FESHM 5031.1 PIPING ENGINEERING NOTE FORM

Prepared by: **Bob Sanders** Preparation Date: **5/15/14**

Piping System Title: **MicroBooNE Cryostat Piping**

Lab Location: **LARTF** Lab Location code: **787 LARTF**

Purpose of system / System description: **Cold piping attached to but cannot be isolated from the cryostat. Includes liquid withdrawal to and discharge from the LAr pumps, GAr supply from and return to the cool-down heat exchanger, bottom pressure tap on the cryostat, gas boil-off to condensers and piping to the relief valves and vent valves.**

Piping System ID Number: EN01740

Appropriate governing piping code: **ASME B31.3**

Fluid Service Category (if B31.3): Category-D / Normal / Category-M / High Pressure (circle one)

Fluid Contents: **Argon Gas and Liquid**

Design Pressure: **30 psig** Design Temperature: **-320 F – 100 F**

Piping Materials: **304 SS**

Drawing Numbers (PID's, weldments, etc.): Fermilab drawing # **497340, 493181, 493136, 493111, 489995, 493144, ValFab drawing 1203-727**

Designer/Manufacturer: **Fermilab**

Test Pressure: **33 psig** Test Fluid: **Argon Gas** Test Date: **XX/XX/XX**

Statement of Compliance

Is this piping system considered exceptional? Yes ____ No____
If "Yes", follow the requirements for an Extended Engineering Note for Exceptional Piping Systems.

Reviewed by: Michael Geynisman (Print Name)

Signature: Michael Geynisman Date: 12/02/14

D/S Head's Signature: [signature] #8973 Date: 12/16/14

The following signatures are required for exceptional piping systems:

ES&H Director's Signature: ______________________ Date: __________

Director's Signature or Designee: ______________________ Date: __________

Pipe Characteristics

Size: **¾" sch 40, 1" sch 10, 1 ½" sch 10, 2" sch 10, 3" sch10, 4" sch 40**

Length: **~32 feet** Volume: **~6 Gallons**

Relief Valve Information

Type: **Spring Loaded** Manufacturer: **Crosby JBS-E-32-J**

Set Pressure: **30 psig** Relief Capacity: **2434 scfm air**
Relief Design Code: **ASME BPVC VIII D1**

Is the system designed to meet the identified governing code? (Yes) / No

System Documentation

Process and Instrumentation diagram appended? (Yes) / No

Process and Instrumentation component list appended? (Yes) / No

Is an operating procedure necessary for safe operation? Yes / (No)
If 'yes', procedure must be appended.

Fabrication Quality Assurance

List vendor(s) for assemblies welded/brazed off site: **Val-Fab**

List welder(s) for assemblies welded/brazed in-house: **Bill Gatfield, Ryan Mahoney**

Are welder qualification records available for in-house welded/brazed assemblies? (Yes) / No
If yes, append documents or make available to reviewer.

Are all quality verification records required by the identified code available? (Yes) / No
(e.g. examiner's certification, inspector's certification, test records, etc.)
If yes, append documents or make available to reviewer.

Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number: MD-ENG-516 Date: 4/29/14

Project Internal Reference:

Project: Microboone

Title: Microboone Cryostat Piping Engineering Note

Author(s): Mike Zuckerbrot / Bob Sanders

Reviewer(s): Michael Geynisman

Key Words:

Applicable Codes: ASME B31.3

Abstract Summary: The following FESHM 5031.1 required piping engineering note covers the Microboone Cryostat Piping.

MicroBooNE Cryostat Piping Engineering Note

PPD-MD-ENG-516

Table of Contents

1.0) System Introduction and Description

This Piping Engineering Note is for the Normal class piping that cannot be isolated by valves from the cryostat. The cryostat is an ASME coded vessel fabricated by Val Fab, an ISO9001 certified manufacturer. A certificate of compliance and an entire package of code documentation which Val Fab supplied is available in Microboone docdb #2582.

2.0) Design Code and Criteria

The MicroBooNE Cryostat Piping meets the requirements of Section 5031.1 of the Fermilab ES&H Manual. This section states that systems which fall under the ASME B31.3 Normal Fluid Service category shall have an engineering note prepared by the appropriate governing code. Table 1 in Section 5031.1 stated ASME B31.3 shall be used for cryogenic liquid or gas.

3.0) Materials and Drawings

3.1) Description

The phase 2 MicroBooNE Cryostat Piping is considered to be all piping attached to the cryostat that contains cold (< -20F) argon and cannot be isolated by valves from the cryostat. There are seven separate sections of cryostat piping. the liquid withdrawal to and discharge from the liquid argon pumps, Gas argon from and return to the cool-down heat exchanger, the bottom pressure tap on the cryostat, the gas boil-off to condensers and piping to the relief valves and vent valves. All of the piping is 304 Stainless Steel piping. See section 3.2 and *Appendix B* for details and fabrication drawings.

The figures below show the seven sections of the cryostat piping.

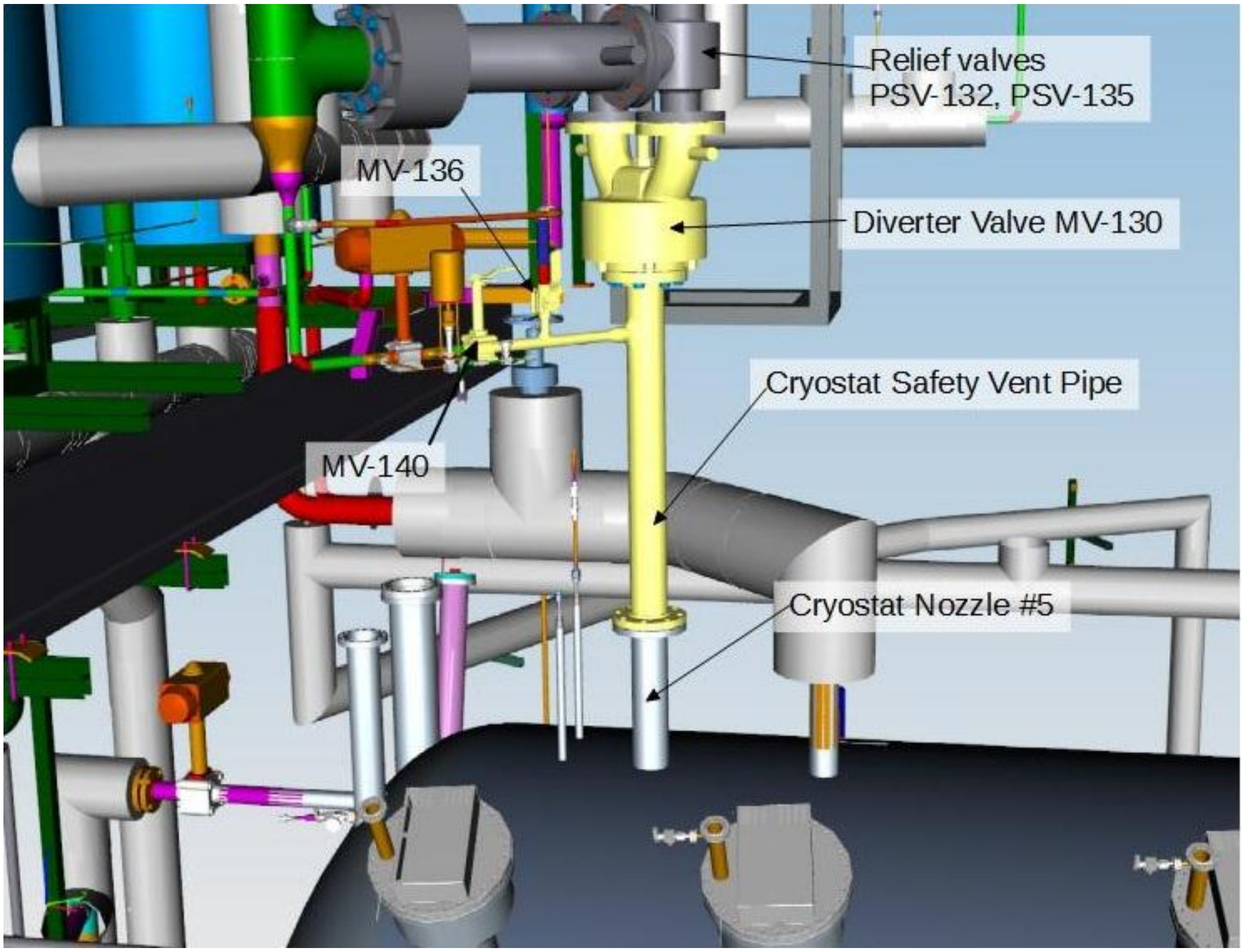


Fig. 3.1 above shows the cryostat vent pipe attached to nozzle #5 on the cryostat..

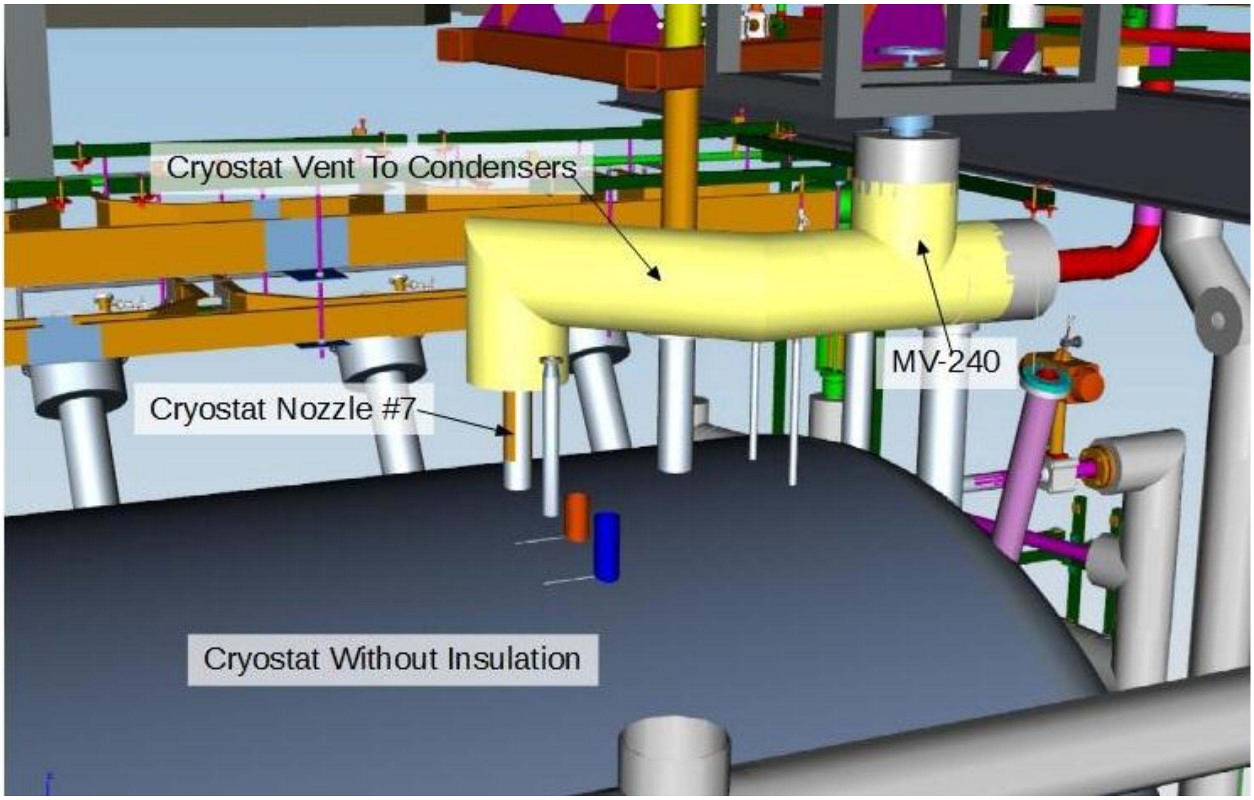


Fig 3.2 Vent pipe from nozzle #7 on the top of the cryostat to the condenser.

