pmatrix} 3.25 \\ 1.55 \\ 1.57 \\ 1.62 \\ 1.61 \\ 1.60 \\ 1.57 \\ 1.57 \\ 1.57 \end{pmatrix}$$

>= 1.0 OK

$$Check4_j := \text{if}\left(\frac{\varepsilon_D}{\varepsilon_{Bm_j}} > 1, \text{"Ok"}, \text{"Failed"}\right)$$

$$Check4^T = (\text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"} \quad \text{"Ok"})$$

Check Buried Duct for Buckling

Ref. AWWA M-45 5.7.5

Scala calibration factor . . . . $C_n := 0.55$

Variability in stiffness of compacted soil factor . . $\phi_s := 0.9$

Modulus correction factor for soil poisson's ratio . . . . $k_\nu := 0.74$

Design factor . . . . $FS := 2.5$

Worst case empirical coefficient of elastic support . . $B' := 0.20$

Worst case buoyancy factor . . . . $R_w := 1.0$

Correction factor for depth of fill . . . . $R_h := \frac{11.4}{11 + \frac{D}{12H}}$

$$R_{hm} := \frac{11.4}{11 + \frac{D}{12\cdot h}}$$

$$R_h^T = (\,1.034 \quad 1.031 \quad 1.029 \quad 1.026 \quad 1.023 \quad 1.021 \quad 1.017 \quad 1.017 \quad 1.017\,)$$

$$R_{hm}^T = (\,1.03 \quad 1.02 \quad 1.01 \quad 1.00 \quad 0.99 \quad 0.98 \quad 0.96 \quad 0.96 \quad 0.96\,)$$

Calculate the allowable buckling pressure

$$q_{aH} := \overrightarrow{\frac{1.2 \cdot C_n \cdot (E_{hf} \cdot I)^{\frac{1}{3}} \cdot (\phi_s \cdot M_s \cdot k_\nu)^{\frac{2}{3}} \cdot R_h}{FS \cdot r}} \qquad q_{aH} = \begin{pmatrix} 162.42 \\ 81.00 \\ 53.87 \\ 40.30 \\ 42.88 \\ 35.64 \\ 28.41 \\ 28.41 \\ 28.41 \end{pmatrix} \text{ psi}$$

$$q_{am} := \overrightarrow{\frac{1.2 \cdot C_n \cdot (E_{hf} \cdot I)^{\frac{1}{3}} \cdot (\phi_s \cdot M_s \cdot k_\nu)^{\frac{2}{3}} \cdot R_{hm}}{FS \cdot r}} \qquad q_{am} = \begin{pmatrix} 161.20 \\ 79.80 \\ 52.68 \\ 39.13 \\ 41.33 \\ 34.12 \\ 26.91 \\ 26.91 \\ 26.91 \end{pmatrix} \text{ psi}$$

Check Buckling

$$\rho_w = 0.0361$$

$$Buckling\_FactorH_j := \overrightarrow{\frac{q_{aH_j}}{p_e + 12H \cdot \rho_w + R_w \cdot W_c + W_L}} \qquad Buckling\_FactorH = \begin{pmatrix} 9.57 \\ 4.77 \\ 3.17 \\ 2.37 \\ 2.53 \\ 2.1 \\ 1.67 \\ 1.67 \\ 1.67 \end{pmatrix} \quad > 1 \text{ OK}$$

$$\text{Buckling\_Factorm}_j := \overrightarrow{\left(\frac{q_{am_j}}{p_e + 12h \cdot \rho_w + R_w \cdot W_{cm} + W_{Lm}}\right)} \qquad \text{Buckling\_Factorm} = \begin{pmatrix} 11.93 \\ 5.91 \\ 3.90 \\ 2.90 \\ 3.06 \\ 2.52 \\ 1.99 \\ 1.99 \\ 1.99 \end{pmatrix} > 1 \text{ OK}$$

$W_c = 10$ psi $\quad W_L = 1.06$ psi $\quad W_{cm} = 2.5$ psi $\quad W_{Lm} = 8.99$ psi

Pipe axial modulus . . . .

$$E_a := \begin{pmatrix} 1.3 \\ 1.3 \\ 1.3 \\ 1.3 \\ 1.3 \\ 1.3 \\ 1.3 \\ 1.3 \\ 1.3 \end{pmatrix} \cdot 10^6 \quad \text{psi}$$

Calculate the stiffness factor

$$EI := \overrightarrow{\left[\frac{\pi}{64} \cdot E_a \cdot \left[(D + 2t)^4 - D^4\right]\right]} \qquad EI = \begin{pmatrix} 9.37 \times 10^6 \\ 6.86 \times 10^7 \\ 2.25 \times 10^8 \\ 5.25 \times 10^8 \\ 1.37 \times 10^9 \\ 2.35 \times 10^9 \\ 4.55 \times 10^9 \\ 4.55 \times 10^9 \\ 4.55 \times 10^9 \end{pmatrix} \quad \text{lb in\^{}2}$$

Density of FRP . . . . $\rho_f := 0.065$ pci

Calculate the minimum weight of FRP $\quad Wt := \overrightarrow{\left[\frac{12\pi}{4}\cdot\rho_f\cdot\left[(D + 2t + 2\cdot cb)^2 - D^2\right]\right]}$

Summary

Duct I.D. $\qquad$ Pipe Thickness $\qquad$ Minimum weight per foot

$$D = \begin{pmatrix} 4 \\ 8 \\ 12 \\ 16 \\ 20 \\ 24 \\ 30 \\ 30 \\ 30 \end{pmatrix} \text{ in} \qquad t + cb = \begin{pmatrix} 0.34 \\ 0.34 \\ 0.34 \\ 0.34 \\ 0.42 \\ 0.42 \\ 0.42 \\ 0.42 \\ 0.42 \end{pmatrix} \text{ in} \qquad Wt = \begin{pmatrix} 3.6 \\ 6.9 \\ 10.3 \\ 13.6 \\ 21.0 \\ 25.1 \\ 31.3 \\ 31.3 \\ 31.3 \end{pmatrix} \text{ lb / ft}$$

Laminate Sequence:

Corrosion barrier then wind pipe at 65° angle.

Laminate Construction

Layer	Thickness in	Reinforcement Wt%	Reinforcement oz/sq ft	Orientation Angle	Reinforcement	Matrix
1	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
2	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.
3	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
4	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.
5	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
6	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.
7	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
8	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.
9	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
10	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.

Total - 0.250 in

Calculated Laminate Properties

```
Tensile                    Modulus
    - Longitudinal  =  1,370,401  psi
    - Transverse    =  3,365,802  psi
    - Normal        =  1,563,992  psi

Flexural
    - Longitudinal  =  1,370,400  psi
    - Transverse    =  3,365,801  psi
Shear
    - L-T (Inplane) =  1,069,212  psi
    - L-N           =    574,186  psi
    - T-N           =    490,649  psi

Poisson ratios - Load direction / Strain direction
    - L/T = -0.27          T/L = -0.65
    - L/N = -0.24          N/L = -0.27
    - T/N = -0.16          N/T = -0.08

Neutral axis (measured from the centroid)
    - Longitudinal  = -0.000  in
    - Transverse    = -0.000  in

Thermal expansion coefficient
    - Longitudinal  =  22.8E-06  /F
    - Transverse    =  30.6E-07  /F
    - Normal        =  26.4E-06  /F

Specific heat       =   0.215  Btu/lb F

Thermal conductance =   8.736  Btu/hr sq ft F

Laminate weight     =   2.53  lb/sq ft

Reinforcement Wt.   =   1.60  lb/sq ft

Total reinforcement =  63.21   % by weight

Laminate density    =   0.070  lb/cu in

Laminate thickness  =   0.250  in
```

Laminate Construction

Layer	Thickness in	Reinforcement Wt%	oz/sq ft	Orientation Angle	Reinforcement	Matrix
1	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
2	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.
3	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
4	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.
5	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
6	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.
7	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
8	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.
9	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
10	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.
11	0.025	63.2	2.56	65	E Glass Roving	FR V.E.
12	0.025	63.2	2.56	-65	E Glass Roving	FR V.E.

Total - 0.300 in

Estimated Laminate Properties

```
Tensile                  Modulus
    - Longitudinal  =  1,370,509  psi
    - Transverse    =  3,376,110  psi
    - Normal        =  1,564,098  psi

Flexural
    - Longitudinal  =  1,370,509  psi
    - Transverse    =  3,376,110  psi
Shear
    - L-T (Inplane) =  1,072,762  psi
    - L-N           =    574,232  psi
    - T-N           =    490,689  psi

Poisson ratios - Load direction / Strain direction
    - L/T = -0.27          T/L = -0.66
    - L/N = -0.24          N/L = -0.27
    - T/N = -0.16          N/T = -0.08

Neutral axis (measured from the centroid)
    - Longitudinal  = -0.000  in
    - Transverse    = -0.000  in

Thermal expansion coefficient
    - Longitudinal  =  18.5E-06  /F
    - Transverse    =  29.8E-07  /F
    - Normal        =  21.2E-06  /F

Specific heat       =   0.215  Btu/lb F

Thermal conductance =   7.280  Btu/hr sq ft F

Laminate weight     =   3.04  lb/sq ft

Reinforcement Wt.   =   1.92  lb/sq ft

Total reinforcement =  63.21   % by weight

Laminate density    =   0.070  lb/cu in

Laminate thickness  =   0.300  in
```

SECTION 5

FIELD LAMINATION PROCEDURES AND MATERIALS LIST

FIELD JOINING PROCEDURE

Courtesy of Ashland Chemical

Introduction:

This procedure covers materials and suggested methods for the general repair of all fiberglass reinforced HETRON and AROPOL polyester resin equipment and for the butt and strap joining technique for fiberglass reinforced pipe or duct. The procedures involve relatively quick and simple processes for field or shop work. However, since a certain amount of know-how is required, it is recommended that properly trained personnel perform all work. It should be recognized that the minimum width of a joint or repair overlay and the number of plies of glass reinforcing required relate to type of construction, wall thickness and/or pressure rating of the equipment. It is extremely important to follow vendor construction specifications and material requirements along with NBS PS 15-69. When in doubt, contact the proper engineering or materials personnel or the equipment supplier.

Preparation of Pipe or Duct:

Cut pipe or duct to desired length making sure that ends are squared and butt closely together. Support sections in position with jig to ensure no movement will occur while making the joint or during curing.

Surface Preparation:

Thoroughly wash down the area to be repaired or joined to remove surface contamination. Remove any damaged areas until only sound material remains. All of the surface area to be covered with fiberglass reinforcement and resin must be thoroughly sanded and roughened with a power sander. Make sure the glossy resin finish is removed. Thoroughly clean roughened areas with an approved safety solvent. Surface must be dry. Apply resin and fiberglass as soon as possible after preparation to prevent possible recontamination of the prepared area.

Mixing Resin:

Under no circumstances should the catalyst and promoter be mixed in the same container or poured into the resin at the same time. When mixed together these two chemicals can react explosively.

Resin used for repairing or joining should be the same type as the resin used in manufacturing the original product. Weigh sufficient resin into a suitable container.

Use this weight to determine the amount of promoter, MEKP catalyst. If a high degree of flame retardancy is required, 3-5 percent antimony trioxide or pentoxide should be added to certain resins. Measure the required amount of promoter into a clean 10cc graduate and mix well into the resin. Measure the required amount of catalyst into a separate graduate and mix well into the resin (or promoted resin).

Joining Pipe or Duct:

Coat all roughened edges with resin mix, completely filling the joint and slightly squeezing the sections together. It may be preferable to add fumed silica to resin for this step to produce a paste or light putty which will fill small voids 1/8 inch or less and irregularities in the joint. It is often desirable to speed-up the hardening time for this step also by increasing the MEK peroxide required by 1 to 2 cc per pound. The interior surface should be relatively smooth but a light bead of resin on the interior is desirable.

Butted sections may be "tabbed" to hold alignment until complete joint can be made. A "tab" consists of 2-3 square inches of fiberglass mat saturated with resin mix. Place the prepared "tab" across joint to be made to form a "tack weld". For this step, it is often desirable to speed-up the hardening time of the resin by increasing the MEK peroxide required by 1 to 2 cc per pound (see Table 1).

Preparation of Strapping

Prepare fiberglass reinforcements according to vendor's specifications or cut sufficient quantity according to size and ply requirements. Joint thickness should be at least as thick as the pipe to be joined. Lay the widest section of fiberglass mat on a flat surface treated with release agent or covered with releasing film. Wet the entire surface with resin mix, using brush and/or roller. Position the next ply of fiberglass offsetting approximately ½ inch on the length. Equal overlap on width is preferable but slight offset (staggered) is acceptable. Wet out each layer with the resin-catalyst mixed solution.

Remove as much air as possible with brush and/or roller moving toward the edges of laminate section. Care must be exercised to avoid excessive pressure which would remove excessive resin from the area of lamination. Repeat with proper sequence of fiberglass until all plies have been saturated with resin and formed into one integral unit (See Figure 1). On very thick or large diameter joints, it may be easier to saturate two or three plies of fiberglass with resin at a time. This technique helps ensure removal of trapped air and facilitates application of the strapping.

Roll out as smooth as possible blending the edges of strapping into pipe. Remove all wrinkles and entrapped air - rolling from center of joint to outside edge. Additional resin may be applied to provide a resin-rich surface. Care must be taken to prevent the strapping from sagging at the bottom of the joint during hardening.

Hardening or Cure:

Resin must be allowed to harden or cure for about 24 hours. This will vary according to weather conditions, temperatures and exact amount of promoter and/or catalyst used. An external heat source such as an infrared heat lamp will decrease hardening time and may be a necessity in cold weather. Generally, work should not be done at temperatures below 55ºF unless an outside source of heat is applied. Since most polyester resins are flammable liquids, external heat sources should be used with caution. Care must be exercised when using an external heat source to prevent overheating which can cause cracking and/or crazing or discoloration.

Acetone lightly rubbed onto the exposed resin surface will determine if the system is adequately cured. If surface softens or becomes tacky, an external heat source can be applied to fully cure the resin. If surface does not cure, entire process must be repeated starting at “Surface Preparation”.

A Barcol Hardness tester can be used to determine if the system is cured adequately. A minimum Barcol of 35 indicates adequate cure for most resins. Consult resin data sheets for additional information.

WELDING ILLUSTRATION

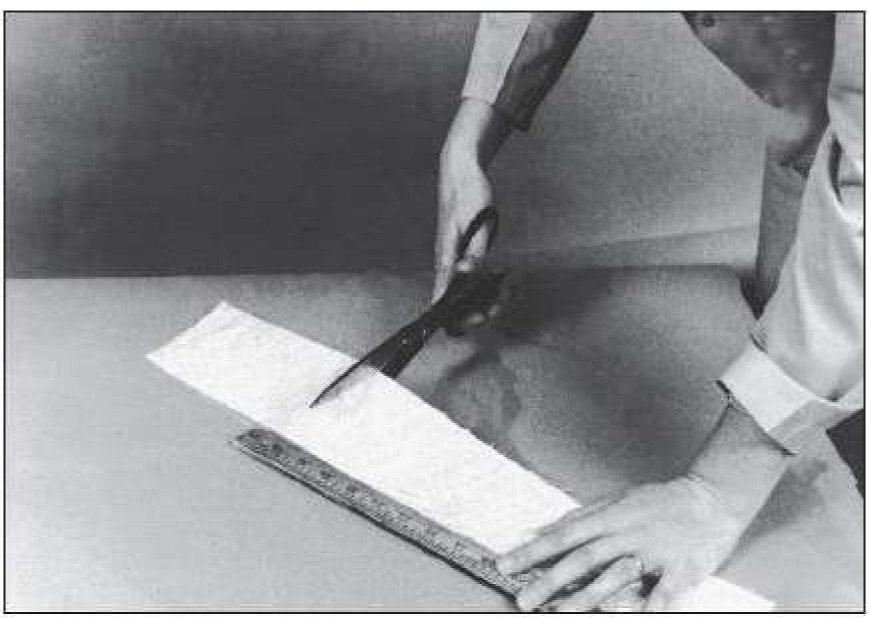
1. Firmly support pipe sections. Square the ends to be joined using a saber saw.

2. Rough the outside surfaces with sander approximately 1 in. (25 mm) farther in from the ends than the finished joint surface. Where inside joints are possible, interior surfaces should be sanded prior to assembly.

3. Coat roughened end edges of pipe with small amount of catalyzed resin. Any large voids may be filled with fumed silica filled resin putty.

4. Support components in joint position as rigidly as possible so that no movement occurs while making the joint. Fill joint with resin.

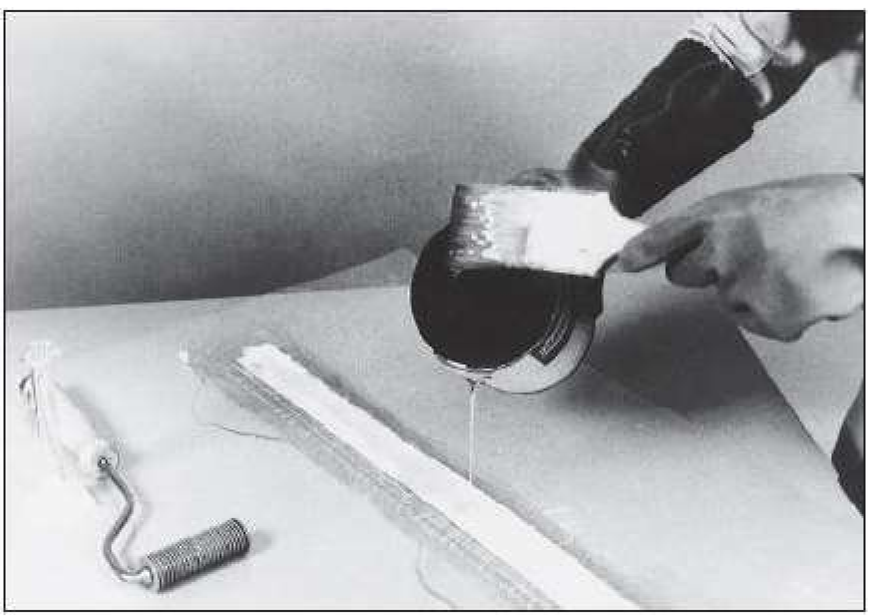
5. A hot-patch technique (see section 4.5) may help temporary prevent movement of pipe during the weld-cure period. Wet 2 in. (50 mm) squares of mat with a small amount of resin. Apply hot-patches at intervals around joint. Curing or hardening in a matter of minutes, they secure duct sections in proper alignment. Mix resin and catalyst for hot-patches in a small paper cup and safely discard after use to avoid contaminating the laminating resin.



6. Lay out fiberglass mat strips on the work table. Length of each strip should be two inches longer than circumference of duct. Strips longer than 36 in. (91 5 mm) may be cut in half to simplify application. Mix prescribed amount of catalyst with required amount of resin in a separate clean container.

Prepare only the amount of resin which can be used immediately (about 1 qt (0.9 liter) per *6* ft2 (0.55 m2) of mat). Resin will harden in approximately 20 to 30 minutes.

7. After mixing in the catalyst thoroughly, pour the resin onto the widest mat first. Spread it over the entire mat strip, working it into the mat fibers manually. (Neoprene gloves are recommended.)



8. Place the next widest strip onto the first the first with one end of the second strip starting approximately 1 in. in from end of the first. Doing this with each

successive strip results in a feathered edge to produce a smooth weld strip joint (see Figure 4-1). Add more resin and work into the second strip.

9. Add other strips in the same manner. In preparing each strip, it is best to be a little "lean" on resin at this stage rather than over-wetting. More resin may be added later, if necessary. After laying the final strip, compress strips together with glove-protected hand to remove large air bubbles and to make sure all layers are wetted with the resin.

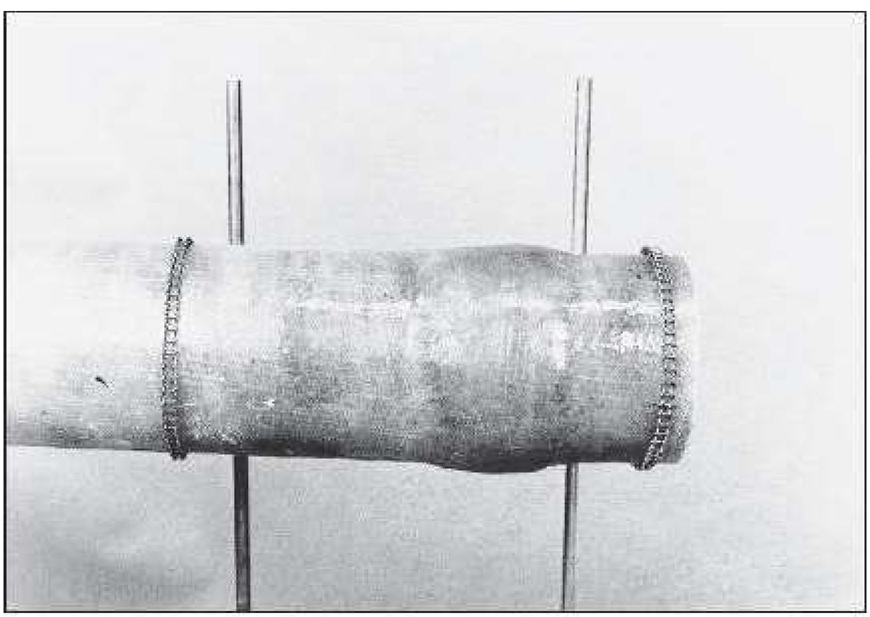
10. Pick up the completed joining strip by one end center it carefully on the duct joint. Apply the end first with the narrowest strip placed directly on the duct joint.

11. Be sure the joining strip is centered, with care taken to avoid wrinkles on the under or back side of the joint. Continue applying the strip around the joint until the free end overlaps the beginning. Lightly press out the air bubbles with gloved hands.

12. Finish the application of the joining strip with the roller. Any remaining air bubbles will appear as light spots. These should be rolled to the edge of the

joint where they will be released and disappear. If joint is not a straight butt joint, a little extra rolling and hand work to shape mat strips to structure configuration will eliminate bumps and ridges.

13. At this stage, resin may be added where necessary if any mat appears to be not thoroughly wetted. It is better to have too little resin on the joining strip, when applied, than too much. Over wetting makes it difficult to keep the strips in place. Finally, coat the remaining surface areas with resin.



14. Allow the completed joint to completely cure, tack free. Do not remove or disturb joint until it is thoroughly cured. If temperature is below 55°F (13°C),

keep joined areas warm with heat lamps. For exterior installations, protect the joint from the weather.

FIELD LAMINATION MATERIALS LIST

Materials required for making a field joint:

1. Glass mat and roving (4” through 24” wide, depending on duct dia.)
2. Resin (sold in 5-gallon pail or 55-gallon drum)
3. Catalyst (sold in 1-gallon container)
4. Bag or Aerosil filler in powder or putty form
5. Surfacing Agent
6. Gel Coat (1 or 5 gallons)

Tools and other accessories not supplied but required for making a field joint:

1. Acetone *
2. Rubber gloves *
3. 3”, 4” and/or 5” brushes to apply resin**
4. Aluminum bristled rollers ½” dia. x 4” and 1” dia. x 4”**
5. 20 oz. plastic mixing buckets*
6. 20-30cc measuring cups*
7. Trim blades *
8. Grinders *
9. Sawzall *
10. Skill saw *
11. Electric drill *
12. Plastic buckets *
13. Safety glasses *
14. Dust masks *
15. Extension wire *

* Items are essential and have not been packed in crew’s kit.
**Limited quantities and sizes initially provided.

Note: Other items may or may not be included in the crew’s kit. Please check with supplier/manufacturer for detail.

SECTION 6

QUALITY CONTROL PROCEDURES AND WARRANTY

QUALITY CONTROL PROCEDURE

I. SCOPE:

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

II. RESPONSIBILITY:

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

III. AREAS OF CONTROL:

a. Engineering design and document control.

b. Materials documentation and control.

c. Purchased items documentation and control.

d. Calibration of quality control instrumentation.

e. Manufacturing and inspection documentation and control.

QUALITY CONTROL PROCEDURE

A. Engineering Design and Document Control:

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

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

B. Materials Documentation and Control:

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

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

C. Purchased Items Documentation and Control:

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

D. Calibration of Quality Control Instrumentation:

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

E. Manufacturing and Inspection Documentation and Control:

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

DANIEL COMPANY
Air & Water Pollution Control Systems

QC REPORT

Project (Number & Name): ____________ **Checked By:** ____________

Part Number: ____________ **Date:** ____________

Rev: ____________

DIMENSIONS

PASS: ☐ FAIL: ☐

THICKNESS

Nominal Duct Size: ____________ Minimum Thickness Required: ____________

1. ________ 2. ________ 3. ________ 4. ________ Average: ________

BARCOL TESTING

Hardness level per manufacturer: ____________

1. ________ 2. ________ 3. ________ 4. ________ Average: ________

ACETONE TEST

PASS: ☐ FAIL: ☐

VISUAL INSPECTION

PASS: ☐ FAIL: ☐

COMMENTS:____

____

____

<u>RESIN SHEET</u>

JOB NAME:________________________________

JOB NUMBER:________________________________

DATE:________________________________

LOT #:________________________________

TYPE OF RESIN REQUIRED:________________________________

RESIN MANUFACTURER:________________________________

RESIN MANUFACTURER'S PHONE NUMBER:________________________________

RESIN MANUFACTURER CONTACT:________________________________

RESIN SHELF LIFE EXPIRATION DATE:________________________________

RESIN QUALITY CONTROL BY:________________________________

VISCOSITY:________________________________

PROMOTED: (YES OR NO):________________________________

PROMOTION TYPE:________________________________

CATALYST TYPE:________________________________

COMMENTS:________________________________

DANIEL COMPANY
Air & Water Pollution Control Systems

HANDLING, STORAGE & PACKAGING

Handling:

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

Storage:

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

Packaging:

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

1939 W. 11th St., Ste. E, Upland, CA 91786 Ph: (909) 982-1555, Fax: (909) 982-1855

DANIEL COMPANY
Air & Water Pollution Control Systems

MANUFACTURER'S LETTER OF WARRANTY

June 24, 2025

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

RE: Hilo WWTP Rehabilitation and Replacement Project Phase 1

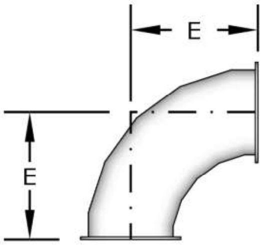
Subject: Warranty Letter for FRP Ductwork

To Whom It May Concern:

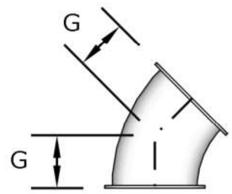
Daniel Company warrants the FRP ductwork represented herein, against defects in materials and workmanship for a period of two (2) years from date of Acceptance. During the warranty period, Daniel Company will at its option, either repair or replace all or any part of products that prove to be defective. All transportation charges, taxes or duties for such parts (defective parts) that are part of the system and not caused by unauthorized, improper, or inadequate maintenance or installation by the Owner shall be paid by manufacturer/supplier of the odor control system. Daniel Company shall have the sole right to determine whether defective parts shall be replaced or repaired. This warranty does not apply to defects resulting from unauthorized, improper or inadequate maintenance, use or installation by the Owner. Daniel Company assumes no liability for damages and delays caused by defective materials and no allowance will be made for local repair expenses without prior written approval from Daniel Company.

SECTION 7

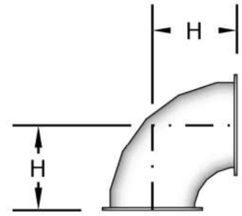
DUCTWORK SHOP DRAWINGS



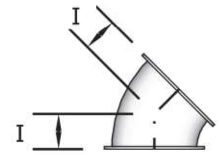
90° LR ELL



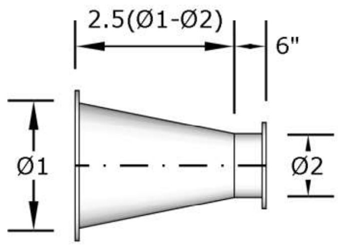
45° LR ELL



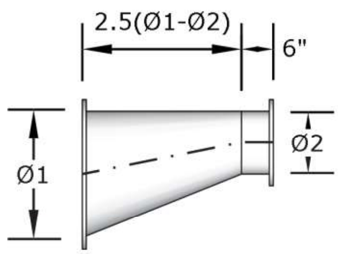
90° SR ELL



45° SR ELL

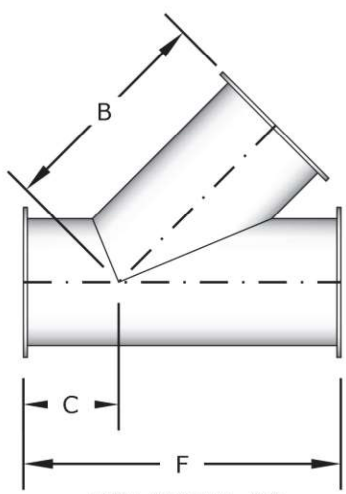


CONCENTRIC REDUCER

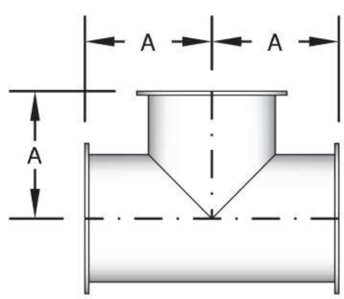


ECCENTRIC REDUCER

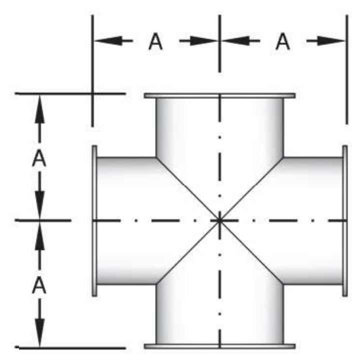
Ø	A	B	C	E	F	G	H	I
2	6	10	6	4	16	1 5/8	2	3/4
3	7	12	6	6	18	2 1/2	3	1 1/4
4	8	14	6	6	20	2 1/2	4	1 3/4
6	10	16	8	9	24	3 3/4	6	2 1/2
8	12	20	10	12	30	5	8	3 1/4
10	14	24	10	15	34	6 1/2	10	4 1/4
12	16	26	12	18	38	7 1/2	12	5
14	18	30	12	21	42	8 3/4	14	5 3/4
16	20	32	14	24	46	10	16	6 1/2
18	21	36	14	27	50	11 1/4	18	7 1/2
20	22	38	16	30	54	12 1/2	20	8 1/4
24	24	42	18	36	60	15	24	10
30	30	52	20	45	72	18 5/8	30	12 1/2
36	33	62	22	54	84	22 1/2	36	15
42	36	72	24	63	96	26	42	17 1/2
48	39	82	26	72	108	28	48	20
54	45	92	28	81	120	30	54	22 1/2
60	54	102	30	90	132	32	60	25
72	60	122	38	108	156	40	72	30



45° LATERAL (Y)



TEE



CROSS

DANIEL COMPANY FIBERGLASS SYSTEMS	SCALE: NTS	FITTINGS BUILD SHEET
	DRAWN BY: CB	

FRP DUCT FLANGE DIMENSIONS

SIZE	FLANGE THICKNESS	FLANGE O.D.	BOLT CIRCLE DIA.	BOLT HOLE DIA.	# OF BOLT HOLES	RECOMMENDED BOLT TORQUE*, FT/LB	MAX. BOLT TORQUE*, FT/LB
4”	¾”	8 3/8”	7”	7/16”	4	25	40
6”	¾”	10 3/8”	9”	7/16”	8	25	40
8”	¾”	12 3/8”	11”	7/16”	8	25	40
10”	¾”	14 3/8”	13”	7/16”	12	25	40
12”	¾”	16 3/8”	15”	7/16”	12	25	40
14”	¾”	18 3/8”	17”	7/16”	12	25	40
16”	¾”	20 3/8”	19”	7/16”	16	25	40
18”	¾”	22 3/8”	21”	7/16”	16	25	40
20”	¾”	24 3/8”	23”	7/16”	20	25	40
24”	¾”	28 3/8”	27”	7/16”	20	25	40
28”	¾”	32 3/8”	31”	7/16”	28	25	40
30”	¾”	34 3/8”	33”	7/16”	28	35	50
32”	¾”	36 3/8”	35”	7/16”	28	35	50
34”	¾”	38 3/8”	37”	7/16”	32	35	50
36”	¾”	40 3/8”	39”	7/16”	32	35	50
38”	¾”	42 3/8”	41”	7/16”	32	35	50
42”	¾”	46 3/8”	45”	7/16”	36	35	50
48”	¾”	54 3/8”	52”	9/16”	44	35	50
54”	¾”	60 3/8”	58”	9/16”	44	35	50
60”	¾”	66 3/8”	64”	9/16”	52	35	50
72”	¾”	78 3/8”	76”	9/16”	60	40	60
84”	¾”	90 3/8”	88”	9/16”	72	40	60
96”	¾”	102 3/8”	100”	9/16”	80	40	60

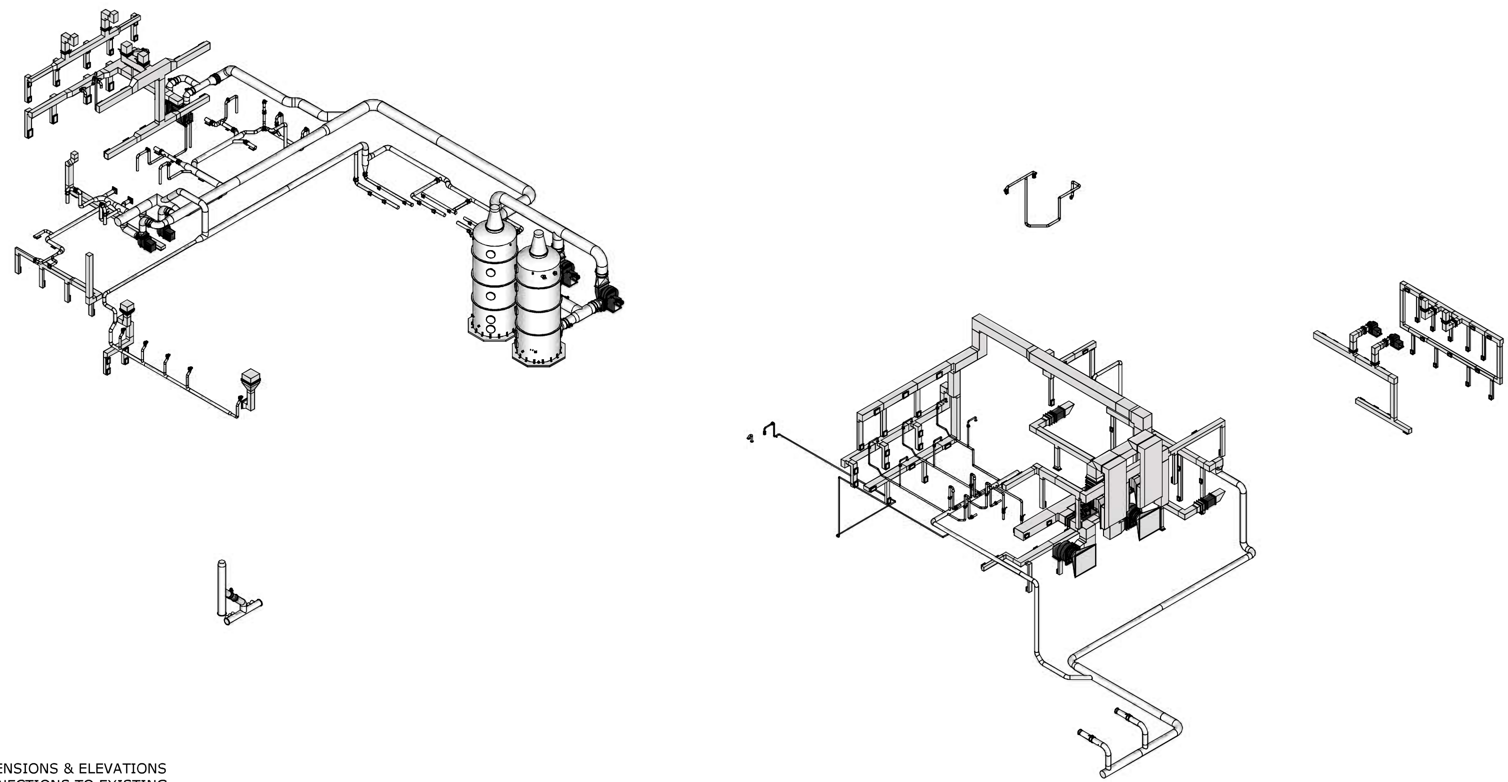
*Torque values are per ASTM 3982 Table 1

COUNTY OF HAWAII

HILO WWTP REHABILITATION AND REPLACEMENT
PROJECT PHASE 1

* Layout drawings will be reviewed and marked up by the Contractor. Once the layout dimensions are finalized, spool drawings shall be generated by Daniel Company and reviewed by the Contractor prior to fabrication release.