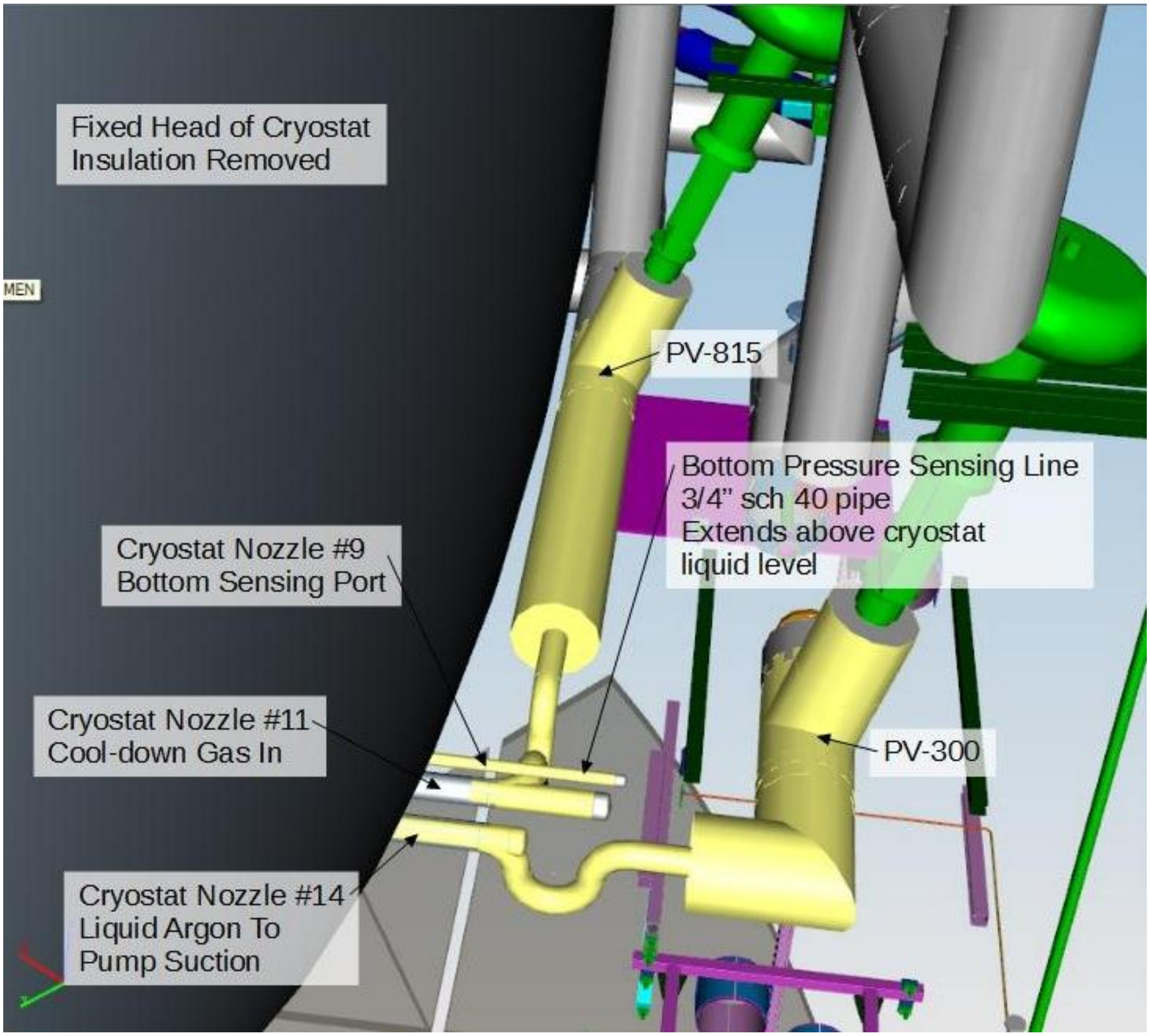


Figure 3.3 shows three sections of the cryostat piping on the bottom of the fixed head of the cryostat. Cryostat nozzle #9 connects to the bottom pressure sensing line. Nozzle #11 connects to the cool-down gas inlet valve PV-815. Nozzle #14 connects to the pump suction valve PV-300.

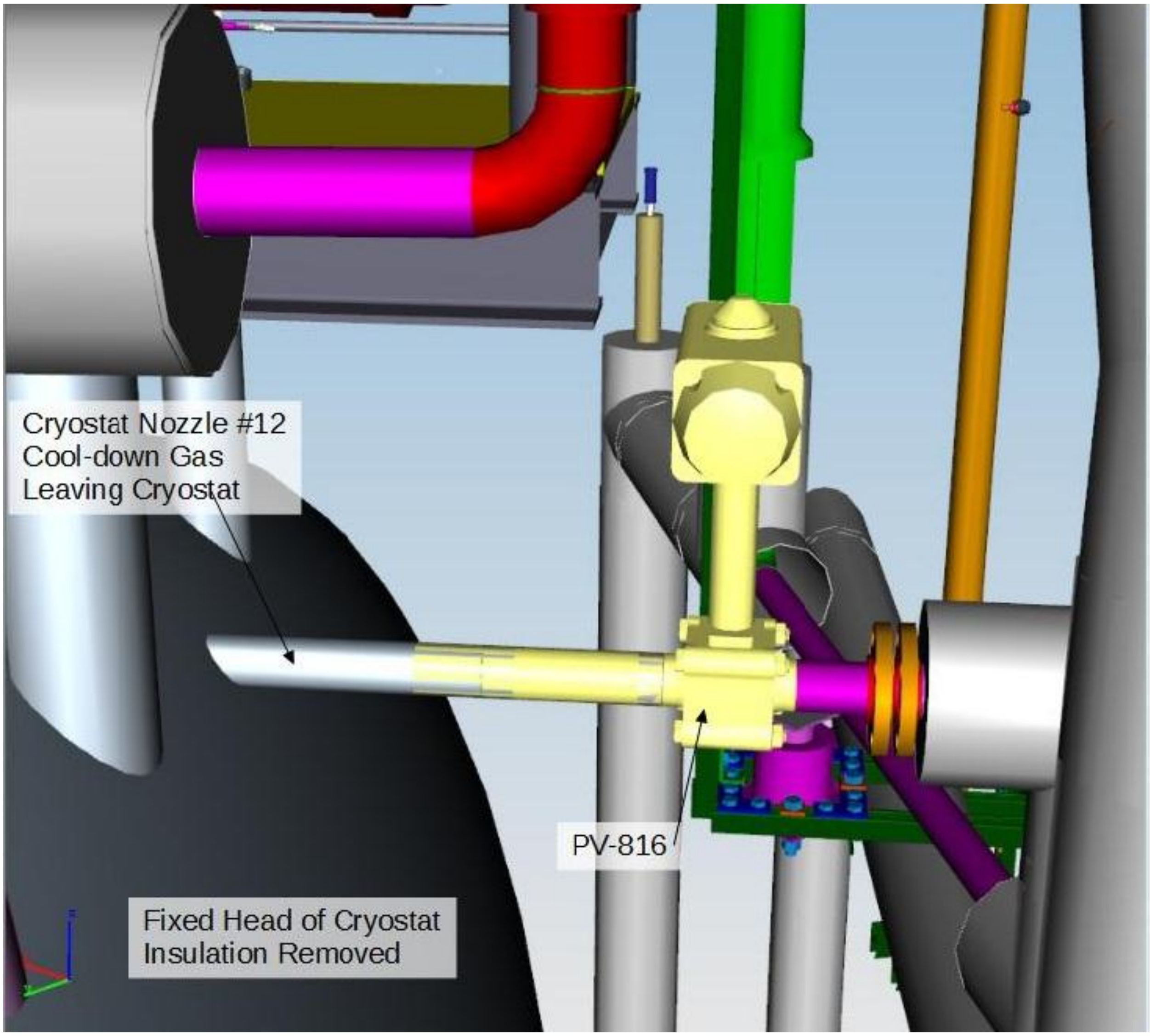


Fig 3.4 Pipe from nozzle #12 on the top of the cryostat fixed head that connects to PV816 for the return of the cool-down gas from the cryostat.

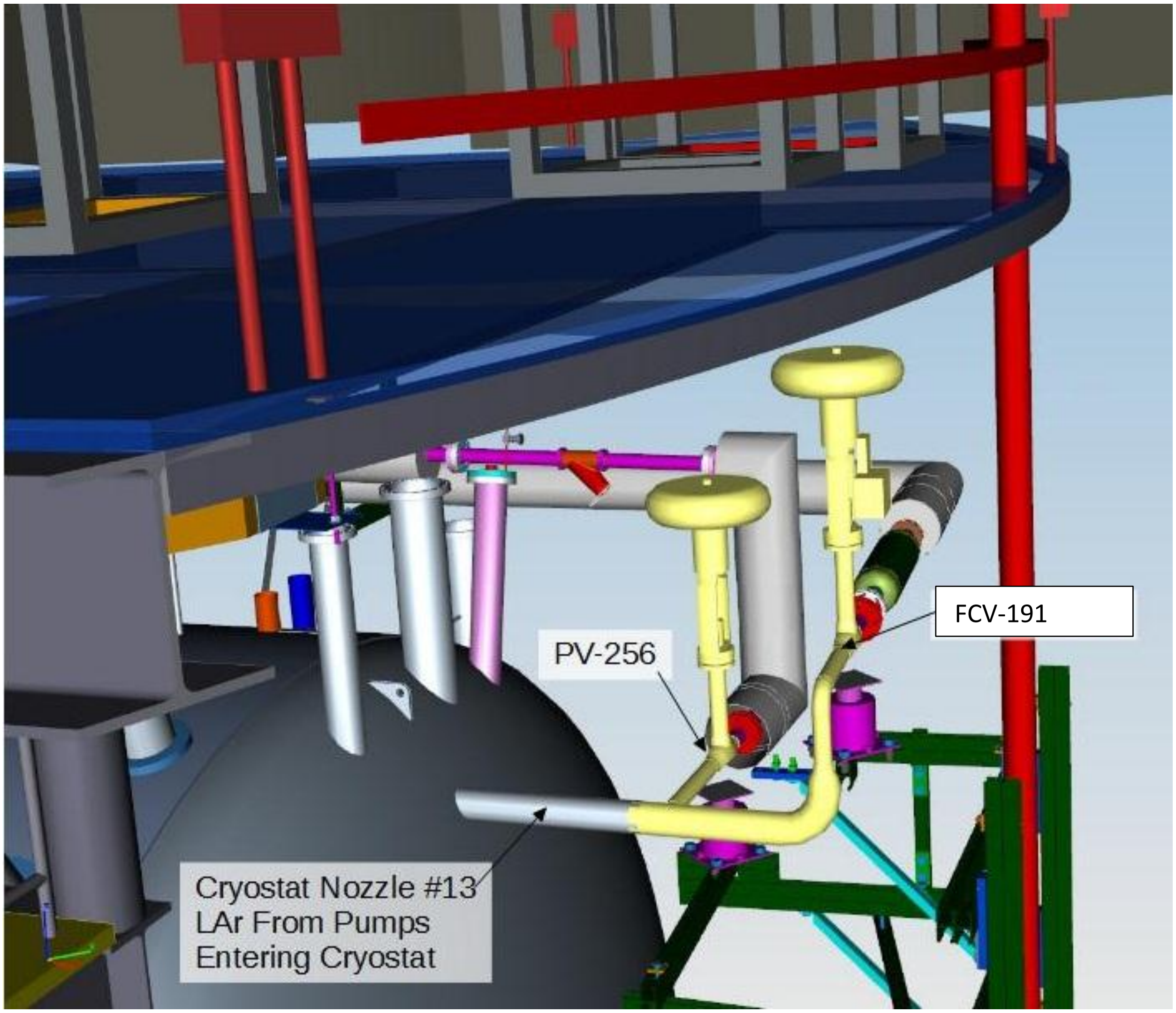


Fig 3.5 Pipe carrying liquid argon to nozzle #13 of the cryostat from either the pump discharge (FCV-191) or from the condenser (PV-256).

3.2) Fabrication Drawings

The MicroBooNE Cryostat Piping has the following fabrication drawings. The fabrication drawing numbers are listed below and can be found in *Appendix B*. A zip file of the Cryostat Piping fabrication drawings can also be found in the MicroBooNE docdb #2480.

The Cryostat vendor Val-Fab fabricated the entire cryostat and attached nozzles as shown on the following drawing package. Val-Fab was required by the contract to fabricate and install all piping components in accordance with ASME B31.3 piping code. It was left to the discretion of Val-Fab and their Authorized Inspector as to where the on each nozzle the piping code applied and the pressure vessel code applied. The Nozzles of interest are nozzle #5, 7, 9, 11, 12, 13 and 14.

- Val-Fab dwg # 1203-727, sheet 1-8

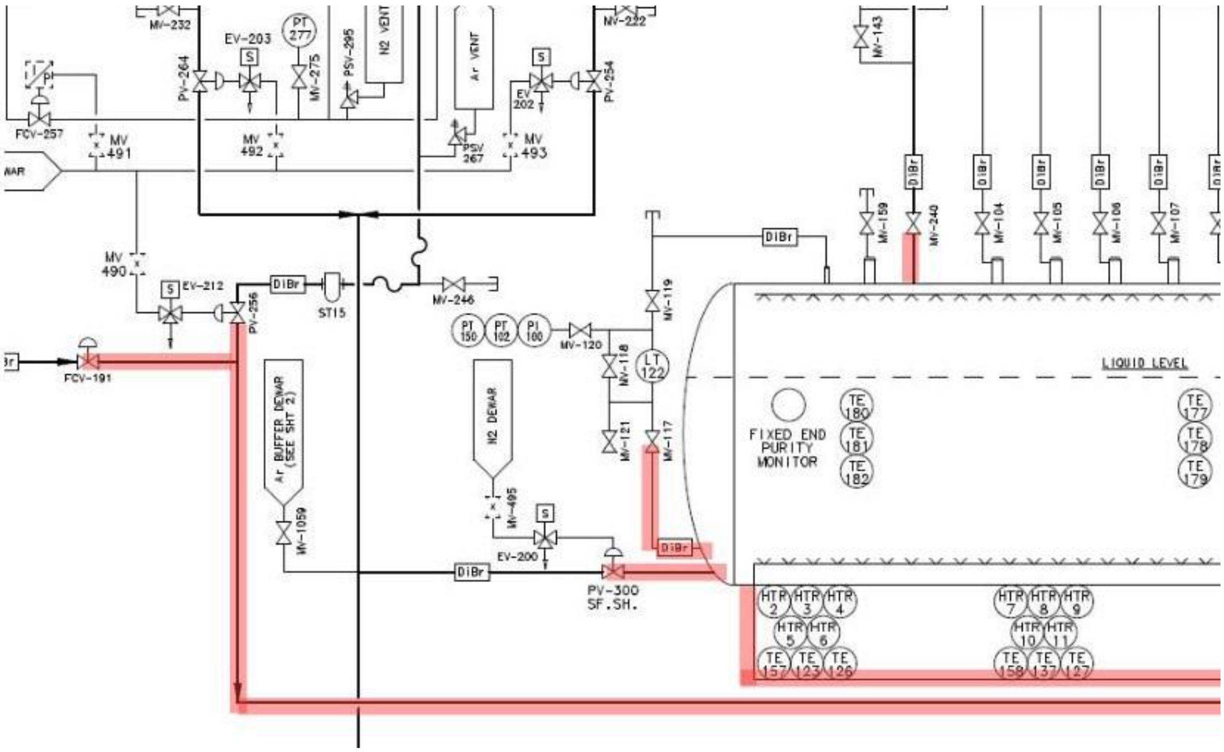
The Cryostat vendor Val-Fab fabricated the entire cryostat and attached nozzles as shown on the following drawing package. Val-Fab was required by the contract to fabricate and install all piping components

- DWG: #497340 – Cryostat vent from Nozzle #5
- DWG: #493181 – Cool-down gas inlet, Nozzle #11
- DWG: #493136 – Pump Suction, Nozzle #14
- DWG: #493111 – Gas to Condenser, Nozzle #7
- DWG: #489995 – Liquid Argon From Pump Discharge, Nozzle #13
- DWG: #493144 – Cool-down Gas outlet, Nozzle #12

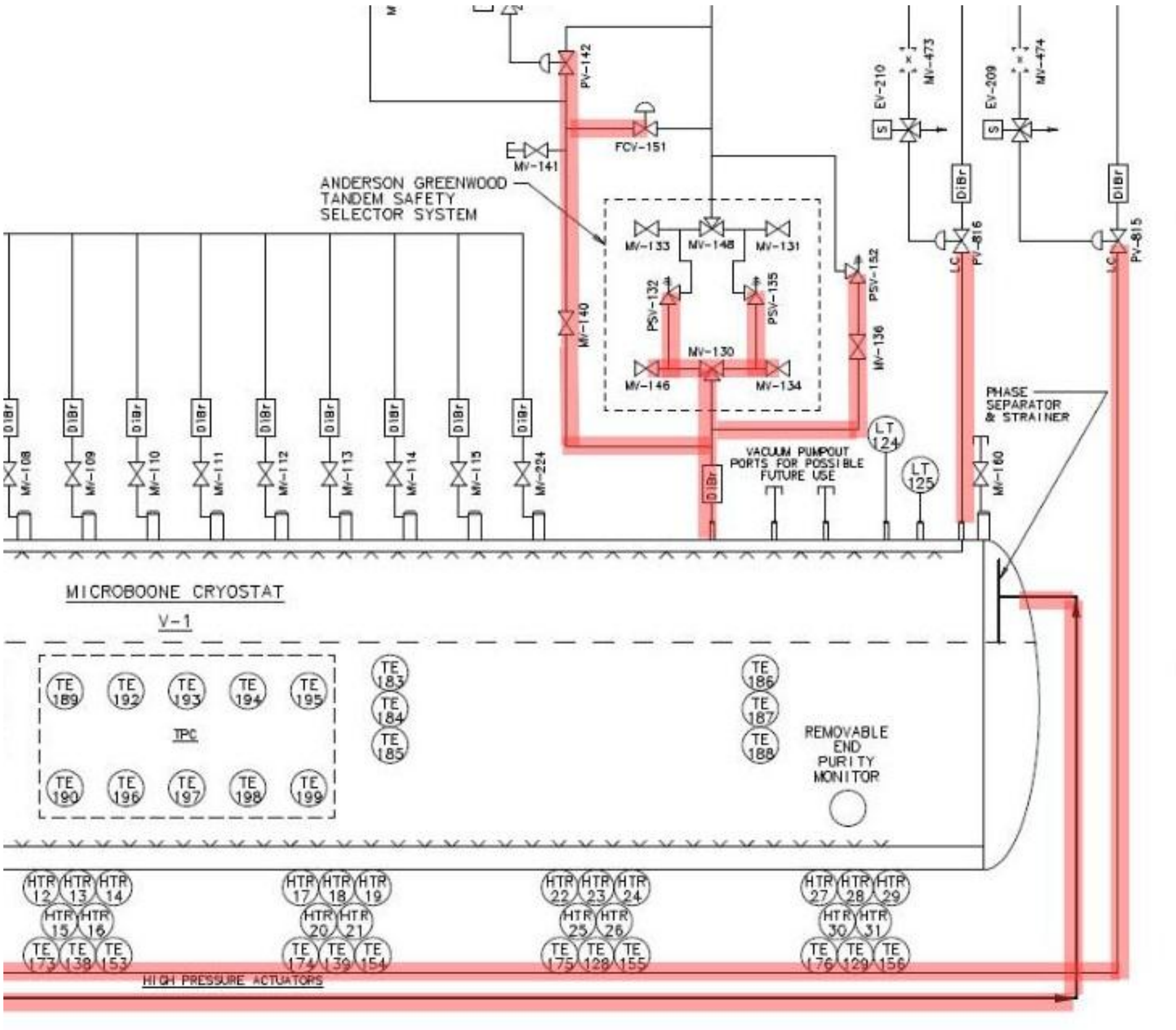
There is no Fermilab drawing for the Bottom Sensing Line from Nozzle #9

3.3) Piping and Instrumentation Diagrams

The MicroBooNE cryostat piping system on the two (right and left) flow schematics below. These drawings with the individual piping engineering note subsystems highlighted can be seen in *Appendix A*. The highlighted piping and instrumentation diagrams can also be found in the MicroBooNE docdb #2579. The unmarked piping and instrumentation diagram for MicroBooNE can be found in MicroBooNE docdb #255.



Left side of cryostat piping flow schematic



Right side of cryostat piping flow schematic

3.4) Valve and Instrument List

The full MicroBooNE Valve and Instrument List can be found in the MicroBooNE docdb #639. The valves and instruments relevant to the MicroBooNE Cryostat Piping are shown below. The valves are unlisted components and their manufacturers pressure rating is below in the table.

Code	Tag #	Fluid	Subsystem - Service	Range / Setpoint	Pressure Rating	Manufacturer	Model Number
MV	130	Ar	Cryostat - Tandem relief valve system inlet changeover control		>535 psig	Anderson Greenwood	SVR-1610F-SSTO
PSV	132	Ar	Cryostat - Code relief valve	30 psig	535 psig	Crosby	4L6 JBS-E-32-J
MV	134	Ar	Cryostat - Tandem relief valve system PSV135 inlet pumpout		>535 psig	Anderson Greenwood	SVR-1610F-SSTO
PSV	135	Ar	Cryostat - Code relief valve	30 psig	535 psig	Crosby	4L6 JBS-E-32-J
MV	136	Ar	Cryostat - Isolation valve for PSV152, operational relief		1450 psig	Sharpe	3/4"-99-6-6-M-T-SW
MV	140	Ar	Cryostat - Vent, isolation for valves PV142 and FCV151		1500 psig	Sharpe	1"-C99-6-6-R-T-BW10
MV	141	Ar	Cryostat - Vent, vacuum pumpout or purge for PV142 line		1000 psig	Swagelok	SS-4H-TW
PV	142	Ar	Cryostat - Vent, actuated valve for the vent piping (fail closed)		1500 psig	Sharpe	1"-C99-6-6-R-T-BW10/SR/NC
MV	146	Ar	Cryostat - Tandem relief valve system PSV132 inlet pumpout		>535 psig	Anderson Greenwood	SVR-1610F-SSTO
FCV	151	Ar	Cryostat - Vent flow control valve for cryostat and cooldown loop		700 psig	Swagelok	SS-4BMRG-TW-XXXX
PSV	152	Ar	Cryostat - Operational relief valve	10 psig	2400 psig	Circle Seal	5180B-6MP
FCV	191	Ar	Cryostat - Main liquid circulation inlet (fail open)		300 psig	ACME	CV15SPHAROP10EA
MV	240	Ar	Condensers - Cryostat to condensers inlets		300 psig	ACME	V-1060-300-SL-X-10
PV	256	Ar	Condensers - Outlet directly to cryostat (fail open)		300 psig	ACME	CV15NOHAROP10EA
PV	300	Ar	Pump Skid - Cryostat to pump suction shutoff valve (fail closed)		300 psig	ACME	CV2000HAROP10EA
PV	815	Ar	Cooldown - Cryostat inlet (fail closed)		300 psig	ACME	CV2000HAROP10EA
PV	816	Ar	Cooldown - Cryostat outlet (fail closed)		1500 psig	Sharpe	2"-C99-6-6-R-T-BW10/SR/NC

3.5) Unlisted Components

The MicroBooNE Cryostat Piping contains several unlisted components which are not manufactured to a standard listed in ASME B31.3 Table 326.1. The use of all unlisted components is allowable per ASME B31.3 Section 304.7.2(a) stating the unlisted components are acceptable with extensive, successful service experience under comparable conditions with similarly proportioned components of the same or like material. The unlisted components are shown in the table below. When similar fittings of varying sizes are present, only the size and type of fitting with the lowest pressure rating will be listed.

Description	Manufacturer / Distributor	Model Number	Pressure Rating
¾” NPT X ¾” compression	McMaster Carr	50915K334	100 psig
Pipe Butt Weld Fittings, ¾” and	Swagelok	SS-16MPW-A-6TSW series	5900 psig

smaller			
Pipe Butt Weld Fittings, ¾" and smaller	Swagelok	SS-16MPW-A-6TSW series	5900 psig

3.6) Listed Components

The listed components other than pipe fittings are below:

Description	Manufacturer / Distributor	Model Number	Pressure Rating
1 1/2" 150# Flange, 304SS	--	--	275 psig
2" 150# Flange, 304SS	--	--	275 psig
4" 150# Flange, 304SS	--	--	275 psig

4.0) Piping Design and Analysis

4.1) Pressure Design

Calculations used to determine the minimum wall thicknesses of pipes and tubes can be found in *Appendix C*. All pipes and tubes in the MicroBooNE Cryostat Piping system are shown to have sufficient wall thickness for the design pressure and temperature. The calculations shown in *Appendix C* are generic and apply to all MicroBooNE piping notes, therefore the design pressures and temperatures used to not specifically match this note. However, this system is within the range of pressures and temperatures the calculations were performed at.

4.2) Thermal Design

The thermal stresses in the piping connected to the condensers and to and from the pump (Nozzles 7, 13 and 14) are evaluated and found to be acceptable in the MicroBooNE Pump Suction-Discharge Piping Engineering Note (document database #2581). The thermal stresses in the piping for the gas cool-down (Nozzles 11 and 12) are evaluated and found to be acceptable in the MicroBooNE Cool-down Piping Engineering Note (document database # 2583).

The bottom pressure sensing line on the cryostat is a ¾" sch 40 pipe that rises vertically next to the cryostat. Above the cryostat liquid level, the pipe converts to ¼" tubing. There is no flow in the sensing line and it is free to move, preventing thermal stresses.