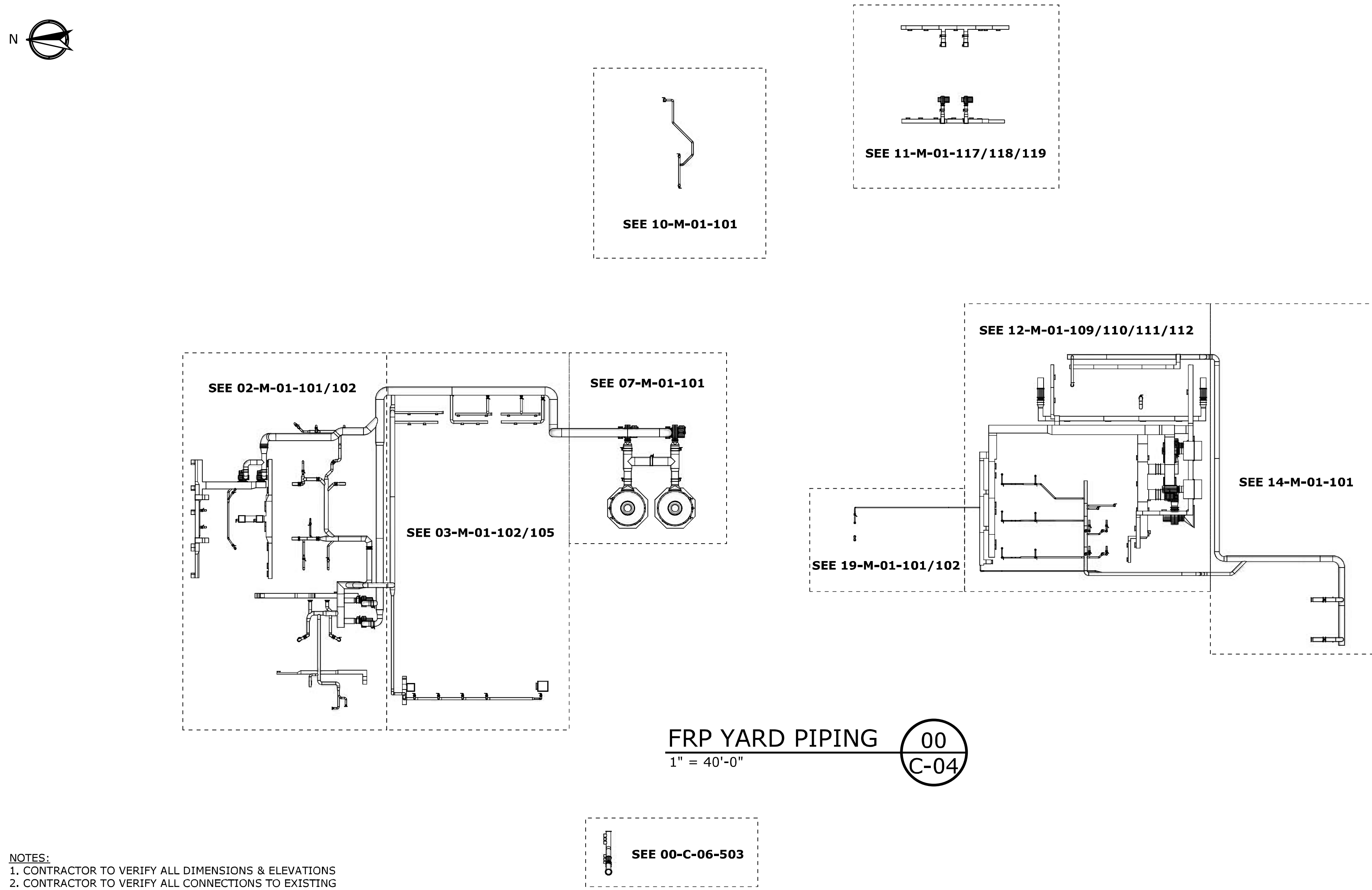
FRP DUCTWORK



NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: Title Page PAGE: 1 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - TITLE PAGE

DRAWN BY: KH LAYOUT REVISED: 1/08/2025

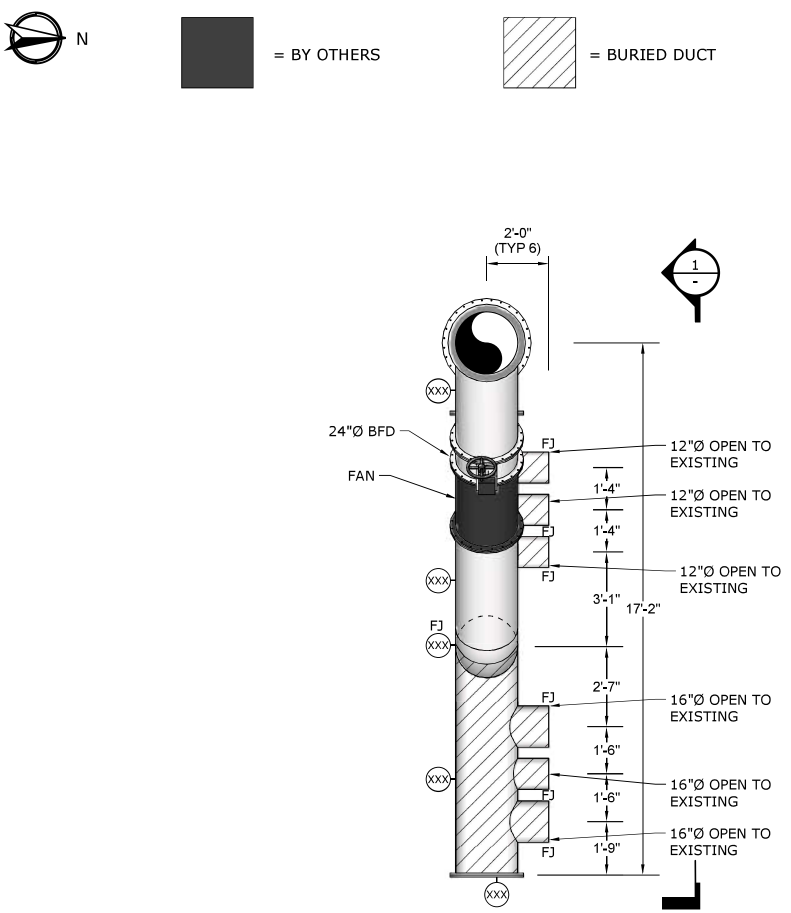


FRP YARD PIPING 00/C-04
1" = 40'-0"

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 00-C-04-102/103/106 PAGE: 2 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 00-C-04-102/103/106

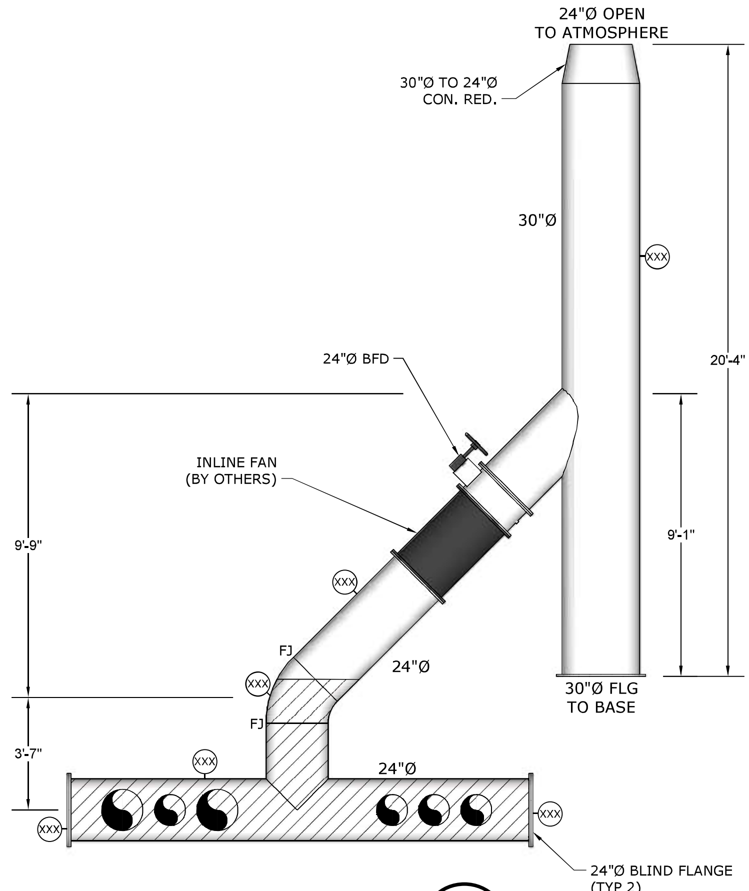
DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



TEMPORARY FOUL AIR STACK

1/4" = 1'-0"

00-C-06
506



SECTION 1

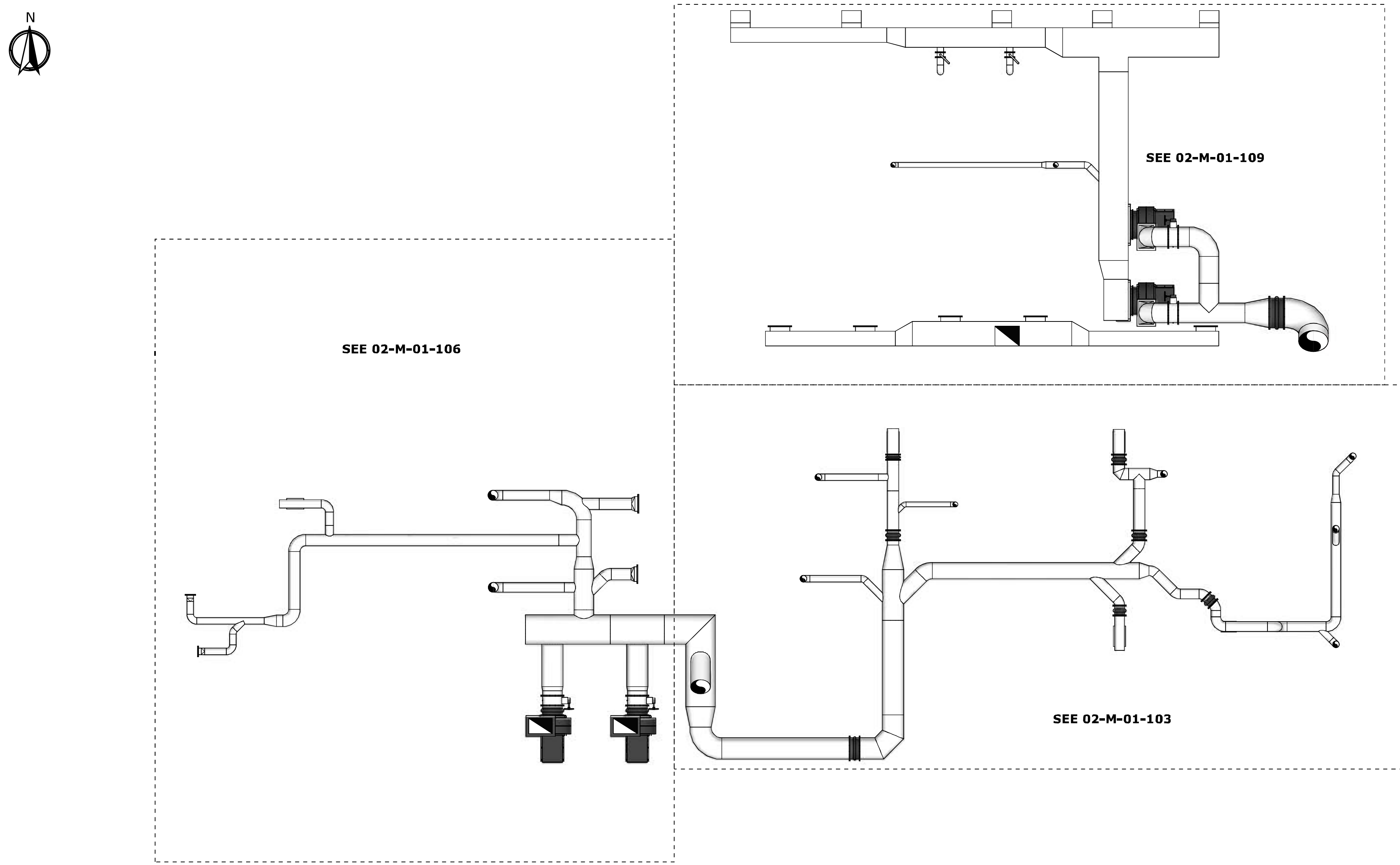
1/4" = 1'-0"

1
-

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 00-C-06-503 PAGE: 3 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 00-C-06-503

DRAWN BY: KH LAYOUT REVISED: 1/08/2025



HEADWORKS PLAN LOWER

1" = 10'-0"

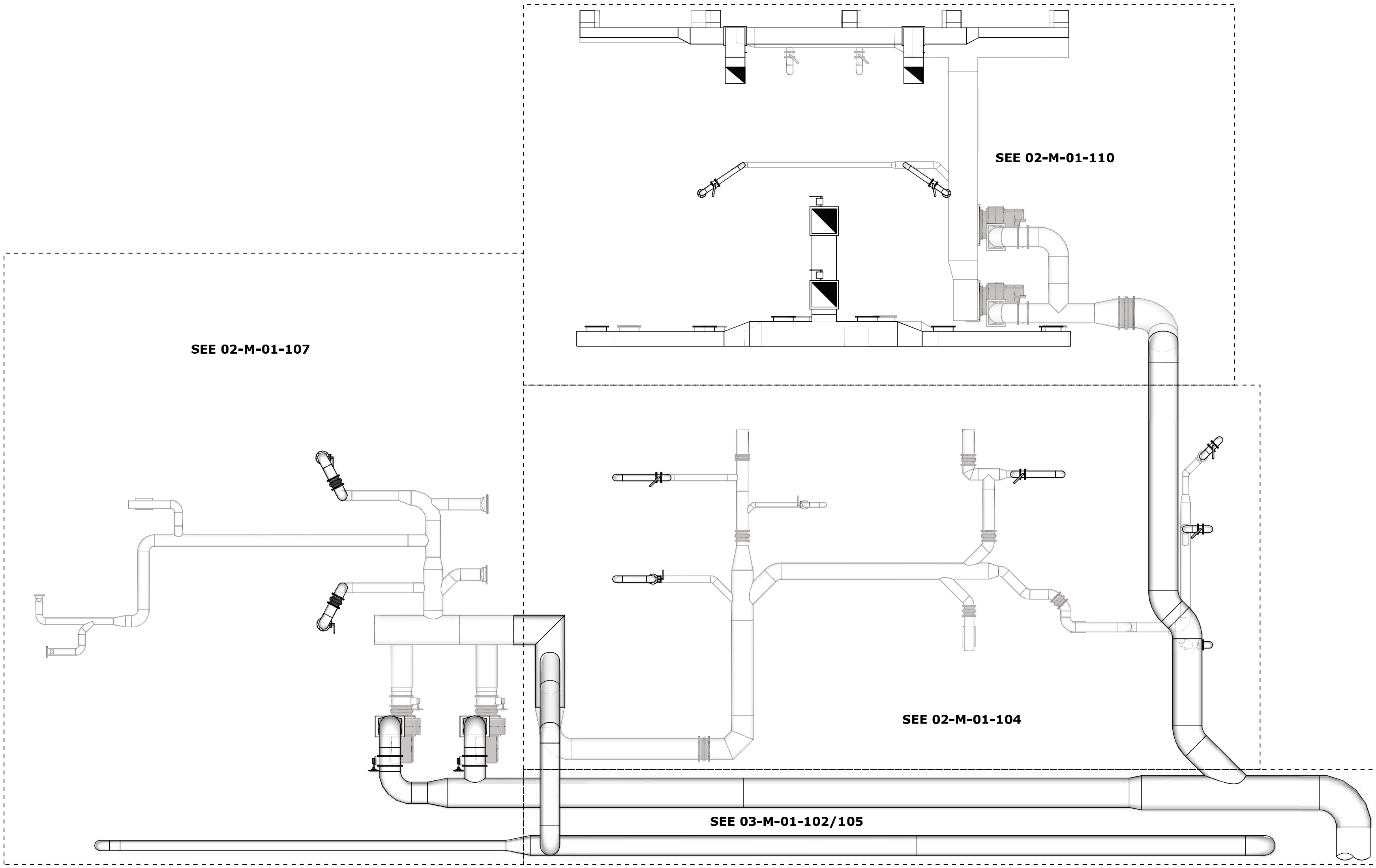
02-M-01
101

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-101 PAGE: 4 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-101/102
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025



HEADWORKS PLAN UPPER

1" = 10'-0"

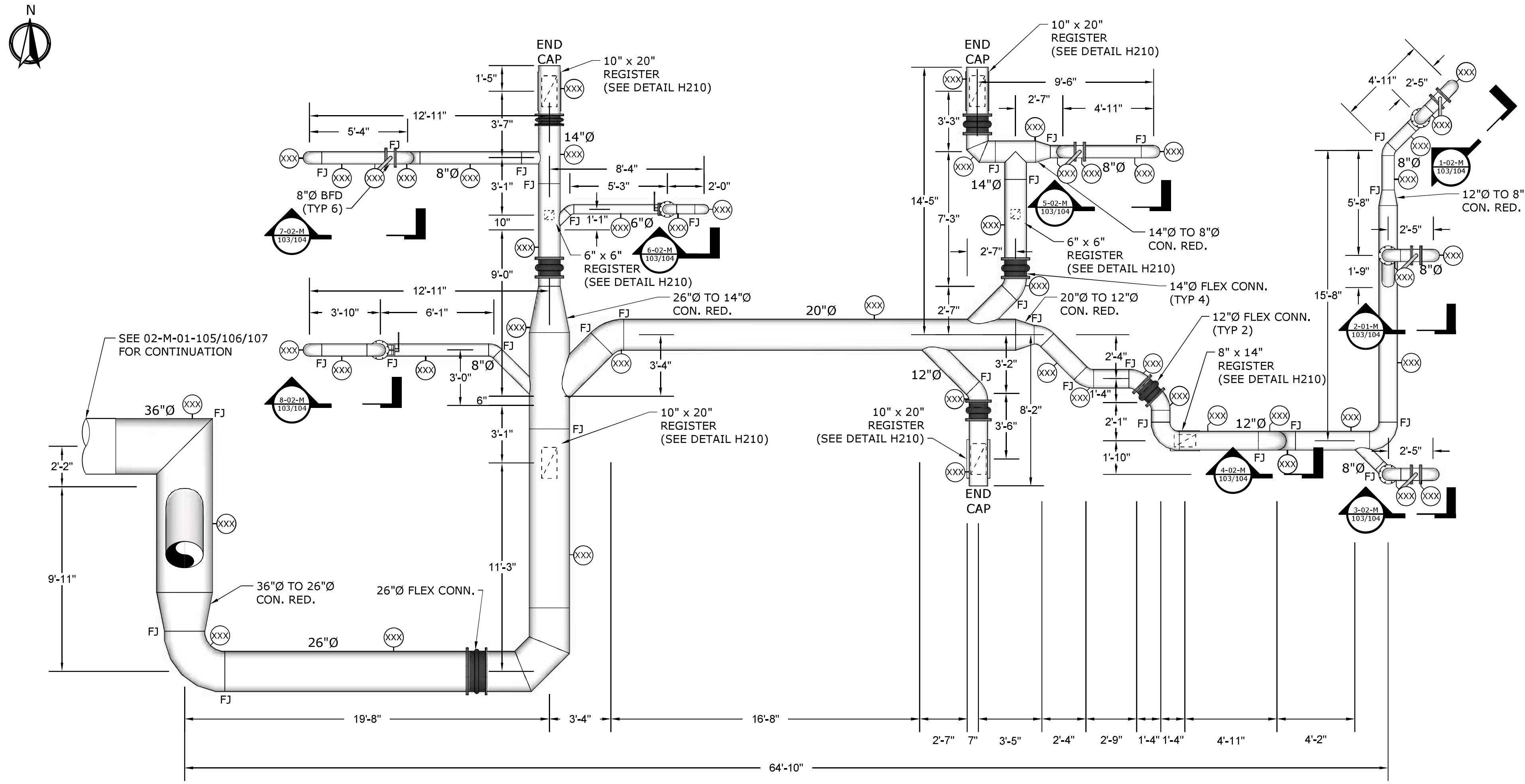
02-M-01
102

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-102 PAGE: 5 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025

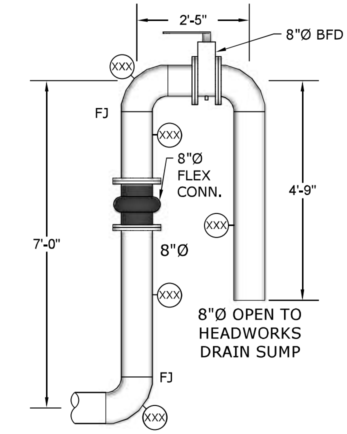


SCREENING CHANNEL PLAN 02-M-01 103/104
3/16" = 1'-0"

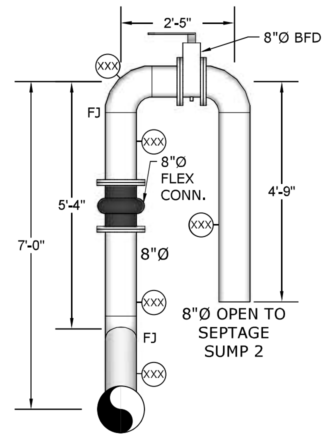
NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-103/104 PAGE: 6 DATE: 06/05/2025	DANIEL COMPANY	1939 W. 11th St. Ste. E	VERIFY SCALE	COUNTY OF HAWAII
5013 Hilo - FRP Ductwork	AIR • WATER • ENVIRONMENTAL • SOLUTIONS	Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	0 1" ORIGINAL IS 1" LONG	HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-103/104

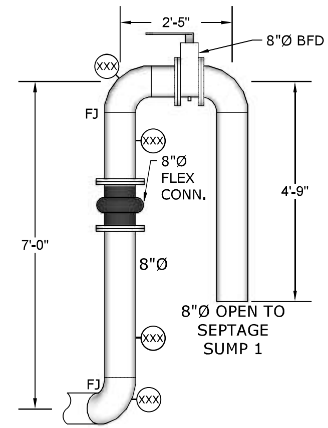
DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



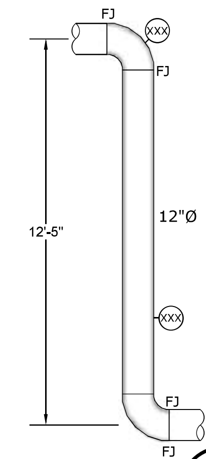
SECTION 1
3/8" = 1'-0"
1-02-M
103/104



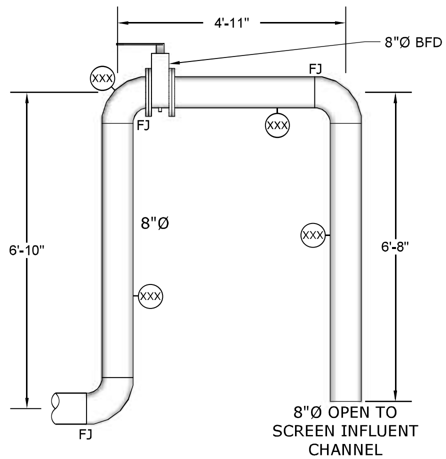
SECTION 2
3/8" = 1'-0"
2-02-M
103/104



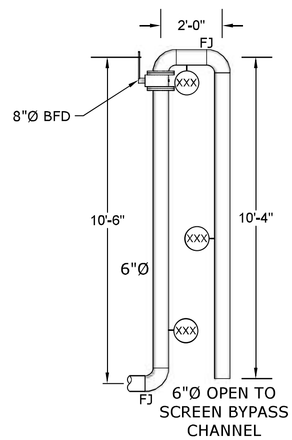
SECTION 3
3/8" = 1'-0"
3-02-M
103/104



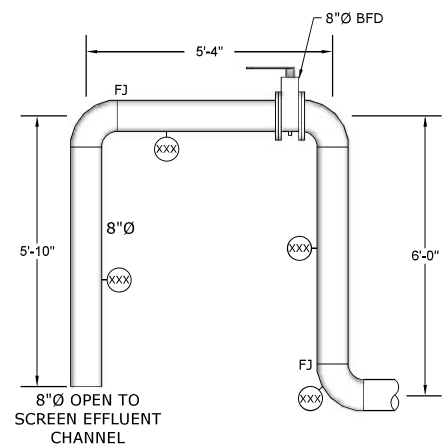
SECTION 4
3/8" = 1'-0"
4-02-M
103/104



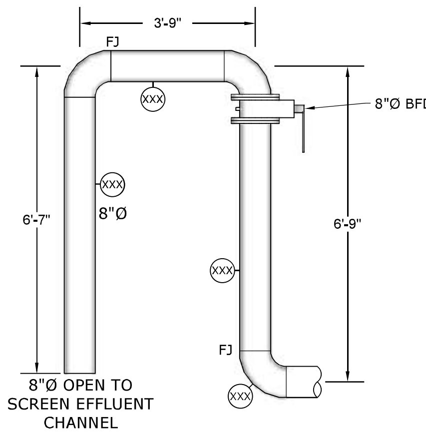
SECTION 5
3/8" = 1'-0"
5-02-M
103/104



SECTION 6
3/8" = 1'-0"
6-02-M
103/104



SECTION 7
3/8" = 1'-0"
7-02-M
103/104

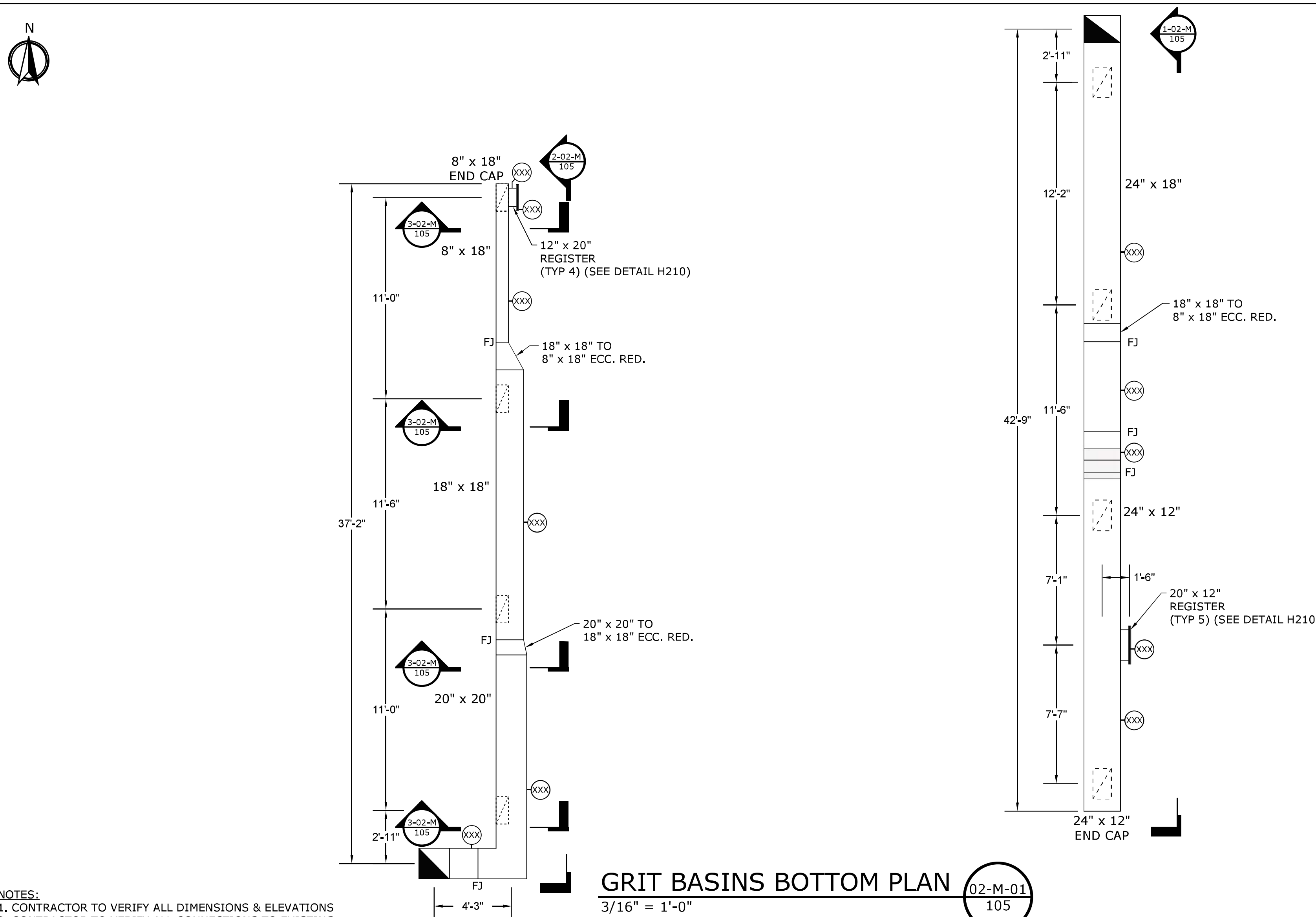


SECTION 8
3/8" = 1'-0"
8-02-M
103/104

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-103/104 SECTIONS PAGE: 7 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-103/104 SECTIONS