The remaining section of cryostat piping is the vent pipe at the top of the cryostat connected to cryostat nozzle #5. Figure 4.1 below shows the Cryostat Vent Support Assembly (Fermilab dwg # 497430) supporting the cryostat relief valves and diverter valves. Four vertical compression springs support the weight of the valves while accommodating the vertical contraction of the cryostat as in cools down to ~90K. The cryostat is anchored at the saddle below the relief valve assembly. The use of four springs in the support allows for angular misalignment. The Cryostat Vent Support Assembly is mounted on a rigid platform above the cryostat.

The 6” vent line on the discharge side of the relief valves has a vertical and a horizontal flexible hose allowing relative motion of the connected components in all directions and angles.

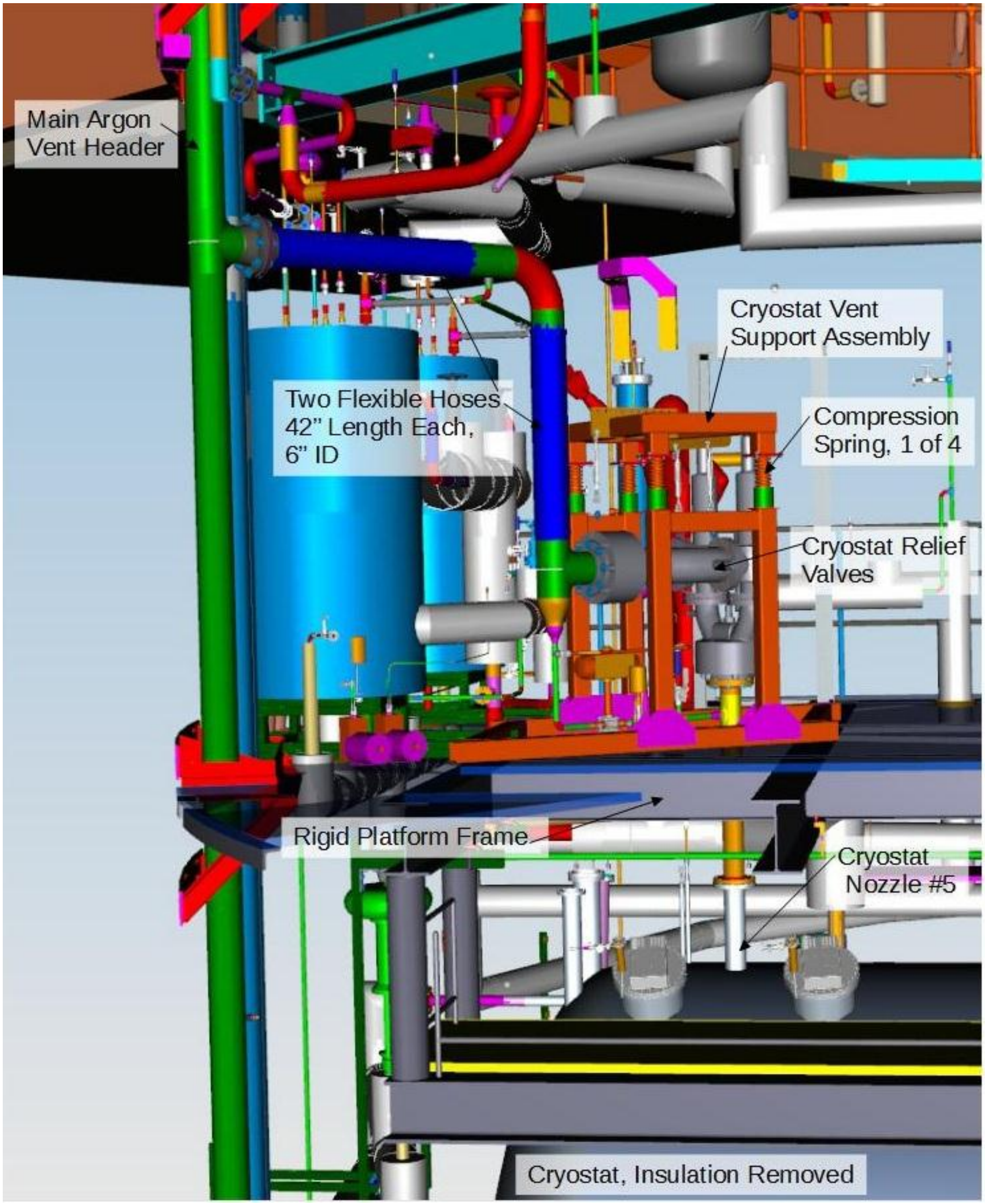


Fig. 4.1 View of the supports of the Cryostat relief valves and diverter valves.

5.0) Pressure Relief System

The MicroBooNE Cryostat Piping has three relief valves. The relief valve PSV-152 is a small operational relief intended to keep the cryostat pressure within acceptable limits if the condensers are not operational. The two main relief valves PSV-132 and PSV-135 protect the cryostat and all of the cryostat piping. The diverter valves, MV-130 and MV-148, select one or the other relief valve so that either PSV-132 or PSV-135 is always protecting the cryostat. The Relief valve sizing calculations for the cryostat are found in the Cryostat Pressure Vessel Engineering Note in MicroBooNE document database #2170.

- **PSV-132:**
  Manufacturer: Crosby JBS-E-32-J
  Set Pressure: 30 psig
  Relief Capacity: 2434 SCFM Air
  Relief Design Code: ASME BPVC VIII D1
- **PSV-135:**
  Manufacturer: Crosby JBS-E-32-J
  Set Pressure: 30 psig
  Relief Capacity: 2434 SCFM Air
  Relief Design Code: ASME BPVC VIII D1
- **PSV-152:**
  Manufacturer: Circle Seal model 5180B-6MP-10
  Set Pressure: 10 psig
  Relief Capacity: 9 SCFM Air @ 16.5 psig
  Relief Design Code: ASME B31.3

6.0) Welding and Inspections

The MicroBooNE Cryostat Piping was fabricated in sections at Lab F as illustrated by the fabrication drawings. All piping was examined at Lab F before final welding at the LARTF enclosure per ASME B31.3 Section 341. In process visual inspection on a weld by weld basis was used per Section 341.4.1(b)(1). All stainless steel piping is covered by WPS SS-9-001 and all stainless steel tubing is covered by WPS SS-8-001, R1. An Argon shield was used on all welds and brazed joints, with the applicable welders being Bill Gatfield and Ryan Mahoney. All weld inspection, welder qualification, and welding procedure documentation can be found in the Microboone docdb #2578.

On the final closure welds for the final welds attaching cryostat piping assemblies to the cryostat nozzle, there was a final pressure test of the entire vessel and all welds were inspected in-process.

7.0) Pressure Testing

Pressure testing of the Microboone Cryostat Piping shall be performed in accordance with Section 5034 of the Fermilab ES&H Manual and ASME B31.3 Section 345.5. The piping shall be pneumatically tested at 110% of the design pressure, 33 psig for the 30 psig rated system. See *Appendix D* for all pressure testing documentation.

Appendix A

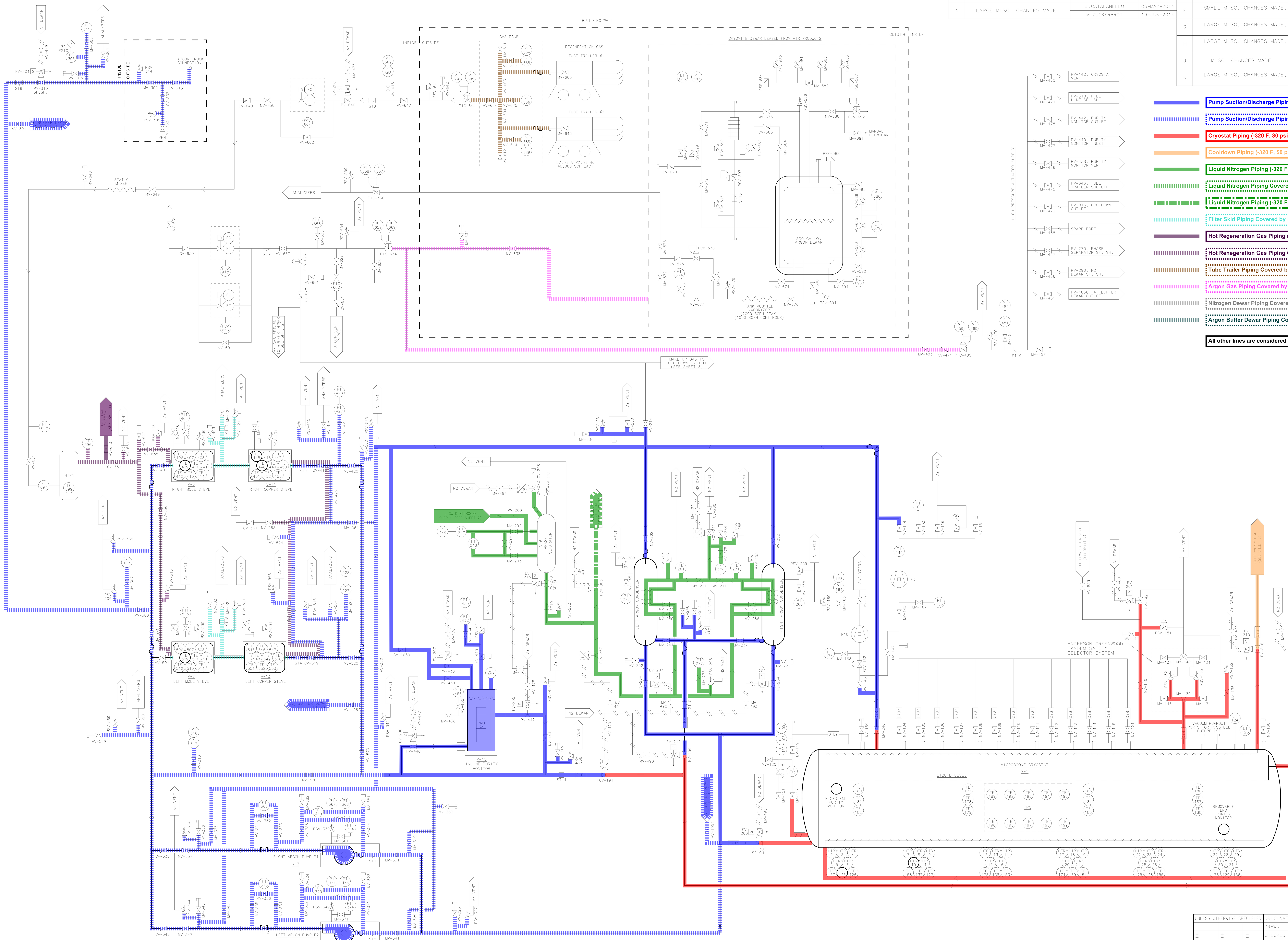
Piping and Instrumentation Diagram

See following pages for:

- **Piping and Instrumentation Diagram with Separate Normal Fluid Piping Systems Highlighted**

L	LARGE MISC. CHANGES MADE.	J.CATALANELLO	29-MAY-2013
		M.ZUCKERBROT	10-JUN-2013
M	CHANGES MADE TO SHEETS 1 & 2.	J.CATALANELLO	23-AUG-2013
		M.ZUCKERBROT	05-SEP-2013
N	LARGE MISC. CHANGES MADE.	J.CATALANELLO	05-MAY-2014
		M.ZUCKERBROT	13-JUN-2014

REV	DESCRIPTION	DRAWN / APPROVED	DATE
E	SMALL MISC. CHANGES MADE.	J.CATALANELLO	02-MAR-2011
		R.SCHMITT	13-MAY-2011
F	SMALL MISC. CHANGES MADE.	J.CATALANELLO	13-JUN-2011
		M.ZUCKERBROT	28-JUL-2011
G	LARGE MISC. CHANGES MADE.	J.CATALANELLO	28-SEP-2011
		M.ZUCKERBROT	03-OCT-2011
H	LARGE MISC. CHANGES MADE.	J.CATALANELLO	29-NOV-2011
		M.ZUCKERBROT	30-MAY-2012
J	MISC. CHANGES MADE.	J.CATALANELLO	12-SEP-2012
		M.ZUCKERBROT	19-SEP-2012
K	LARGE MISC. CHANGES MADE.	J.CATALANELLO	29-JAN-2013
		M.ZUCKERBROT	06-FEB-2013