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



GRIT BASINS BOTTOM PLAN

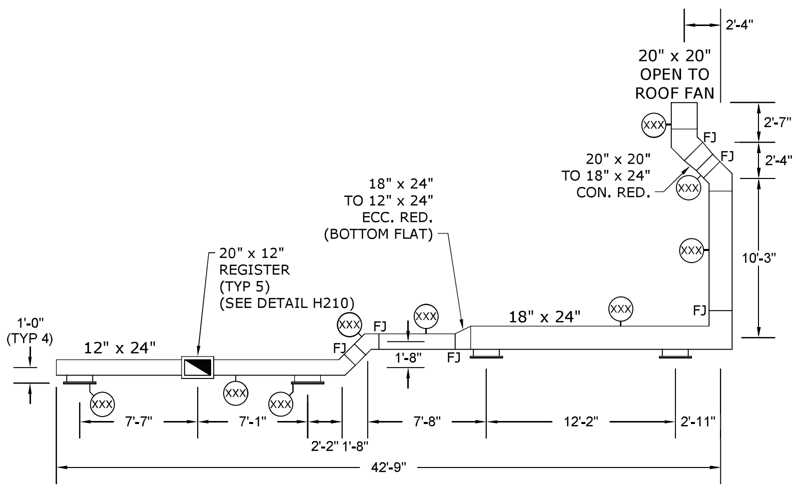
3/16" = 1'-0"

02-M-01
105

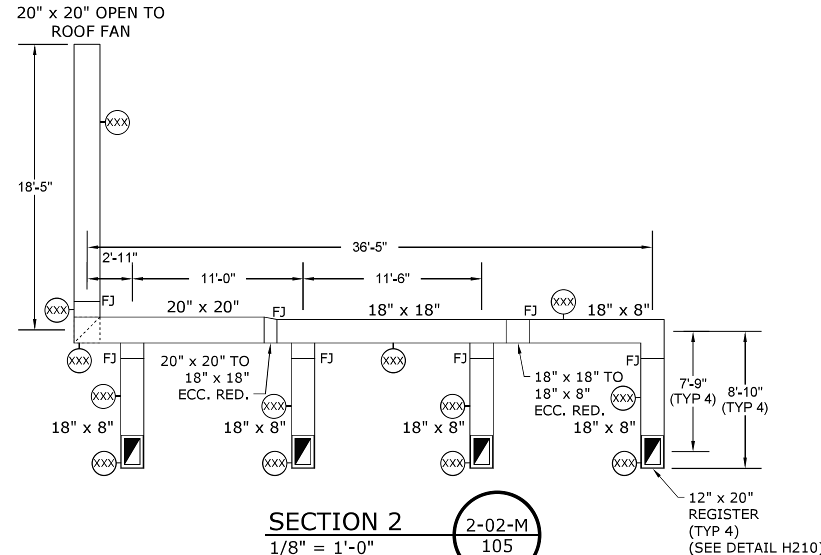
NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-105 PAGE: 8 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-105
5013 Hilo - FRP Ductwork				

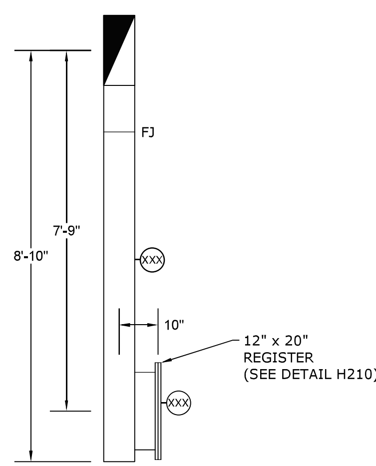
DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



SECTION 1
1/8" = 1'-0"
1-02-M
105



SECTION 2
1/8" = 1'-0"
2-02-M
105

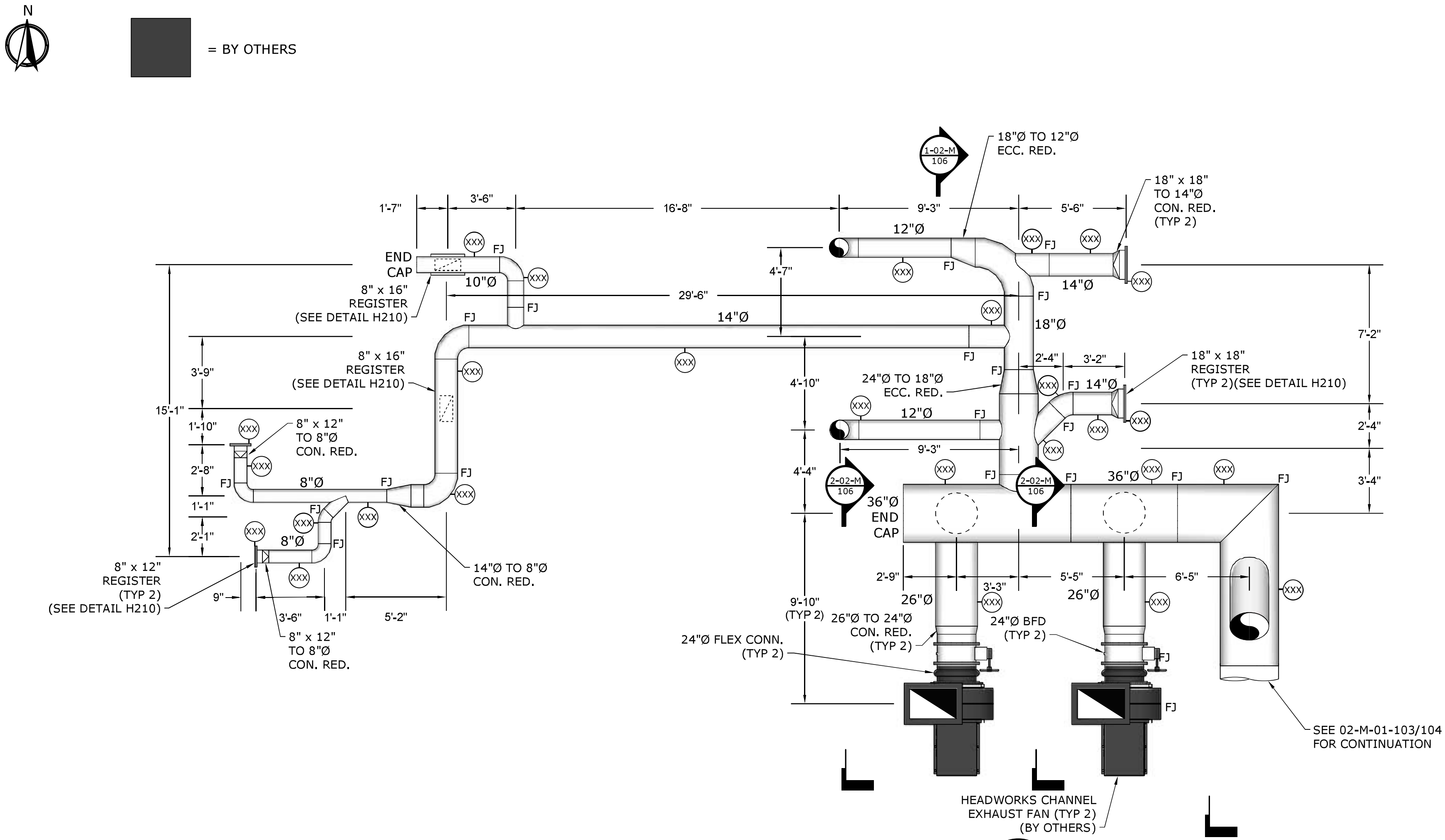


SECTION 3 (TYP 4)
3/8" = 1'-0"
3-02-M
105

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING
& EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-105 SECTIONS PAGE: 9 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-105 SECTIONS

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



GRIT BASINS CHANNEL PLAN

3/16" = 1'-0"

02-M-01
106

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-106 PAGE: 10 DATE: 06/05/2025

5013 Hilo - FRP Ductwork

DANIEL COMPANY
AIR • WATER • ENVIRONMENTAL • SOLUTIONS

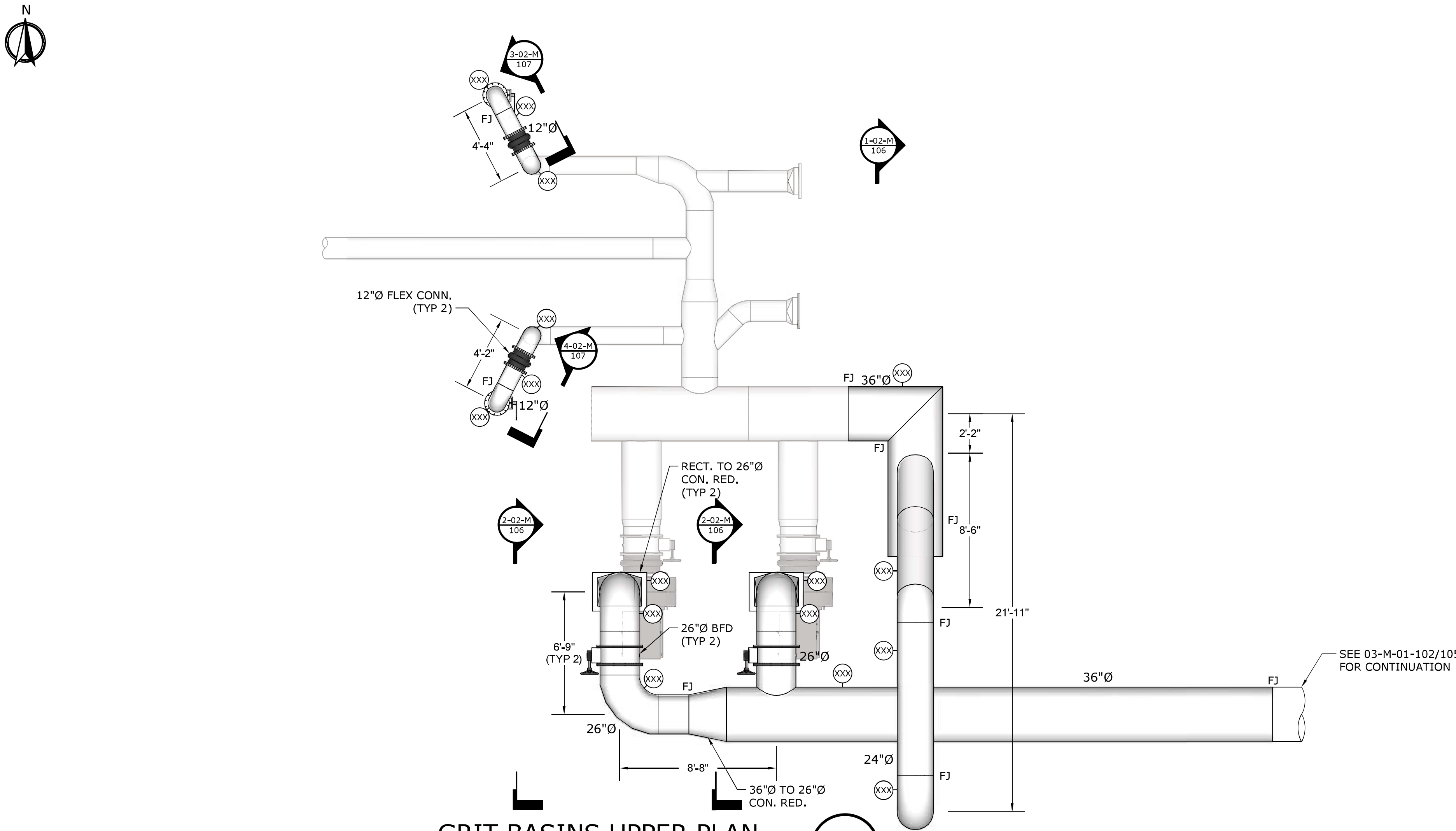
1939 W. 11th St. Ste. E
Upland, CA 91786
Phone: (909) 982-1555
Fax: (909) 982-1855

VERIFY SCALE
0 1"
ORIGINAL IS 1" LONG

COUNTY OF HAWAII
HILO WWTP REHABILITATION AND REPLACEMENT
PROJECT PHASE 1
FRP DUCTWORK - 02-M-01-106

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025



GRIT BASINS UPPER PLAN

3/16" = 1'-0"

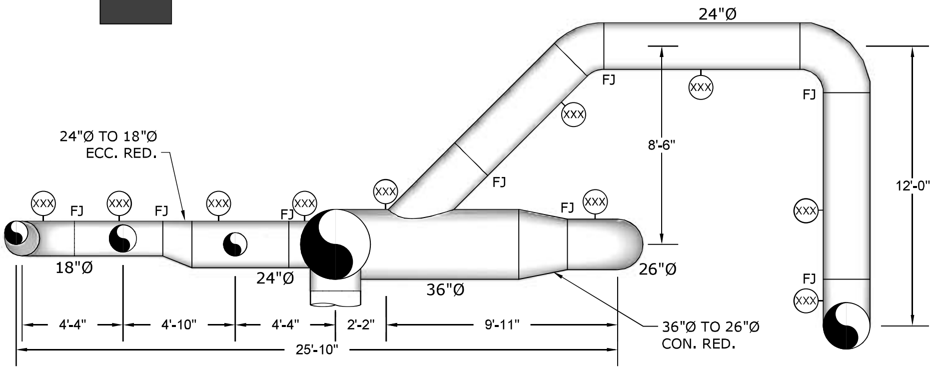
02-M-01 / 107

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

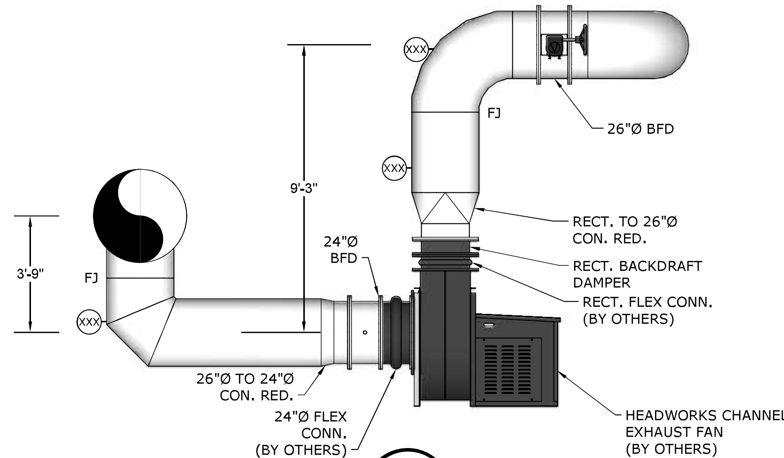
DWG: 02-M-01-107 PAGE: 11 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-107
5013 Hilo - FRP Ductwork				

DRAWN BY: KH LAYOUT REVISED: 1/08/2025

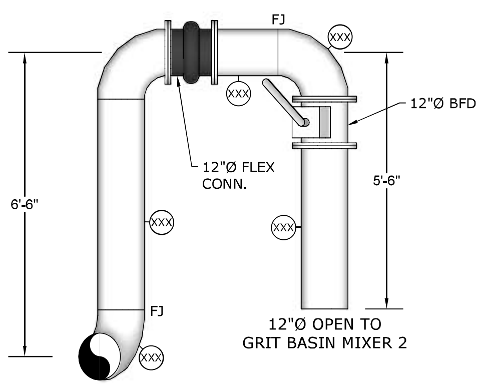
= BY OTHERS



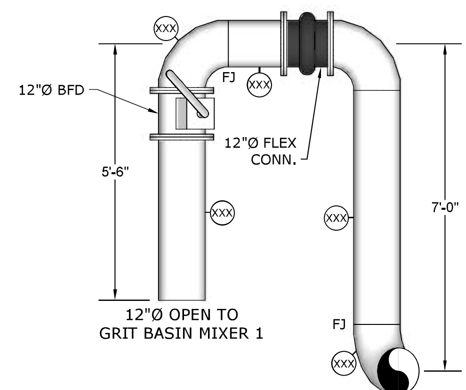
SECTION 1
3/16" = 1'-0"
1-02-M
106



SECTION 2 (TYP 2)
1/4" = 1'-0"
2-02-M
106



SECTION 3
3/8" = 1'-0"
3-02-M
107



SECTION 4
3/8" = 1'-0"
4-02-M
107

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

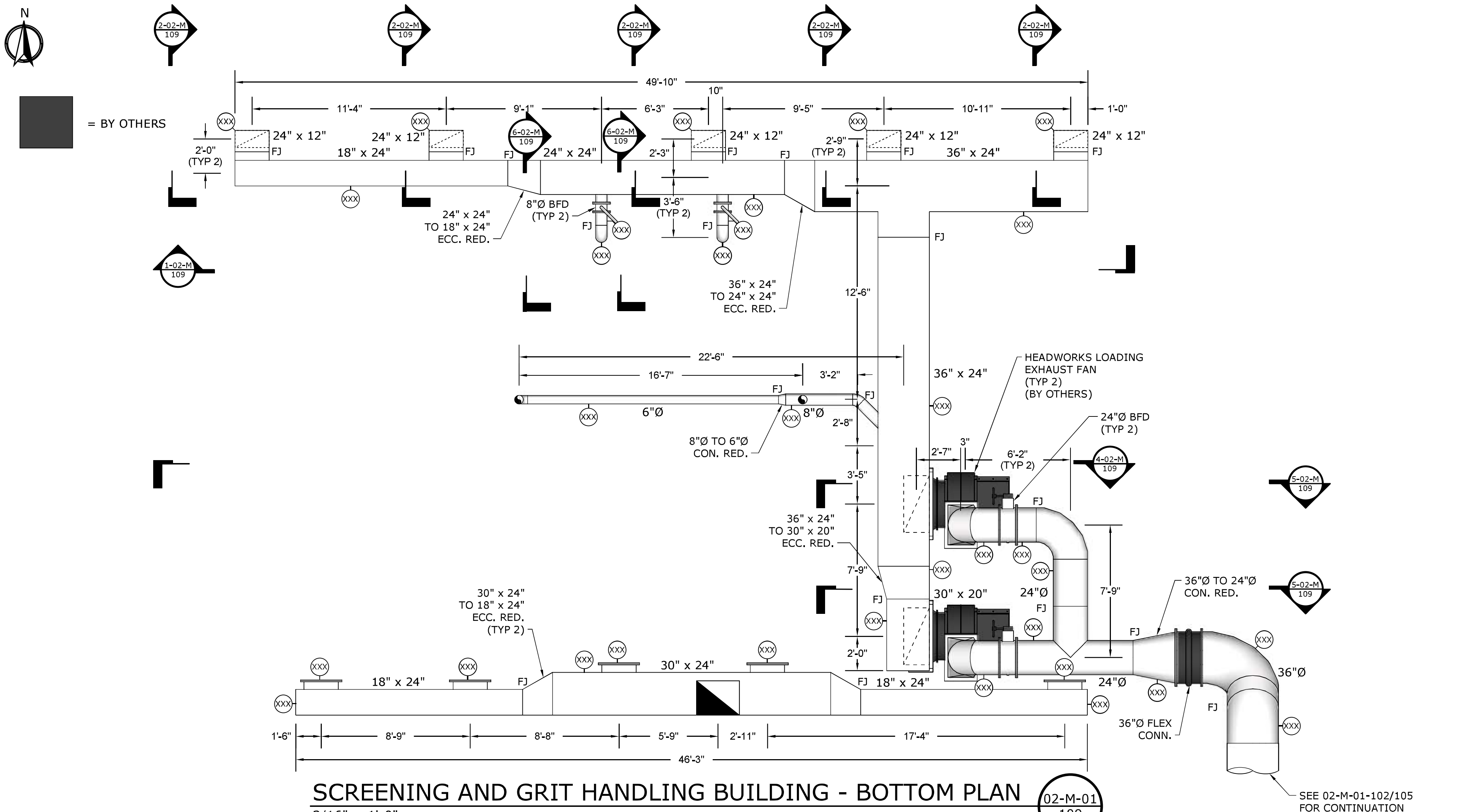
DWG: 02-M-01-106/107 SECTIONS PAGE: 12 DATE: 06/05/2025
5013 Hilo - FRP Ductwork

DANIEL COMPANY
AIR • WATER • ENVIRONMENTAL • SOLUTIONS
1939 W. 11th St. Ste. E
Upland, CA 91786
Phone: (909) 982-1555
Fax: (909) 982-1855

VERIFY SCALE
0 1"
ORIGINAL IS
1" LONG

COUNTY OF HAWAII
HILO WWTP REHABILITATION AND REPLACEMENT
PROJECT PHASE 1
FRP DUCTWORK - 02-M-01-106/107 SECTIONS

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



SCREENING AND GRIT HANDLING BUILDING - BOTTOM PLAN

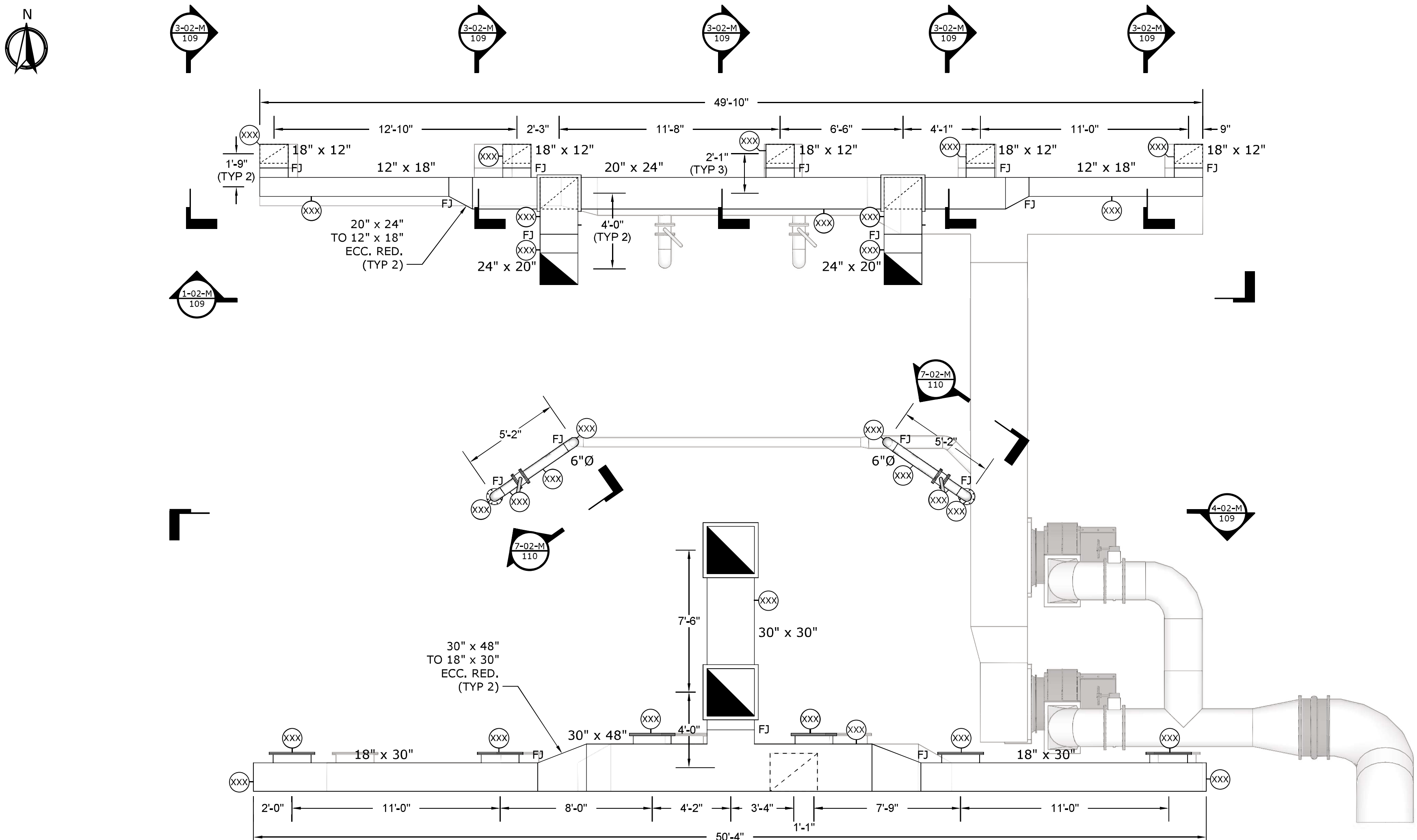
3/16" = 1'-0"

02-M-01
109

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-109 PAGE: 13 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-109
5013 Hilo - FRP Ductwork				

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



SCREENING AND GRIT HANDLING BUILDING - INTERMEDIATE PLAN

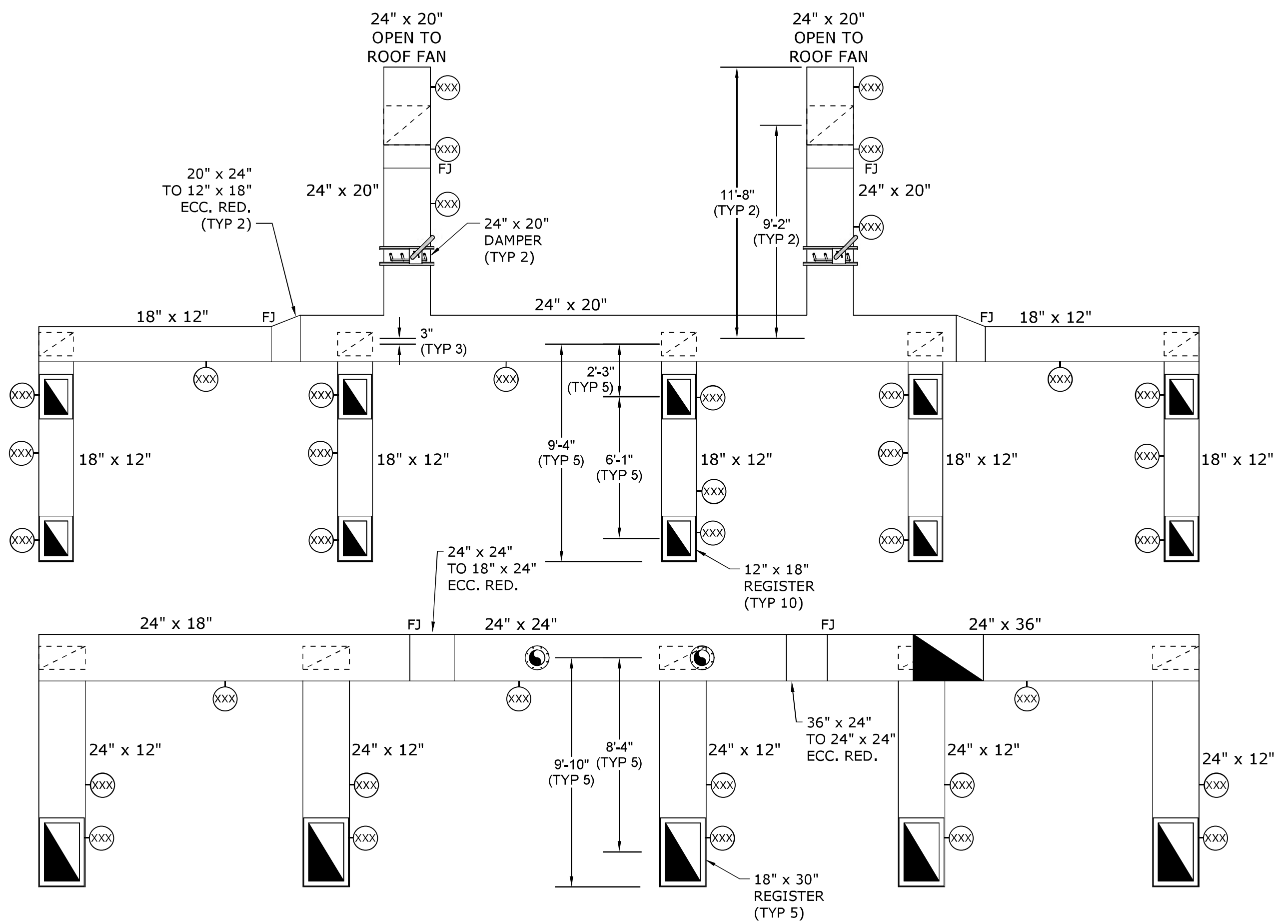
02-M-01
110

3/16" = 1'-0"

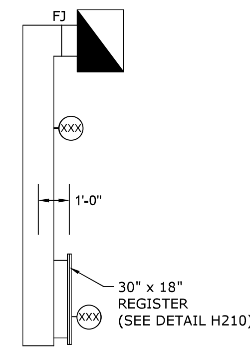
NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-110 PAGE: 14 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-110
5013 Hilo - FRP Ductwork				

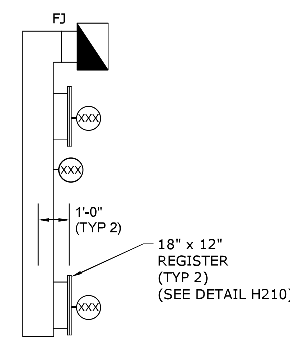
DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



SECTION 1
3/16" = 1'-0"
1-02-M
109



SECTION 2 (TYP 5)
1/4" = 1'-0"
2-02-M
109



SECTION 3 (TYP 5)
1/4" = 1'-0"
3-02-M
109

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING
& EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-109/110 SECTIONS 1 PAGE: 15 DATE: 06/05/2025
5013 Hilo - FRP Ductwork

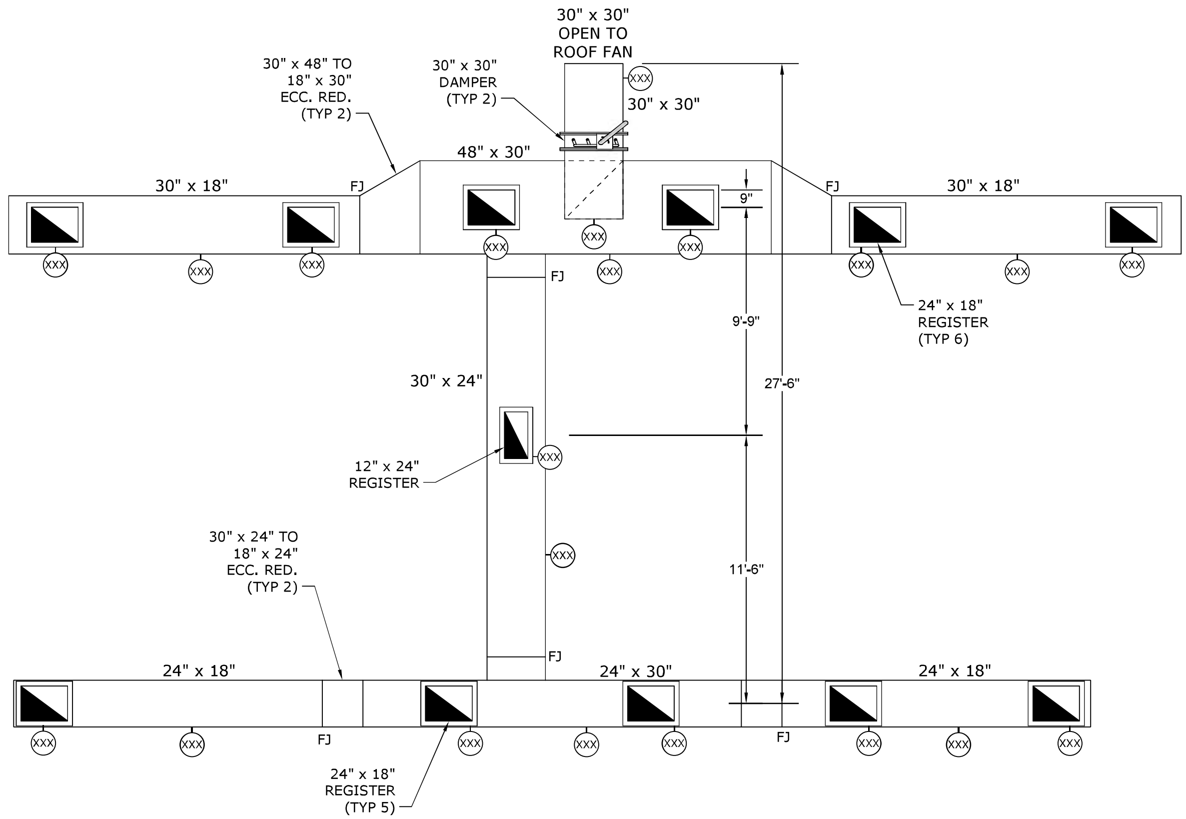
DANIEL COMPANY
AIR • WATER • ENVIRONMENTAL • SOLUTIONS