Pump Suction/Discharge Piping (-320 F, 100 psig)
Pump Suction/Discharge Piping Covered by Phase 1 Documentation
Cryostat Piping (-320 F, 30 psig)
Cooldown Piping (-320 F, 50 psig)
Liquid Nitrogen Piping (-320 F, 75 psig)
Liquid Nitrogen Piping Covered by Phase 1 Documentation (75 psig)
Liquid Nitrogen Piping (-320 F, 50 psig)
Filter Skid Piping Covered by Phase 1 Documentation
Hot Regeneration Gas Piping (500 F, 50 psig)
Hot Renegeration Gas Piping Covered by Phase 1 Documentation
Tube Trailer Piping Covered by Phase 1 Documentation
Argon Gas Piping Covered by Phase 1 Documentation
Nitrogen Dewar Piping Covered by Phase 1 Documentation
Argon Buffer Dewar Piping Covered by Phase 1 Documentation

All other lines are considered Class D piping or are instrument lines

UNLESS OTHERWISE SPECIFIED		
ORIGINATOR	R.SCHMITT	26-NOV-2008
DRAWN	J.CATALANELLO	08-DEC-2008
CHECKED	R.SCHMITT	06-JAN-2009
APPROVED	R.SCHMITT	06-JAN-2009

1. BREAK ALL SHARP EDGES MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. MAX. ALL MACH. SURFACES
5. DRAWING UNITS: U.S. INCH

USED ON

MATERIAL

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

MICROBOONE LAR TPC PIPING AND INSTRUMENT DIAGRAM CRYOGENIC SYSTEM

SCALE	DRAWING NUMBER	SHEET	REV
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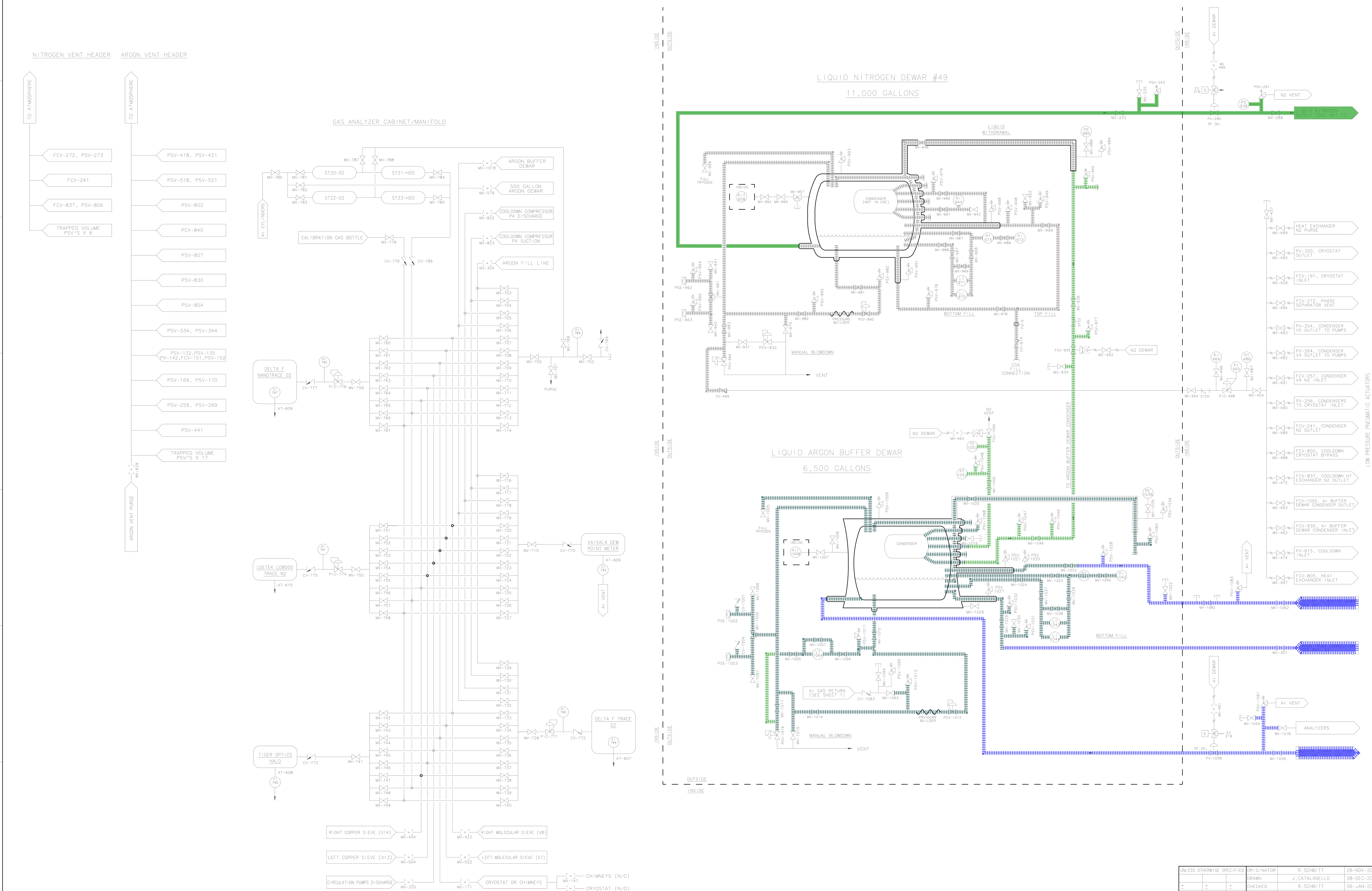
CREATED WITH : Ideas12NXSeries GROUP: PPD/MECHANICAL DEPARTMENT



UNLESS OTHERWISE SPECIFIED			ORIGINATOR	R.SCHMITT	26-NOV-2008
			DRAWN	J.CATALANELLO	08-DEC-2008
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			APPROVED	R.SCHMITT	06-JAN-2009

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4. MAX. ALL MACH. SURFACES
5. DRAWING UNITS: U.S. INCH

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MATERIAL

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

MICROBOONE LAR TPC PIPING AND INSTRUMENT DIAGRAM CRYOGENIC SYSTEM

SCALE	DRAWING NUMBER	SHEET	REV
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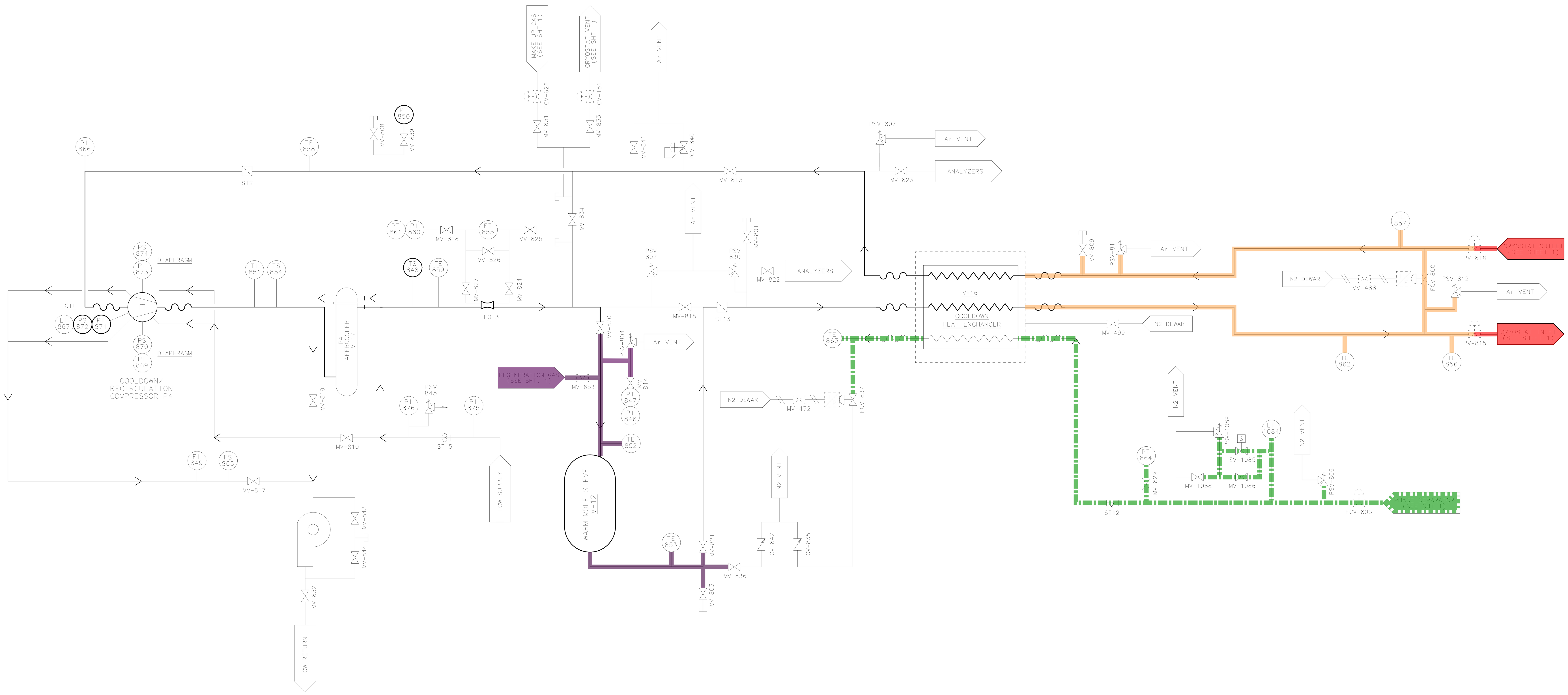
CREATED WITH : Ideas12NXSeries — GROUP: PPD/MECHANICAL DEPARTMENT

COOLDOWN/RECIRCULATION SYSTEM



UNLESS OTHERWISE SPECIFIED	ORIGINATOR	R.SCHMITT	26-NOV-2008
± ± ±	DRAWN	J.CATALANELLO	08-DEC-2008
	CHECKED	R.SCHMITT	06-JAN-2009
	APPROVED	R.SCHMITT	06-JAN-2009

1. BREAK ALL SHARP EDGES MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. MAX. ALL MACH. SURFACES √
5. DRAWING UNITS: U.S. INCH

USED ON

MATERIAL

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

MICROBOONE LAR TPC
PIPING AND INSTRUMENT DIAGRAM
CRYOGENIC SYSTEM

SCALE	DRAWING NUMBER	SHEET	REV
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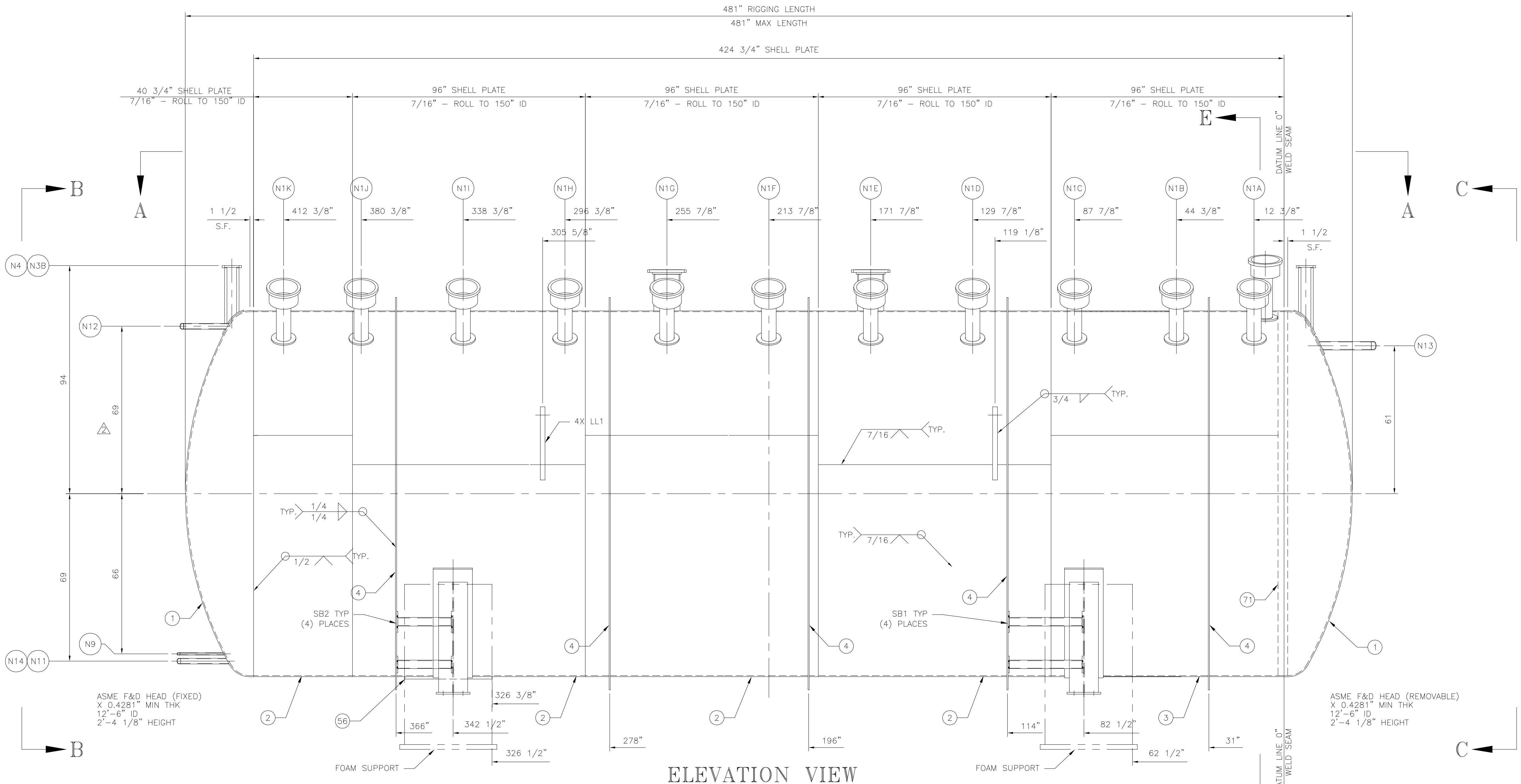
CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