1939 W. 11th St. Ste. E
Upland, CA 91786
Phone: (909) 982-1555
Fax: (909) 982-1855

VERIFY SCALE
0 1"
ORIGINAL IS
1" LONG

COUNTY OF HAWAII
HILO WWTP REHABILITATION AND REPLACEMENT
PROJECT PHASE 1
FRP DUCTWORK - 02-M-01-109/110 SECTIONS 1

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



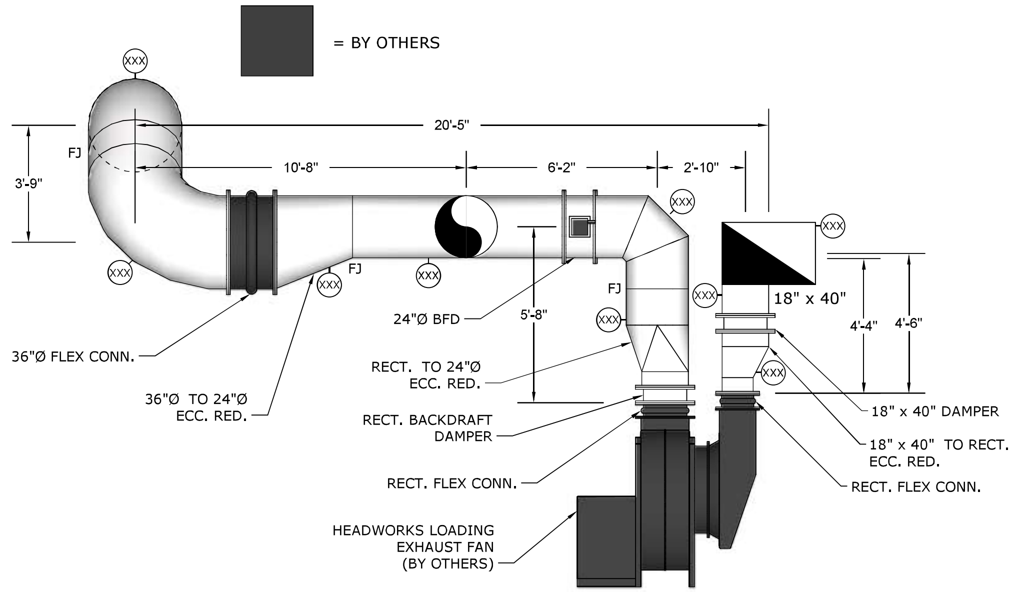
SECTION 4
3/16" = 1'-0"

4-02-M
109

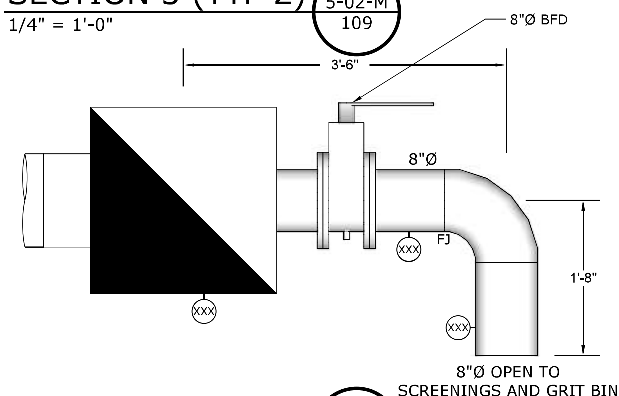
NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING
& EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-109/110 SECTIONS 2 PAGE: 16 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-109/110 SECTIONS 2

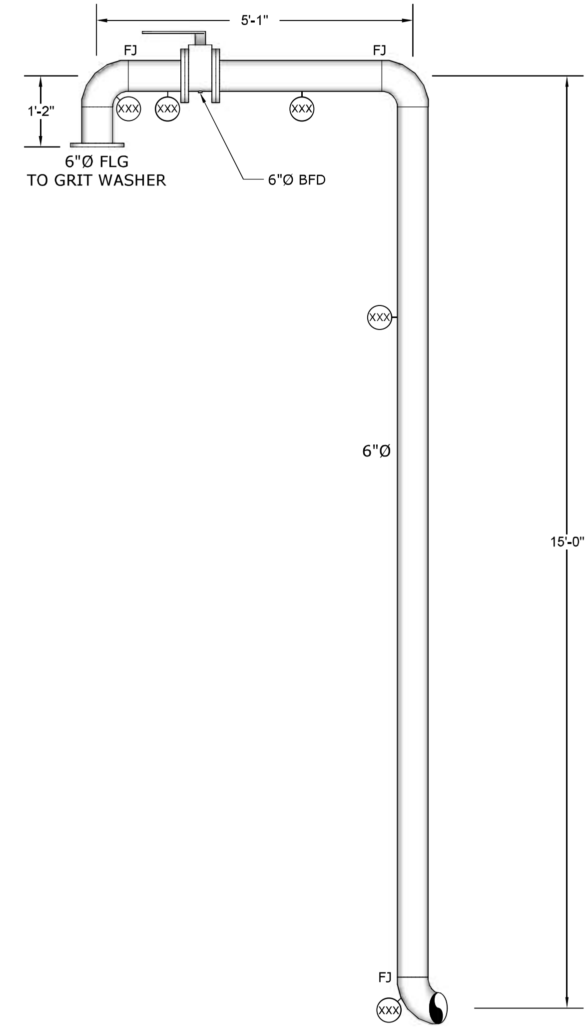
DRAWN BY: KH LAYOUT REVISED: 1/08/2025



SECTION 5 (TYP 2)
1/4" = 1'-0"



SECTION 6 (TYP 2)
3/4" = 1'-0"

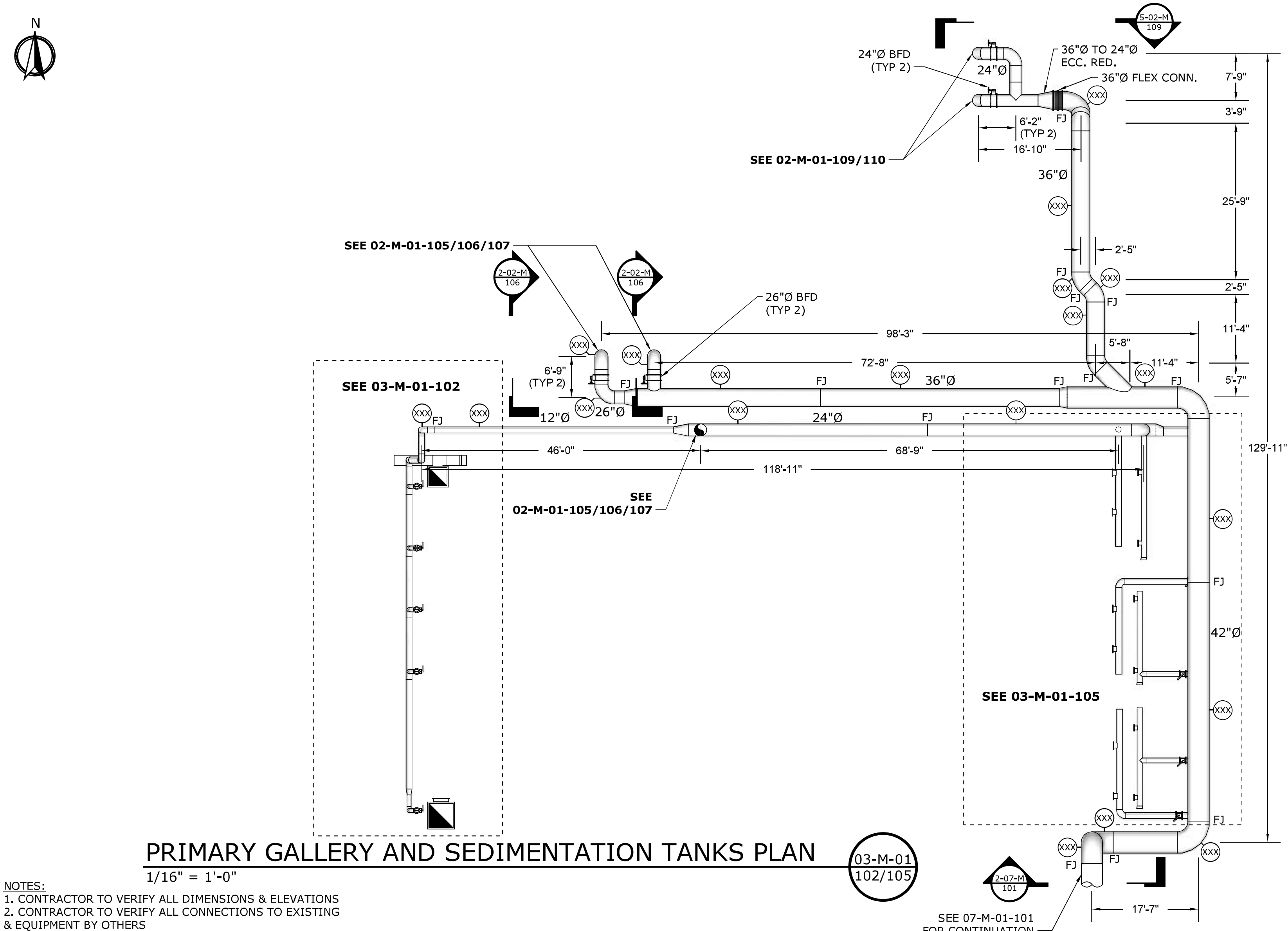


SECTION 7 (TYP 2)
1/2" = 1'-0"

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 02-M-01-109/110 SECTION 3 PAGE: 17 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 02-M-01-109/110 SECTIONS 3

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



PRIMARY GALLERY AND SEDIMENTATION TANKS PLAN

1/16" = 1'-0"

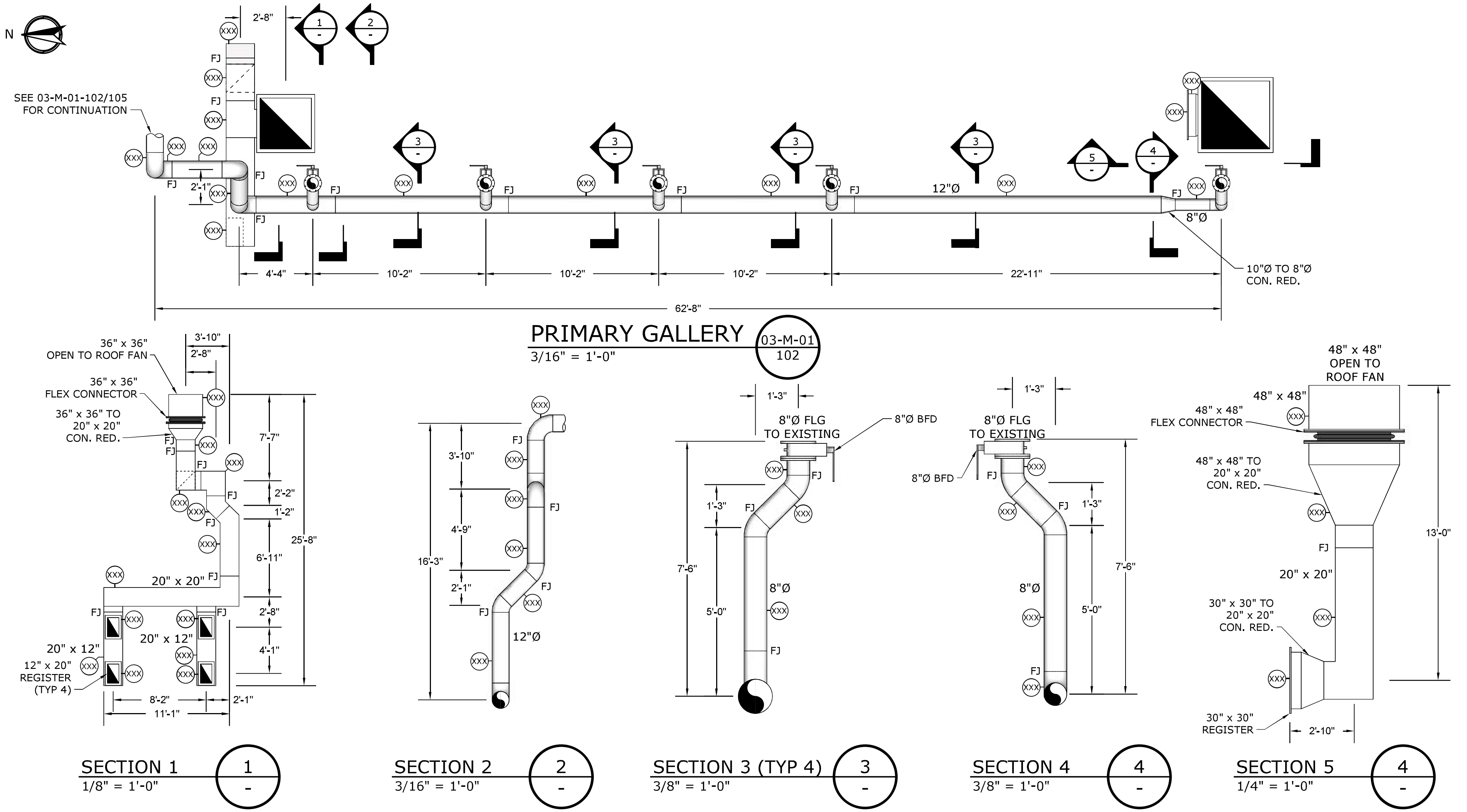
03-M-01
102/105

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 03-M-01-102/105 PAGE: 18 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 03-M-01-102/105
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

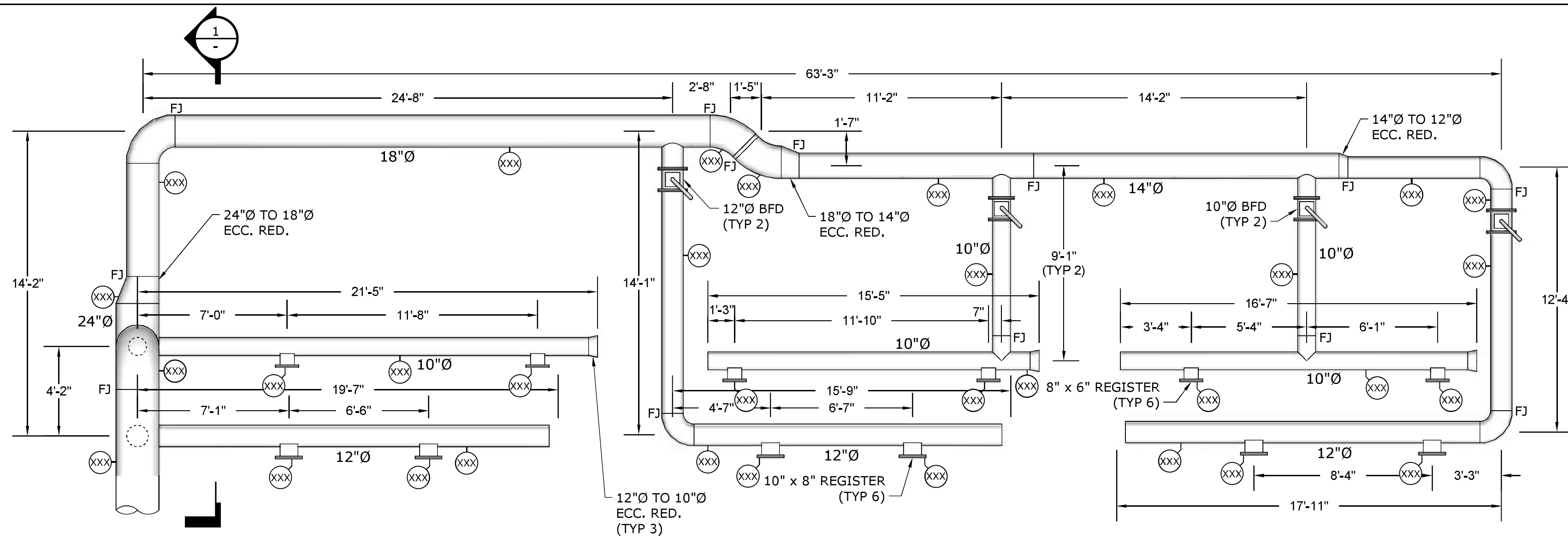
LAYOUT REVISED: 1/08/2025



NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 03-M-01-102 PAGE: 19 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 03-M-01-102
5013 Hilo - FRP Ductwork				

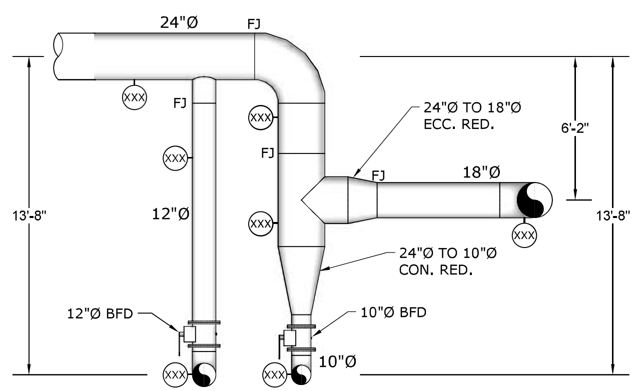
DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



PRIMARY GALLERY

3/16" = 1'-0"

03-M-01
105



SECTION 1

3/16" = 1'-0"

1
-

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 03-M-01-105 PAGE: 20 DATE: 06/05/2025

5013 Hilo - FRP Ductwork

DANIEL COMPANY
AIR • WATER • ENVIRONMENTAL • SOLUTIONS

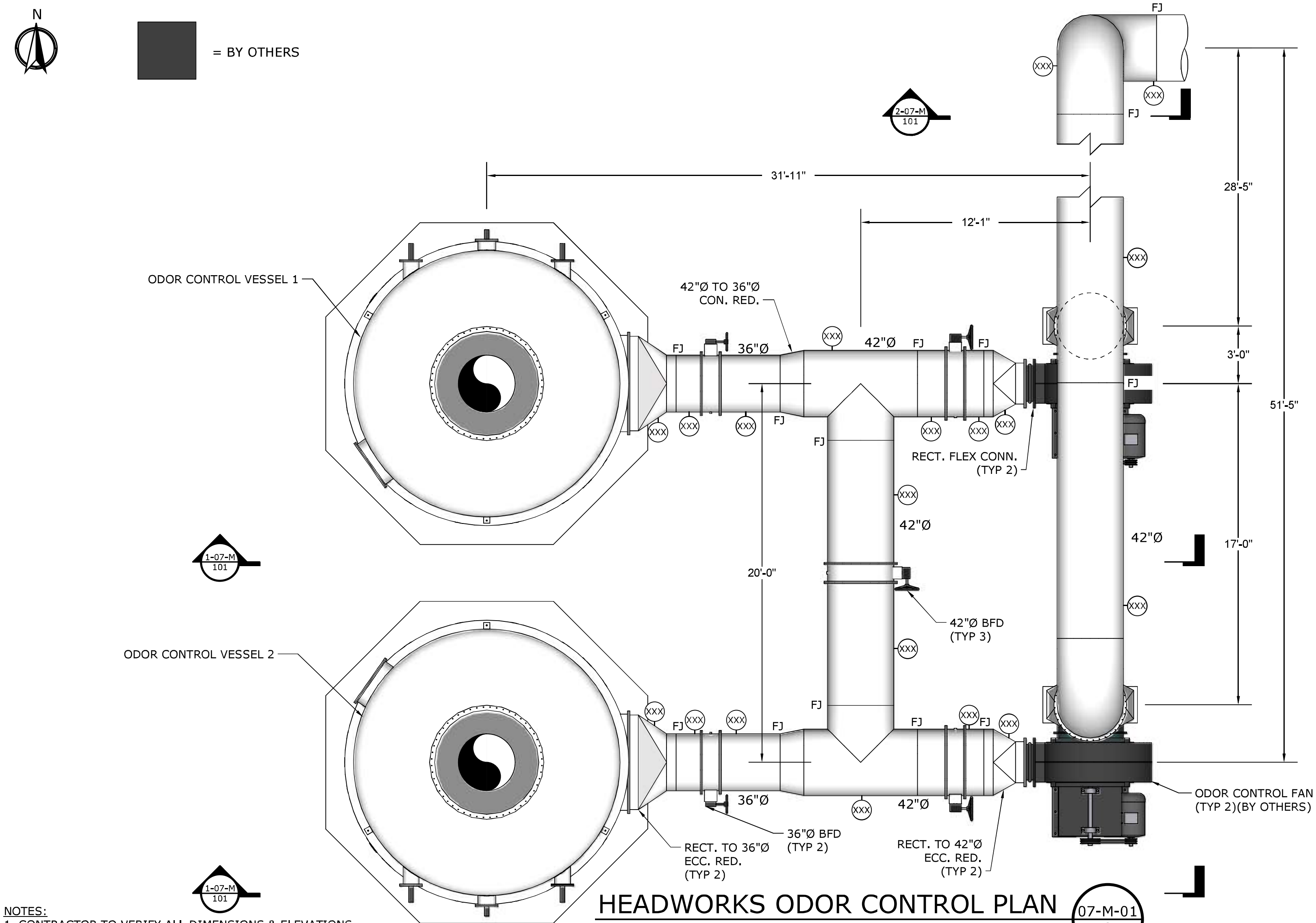
1939 W. 11th St. Ste. E
Upland, CA 91786
Phone: (909) 982-1555
Fax: (909) 982-1855

VERIFY SCALE
0 1"
ORIGINAL IS
1" LONG

COUNTY OF HAWAII
HILO WWTP REHABILITATION AND REPLACEMENT
PROJECT PHASE 1
FRP DUCTWORK - 03-M-01-105

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025



HEADWORKS ODOR CONTROL PLAN

3/16" = 1'-0"

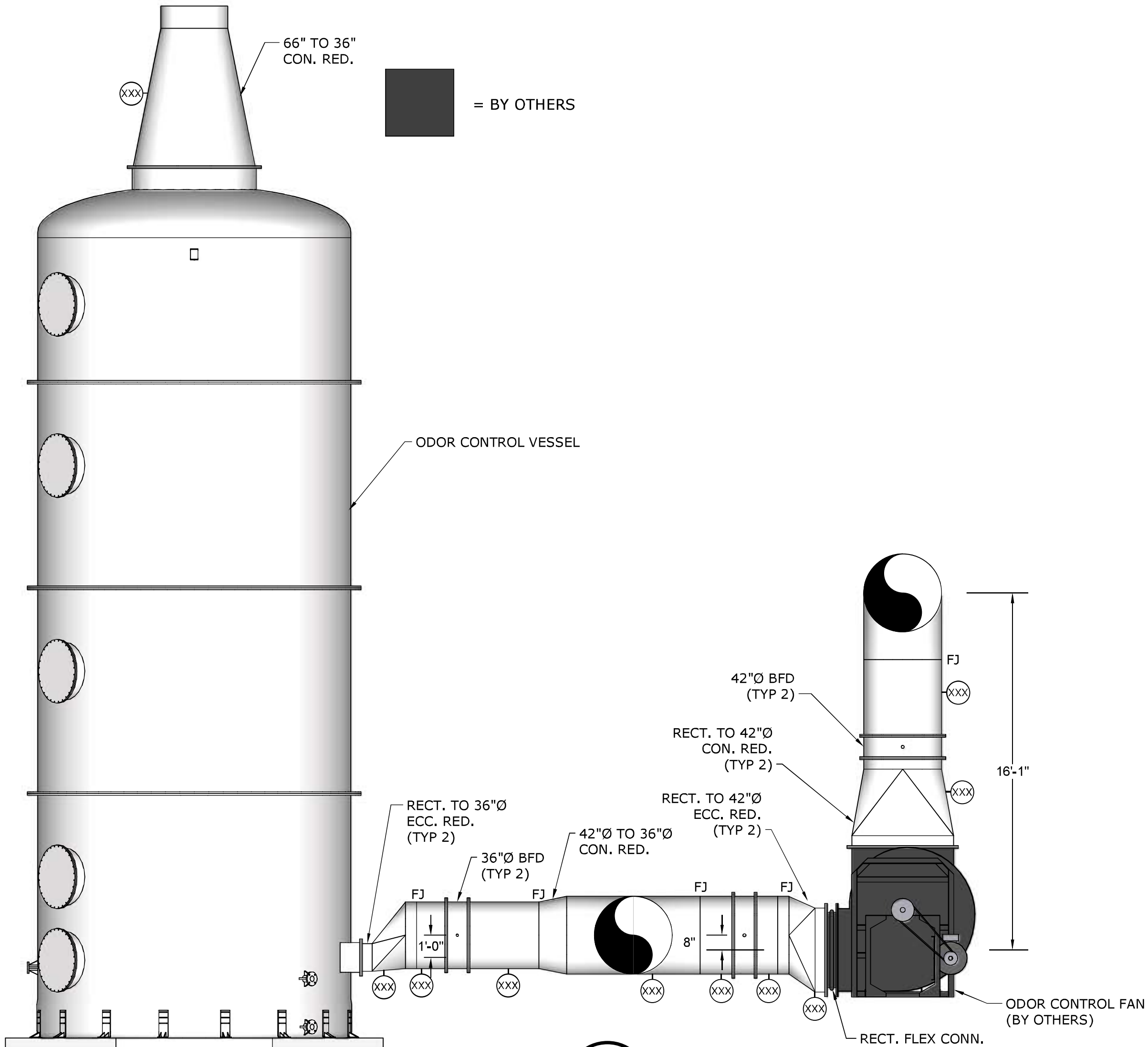
07-M-01
101

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 07-M-01-101 PAGE: 21 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 07-M-01-101

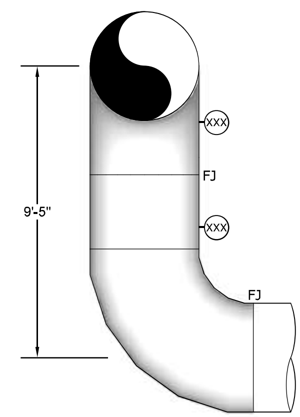
DRAWN BY: KH

LAYOUT REVISED: 1/08/2025



NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

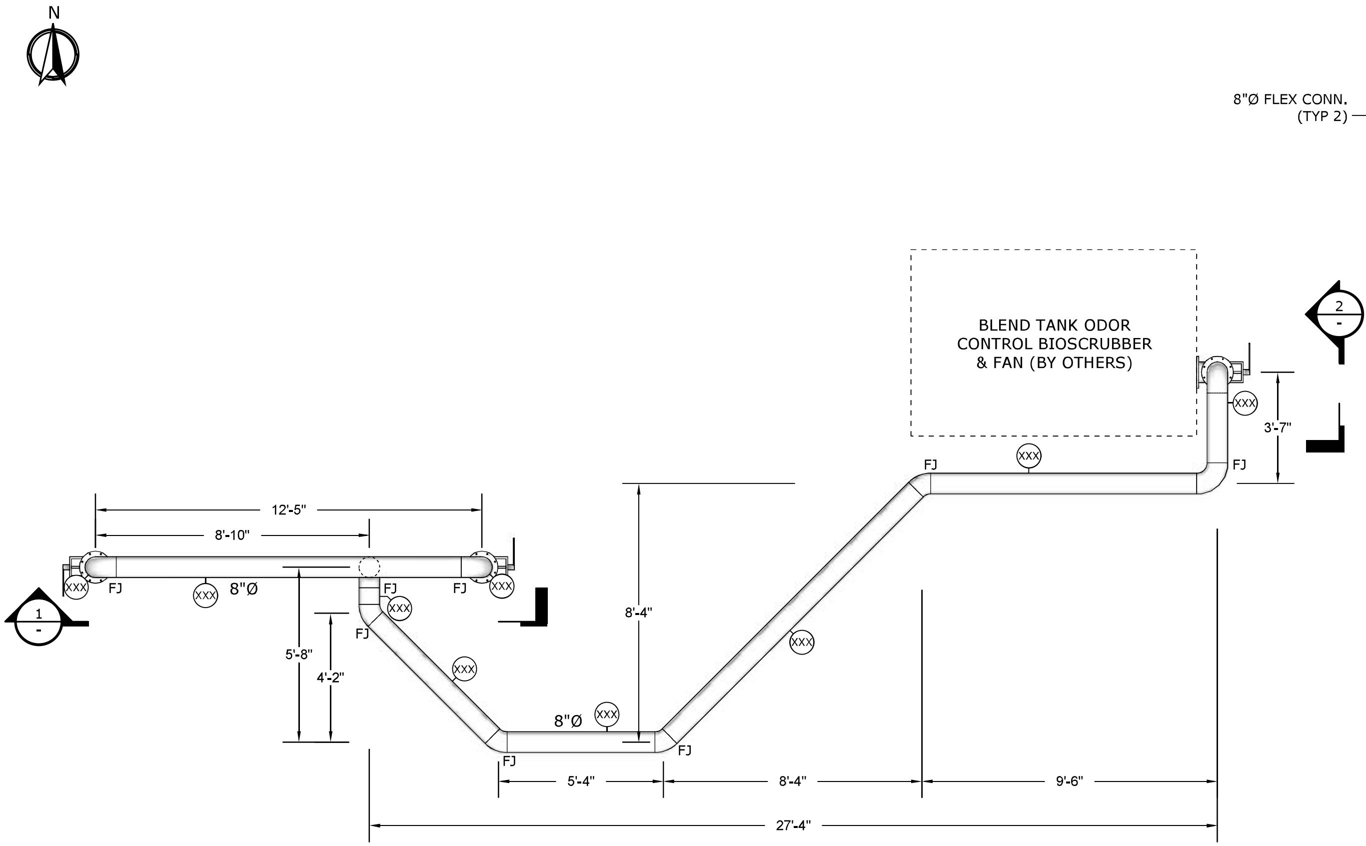
SECTION 2 (TYP 2)
3/16" = 1'-0"
1-07-M
101



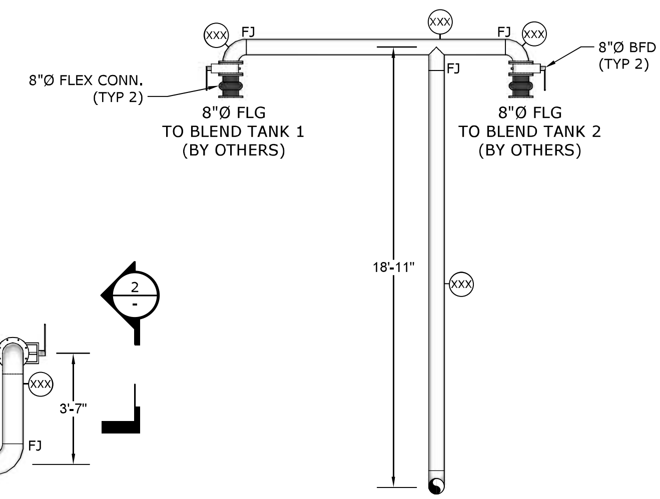
SECTION 2
1/4" = 1'-0"
2-07-M
101

DWG: 07-M-01-101 SECTIONS PAGE: 22 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 07-M-01-101 SECTIONS
5013 Hilo - FRP Ductwork				

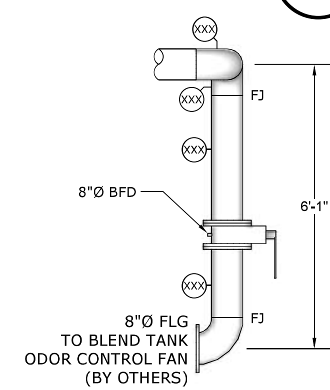
DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