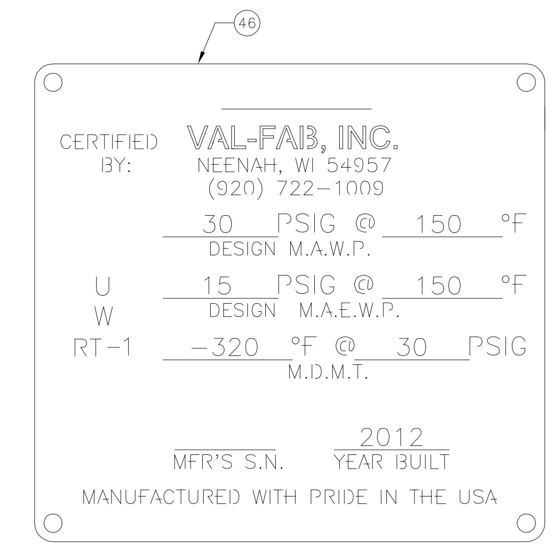
Appendix B

Fabrication Drawings

See following pages for:

- **Val-Fab DWG # 1203-727, sheet 1-8**
- **DWG: #497340 – Cryostat vent from Nozzle #5**
- **DWG: #493181 – Cool-down gas inlet, Nozzle #11**
- **DWG: #493136 – Pump Suction, Nozzle #14**
- **DWG: #493111 – Gas to Condenser, Nozzle #7**
- **DWG: #489995 – Liquid Argon From Pump Discharge, Nozzle #13**
- **DWG: #493144 – Cool-down Gas outlet, Nozzle #12**





MAJOR COMPONENT DESIGN DATA

VESSEL CALCULATIONS PER THE 2010 EDITION OF THE ASME CODE SECTION VIII DIVISION 1 A11 ADDENDA.

VESSEL

INT. DESIGN PRES: 30 PSIG @ 150°F
EXT. DESIGN PRES: 15 PSIG @ 150°F
PNEUMATIC-TEST PRES: 33 PSIG @ 70°F

PWHT: NONE
WIND CODE: NO WIND LOAD
HEAD TYPE, RIGHT: FLANGED & DISHED

MAWP: 30 PSIG
MAP: 30 PSIG
MDMT: -320°F
SEISMIC CODE: IBC 2009 CLASS C
HEAD TYPE, LEFT: FLANGED & DISHED

HELIUM LEAK TEST: PER SPECIFICATION

RADIOGRAPHY:
HEAD/SHELL: FULL UW-11(a)
SHELL CIRC: FULL UW-11(a)
SHELL LONG: FULL UW-11(a)

JOINT EFFICIENCY:
HEAD/SHELL: 1.0
SHELL CIRC: 1.0
SHELL LONG: 1.0

ESTIMATED WEIGHT:
EMPTY: 37,400 LBS
TEST: 344,369 LBS
OPERATING: 492,000 LBS

ESTIMATED CAPACITY:
35,174 US GALLONS

INTERIOR FINISHES:
WELDS: COLOR CLEANED
SURFACE PREP: MILL/2B
COATING: NONE

EXTERIOR FINISHES:
WELDS: COLOR CLEANED
SURFACE PREP: MILL/2B
COATING: NONE

GENERAL NOTES

1. FLANGE BOLT HOLES TO STRADDLE NORMAL VESSEL CENTERLINES, UNLESS OTHERWISE NOTED (UON).
2. WELDS SHALL BE NEAT IN APPEARANCE AND FREE OF SLAG, UNDERCUTS AND OTHER DEFECTS.
3. VESSEL SHALL BE CLEANED OF SCALE, OIL, WELD SPATTER AND ALL OTHER FOREIGN MATTER BEFORE PNEUMATIC TESTING.
4. PROTECT ALL MACHINED SURFACES AND THREADED CONNECTIONS WITH WOOD OR PLASTIC PROTECTORS BEFORE SHIPMENT.
5. ALL COUPLINGS TO BE RE-TAPPED AFTER INSTALLATION
6. ALL THREADED PIPE FITTING CONNECTIONS (CAPS, PLUGS, THERMOWELLS, ETC.) ARE TO BE WRAPPED WITH TEFLON TAPE PRIOR TO ASSEMBLY.
7. REINFORCING PADS AND PAD SECTIONS SHALL HAVE 1/4" NPT WEEP HOLE LOCATED AS LOW AS POSSIBLE IN THE PAD WHEN THE VESSEL IS IN OPERATING POSITION.
8. 6" NOM EXTERNAL NOZZLE PROJECTION, FLUSH INTERNAL PROJECTION, U.N.O.
9. (2) ALL FLANGE FACES TO HAVE 125/250 RA PHONOGRAPHIC GASKET SURFACE SERRATIONS. ALL CONFLAT FLANGES TO HAVE THEIR SEALING SURFACE PROTECTED.
10. (2) THERE ARE TO BE NO SHARP EDGES INSIDE THE VESSEL.

VAL-FAB, Inc.
201 Jackson Street
Neenah, WI 54956
(920) 722-1009

REV	DATE	BY	DESCRIPTION
1	8/13/12	BCR	REVISED PER CUSTOMER MARK-UPS AND CUSTOMER DRAWINGS REV D.
2	8/29/12	BCR	ADDED TAPPED HOLE TO JACKING ANGLE PER EMAIL FROM 8/28/12
3	9/26/12	BCR	REVISED PER CUSTOMER REQUEST PER EMAIL NOTES DATED 9/13/12
4	10/15/12	BCR	REVISED PER ENGINEERING CHANGES

VAL-FAB, Inc.
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(920) 722-1009
APPROVED FOR CONSTRUCTION
ENG. ____________

TOLERANCE:
X.±0.250
X.X±0.125
X.XX±0.060
X.XXX±0.030
ANGLE±1
UNLESS OTHERWISE NOTED

TOLERANCES:

NOZZLES SHALL HAVE AN ANGULARITY OF NO MORE THAN 2° OFF VERTICAL OR HORIZONTAL UNO.

NOZZLES SHALL BE LOCATED NO MORE THAN 1", WITH A MAXIMUM CIRCUMFERENTIAL DIFFERENCE OF 1/4" FROM THE LOCATION SPECIFIED.

DIMENSIONS OF THE FINISHED PRODUCT SHALL BE OFF BY NO MORE THAN 1/4" FROM THE DIMENSIONS SPECIFIED ON THE DWG., UNLESS OTHERWISE SPECIFIED.

VESSELS WILL BE STRAIGHT WITHIN 1/4" FOR THE FIRST 20 FT. OF LENGTH; AND PLUS 1/8" FOR EACH ADDITIONAL 10 FT. (OR PART THERE OF) OF LENGTH.

CUSTOMER NAME:
FERMI NATIONAL ACCELERATOR LABORATORY

TITLE:
MicroBooNE VESSEL 12'-6" ID x 35'-5" T/T BATAVIA, IL

DWN BY: BCR	CHK'D & APRV'D BY:	D-SIZE SHEET	JOB: 1203-727
DATE: 06/25/12	CUST PO: 606341	DWG: 1203-727 S1	REV: 4
SCALE: 1 = 4			

BILL OF MATERIAL

REV	ITEM	QUANTITY	MATERIAL	DESCRIPTION	NOZZLE
△4	1	2	SA-240-304	HEAD: ASME F&D, 150" ID X 1/2" (0.4281) MIN THICKNESS, 1.50" S.F., 144" IDR, 9.06" IKR	
	2	4	SA-240-304	SHELL PLATE: PLATE 7/16" X 96.00" X 472.61" ROLL TO 150" ID	
	3	1	SA-240-304	SHELL PLATE: PLATE 7/16" X 40.75" X 472.61" ROLL TO 150" ID	
	4	5	SA-240-304	VACUUM RINGS: PLATE 5/8" X 150.88" ID X 162.88" OD X DETAIL	
	5	12	304SS	FLANGE CF TYPE- 14" FIXED – MDC VACUUM	N1A THRU N1K N16
	6	3	304SS	FLANGE CF TYPE- 8" FIXED – MDC VACUUM	N2 N3A N3B
	7	4	304SS	FLANGE CF TYPE- 6" FIXED – MDC VACUUM	N4 N17 N18 N19
	8	2	304SS	FLANGE CF TYPE- 2.75" FIXED – MDC VACUUM	N15A N15B
△4	9	2	SA-182-F304	FLANGE – 10" 150# RFWN	N6A N6B
△4	10	1	SA-182-F304	FLANGE – 4" 150# RFWN	N5
	11	12	SA-249-304	TUBE – 12" OD X 0.165" WALL X DETAIL	N1A THRU N1K N16 N2
	12	15	SA-249-304	TUBE – 6" OD X 0.083" WALL X DETAIL	N1A THRU N1K N2 N3A N3B N16
	13	4	SA-249-304	TUBE – 4" OD X 0.083" WALL X DETAIL	N4 N17 N18 N19
△4	14	4	SA-249-304	TUBE – 2" OD X 0.065" WALL X DETAIL	N4 N17 N15A N15B
	15	2	SA-312-TP304	PIPE – 10" SCH. 10 X DETAIL	N6A N6B
△4	16	5	SA-312-TP304	PIPE – 4" SCH. 40 X DETAIL	N4 N5 N17
	17	4	SA-312-TP304	PIPE – 3" SCH. 40 X DETAIL	N7 N13
△4	18	5	SA-312-TP304	PIPE – 2" SCH. 40 X DETAIL	N11 N12 N14 N15A N15B
	19	4	SA-312-TP304	PIPE – 3/4" SCH. 40 X DETAIL	N8 N9 N10A N10B
	20	2	SA-403-304	PIPE CAP – 3" SCH. 40	N7 N13
△2	21	5	SA-403-304	PIPE CAP – 2" SCH. 40	N11 N12 N14
	22	4	SA-403-304	PIPE CAP – 3/4" SCH. 40	N8 N9 N10A N10B
△2	23	5	SA-403-304	PIPE ELBOW – 2" SCH. 40 S.R. 90°	N11 N12 N14
△2	24				
	25	1	SA-403-304	TEE – 3" SCH. 40 WELD	N13
	26	2	SA-240-304	WEAR PLATE – 3/8" X 14" X 173.80" X DETAIL	
	27	2	SA-516-70	CENTER RIB PLATE – 1/2" X 43.34" X 131" X DETAIL	
	28	4	SA-516-70	RIB PLATE – 1/2" X 12" X 43.34" X DETAIL	
	29	8	SA-516-70	RIB PLATE – 1/2" X 5.75" X 19.75" X DETAIL	
	30	8	SA-516-70	RIB PLATE – 1/2" X 5.75" X 9.06" X DETAIL	
	31	6	SA-516-70	RIB PLATE – 1/2" X 5.75" X 5.88" X DETAIL	
	32	2	SA-516-70	BASE PLATE – 7/8" X 14" X 134" X DETAIL	
	33	5	SA-240-304	PMT UPPER SUPPORT PLATE – 1/2" X 4" X 72" X DETAIL	
	34	5	SA-240-304	PMT UPPER SUPPORT PLATE – 1/2" X 2" X 72" X DETAIL	
	35	10	SA-240-304	PMT UPPER GUSSET PLATE – 1/2" X 4.58" X 7.22" X DETAIL	
	36	5	SA-240-304	PMT LOWER SUPPORT PLATE – 1/2" X 4" X 72" X DETAIL	
	37	10	SA-240-304	PMT LOWER GUSSET PLATE – 1/2" X 4.58" X 7.22" X DETAIL	
	38	12	SA-240-304	ADAPTER PLATE – 1/2' X 12" OD X 6.63" ID X DETAIL	N1A THRU N1K N16
	39	2	304SS	CONC REDUCER – 2" X 1.5" X 0.065 WALL – MDC VACUUM #402504	N15A N15B
△2	40	1	SA-240-304	VENT TUBE – 1/4" OD X DETAIL	N2
	41	2	SA-182-304	UNION – 2" 3000# SW X SW – HART TYPE	N11 N12
	42	2	SA-312-TP304	PIPE – 2" SCH. 10 X DETAIL	N11 N12
	43	2	SA-240-304	CART RAIL – L2 1/2"X2"x3/8" X 34'-5" X DETAIL	
	44	4	SA-240-304	TPC FEET – L6x6x1/2 X 12" X DETAIL	
	45	4	304SS	PIPE ROLLER HANGERS – 2" PIPE SIZE – FIG. #71 FM STAINLESS	

BILL OF MATERIAL (CONT.)