SLUDGE BLENDING PLAN
1/4" = 1'-0"
10-M-01
101



SECTION 1
3/16" = 1'-0"
1
-

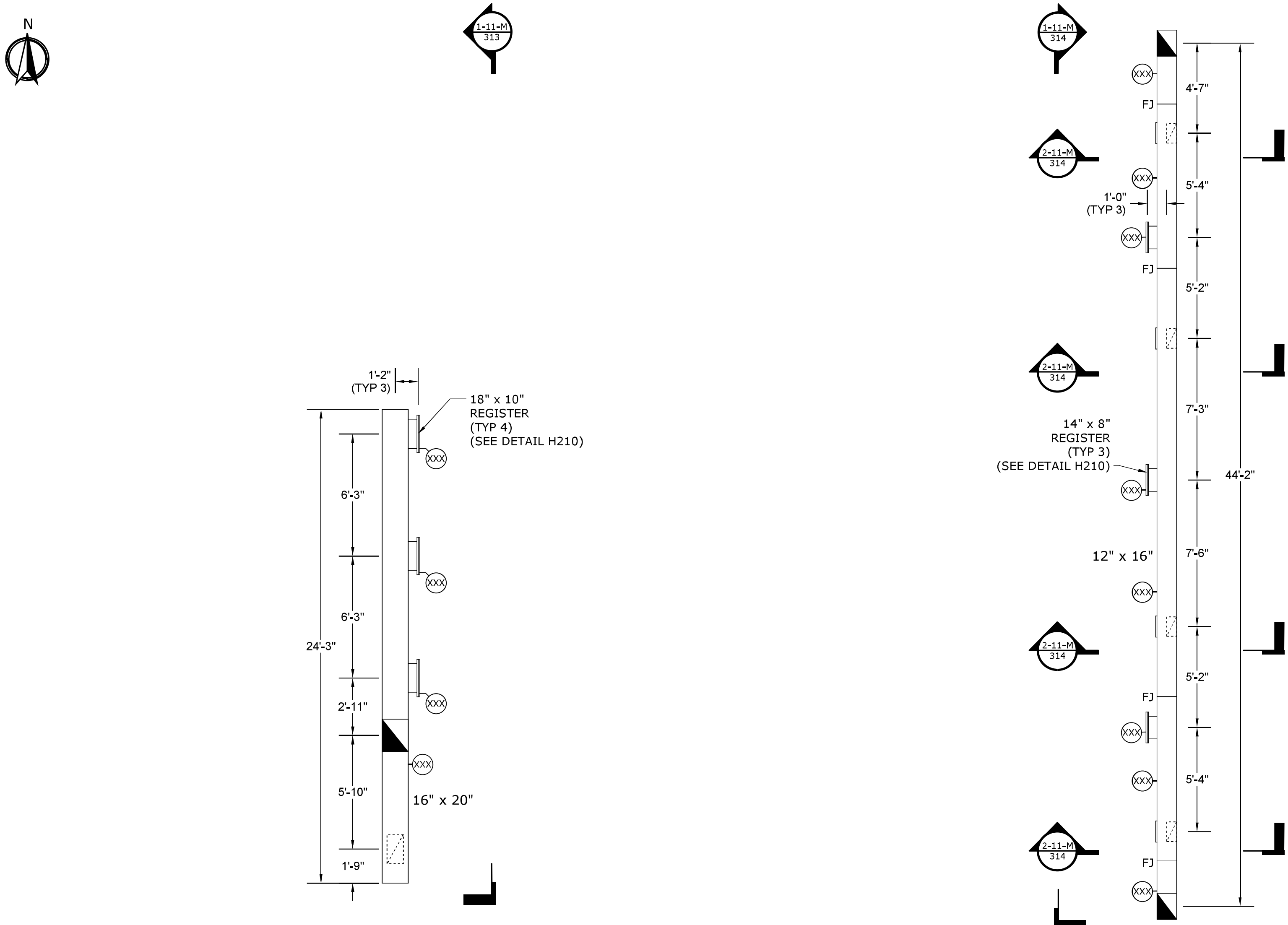


SECTION 2
3/8" = 1'-0"
2
-

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 10-M-01-101 PAGE: 23 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 10-M-01-101
5013 Hilo - FRP Ductwork				

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



DIGESTER CONTROL BUILDING 2 BASEMENT HVAC PLAN

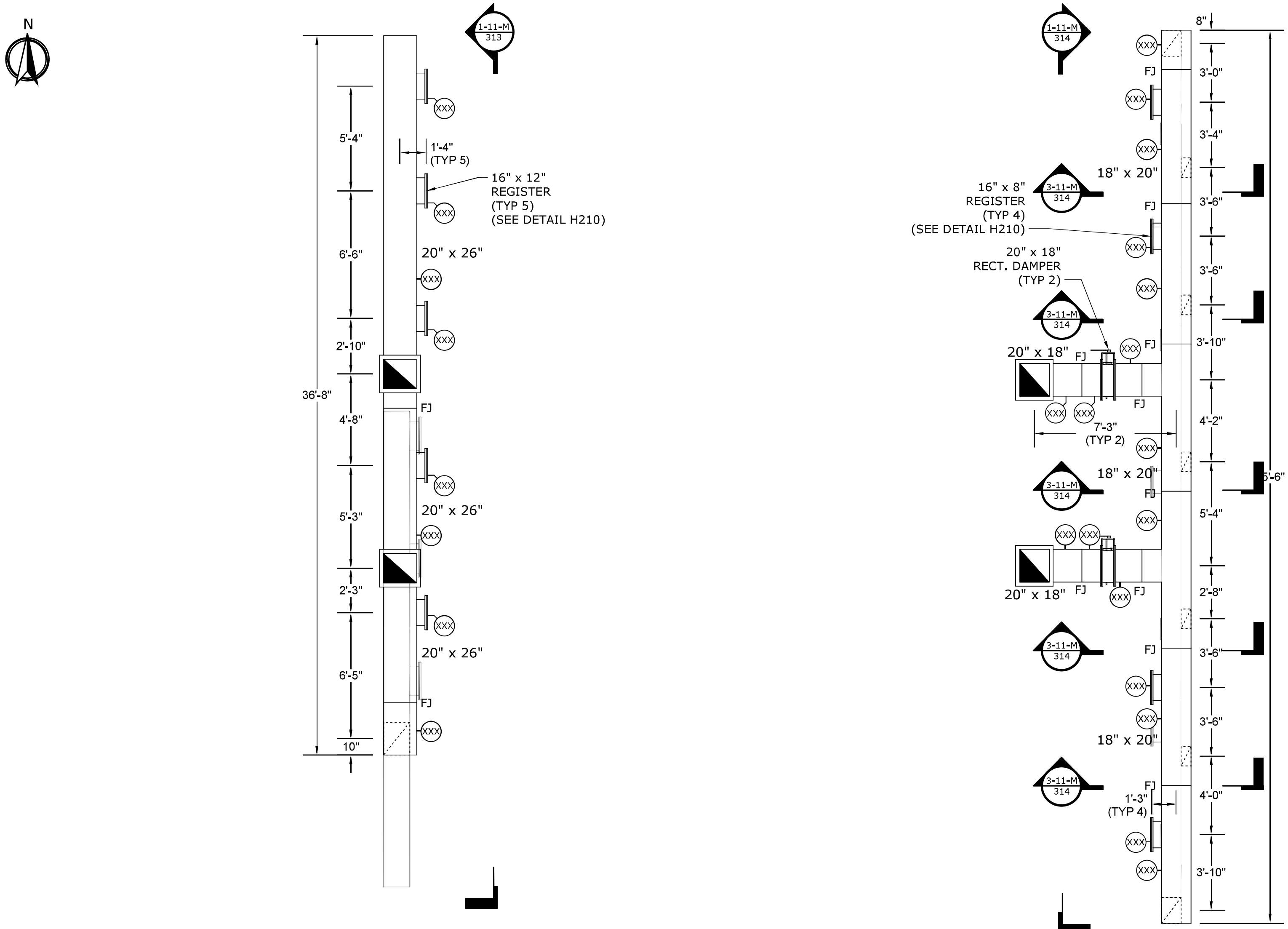
3/16" = 1'-0"

11-M-01
117

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 11-M-01-117 PAGE: 24 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 11-M-01-117

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



DIGESTER CONTROL BUILDING 2 FLOOR HVAC PLAN

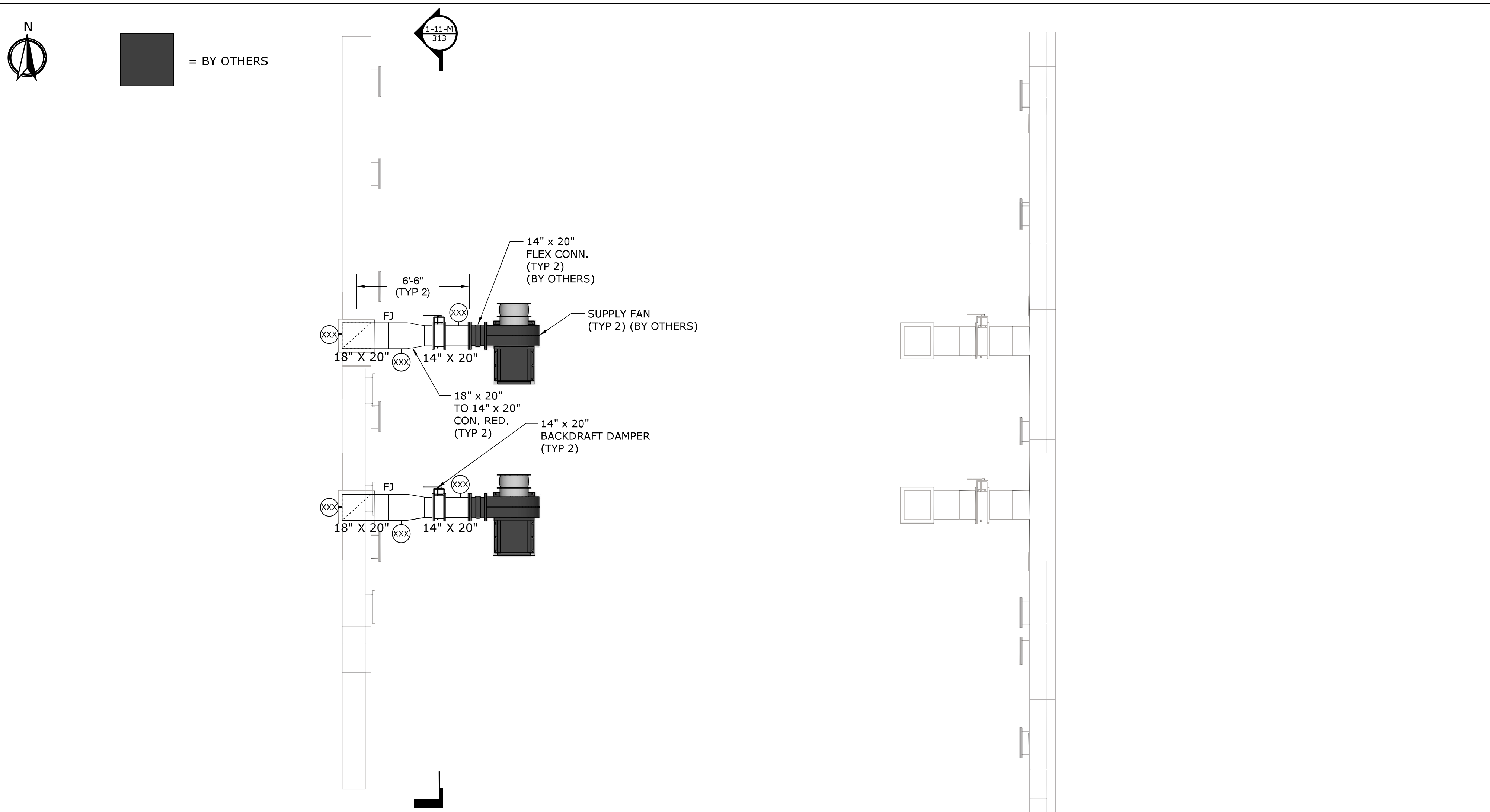
3/16" = 1'-0"

11-M-01
118

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 11-M-01-118 PAGE: 25 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 11-M-01-118

DRAWN BY: KH LAYOUT REVISED: 1/08/2025



NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DIGESTER CONTROL BUILDING 2 ROOF HVAC PLAN

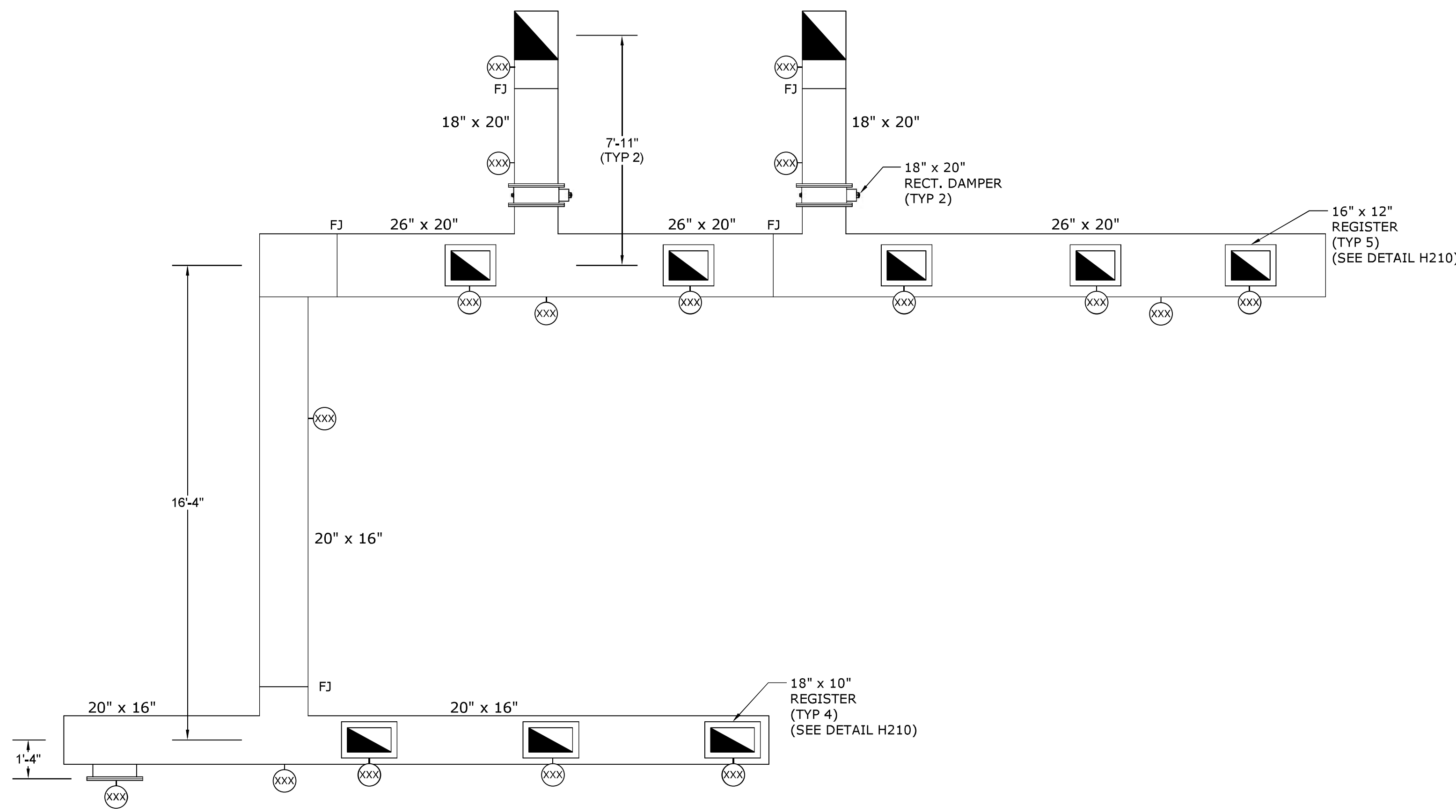
3/16" = 1'-0"

11-M-01
119

DWG: 11-M-01-119 PAGE: 26 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 11-M-01-119
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025



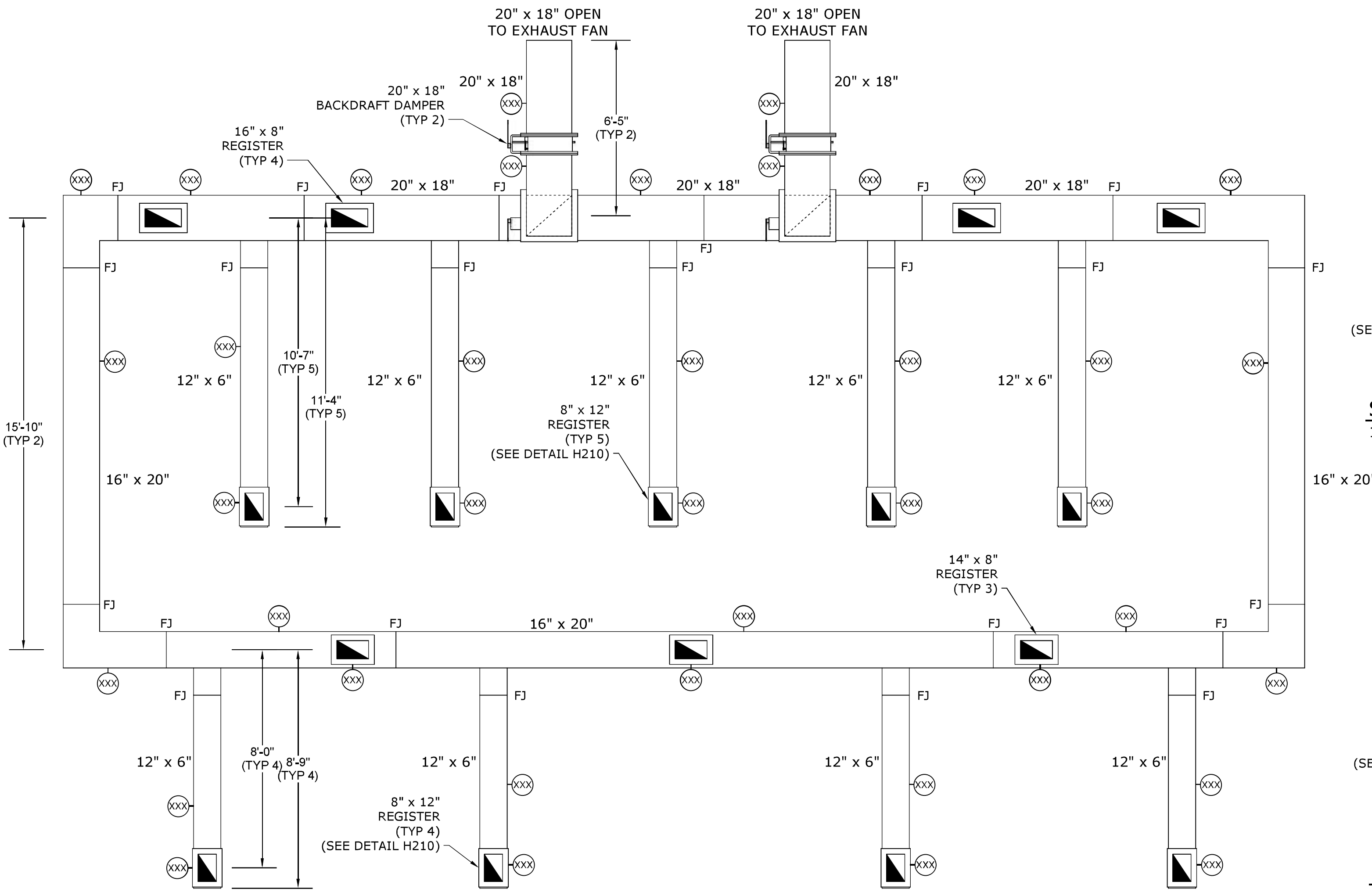
SECTION 1
1/4" = 1'-0"

1-11-M
313

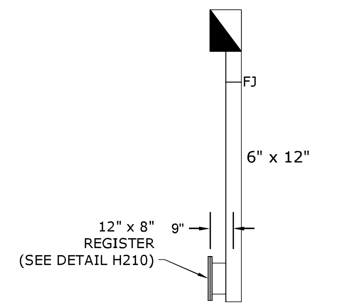
NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 11-M-01-313 PAGE: 27 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 11-M-01-313
5013 Hilo - FRP Ductwork				

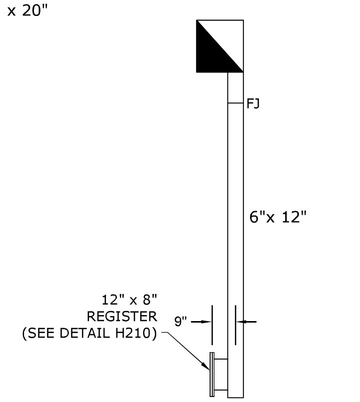
DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



SECTION 2
1/4" = 1'-0"
2-11-M
314



SECTION 3 (TYP 4)
1/4" = 1'-0"
3-11-M
314

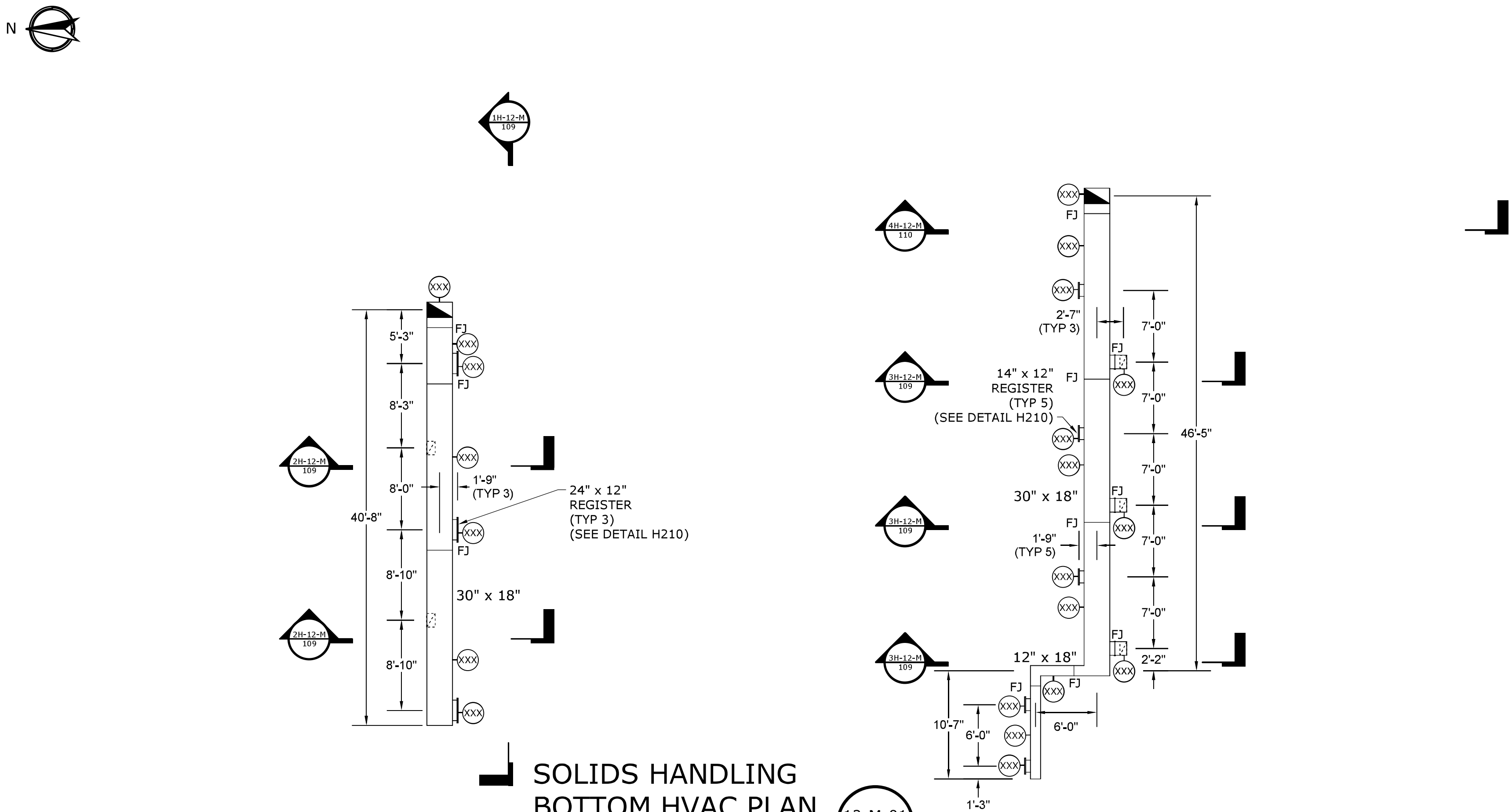


SECTION 4 (TYP 5)
1/4" = 1'-0"
4-11-M
314

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 11-M-01-314 PAGE: 28 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 11-M-01-314

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



SOLIDS HANDLING BOTTOM HVAC PLAN

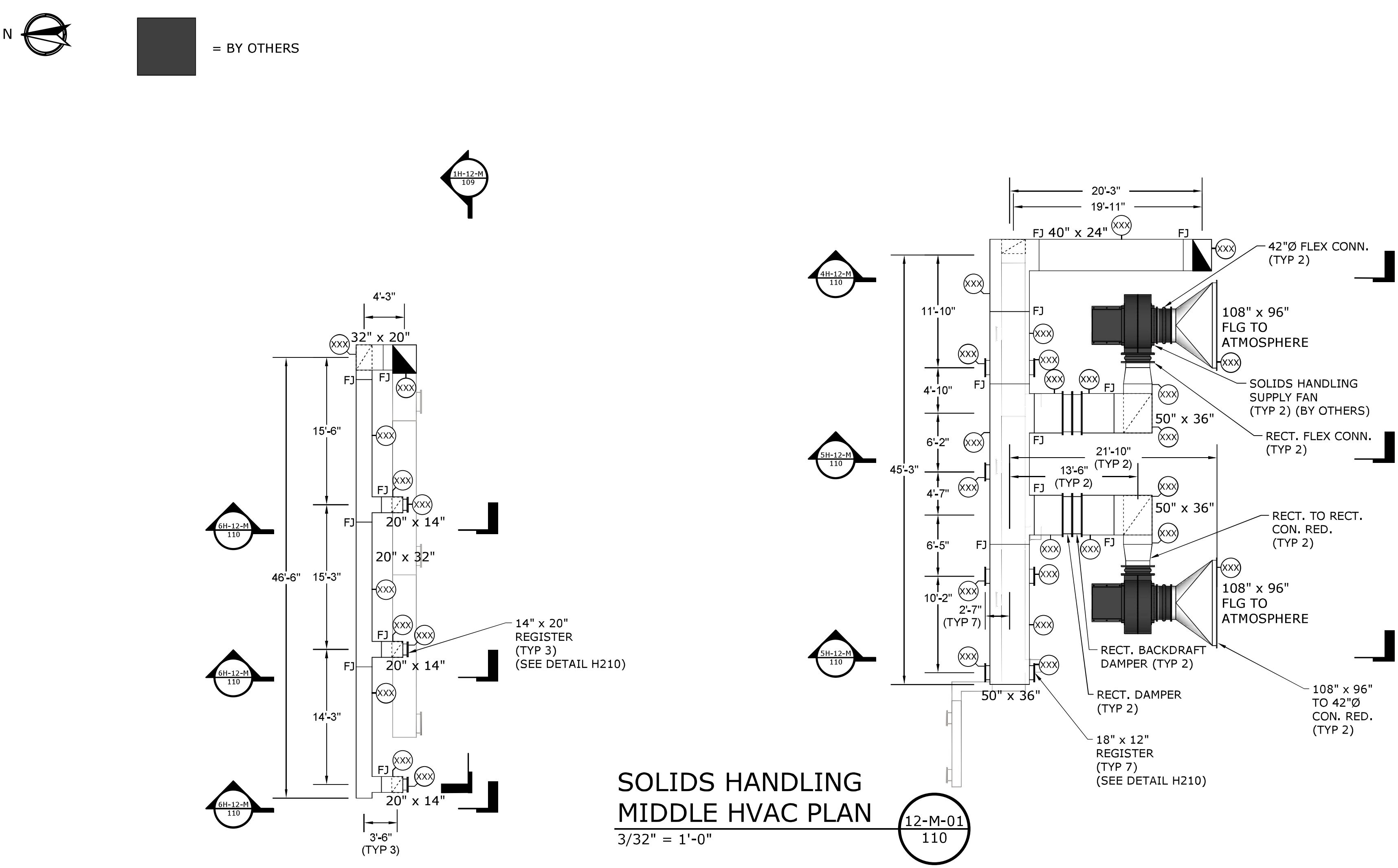
3/32" = 1'-0"

12-M-01
109

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 12-M-01-109 HVAC PAGE: 29 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 12-M-01-109 HVAC

DRAWN BY: KH LAYOUT REVISED: 1/08/2025



SOLIDS HANDLING MIDDLE HVAC PLAN

3/32" = 1'-0"

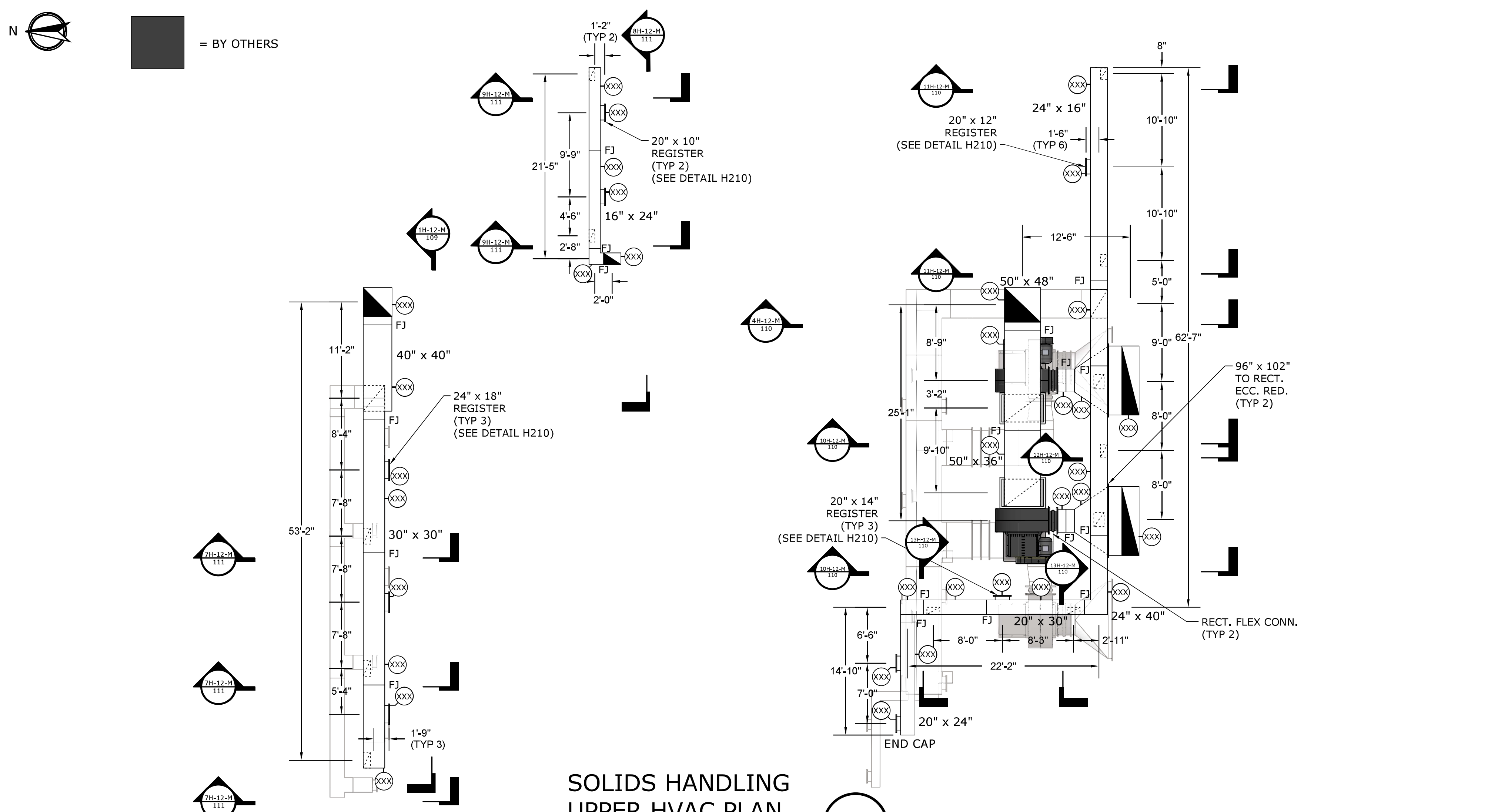
12-M-01 110

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 12-M-01-110 HVAC PAGE: 30 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 12-M-01-110 HVAC
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025



SOLIDS HANDLING UPPER HVAC PLAN

3/32" = 1'-0"

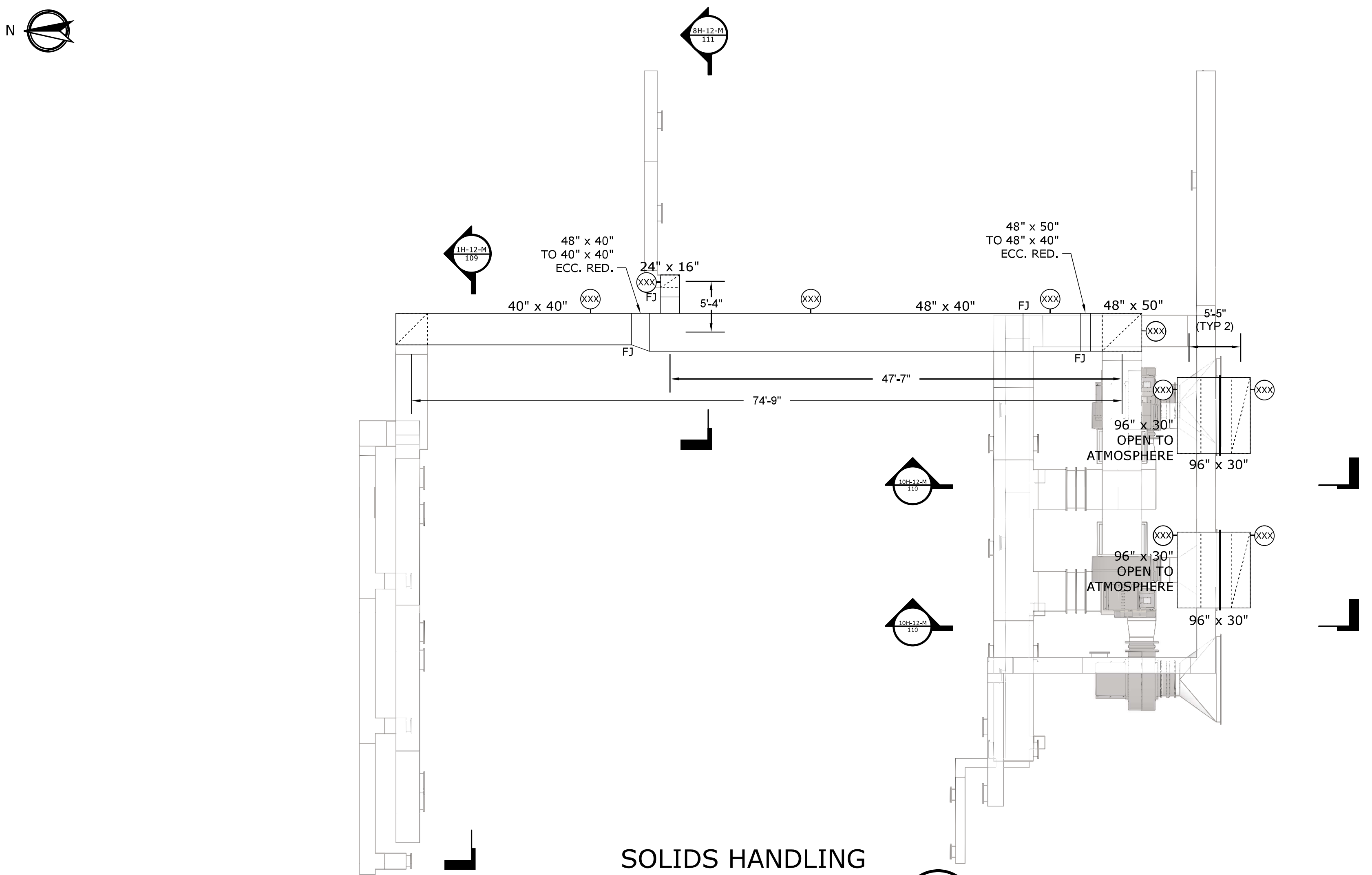
12-M-01
111

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 12-M-01-111 HVAC PAGE: 31 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 12-M-01-111 HVAC
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025



SOLIDS HANDLING ROOF HVAC PLAN

3/32" = 1'-0"

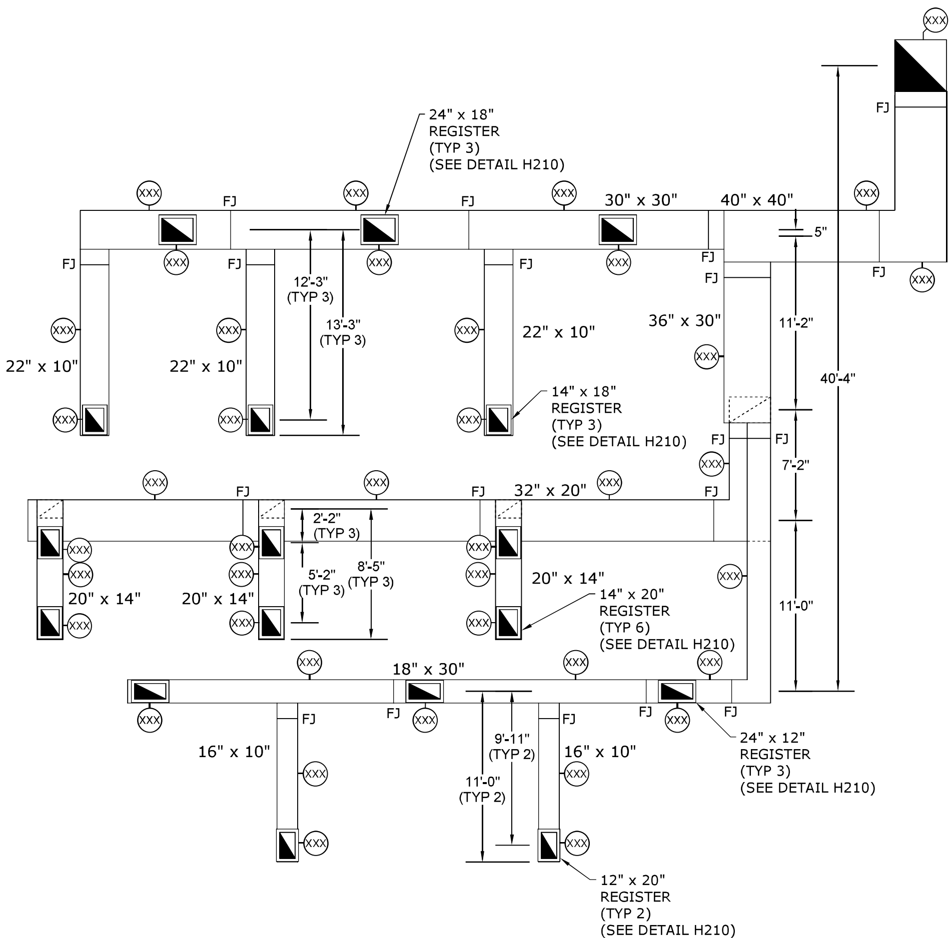
12-M-01
112

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

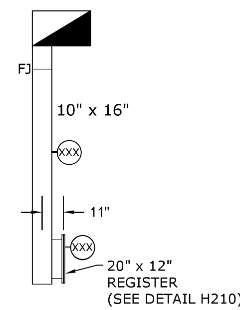
DWG: 12-M-01-112 HVAC PAGE: 32 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 12-M-01-112 HVAC
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

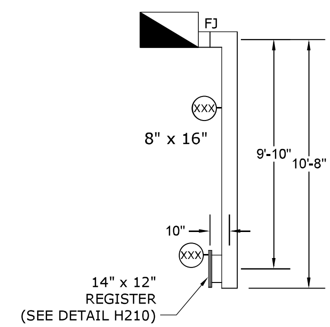
LAYOUT REVISED: 1/08/2025



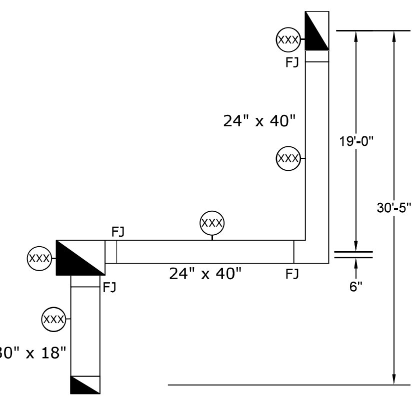
SECTION 1
1H-12-M
109
1/8" = 1'-0"



SECTION 2 (TYP 2)
2H-12-M
109
3/16" = 1'-0"



SECTION 3 (TYP 3)
3H-12-M
109
3/16" = 1'-0"



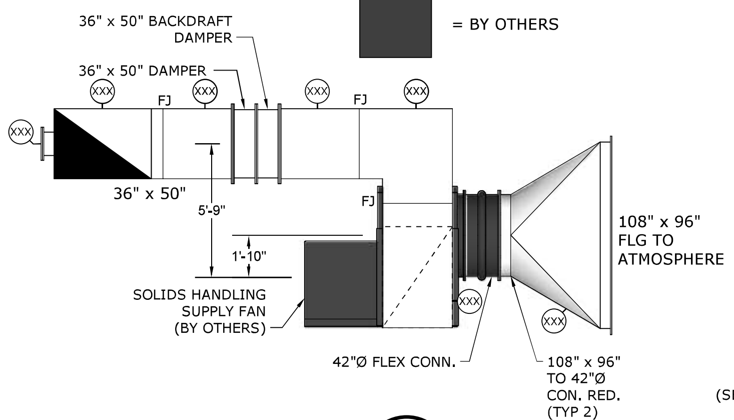
SECTION 4
4H-12-M
109
3/32" = 1'-0"

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

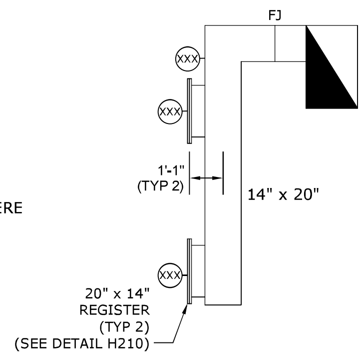
DWG: SOLIDS HVAC SECTIONS 1 PAGE: 33 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - SOLIDS HVAC SECTIONS 1

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025

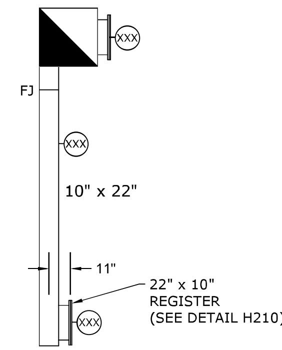
= BY OTHERS



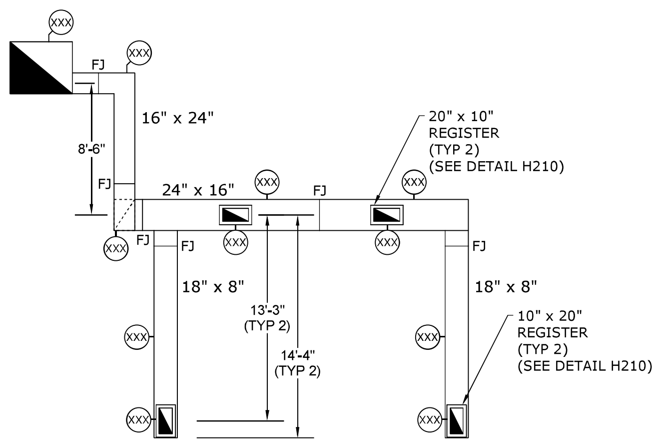
SECTION 5 (TYP 2) 5H-12-M 110
3/16" = 1'-0"



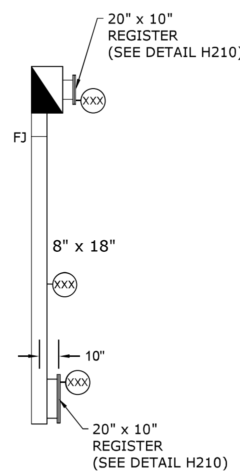
SECTION 6 (TYP 3) 6H-12-M 110
1/4" = 1'-0"



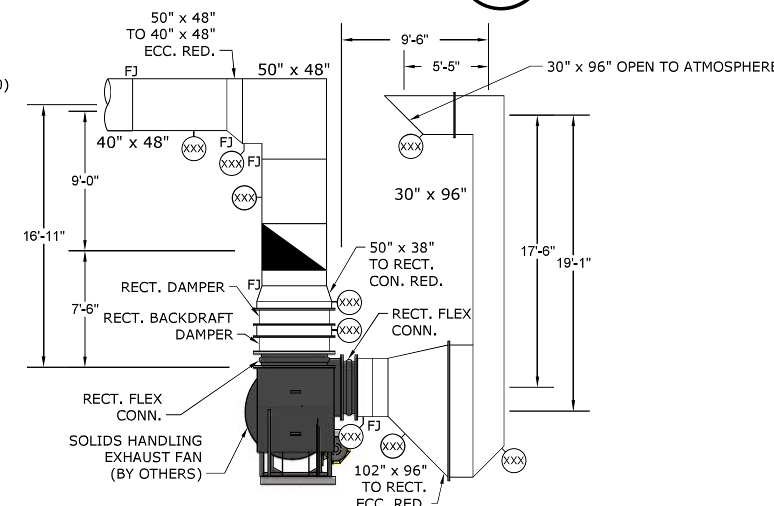
SECTION 7 (TYP 3) 7H-12-M 111
3/16" = 1'-0"



SECTION 8 8H-12-M 111
1/8" = 1'-0"



SECTION 9 (TYP 2) 9H-12-M 111
3/16" = 1'-0"

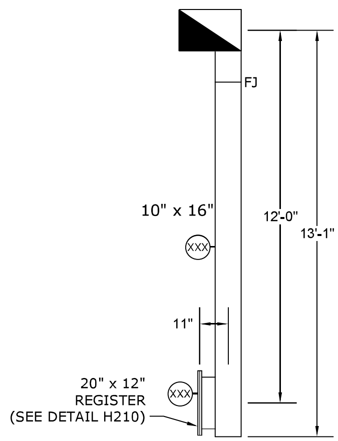


SECTION 10 (TYP 2) 10H-12-M 111
1/8" = 1'-0"

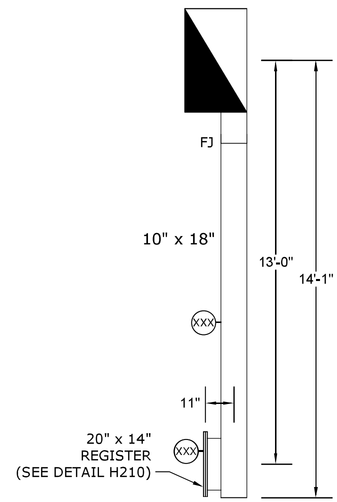
NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: SOLIDS HVAC SECTIONS 2 PAGE: 34 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - SOLIDS HVAC SECTIONS 2

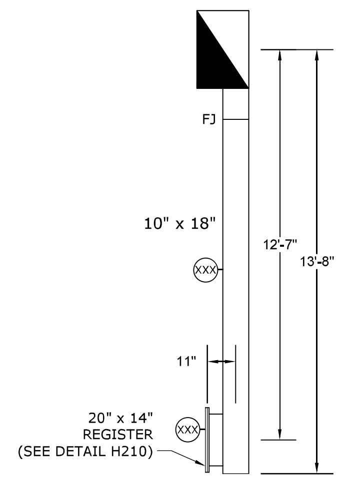
DRAWN BY: KH LAYOUT REVISED: 1/08/2025



SECTION 11 (TYP 2) 11H-12-M 111
1/4" = 1'-0"



SECTION 12 12H-12-M 111
1/4" = 1'-0"



SECTION 13 (TYP 2) 13H-12-M 111
1/4" = 1'-0"

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

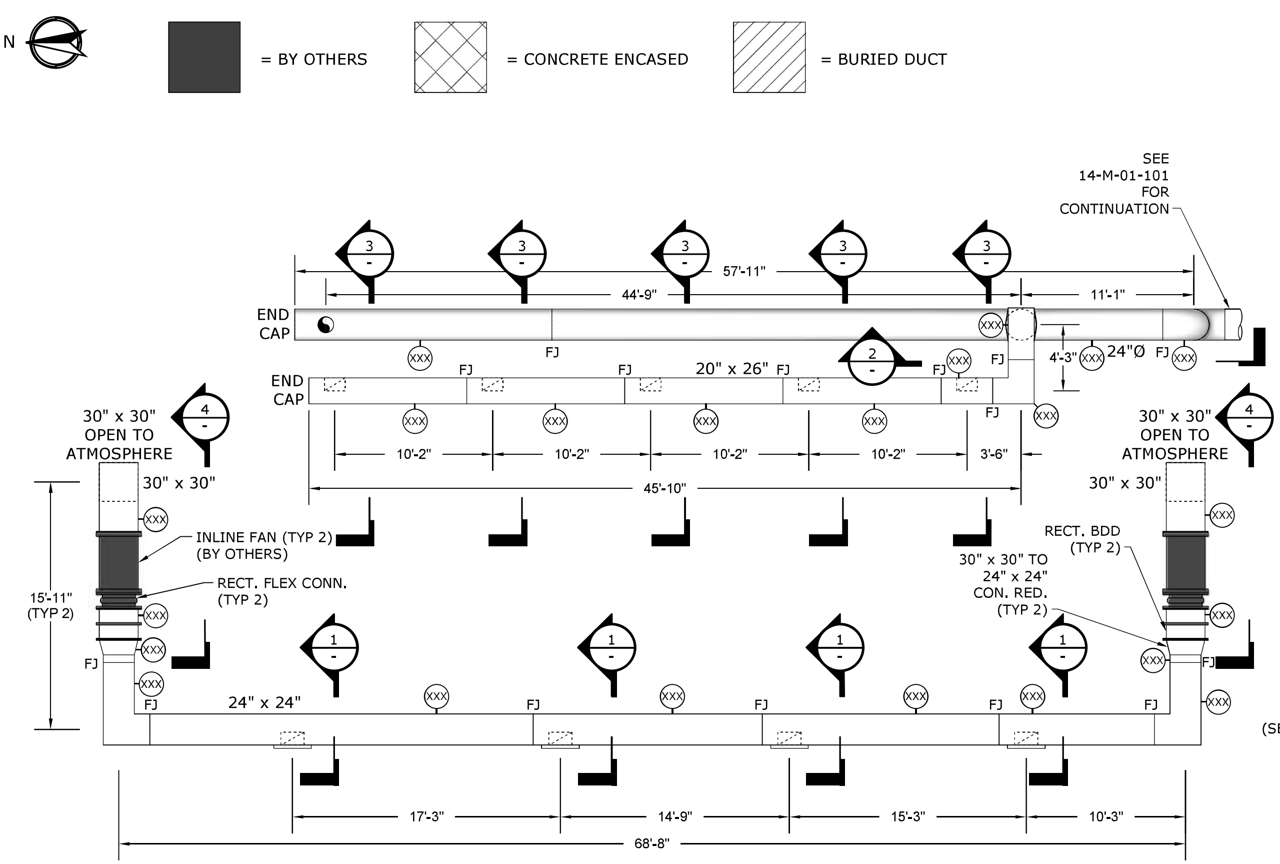
DWG: SOLIDS HVAC SECTIONS 3 PAGE: 35 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - SOLIDS HVAC SECTIONS 3

DRAWN BY: KH LAYOUT REVISED: 1/08/2025

= BY OTHERS

= CONCRETE ENCASED

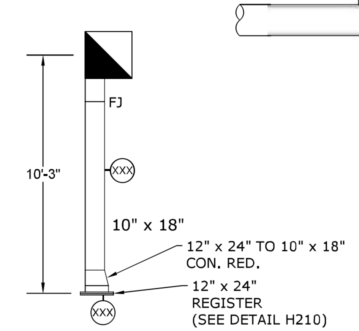
= BURIED DUCT



SOLIDS HANDLING TRUCK LOADING LOWER PLAN

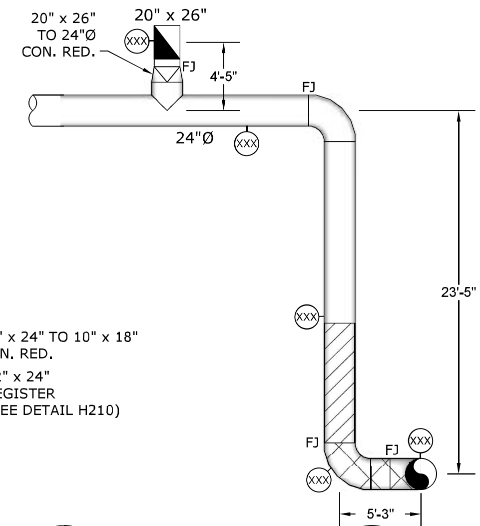
1/8" = 1'-0"

12-M-01
110



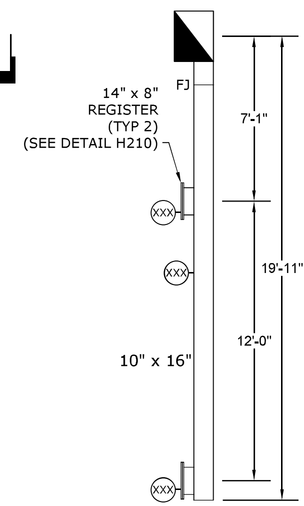
SECTION 1 (TYP 4)
3/16" = 1'-0"

1
-



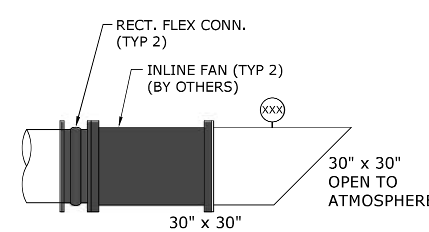
SECTION 2
1/8" = 1'-0"

2
-



SECTION 3 (TYP 5)
3/16" = 1'-0"

3
-



SECTION 4 (TYP 2)
1/4" = 1'-0"

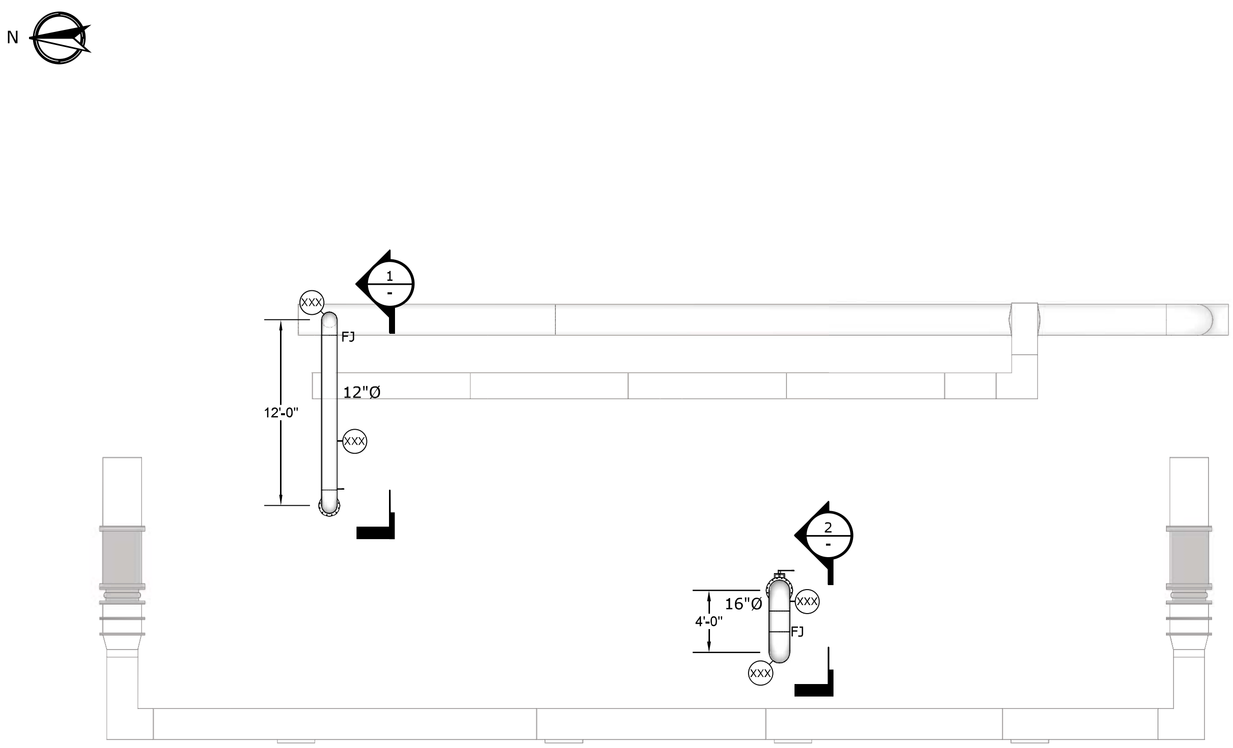
4
-

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING
& EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 12-M-01-110 TRUCK LOADING PAGE: 36 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 12-M-01-110 TRUCK LOADING
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

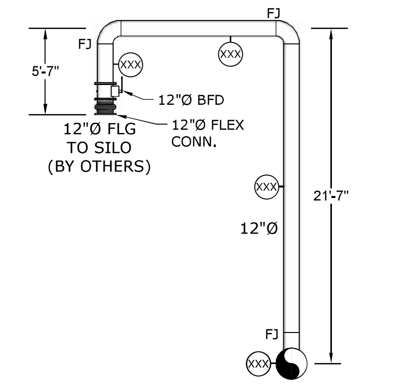
LAYOUT REVISED: 1/08/2025



SOLIDS HANDLING TRUCK LOADING UPPER PLAN

1/8" = 1'-0"

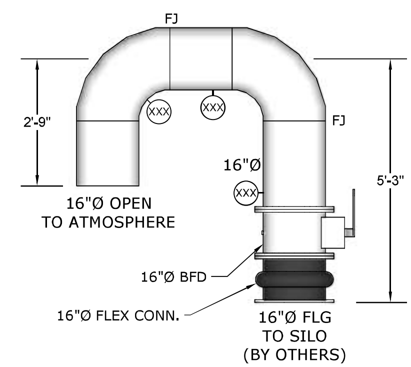
12-M-01
111



SECTION 1

1/8" = 1'-0"

1
-



SECTION 2

3/8" = 1'-0"

2
-

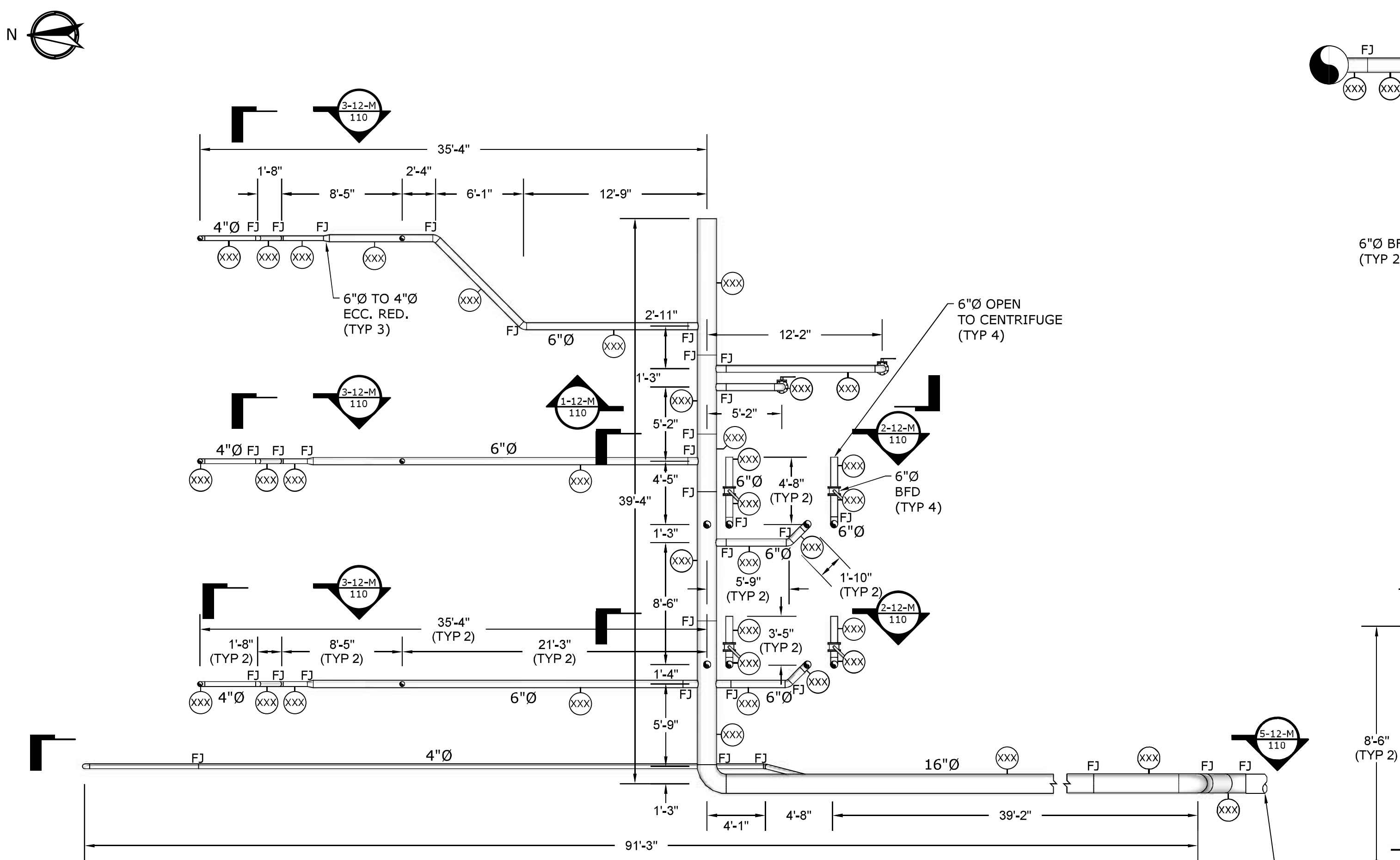
NOTES:

1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 12-M-01-111 TRUCK LOADING PAGE: 37 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 12-M-01-111 TRUCK LOADING
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025

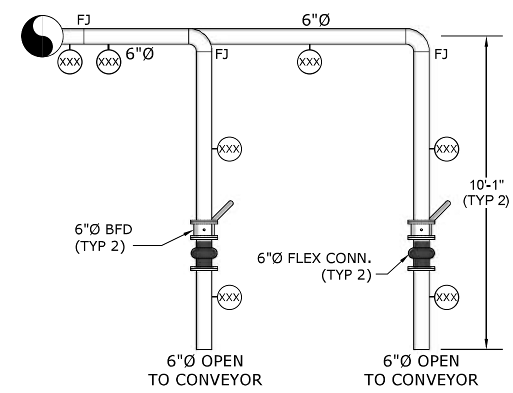


SOLIDS HANDLING ODOR CONTROL PLAN

1/8" = 1'-0"

12-M-01
110

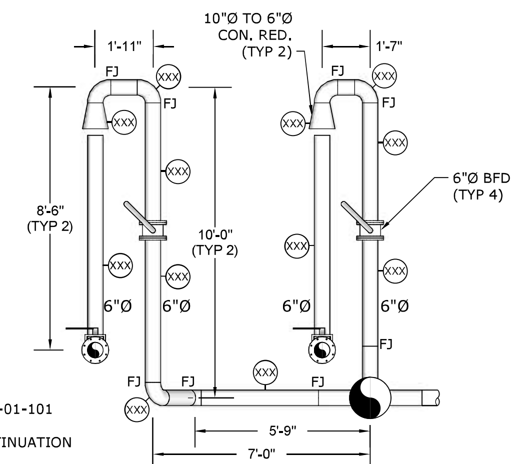
SEE
14-M-01-101
FOR
CONTINUATION



SECTION 1

1/4" = 1'-0"

1-12-M
110



SECTION 2 (TYP 2)

1/4" = 1'-0"

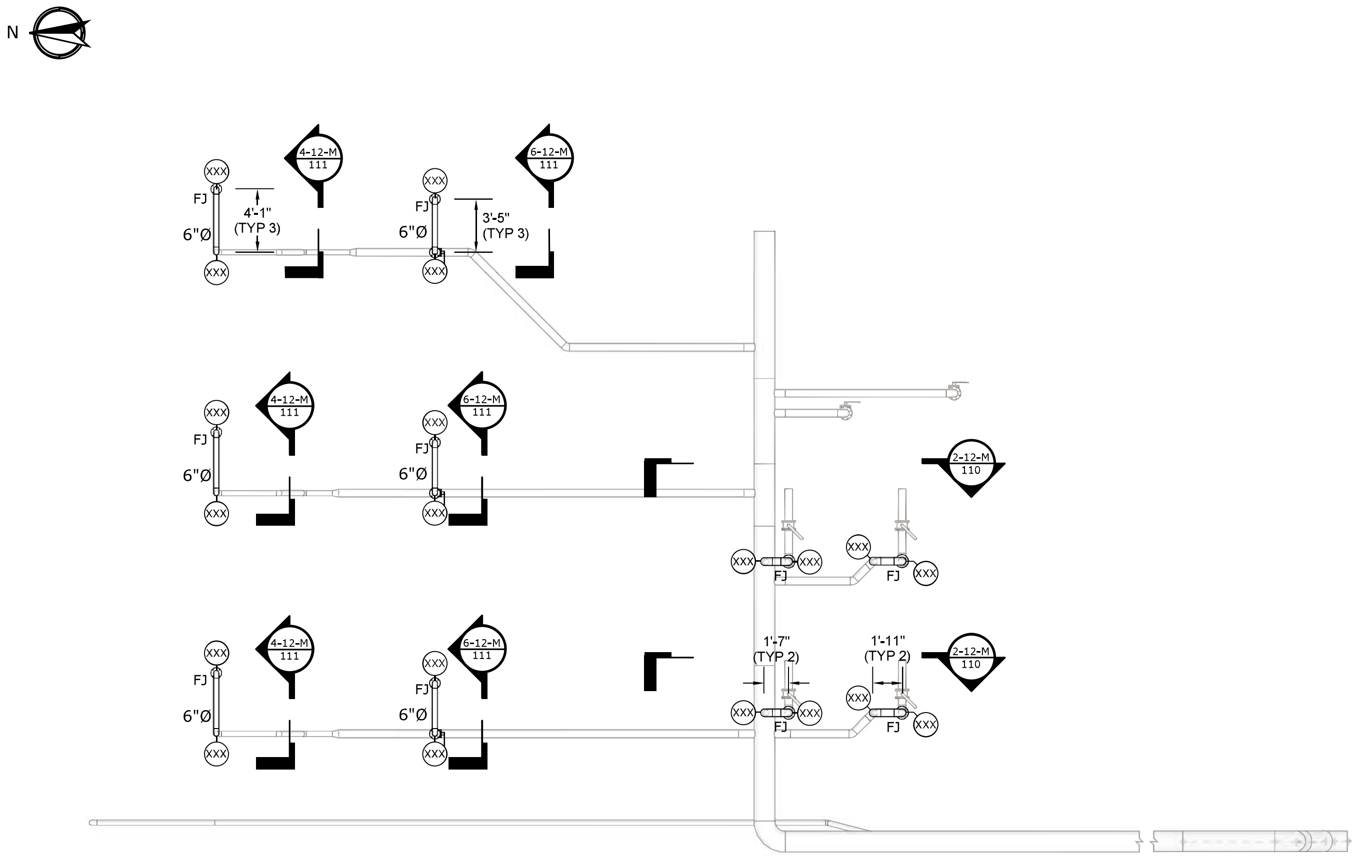
2-12-M
110

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

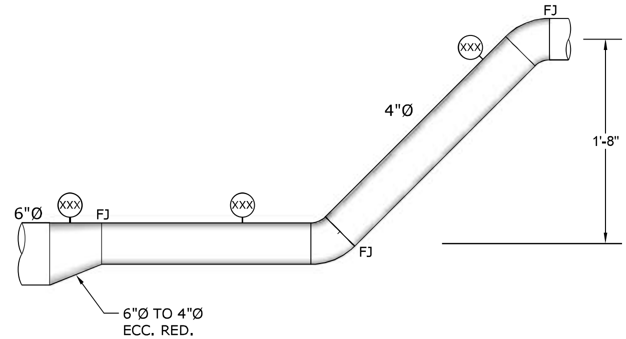
DWG: 12-M-01-110 ODOR CONTROL PAGE: 38 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 12-M-01-110 ODOR CONTROL
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