REV	ITEM	QUANTITY	MATERIAL	DESCRIPTION	NOZZLE
	46	1	304SS	ASME DATA TAG – VALFAB	
	47	1	SA-240-304	DATA TAG BRACKET – PLATE 1/8" X 9 X 16.5 X DETAIL	
△4	48	12	SA-240-304	REPAD 6" PIPE – PLATE 1/4 X 6.63" ID X 10.63" OD X DETAIL	N1A THRU N1K
△4	49	2	SA-240-304	REPAD 10" PIPE – PLATE 1/4 X 11.0" ID X 16.0" OD X DETAIL	N6A N6B
△4	50	2	SA-240-304	REPAD 6" PIPE – PLATE 7/16 X 6.63" ID X 16.63" OD ± X DETAIL	N3A N3B
	51	4	SA-240-304	REPAD 4" PIPE – PLATE 1/4 X 4.38" ID X 9.38" OD X DETAIL	N4 N17 N18 N19
	52	1	SA-240-304	REPAD 4" PIPE – PLATE 1/4 X 4.75" ID X 8.75" OD X DETAIL	N5
	53	1	SA-240-304	REPAD 6" PIPE – PLATE 1/4 X 9.68" ID X 13.68" OD X DETAIL	N2
△4	54				
	55	1	SA-240-304	REPAD 3" PIPE – PLATE 1/4 X 3.88" ID X 7.88" OD X DETAIL	N13
	56	1	SA-240-304	ALIGNMENT BAR – 1/2 X 1.0" X 36" LONG	
	57	4	A36	JACKING ANGLE – L8x8x3/4 X 12" LONG X DETAIL	
	58	8	A36	JACKING ANGLE GUSSET – PLATE 3/4 X 7.25" X 7.25" X DETAIL	
	59	4	SA-53B	SADDLE BRACE – PIPE 3" SCH. 40 X 30" X DETAIL	
	60	4	SA-53B	SADDLE BRACE – PIPE 3" SCH. 40 X 22" X DETAIL	
	61	16	A36	SADDLE BRACE PLATE – 1/2 X 4 X 8.5" X DETAIL	
	62	29	SA-240-304	RDT MOUNTING BLOCK – PLATE 1" X 1.5" X 1.5" X DETAIL	
	63	2	SA-240-304	GROUNDING LUG – PLATE 5/16 X 2 X 20" X DETAIL	
	64	4	SA-312-304	LASER PIPE SUPPORT – PIPE 2 1/2" SCH. 40 X DETAIL	
	65	4	SA-312-304	LASER PIPE SUPPORT – PIPE 2 1/2" SCH. 40 X DETAIL	
	66	48	SS	HEX NUT – 1/4-20	
	67	4	SA-240-304	LIFTING LUG – PLATE 2" X 8.75" X 29.31" X DETAIL	
	68	2	SA-240-304	LIFTING LUG – PLATE 3/4" X 6.06" X 9.63" X DETAIL	
	69	8	304SS	COUPLING NUT – 3/8-16 MCMASTER #90268A031	
△2	70	4	SA-240-304	SPARGER PIPE SUPPORT – PLATE 1/8" X 2.5" X DETAIL	
	71	1	SA-240-304	BACKING PLATE – 1/4" X 4.0" X 470.45" ROLL TO 150" OD	
△4	72	1	SA-240-304	REPAD 3/4" PIPE – PLATE 1/4 X 1.05" ID X 1.94" OD X DETAIL	N9
△4	73	1	SA-240-304	REPAD 2" PIPE – PLATE 1/4 X 2.38" ID X 4.56" OD X DETAIL	N11
△4	74	1	SA-240-304	REPAD 2" PIPE – PLATE 1/4 X 2.38" ID X 4.38" OD X DETAIL	N14
△4	75	2	SA-312-TP304	PIPE – 2" SCH. 40 X 3.00" X DETAIL	N15A N15B
△4	76	16	SA-312-TP304	PIPE – 6" SCH. 40 X DETAIL	N1A THRU N1K N2 N3A N3B N16

NOZZLE SCHEDULE

		NOZZLE			FLANGE / PIPE CAP				REINFORCING PAD	GASKET		
MARK	IDENTIFIER	SIZE	DESCRIPTION	NECK MAT'L	SIZE	TYPE	CLASS	FLG MAT'L	MATERIAL	THICK	GASKET MAT'L	QTY REQ'D
N1A THRU N1K	TPC SIGNAL FEEDTHROUGH	6"	PIPE SCH. 40	SA-312 TP304	14"	CF	FIXED	SA-182-304	SA-240-304			11
N2	TPC HV FEEDTHROUGH	6"	PIPE SCH. 40	SA-312 TP304	8"	CF	FIXED	SA-182-304	SA-240-304			1
N3A N3B	PURITY MONITOR	6"	PIPE SCH. 40	SA-312 TP304	8"	CF	FIXED	SA-182-304	SA-240-304			2
N4	RTD SIGNAL FEEDTHROUGH	4"	PIPE SCH. 40	SA-312 TP304	6"	CF	FIXED	SA-182-304	SA-240-304			1
N5	SAFETY VENT	4"	PIPE SCH. 40	SA-312 TP304	4"	RFWN	150	SA-182-304	SA-240-304			1
N6A N6B	VACUUM PUMP-OUT PORT	10"	PIPE SCH. 10	SA-312 TP304	10"	RFWN	150	SA-182-304	SA-240-304			2
N7	CONDENSER	3"	PIPE SCH. 40 W/ PIPE CAP	SA-312 TP304	3"			SA-403-304	SA-240-304			1
N8	TOP INSTRUMENT PORT	3/4"	PIPE SCH. 40	SA-312 TP304								1
N9	BOTTOM INSTRUMENT PORT	3/4"	PIPE SCH. 40 W/ PIPE CAP	SA-312 TP304	3/4"			SA-403-304				1
N10A N10B	AIM LIQUID LEVEL PROBE	3/4"	PIPE SCH. 40	SA-312 TP304								2
N11	GAS CIRCULATION IN	2"	PIPE SCH. 40 W/ PIPE CAP	SA-312 TP304	2"			SA-403-304	SA-240-304			1
N12	GAS CIRCULATION OUT	2"	PIPE SCH. 40 W/ PIPE CAP	SA-312 TP304	2"			SA-403-304	SA-240-304			1
N13	FROM LAr FILTERS	3"	PIPE SCH. 40 W/ PIPE CAP	SA-312 TP304	3"			SA-403-304	SA-240-304			1
N14	TO LAr PUMPS	2"	PIPE SCH. 40 W/ PIPE CAP	SA-312 TP304	2"			SA-403-304	SA-240-304			1
N15A N15B	SPARE FEEDTHROUGH	2"	PIPE SCH. 40	SA-312 TP304	2.75"	CF	FIXED	SA-182-304				2
N16	PMT SIGNAL FEEDTHROUGH	6"	PIPE SCH. 40	SA-312 TP304	14"	CF	FIXED	SA-182-304	SA-240-304			1
N17	SPARE FEEDTHROUGH	4"	PIPE SCH. 40	SA-312 TP304	6"	CF	FIXED	SA-182-304	SA-240-304			1
N18	RTD VESS SIG PORT	4"	PIPE SCH. 40	SA-312 TP304	6"	CF	FIXED	SA-182-304	SA-240-304			1
N19	SPARE PORT	4"	PIPE SCH. 40	SA-312 TP304	6"	CF	FIXED	SA-182-304	SA-240-304			1

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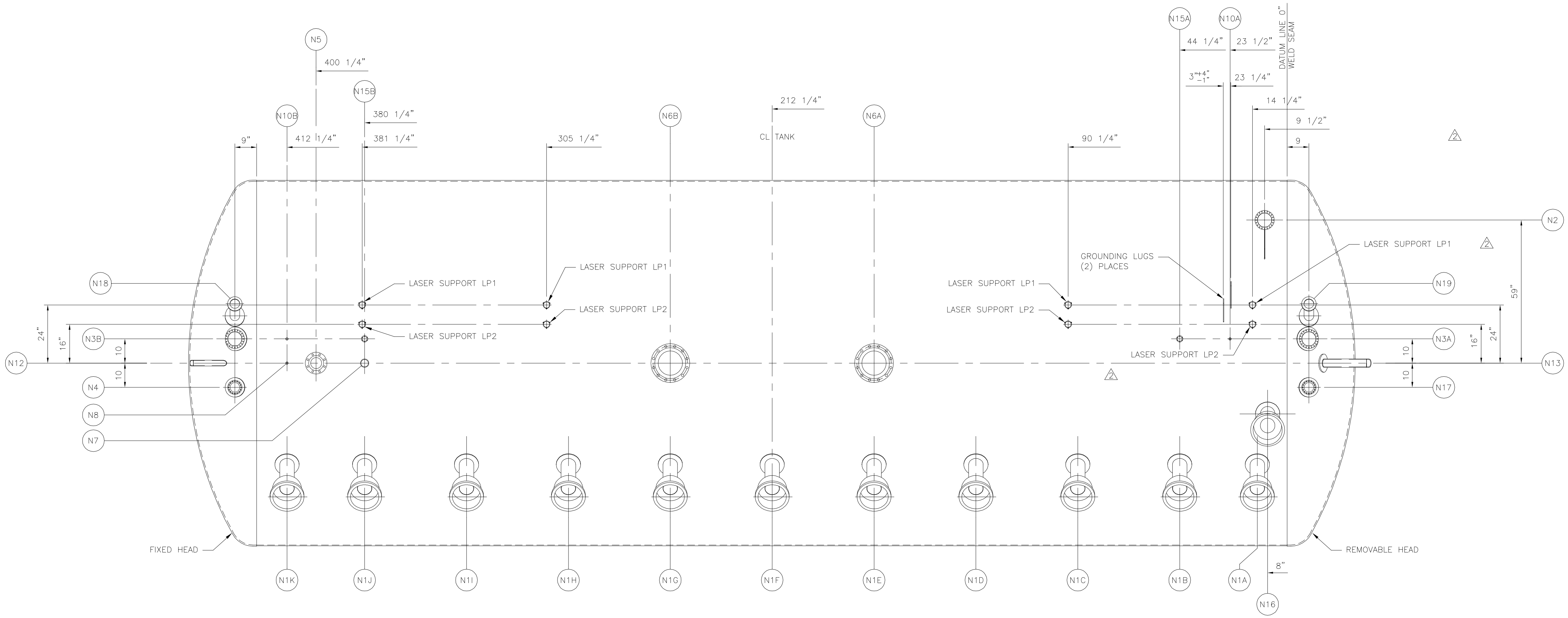
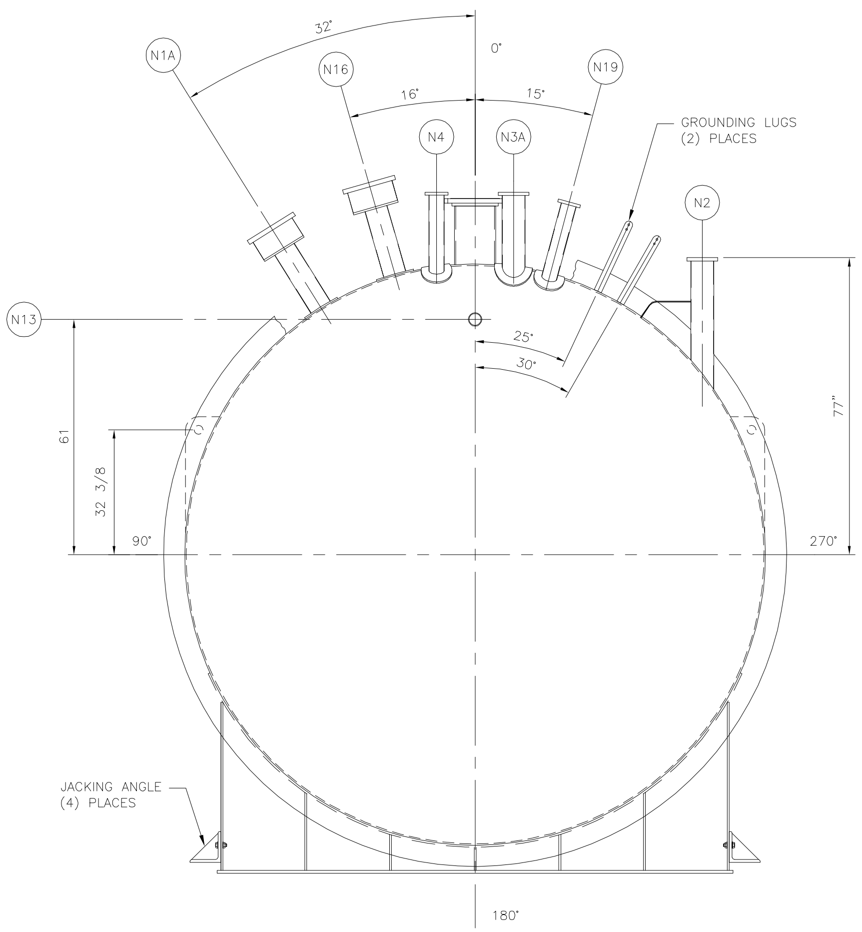
12'-6" ID x 35'-5" T/T
BATAVIA, IL