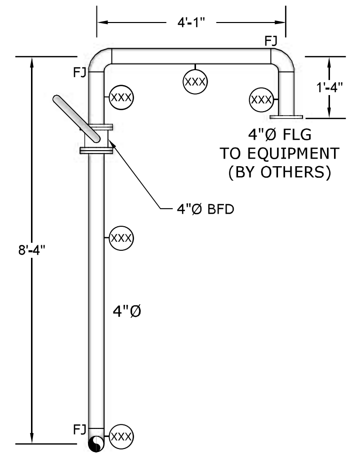
LAYOUT REVISED: 1/08/2025



SOLIDS HANDLING ODOR CONTROL UPPER PLAN
1/8" = 1'-0"
12-M-01
111



SECTION 3
1" = 1'-0"
3-12-M
110

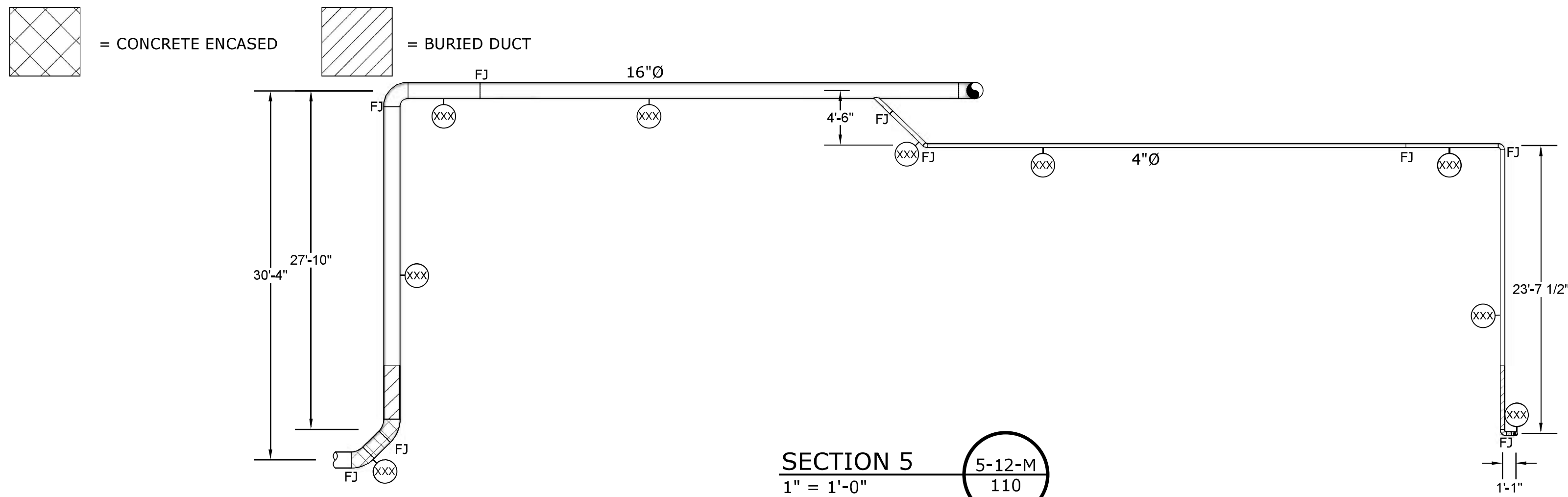


SECTION 4 (TYP 3)
3/8" = 1'-0"
4-12-M
111

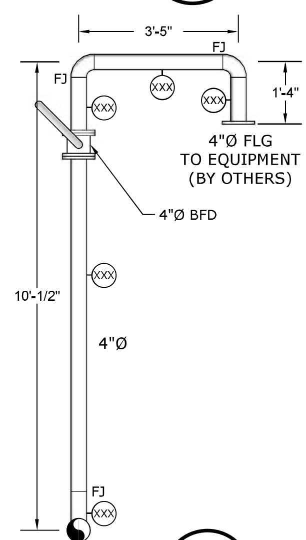
NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 12-M-01-111 ODOR CONTROL PAGE: 39 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 12-M-01-111 ODOR CONTROL

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



SECTION 5
1" = 1'-0"
5-12-M
110

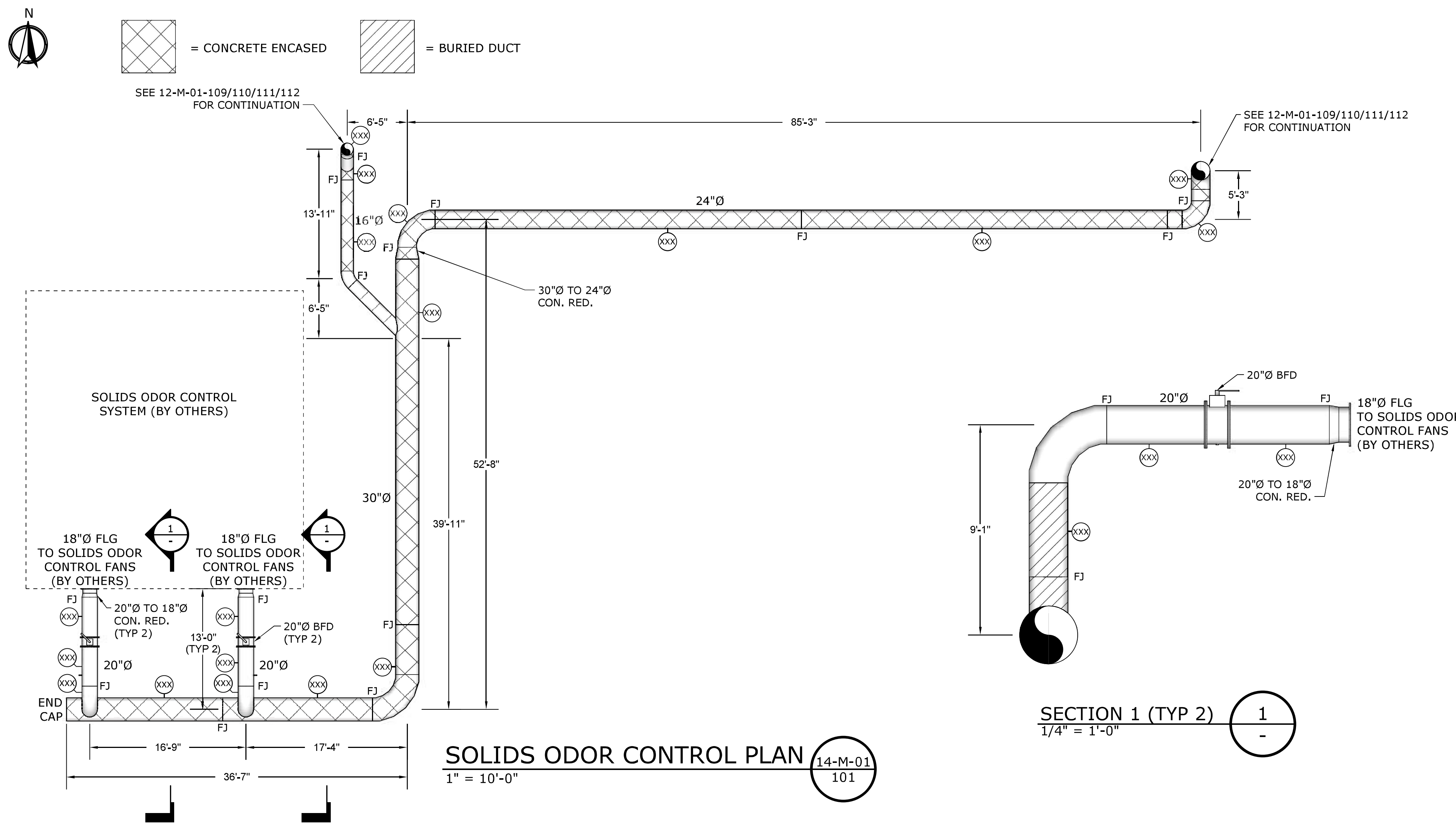


SECTION 6 (TYP 3)
3/8" = 1'-0"
6-12-M
111

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: ODOR CONTROL SECTIONS 1 PAGE: 40 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - ODOR CONTROL SECTION 1

DRAWN BY: KH
LAYOUT REVISED: 1/08/2025



SOLIDS ODOR CONTROL PLAN 14-M-01 / 101

1" = 10'-0"

SECTION 1 (TYP 2) 1 / -

1/4" = 1'-0"

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

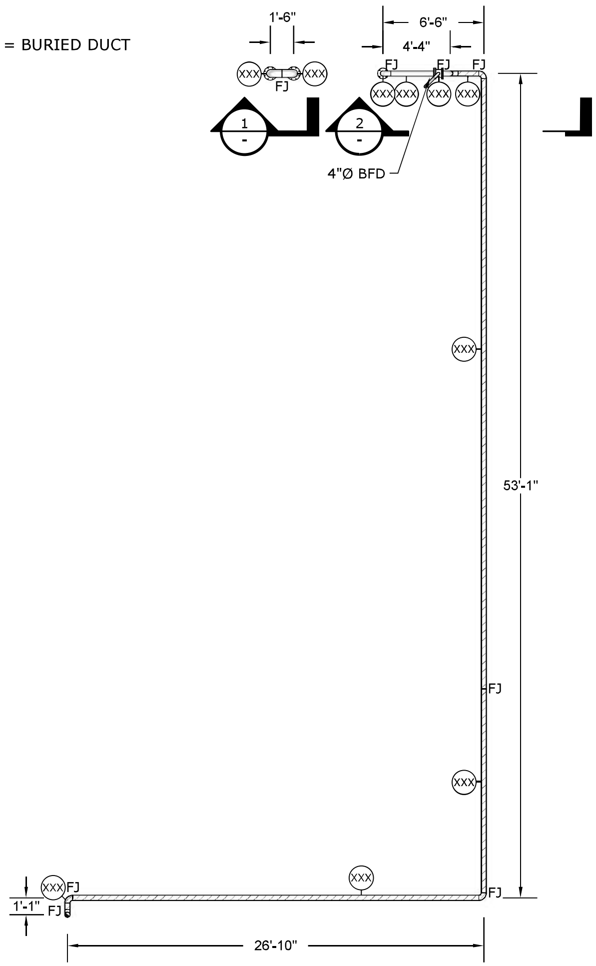
DWG: 14-M-01-101 PAGE: 41 DATE: 06/05/2025 5013 Hilo - FRP Ductwork	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 14-M-01-101

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025

N

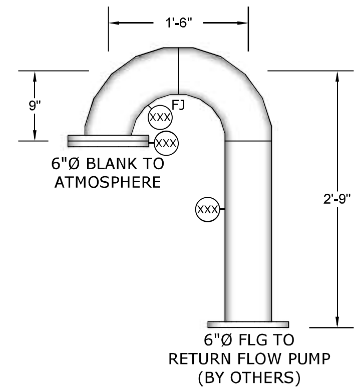
= BURIED DUCT



RETURN FLOW PUMP STATION PLAN

1/8" = 1'-0"

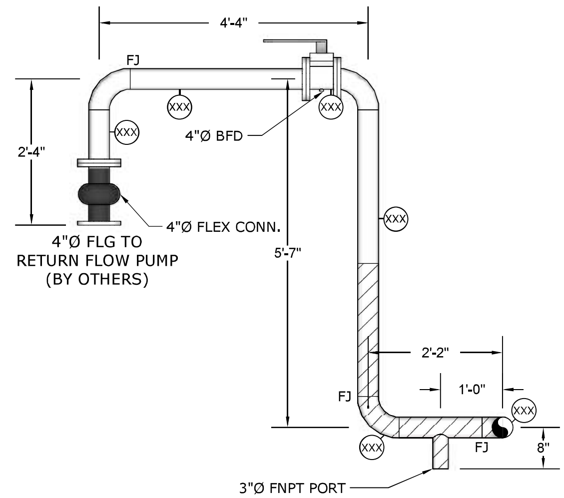
19-M-01
101



SECTION 1

3/4" = 1'-0"

1
-



SECTION 2

1/2" = 1'-0"

2
-

NOTES:
1. CONTRACTOR TO VERIFY ALL DIMENSIONS & ELEVATIONS
2. CONTRACTOR TO VERIFY ALL CONNECTIONS TO EXISTING & EQUIPMENT BY OTHERS
3. ALL SLOPES TO BE ACHIEVED IN FIELD BY INSTALLER

DWG: 19-M-01-101 PAGE: 42 DATE: 06/05/2025	DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	1939 W. 11th St. Ste. E Upland, CA 91786 Phone: (909) 982-1555 Fax: (909) 982-1855	VERIFY SCALE 0 1" ORIGINAL IS 1" LONG	COUNTY OF HAWAII HILO WWTP REHABILITATION AND REPLACEMENT PROJECT PHASE 1 FRP DUCTWORK - 19-M-01-101
5013 Hilo - FRP Ductwork				

DRAWN BY: KH

LAYOUT REVISED: 1/08/2025

SECTION 8

DUCTWORK ACCESSORIES

DANIEL COMPANY
Fiberglass Air Pollution Control Systems

* Flex connector schedule to be reviewed, marked up, and approved by the Contractor once final ductwork layout is confirmed.

Project: 5013 Hilo
Date: 6/27/2025
Revision: 0

INITIAL INDICATING ______
APPROVAL & RELEASE TO FABRICATE PER:
SCHEDULE ☐
AMENDED SCHEDULE ☐

FLEX CONNECTOR SCHEDULE

Flex Connectors (Holz Style 952/777)			
Size	**Qty.**	**Connection Type**	**F/F**
4"Ø	1	NBS x NBS	12"
6"Ø	2	NBS x NBS	12"
8"Ø	5	NBS x NBS	12"
12"Ø	5	NBS x NBS	12"
14"Ø	4	NBS x NBS	12"
16"Ø	1	NBS x NBS	12"
** 18"Ø	2	** To match Solids Odor Control Fans	** TBD
** 24"Ø	2	** To match Headworks Channel Exhaust Fan Inlet	** TBD
26"Ø	1	NBS x NBS	12"
36"Ø	1	NBS x NBS	12"
** 42"Ø	2	** To match Solids Handling Supply Fans Inlet	** TBD
** RECT	2	** To match Headworks Channel Exhaust Fans Outlet	** TBD
** RECT	2	** To match Headworks Loading Exhaust Fans Inlet	** TBD
** RECT	2	** To match Headworks Loading Exhaust Fans Outlet	** TBD
** RECT	2	** To match Headworks Odor Control Fans Outlet	** TBD
** RECT	2	** To match Digester Supply Fans Outlet	** TBD
** RECT	2	** To match Solids Handling Supply Fans Outlet	** TBD
** RECT	2	** To match Truck Loading Supply Fans Outlet	** TBD
** RECT	2	**To match Solids Handling Exhaust Fan Inlet	** TBD
** RECT	2	** To match Solids Handling Exhaust Fan Outlet	** TBD
** RECT	1	** To match Primary Galley Roof Fan	** TBD
** RECT	1	** To match Primary Galley Roof Fan	** TBD

NOTES:

- *Contractor to verify flange dimensions on all flex connectors connecting to equipment by others.*
- *All gaskets and hardware by others.*
- *** Dimensions need to be verified for fan connections.*

HOLZ
Rubber Company, Inc.

Flue Duct Expansion Joints

The Expansion Joint Experts

Holz provides application-matched expansion joints for a wide range of industries and uses. Whether it is an elastomeric, fabric or metal expansion joint, Holz has engineered products and application expertise to solve your specific issue or problem.

Holz Rubber is the leading supplier of elastomeric, fabric and metal expansion joints serving the power generation, refining, cement, pulp and paper, waste water and all other heavy industrial applications.

Flue Duct Joints For Ducting Systems

Holz Rubber Company offers a wide variety of Flue Duct Expansion Joints, depending upon your specific application requirements. All Holz Rubber Flue Duct products offer superior design, durability and application-matched performance.

Elimination of Corner Failures

Each corner is fabricated independently in a fully molded configuration without splices.

Margin of Engineered Safety

Typically, flue duct joints have a higher pressure rating than fabric joints.

Adaptability

Available in round or rectangular configurations with variable face-to-face dimensions, the expansion joint may be made to fit existing ductwork easily.

Elimination of Costly Gaskets

The integral rubber flanges act as a built-in gasket. Eliminating a separate gasket makes for a much faster and easier installation.

Chemical Resistance

We offer a full range of elastomers suitable for any application. Call our trained staff in order to help you make the right choice.

Materials and Temperature Selection Guide

Maximum Continuous Operating Temperatures	Material		Holz Rubber Material Code	Typical Application
	Toward Gas Flow Tube	Toward Atmosphere Cover		
250˚ F	Neoprene	Neoprene	333	Hot Oily Air/ Gas Special Chemicals
300˚ F 300˚ F 400˚ F	Butyl E.P.D.M. Viton	Butyl E.P.D.M. Viton	555 777 888	Hot Non Oily Air/Gas Hot Air/Gas Very Hot Air/Gas

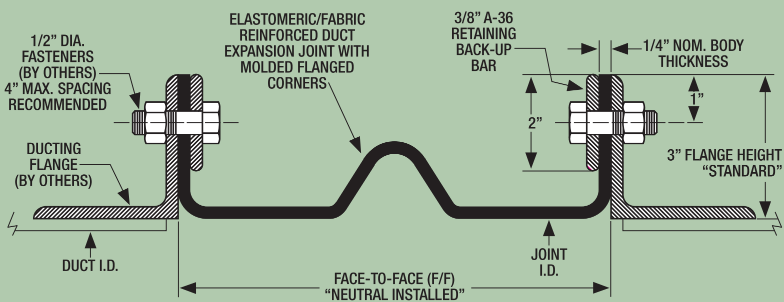
Flue Duct Joint Applications

- Paint and Powder Coating Booths
- Welding Booths
- Environmental Systems
- HVAC and Air Handling Systems
- Fan Connectors
- Flex Element for F.R.P. Piping
- FGD Systems

Style 952 Arch-Design *(For Ultra-High Movements)*

Designed for ultra-high movements in short face-to-face applications. Constructed with a large, high "V" shaped arch which allows very high axial movement while exerting very low forces on the ductwork, duct flanges and equipment.

Typical Installation Arrangement



Maximum Movement Capabilities (in inches)

Movement shown at face-to-face

Size	Axial Compression	Axial Extension	Lateral Offset
6" F/F	2.25	1.25	1.25
9" F/F	3.0	1.5	2.0
12" F/F	4.0	2.0	2.5
16" F/F	5.0	2.75	3.0

Lateral Offset figures are based on the assumption that all lateral movement occurs prior to compression movements. In practice, movements may occur simultaneously, thus the allowable lateral offset may increase or decrease.

Extension may be increased or decreased by pre-compression during installation. However, the amount of pre-compression will correspondingly reduce the compression rating.

Pressure/Vacuum Ratings

Nominal Body Thickness	Number of Body Plies	Pressure Vacuum			
		PSIG	In.H2O	kPa	Excursion PSIG
1/8"	1	+/-1	+/-28	+/-6.9	+/-2
1/4"	2	+/-2	+/-55	+/-13.8	+/-3
3/8"	3	+/-4	+/-111	+/-27.6	+/-6

Positive Pressure Applications are recommended. Not recommended for constant vacuum and extension. If joint is to be subjected to axial extension under vacuum conditions, vacuum rating may be reduced and a set-back may be required to ensure the joint is not in the media stream.

Product Weight

Nominal Body Thickness	Pounds per (sq. ft.) Elastomer		(linear ft.) Retaining Rings/Bars
	EPDM	VITON	
1/8"	.90	1.4	5.0
1/4"	1.4	2.1	
3/8"	2.1	3.1	

Add 8 inches to the face-to-face dimension for calculating the square footage. Retaining Bars: 3/8" X 2", A-36 Carbon Steel.

* Damper schedule to be reviewed, marked up, and approved by the Contractor once final ductwork layout is confirmed.

Project: 5013 Hilo
Date: 6/27/2025
Revision: 0

INITIAL INDICATING ______
APPROVAL & RELEASE TO FABRICATE PER:
SCHEDULE ☐
AMENDED SCHEDULE ☐

DAMPER SCHEDULE

Round Dampers (Daniel Company DanELAST Zero-Leakage FRP Dampers)						
Size	**Qty.**	**Operator Type**	**Connection Type**	**F/F**	**Orientation**	**Location**
4"Ø	6	Hand Lever	NBS x NBS	12"	Vertical	Indoors
6"Ø	6	Hand Lever	NBS x NBS	12"	Horizontal	Indoors
6"Ø	6	Hand Lever	NBS x NBS	12"	Vertical	Indoors
8"Ø	2	Hand Lever	NBS x NBS	12"	Horizontal	Indoors
8"Ø	5	Hand Lever	NBS x NBS	12"	Vertical	Indoors
12"Ø	1	Hand Lever	NBS x NBS	12"	Vertical	Indoors
16"Ø	1	Hand Lever	NBS x NBS	12"	Vertical	Indoors
24"Ø	4	Hand Wheel	NBS x NBS	12"	Horizontal	Indoors
4"Ø	1	Hand Lever	NBS x NBS	12"	Horizontal	Outdoors
6"Ø	1	Hand Lever	NBS x NBS	12"	Vertical	Outdoors
8"Ø	5	Hand Lever	NBS x NBS	12"	Horizontal	Outdoors
8"Ø	4	Hand Lever	NBS x NBS	12"	Vertical	Outdoors
10"Ø	2	Hand Lever	NBS x NBS	12"	Horizontal	Outdoors
10"Ø	1	Hand Lever	NBS x NBS	12"	Vertical	Outdoors
12"Ø	2	Hand Lever	NBS x NBS	12"	Horizontal	Outdoors
12"Ø	3	Hand Lever	NBS x NBS	12"	Vertical	Outdoors
20"Ø	2	Hand Lever	NBS x NBS	12"	Horizontal	Outdoors
24"Ø	1	Hand Wheel	NBS x NBS	12"	Vertical	Outdoors
26"Ø	2	Hand Wheel	NBS x NBS	12"	Horizontal	Outdoors
36"Ø	2	Hand Wheel	NBS x NBS	12"	Horizontal	Outdoors
42"Ø	2	Hand Wheel	NBS x NBS	12"	Horizontal	Outdoors
42"Ø	3	Hand Wheel	NBS x NBS	12"	Vertical	Outdoors

Rectangular Dampers (Volume, Ruskin Model 1108AF)					
Size	**Qty.**	**Connection Type**	**F/F**	**Orientation**	**Location**
24"x20"	2	TBD	TBD	Vertical	Indoors
18"x40"	2	TBD	TBD	Vertical	Indoors
30"x30"	2	TBD	TBD	Vertical	Indoors
20"x18"	2	TBD	TBD	Horizontal	Indoors
18"x20"	2	TBD	TBD	Vertical	Indoors
50"x36"	2	TBD	TBD	Horizontal	Indoors
36"x54"	2	** To match Solids Handling Exhaust Fans Inlet	TBD	Vertical	Indoors

Rectangular Dampers (Backdraft, Ruskin Model 426)					
Size	**Qty.**	**Connection Type**	**F/F**	**Orientation**	**Location**
18"x29"	2	** To match Headworks Channel Exhaust Fans Outlet	TBD	Vertical	Indoors
20"x18"	2	TBD	TBD	Vertical	Indoors
50"x36"	2	TBD	TBD	Horizontal	Indoors
36"x54"	2	** To match Solids Handling Exhaust Fans Outlet	TBD	Vertical	Indoors
18"x28"	2	** To match Headworks Loading Exhaust Fans Outlet	TBD	Vertical	Indoors
14"x20"	2	** To match Digester Supply Fans Outlet	TBD	Horizontal	Outdoors
30"x30"	2	** To match Truck Loading Supply Fans Outlet	TBD	Horizontal	Outdoors

Registers (Daniel Company Detail H210)					
Size	**Qty.**	**Connection Type**	**F/F**	**Orientation**	**Location**
TBD	TBD	See Detail H210	TBD	TBD	TBD

NOTES:

1. All gaskets and hardware by others.
2. All worm gear operators shall have a corrosion resistant epoxy coating.
3. Contractor to verify flange dimensions on all dampers connecting to equipment by others.
4. Contractor to verify operator type.
5. ** Dimensions need to be verified for fan connections.

Daniel Mechanical Company
1939 West 11th Street Ste. E
Upland, CA 91786

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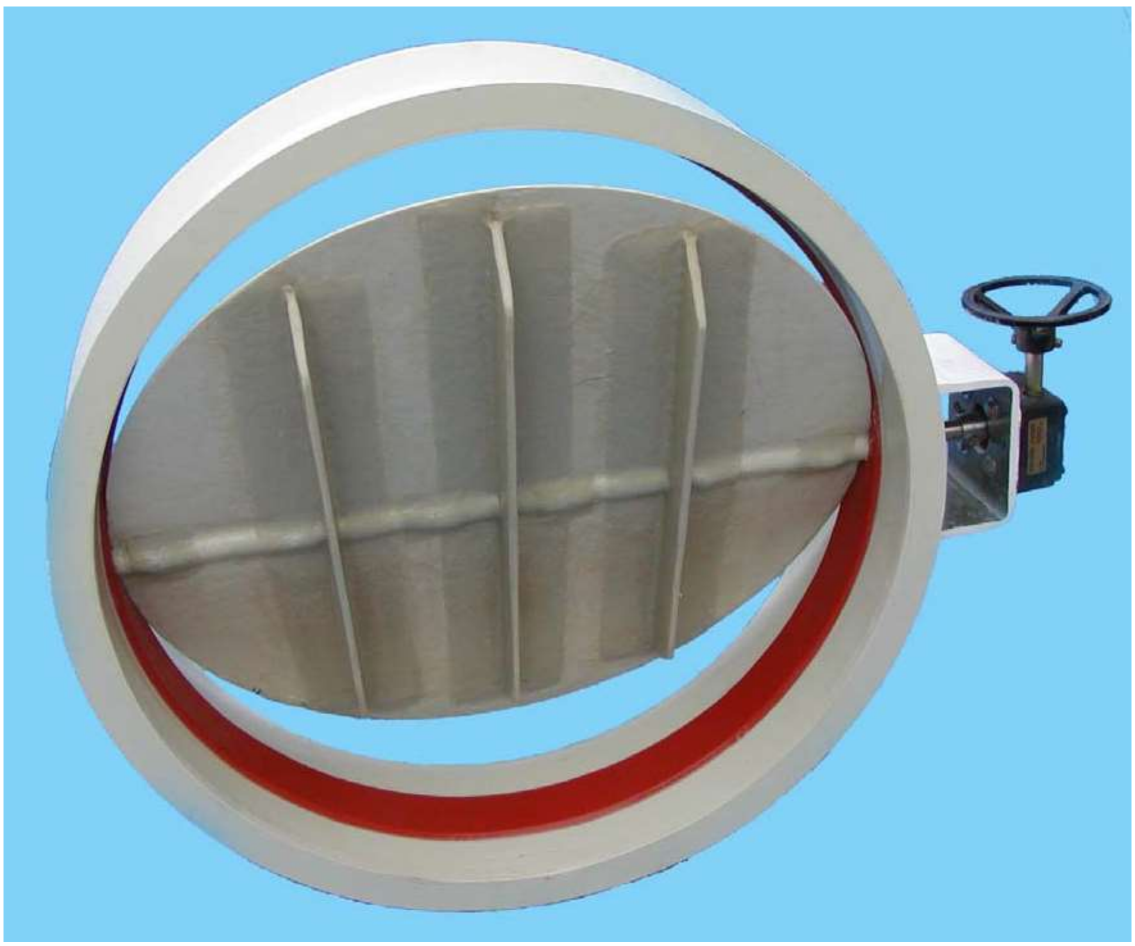
*DanELAST**

ZERO-LEAKAGE AIR ISOLATION FRP DAMPER



*Patent Pending

DanELAST ROUND FRP ZERO-LEAKAGE AIR ISOLATION DAMPER

DANIEL MECHANICAL COMPANY offers precision-engineered fiberglass reinforced plastic zero-leakage ***DanELAST*** isolation dampers utilizing only high corrosion resistant parts for air movement and controls. Zero-leakage ***DanELAST*** dampers are fire retardant, corrosion resistant, and UV protected. All components are designed with replaceable parts that are easily disassembled for maintenance. The blade shafts are constructed of custom-milled, solid 316SST metal. Daniel Mechanical Company's zero-leakage ***DanELAST*** damper utilizes a specially formulated elastomer with corrosion resistance equal to and/or superior to EPDM, Hypalon, and even Viton.

No circumferential blade seals are required to achieve a full shutoff of the zero-leakage ***DanELAST*** isolation damper. This is largely due to the innovative design and expert hand craftsmanship of each key part. By constructing the unitary FRP blade to exact tolerances and without a commonly used circumferential blade seal, the weakest part of the damper is eliminated, thus improving its reliability. No blade stops are utilized, decreasing the pressure loss across the damper when in the full open position. Each zero-leakage ***DanELAST*** damper is factory tested to operating pressures exceeding 30 inches w.g. Leakage rates are tested using AMCA 500-D procedures, and the certified ratings are authorized by AMCA.

The zero-leakage ***DanELAST*** damper blade is operated using a hand-wheel driven worm gear operator. Pneumatic, electric, or chain-wheel type operators are optional. Long life Teflon bearings and extensively tested molded plastic bushings accessible from the exterior of the damper require minimal maintenance and ensure unrestricted movement of the rotating shaft. All metal parts in contact with process air stream are at a minimum 316 stainless steel and may be manufactured of more exotic metals such as Hastelloy-C and Titanium.

Zero-leakage ***DanELAST*** dampers enhance safety by providing greater isolation of process air during shutdown of low pressure exhaust system duct lines conveying hazardous air streams. When dealing with confined space entry conditions, use of zero-leakage ***DanELAST*** isolation dampers may reduce safety risks caused by contaminant air leaks.

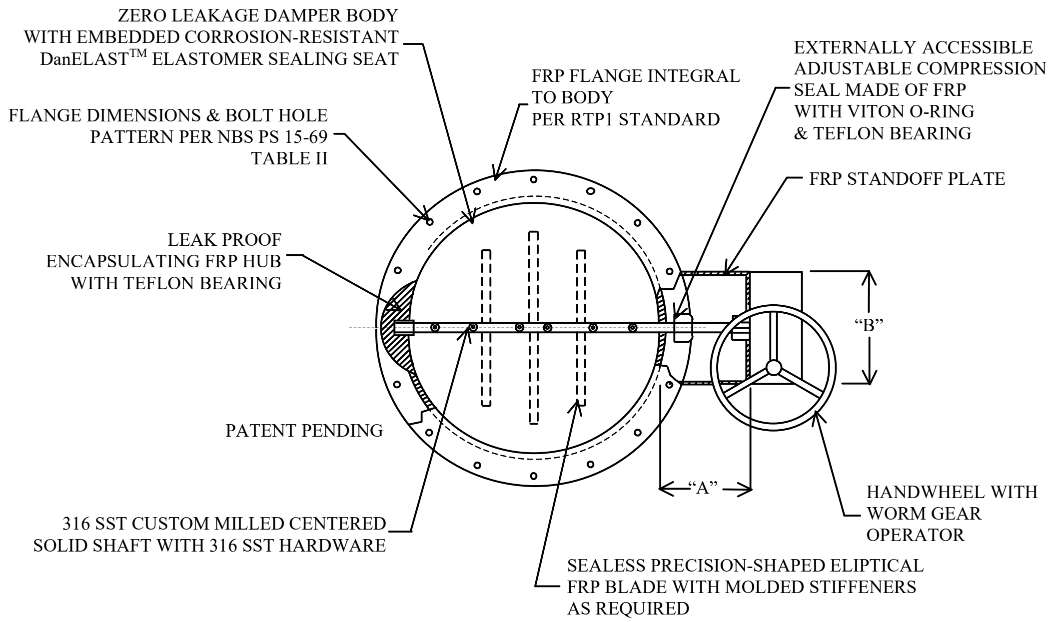
Zero-leakage ***DanELAST*** isolation dampers require far less maintenance, are more durable, and outperform conventional butterfly dampers.

Zero-leakage ***DanELAST*** dampers range in sizes from 4-inch diameter to 120-inch diameter.

STANDARD CONSTRUCTION

FRAME—Vinyl ester resin fabricated to ASME/ANSI RTP-1
FLANGE—NBS PS 15-69-3.4.7 ¾" thick, hand lay-up integral to body per ASME RTP-1-2000 Standard Fig. 4-7.
BLADE—Vinyl ester resin similar to damper frame. Unitary construction with no circumferential seal or backstop, having a calculated percent deflection of L/360
STIFFENERS—Same material as frame and integrally molded to blade
SHAFT—316 SST with nuts, bolts, and washers (FRP encapsulated if required)
SHAFT SEAL—Externally adjustable compression type with FRP housing and Viton O-ring
BEARING—Teflon
OPERATOR—Worm gear with hand wheel, chain wheel, pneumatic, or electric actuation
GEL COAT—Paraffinated, with ultraviolet inhibitor
COLOR—White unless specified otherwise
MAXIMUM TEMPERATURE—200°F
MAXIMUM PRESSURE—30" w.g.
MAXIMUM LEAKAGE—Zero cubic feet per minute per square-foot of cross sectional area
LUBRICANT—None required

DanELAST ROUND FRP ZERO-LEAKAGE AIR ISOLATION DAMPER DETAIL DRAWING



NOTES:

TOP VIEW

1. ALL KEY PARTS ARE DETACHABLE AND EASILY REPLACED WITH SPARE PARTS.
2. DAMPER SHALL BE FULLY OPERATIONAL AT TEMPERATURES UP TO 200° F.
3. DAMPER HAS A LEAKAGE RATING OF ZERO CFM @ 30" W.C.
4. ALL METAL PARTS IN CONTACT WITH PROCESS AIR STREAM ARE 316 SST. MORE EXOTIC METALS SUCH AS HASTELLOY-C AND TITANIUM ARE OPTIONAL.

DanELAST ROUND FRP ZERO-LEAKAGE AIR ISOLATION DAMPER DIMENSIONS

SIZE	FLANGE THICKNESS	FLANGE O.D.	BOLT CIRCLE DIA.	BOLT HOLE DIA.	# OF BOLT HOLES	BLADE THICKNESS	AXLE DIA.	"A"	"B"	DAMPER WIDTH
4"	¾"	8 3/8"	7"	7/16"	4	3/8"	¾"	5"	6"	6"
6"	¾"	10 3/8"	9"	7/16"	8	3/8"	¾"	6"	8"	6"
8"	¾"	12 3/8"	11"	7/16"	8	3/8"	¾"	6"	8"	6"
10"	¾"	14 3/8"	13"	7/16"	12	3/8"	¾"	6"	8"	12"
12"	¾"	16 3/8"	15"	7/16"	12	3/8"	1"	6"	8"	12"
14"	¾"	18 3/8"	17"	7/16"	12	3/8"	1"	6"	8"	12"
16"	¾"	20 3/8"	19"	7/16"	16	3/8"	1"	6"	8"	12"
18"	¾"	22 3/8"	21"	7/16"	16	3/8"	1 ¼"	6"	8"	12"
20"	¾"	24 3/8"	23"	7/16"	20	3/8"	1 ¼"	6"	8"	12"
24"	¾"	28 3/8"	27"	7/16"	20	3/8"	1 ¼"	7.5"	8"	12"
30"	¾"	34 3/8"	33"	7/16"	28	3/8"	1 ¼"	7.5"	8"	12"
36"	¾"	40 3/8"	39"	7/16"	32	½"	1 ¼"	7.5"	8"	12"
42"	¾"	46 3/8"	45"	7/16"	36	½"	1 7/8"	7.5"	8"	12"
48"	¾"	54 3/8"	52"	9/16"	44	½"	1 7/8"	7.5"	8"	12"
54"	¾"	60 3/8"	58"	9/16"	44	½"	1 7/8"	10"	8"	12"
60"	¾"	66 3/8"	64"	9/16"	52	½"	1 7/8"	10"	8"	12"
72"	¾"	79"	76"	9/16"	64	½"	1 7/8"	12"	12"	18"

SUGGESTED SPECIFICATIONS FOR ROUND FRP AIR CONTROL DAMPERS

Dampers are installed as shown on plans and per specifications. Damper frame shall be of one-piece construction with a resin rich interior corrosion barrier having a minimum thickness of 100 mils. A structural wall shall consist of alternate layers of chopped strand mat and woven roving to conform to ASME/ANSI RTP-1 and NBS PS 15-69. The overall glass and resin content shall be 40% and 60% by weight, respectively.

The fiberglass flange dimensions shall be per NBS PS 15-69 Table 2 for dimensions and bolthole drilling pattern. The flanges shall have a minimum thickness of 3/4 inch and shall be constructed integral to the cylindrical body of the damper, using the hand lay-up technique per ASME RTP-1-2000 standard Fig 4-7. The distance between the faces of the flanges shall be 6 inches for dampers having a diameter size of 8 inches or less. For all other damper sizes, this distance shall be 12 inches long. The damper blade and stiffeners shall be fabricated using the same resin as the damper frame. The damper blade shall be of unitary construction having no detachable parts or circumferential or wiper blade seals. Damper blade shall be designed to prevent over-rotation without the use of backstops located anywhere in the air stream. 316 SST blade shaft shall be continuous, centered, and custom-milled to fit the operator. Both the damper blade and shaft shall be fully detachable from each other and readily disassembled from the damper body for easy repair or maintenance.

Damper shall have an FRP structural stand-off bracket integrally laminated to the exterior of the body for mounting a worm gear operator.

Damper shall be provided with a self-lubricated hand-wheel driven worm gear operator, as manufactured by:

1. Dynatorque, or equal

Operator shall be sized according to required operating torque. Operator shall be coated with corrosion resistant epoxy. All metal parts exposed to the air stream shall be 316 SST. All zero-leakage dampers located at elevations exceeding 6'-6" above finished floor shall, in addition to the hand wheel, be equipped with chain wheel sprockets and appropriately sized chain lengths, as manufactured by:

1. Babbitt, or equal

Chain wheel sprockets shall have integral chain guides to prevent "gagging".

Annular *DanELAST* corrosion resistant elastomer sealing seat shall be embedded in the damper body to achieve zero leakage.

Exterior surface of damper shall contain UV inhibitor, and be gel coated or painted with color to match existing ducting.

FRP dampers shall be tested for pressure drop and leakage in accordance with AMCA Standard 500-D. AMCA 500-D leakage tests shall be performed by AMCA certified testing facilities. The leakage rate shall be a maximum of 0 C.F.M per square-foot of cross-sectional area at 30-inches w.g. pressure. The test results shall be submitted for review and approval by the Engineer. The zero-leakage damper shall bear the AMCA seal.

Approved manufacturer of zero-leakage isolation damper shall be:

1. Daniel Mechanical – Model: ***DanELAST 303***
2. Or equal

CERTIFIED RATINGS AUTHORIZED BY AMCA

Damper Diameter	Torque inch lbs.	Leakage Class	Blade Fixed Open	
			ΔP (in. wg)	CFM
4"	66	1A	-	-
12"	891	1A	0.11	1,983
24"	486	1A	0.04	6,585
36"	360	1A	0.03	14,072
48"	464	1A	-	-
54"	630	1A	-	-
60"	866	1A	-	-
72"	360	1A	-	-

Daniel Mechanical Company certifies that the Model 303 dampers shown herein are licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 511 and comply with the requirements of the AMCA Certified Ratings Program. The AMCA Certified Ratings Seal applies to air performance and air leakage ratings.
Test method is per AMCA Standard 500-D-98 Figures 5.3, 5.4 Alternate-6.3, 5.5, & 5.6, 6.5. Data are based on a seating torque of chart listed in-lbs applied to hold the damper in the closed position. Air leakage is based on operation between 50°F - 104°F.

SWARTWOUT

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1108AF FIBERGLASS CONTROL DAMPER

Airfoil Blade

STANDARD CONSTRUCTION

FRAME
Vinyl Ester Resin. See table for dimensions.

BLADE
Vinyl Ester Resin, Airfoil Shape, 6 5/8" (168) wide x 1/4" (6) thick.

AXLES
3/4" (19) diameter fiberglass rod.

BEARINGS
Molded PTFE.

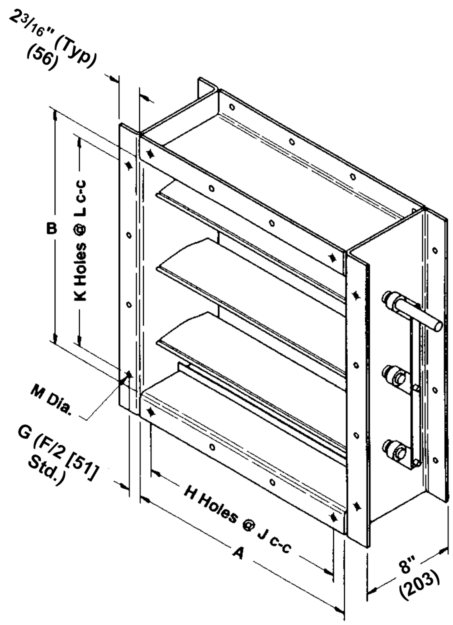
LINKAGE
316SS out of airstream.

MAXIMUM TEMPERATURE
200°F (94°C).

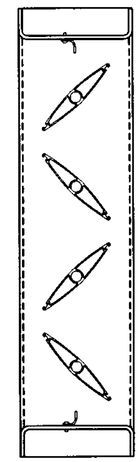
MINIMUM SIZE
Single blade, parallel action 6"w x 8"h (152 x 203).
Two blades, parallel or opposed action 6"w x 12"h (152 x 305).

MAXIMUM SIZE
48"w x 72"h (1219 x 1829).

Dimensions in parenthesis ( ) indicate millimeters.



Illustrated with Optional Bolt Holes



Opposed Blade Action Illustrated

PRESSURE LIMITATIONS

DAMPER WIDTH	MAXIMUM SYSTEM PRESSURE	MAXIMUM SYSTEM VELOCITY
48" (1219)	12" w.g.	4000 fpm
40" (1016)	14" w.g.	4000 fpm
24" (610)	20" w.g.	4000 fpm
12" (305)	28" w.g.	4000 fpm

FRAME	BLADES	SEALS (Optional)	AXLES	BEARINGS	LINKAGE	ACCESSORIES (Optional)
8" x 2 3/16" x 1/4" (203 x 56 x 6) Channel	6 5/8" (168) Airfoil	Silicone Rubber Blade Seal	3/4" (19) Diameter Fiberglass	Molded PTFE	316SS Out of Airstream	Bolt Holes
		EPDM Blade Seal	3/4" (19) Diameter SS			One (1) Flange
		Viton Blade Seal				Both (2) Flanges
		Polycarbonate Jamb Seal				Manual Actuator
		Stainless Steel Jamb Seal				Crank Lever (CL)
		Axle Shaft Seals				Hand Quad (HQ)
						Actuators
						Electric
						Pneumatic

QTY.	BLADE ACTION		DIMENSIONS								VARIATIONS	TAG
	PB	OB	A	B	G	H	J	K	L	M		

PROJECT:
ARCH/ENGR:
REPRESENTATIVE:
LOCATION:
CONTRACTOR:
DATE:

 ALL STATED SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE OR OBLIGATION.

1108AF LEAKAGE DATA

TOTAL CFM LEAKAGE AT ONE INCH
WATER GAGE STATIC PRESSURE DIFFERENTIAL

FOR DAMPER EQUIPPED WITH OPTIONAL BLADE AND JAMB SEALS

DAMPER WIDTH	DAMPER HEIGHT										
	12" (305)	**18"** (457)	**24"** (610)	**30"** (762)	**36"** (914)	**42"** (1067)	**48"** (1219)	**54"** (1372)	**60"** (1524)	**66"** (1676)	**72"** (1829)
12" (305)	7.5	11	15	19	23	26	30	34	38	41	45
24" (610)	10	15	20	25	30	35	40	45	50	55	60
36" (914)	12	18	24	30	36	42	48	54	60	66	72
48" (1219)	16	24	32	40	48	56	64	72	80	88	96

FOR DAMPER WITHOUT BLADE AND JAMB SEALS

DAMPER WIDTH	DAMPER HEIGHT										
	12" (305)	**18"** (457)	**24"** (610)	**30"** (762)	**36"** (914)	**42"** (1067)	**48"** (1219)	**54"** (1372)	**60"** (1524)	**66"** (1676)	**72"** (1829)
12" (305)	60	90	120	150	180	210	240	270	300	330	360
24" (610)	80	120	160	200	240	280	320	360	400	440	480
36" (914)	96	144	192	240	288	336	384	432	480	528	576
48" (1219)	128	192	256	320	384	448	512	576	640	704	768

Dimensions in parenthesis ( ) indicate millimeters.

LEAKAGE CORRECTION FACTOR

Static Pressure (in. w.g.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Correction Factor	1.0	1.4	1.7	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.3	3.5	3.6	3.7	3.9	4.0	4.1	4.2	4.4	4.5

DETERMINING LEAKAGE:

To determine leakage at static pressure differentials higher than one inch water gage, multiply leakage at one inch (determined from appropriate table above) by correction factor for higher static pressure (determined from the Leakage Correction Factor Table).

Example:
Find leakage for a 36" wide x 24" high (914 x 610) damper equipped with optional blade and jamb seals at 3 inches water gage: 24 CFM x 1.7 = 40.8 CFM leakage at 3 inches water gage.

Leakage ratings are based on AMCA Standard 500 using Test Setup Apparatus Figure 5.5. Torque applied holding damper closed at 10 in. lbs. per sq. ft. of damper with minimum of 20 in. lbs.

INSTALLATION:

For proper operation, damper must be installed square and free from racking. Opposed blade dampers must be operated from a power blade or drive axle.

NOTE:
Dampers are designed for operation with blades running horizontally. Dampers to be installed with vertical blades require thrust collars be added at time of damper manufacture and at additional cost. Some standard features are not available with vertical bladed dampers.

1108AF PRESSURE DROP DATA

AREA FACTOR TABLE

B Dimension Height in Inches	A Dimension – Width in Inches														
	6" (152)	**9"** (229)	**12"** (305)	**15"** (381)	**18"** (457)	**21"** (533)	**24"** (610)	**27"** (686)	**30"** (762)	**33"** (838)	**36"** (914)	**39"** (991)	**42"** (1067)	**45"** (1143)	**48"** (1219)
6" (152)	7.05	4.70	3.53	2.82	2.35	2.01	1.76	1.57	1.41	1.28	1.18	1.08	1.01	0.94	0.88
9" (229)	4.17	2.78	2.08	1.66	1.39	1.19	1.04	0.92	0.84	0.75	0.69	0.64	0.59	0.55	0.52
12" (305)	2.92	1.95	1.46	1.17	0.98	0.84	0.73	0.65	0.58	0.53	0.49	0.45	0.41	0.39	0.36
15" (381)	2.17	1.45	1.08	0.87	0.72	0.63	0.54	0.49	0.43	0.39	0.36	0.34	0.31	0.24	0.28
18" (457)	1.84	1.23	0.92	0.73	0.61	0.53	0.46	0.41	0.37	0.34	0.31	0.29	0.27	0.29	0.23
24" (610)	1.35	0.90	0.67	0.54	0.45	0.38	0.34	0.30	0.27	0.24	0.22	0.21	0.19	0.18	0.17
30" (762)	1.02	0.68	0.51	0.41	0.34	0.30	0.25	0.22	0.20	0.19	0.17	0.16	0.15	0.14	0.13
36" (914)	0.85	0.56	0.42	0.34	0.24	0.21	0.21	0.19	0.17	0.16	0.14	0.13	0.12	0.12	0.11
42" (1067)	0.72	0.49	0.36	0.29	0.24	0.21	0.18	0.16	0.15	0.13	0.12	0.12	0.11	0.10	0.10
48" (1219)	0.64	0.42	0.32	0.25	0.21	0.18	0.16	0.14	0.13	0.12	0.11	0.10	0.10	0.08	0.07
54" (1372)	0.56	0.37	0.28	0.22	0.19	0.16	0.14	0.13	0.12	0.11	0.10	0.08	0.08	0.07	0.07
60" (1524)	0.50	0.33	0.24	0.20	0.17	0.14	0.13	0.11	0.10	0.08	0.08	0.07	0.07	0.06	0.06
66" (1676)	0.45	0.30	0.22	0.18	0.15	0.13	0.12	0.10	0.08	0.08	0.07	0.07	0.06	0.06	0.05
72" (1829)	0.41	0.28	0.20	0.17	0.14	0.12	0.11	0.10	0.08	0.07	0.06	0.06	0.06	0.05	0.05

Dimensions in parenthesis ( ) indicate millimeters.

DETERMINING PRESSURE DROP

Use the Area Factor Table and Pressure Drop Chart to determine pressure drop through 1108AF Dampers.

1. Determine area factor for damper by entering the Area Factor Table through duct width and height.
2. Find the conversion velocity (CV) by multiplying the selected size damper's area factor by the flow rate in CFM:

   CV = Area Factor x CFM
3. Enter the Pressure Drop Chart at the determined area factor and proceed up to appropriate conversion velocity (CV) line. Then, read across to static pressure drop at left side of chart.

EXAMPLE

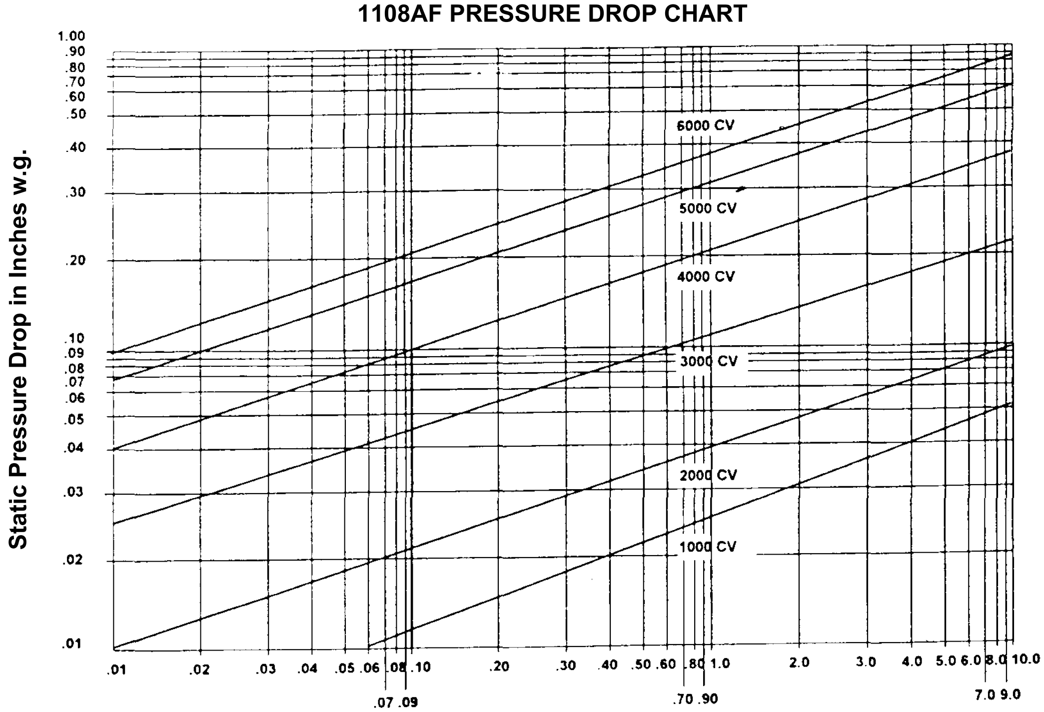
1. Find the pressure drop across an 18" wide x 18" high (457 x 457) Model 1108AF Damper handling 8570 CFM. From the Area Factor Table, area factor is determined to be .61.

   CFM X AREA FACTOR EQUALS CONVERSION VELOCITY
2. Therefore, CV (Conversion Velocity) = 8570 CFM x .61 = 5300. Using the Pressure Drop Chart, pressure drop = .30 inches water gage.

NOTES:

1. Ratings are based on AMCA Standard 500 using Test Setup Apparatus Figure 5.3 (damper is installed with duct upstream and downstream).
2. Static Pressure and Conversion Velocities are corrected to .075 lb./cu. ft. air density.

1108AF PRESSURE DROP CHART



AREA FACTOR

Dimensions in parenthesis ( ) indicate millimeters.

1108AF SUGGESTED SPECIFICATION

Furnish and install, at locations shown on plans or in accordance with schedules, Fiberglass airfoil design multiblade control dampers. Dampers shall be of pultruded construction and comply with ASTM D4385-84A, ASTM E-84, and ASME/ANSI RTP1-1989. Material used in construction shall be a flame retardant vinyl ester based substance. All material in airstream must meet or exceed required contamination concentration. Bearing design shall be based on system pressure and shall be of a teflon based material. All exposed glass shall be coated with resin compatible with that used in the pultrusion process and covered with surfacing veil. No exposed cut edges are acceptable. Damper blades shall be minimum 1/4" (6) thick of a hollow airfoil shape and contain pultruded slot for insertion of optional blade seal. Adhesive type seals are not acceptable. Frame shall be 8 inch deep X 2 3/16" inch flanged style, minimum 1/4" thick (203 x 56 x 6). The fiberglass axles shall be minimum 3/4" (19) diameter constructed of a vinyl ester based material, combined with continuous strand roving, and complete with surfacing veil. Damper design shall withstand minimum 14” W.G. and 4000 FPM velocity based on minimum 40” (1016) blade length. Submittal information shall include published performance data based on AMCA Standard 500 testing illustrating damper leakage, pressure drop, and static pressure design characteristics for a full range of damper sizes. Data from one size sample test is not acceptable. Damper shall be Swartwout model 1108AF.

RUSKIN

3900 Dr. Greaves Rd. • Kansas City, MO 64030 • (816) 761-7476 • FAX (816) 765-8955

INDUSTRIAL SWARTWOUT FIBERGLASS SERIES

MODEL 426 FIBERGLASS BACKDRAFT DAMPER

"V" Groove Blade

STANDARD CONSTRUCTION

FRAME
Fiberglass Channel, Vinyl Ester Resin. See table for dimensions.

BLADES
Vinyl Ester Resin, Triple "V" Groove, 6 5/8" wide x 1/8" (168 x 3) thick.

AXLES
3/4" (19) diameter axles. 316SS axles on blades with counterweights; pultruded fiberglass axles on all other blades (vinyl ester resin).

BEARINGS
Molded PTFE.

LINKAGE
316SS out of airstream.

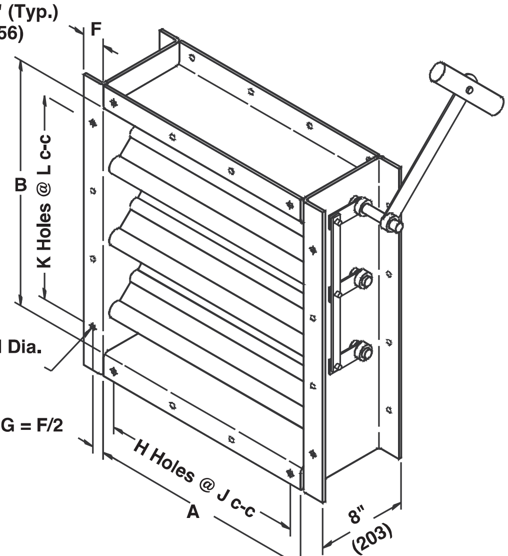
COUNTERBALANCE ASSEMBLY
316SS out of airstream.

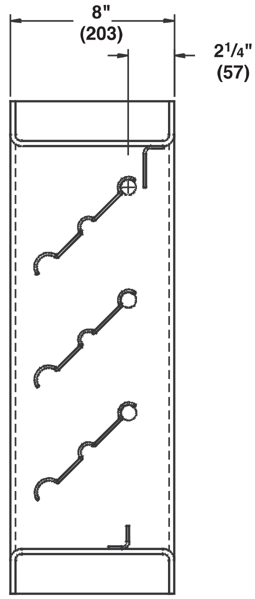
MAXIMUM TEMPERATURE
200°F (94°C).

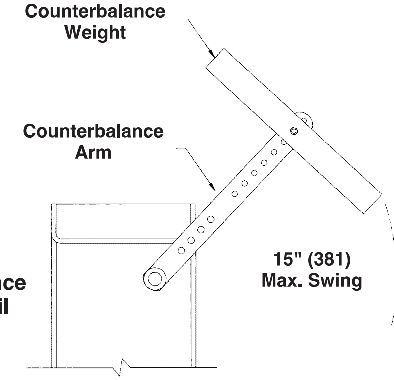
MINIMUM SIZE
6"w x 8"h (152 x 203).

MAXIMUM SIZE
48"w x 72"h (1219 x 1829).
Consult Ruskin for dampers larger than maximum size shown.

Dimensions in parenthesis ( ) indicate millimeters.







All options at additional cost.

FRAME		BLADES		SEALS (Optional)		AXLES		BEARINGS		LINKAGE		ACCESSORIES (Optional)	
8" x 2 3/16" x 1/4" (203 x 56 x 6) Fiberglass Channel		6 5/8" (168) wide, V-Groove shape		EPDM Blade Seal		3/4" (19) diameter fiberglass rod		Molded PTFE		316SS side linkage		Bolt Holes - 1 Flange	
				Viton Blade Seal								Bolt Holes - 2 Flanges	
				Neoprene Blade Seal		3/4" (19) diameter 316 SS (Opt)							
				SS Jamb Seal									
				Polycarbonate Jamb Seal									

QTY.	DIMENSIONS										TEMP. °F	COMMENTS	TAG
	A	B	C	F	G	H	J	K	L	M			

PROJECT:
ARCH/ENGR:
REPRESENTATIVE:
LOCATION:
CONTRACTOR:
DATE:

ALL STATED SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE OR OBLIGATION.

MODEL 426 PERFORMANCE DATA

DAMPER WIDTH	MAXIMUM SYSTEM PRESSURE	MAXIMUM SYSTEM VELOCITY	LEAKAGE WITHOUT SEALS*	
			% OF MAX. FLOW	CFM/SQ. FT.
48" (1219)	2.5" w.g.	2000 fpm	1.60	32 (.91 m^3/min.)
36" (914)	5.5" w.g.	2000 fpm	1.60	32 (.91 m^3/min.)
24" (610)	10" w.g.	2000 fpm	2.00	40 (1.13 m^3/min.)
12" (305)	10" w.g.	2000 fpm	3.00	60 (1.70 m^3/min.)

*Leakage information based on pressure differential of 1" w.g. tested per AMCA Std. 500.

Damper may tolerate higher pressures and velocities than those listed here. Conservative ratings are presented intentionally in an effort to avoid misapplication. Consult Ruskin or your Ruskin representative when a damper is to be applied in conditions exceeding recommended maximums.

MODEL 426 SUGGESTED SPECIFICATION

Furnish and install, at locations shown on plans or in accordance with schedules, fiberglass v-groove blade design backdraft dampers. Dampers shall be of the pultruded construction and comply with ASTM D4385-84. Material used in construction shall be a flame retardant vinyl ester based resin. All material in the airstream must meet or exceed required contamination concentrations. Bearing design shall be based on system pressure and shall be of a Teflon based material with graphite impregnation. All exposed glass shall be coated with resin compatible to that used in the pultrusion process. No exposed or non-coated edges are acceptable. Damper blades shall be a minimum of 1/8" (3) thick single skin design. All surfaces of the blade shall utilize surfacing veils. Open contact or hand layup blades are not acceptable. Damper frame shall be 8" deep x 2 3/16" (203 x 56) flanged style minimum 1/4" (6) thick. Fiberglass axles shall be minimum 3/4" (19) diameter pultruded construction of a vinyl ester based resin combined with continuous strand roving and complete with surfacing veil. Damper linkage shall be located out of airstream and constructed of 316SS. Face linkage in airstream is not acceptable. Standard damper construction shall withstand 10" SP and 2,000 FPM based on a 24" (610) blade length. Submittal information shall include published performance data based on AMCA Standard 500 testing illustrating maximum pressure data, flow ratings, and leakage characteristics for a full range of damper sizes. Data illustrating one size damper only is not acceptable. Manufacturer shall submit a sample damper for construction review and approval. Damper shall be Ruskin Swartwout Series model 426.

RUSKIN

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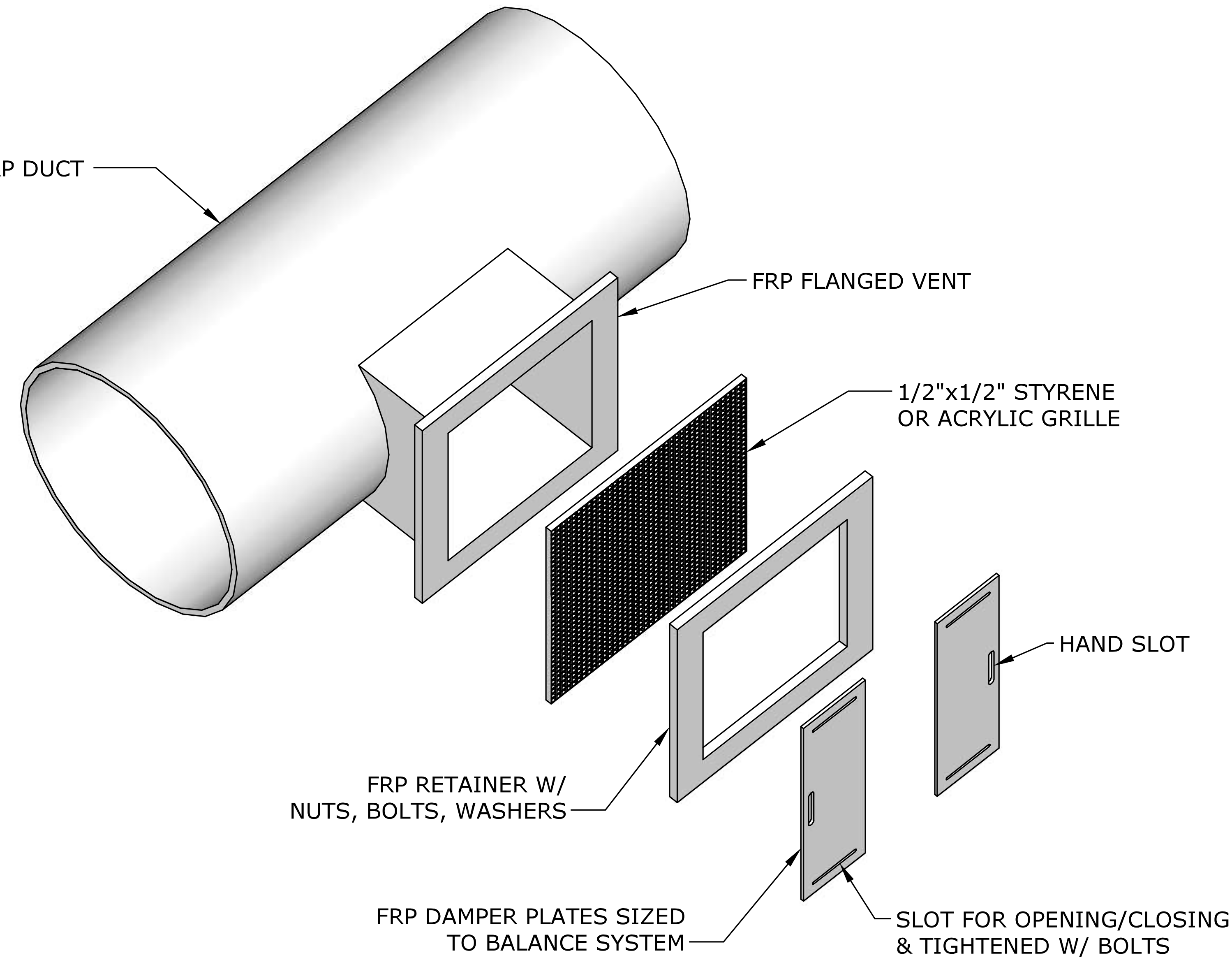

DETAIL H210 - AIR SUPPLY OR EXHAUST GRILLE

H210

DANIEL COMPANY AIR • WATER • ENVIRONMENTAL • SOLUTIONS	SCALE: NTS		
	DRAWN BY: CB	DATE: 04/05/2023	REV: 0

LAYOUT REVISED: 4/28/2020