DWN BY: BCR	CHK'D & APRV'D BY:	D-SIZE SHEET	JOB: 1203-727
DATE: 06/25/12	CUST PO: 606341	DWG: 1203-727 S2	REV: 4
SCALE: 1 = 4			



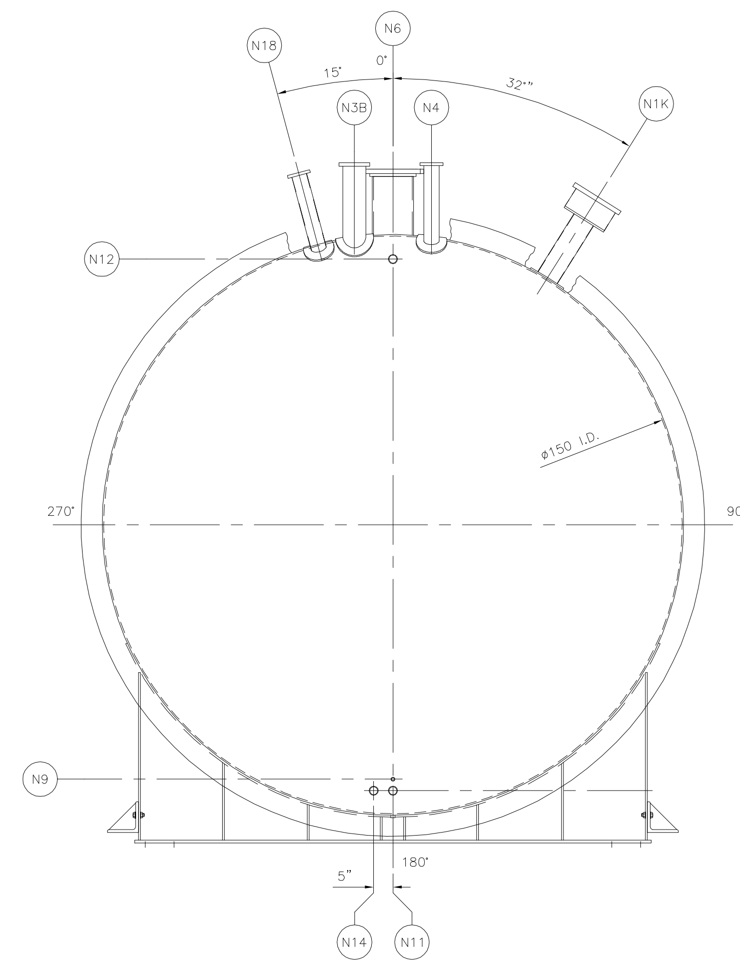
PLAN VIEW A–A

(VACUUM RINGS NOT SHOWN FOR CLARITY



RIGHT SIDE VIEW C–C

LOOKING AT REMOVABLE END



LEFT SIDE VIEW B–B

LOOKING AT FIXED END

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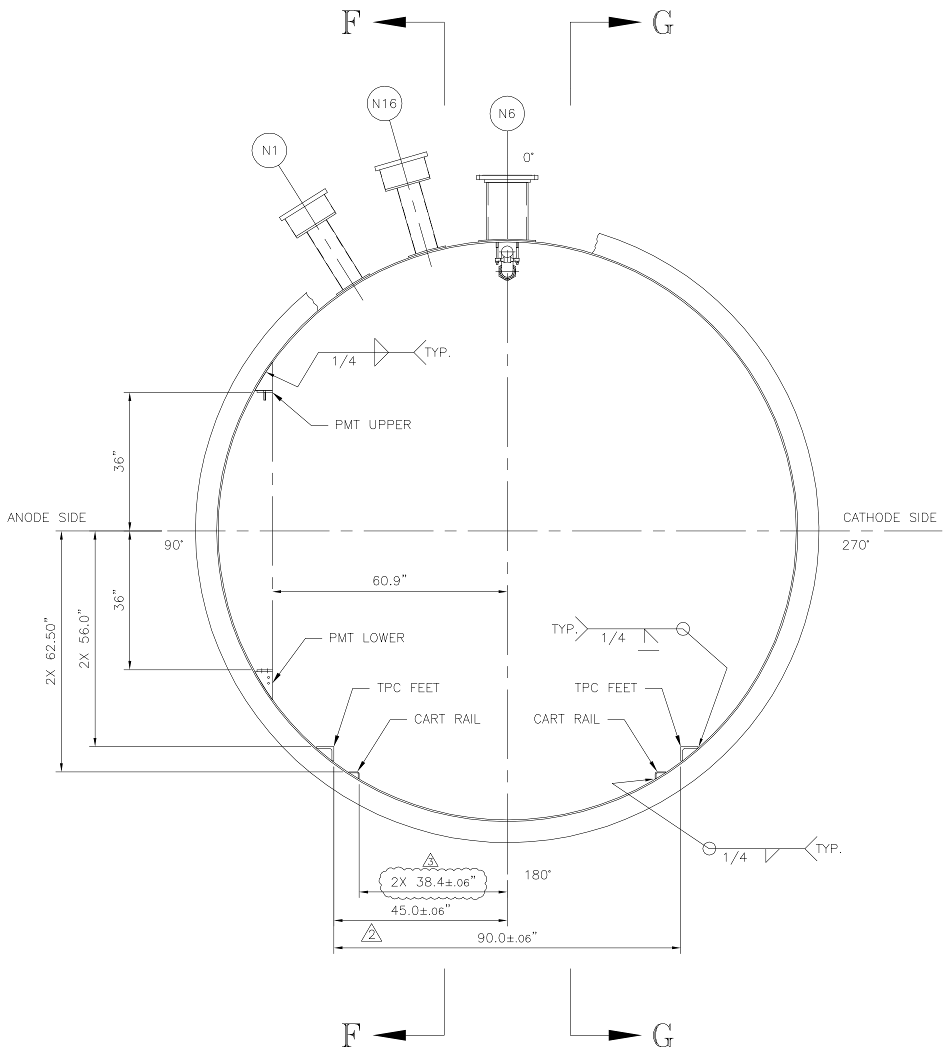
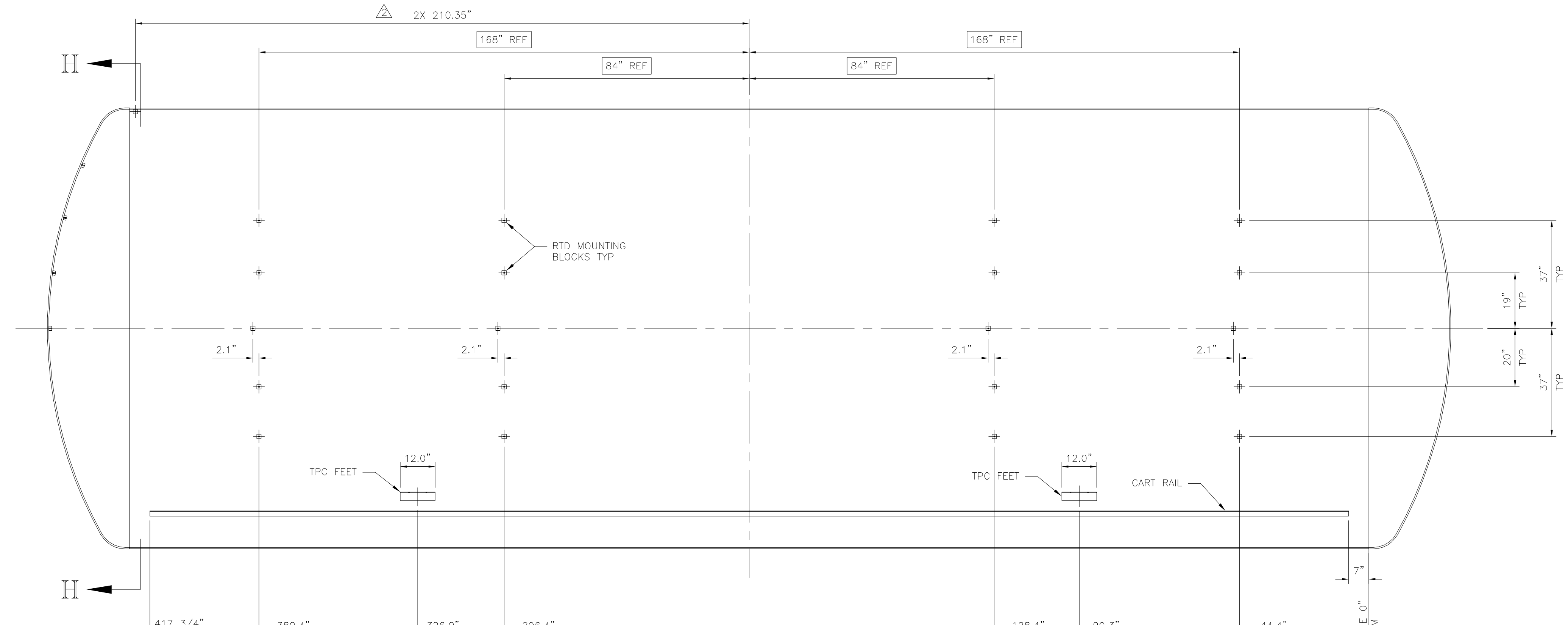
12'-6" ID x 35'-5" T/T
BATAVIA, IL

DWN BY: BCR	CHK'D & APRV'D BY:	D-SIZE SHEET	JOB: 1203-727
DATE: 06/25/12	CUST PO: 606341	DWG: 1203-727 S3	REV: 4
SCALE: 1 = 4			

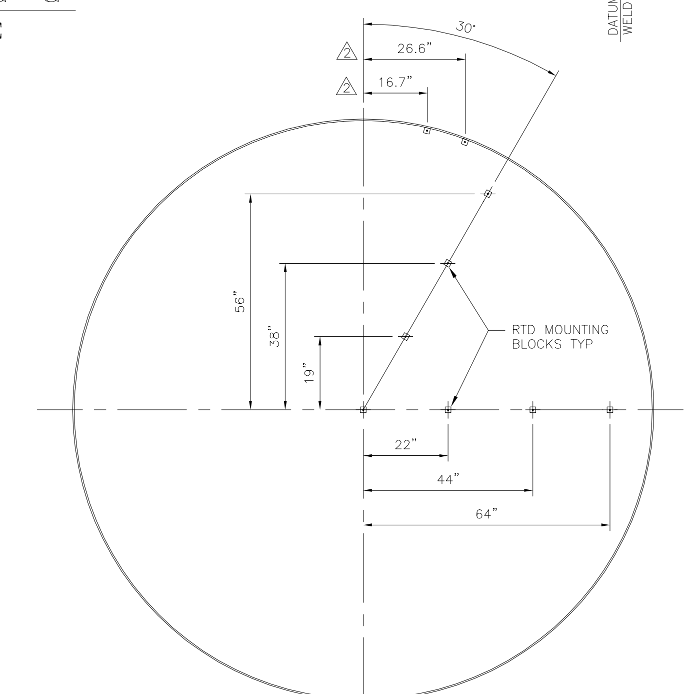


SECTION E-E

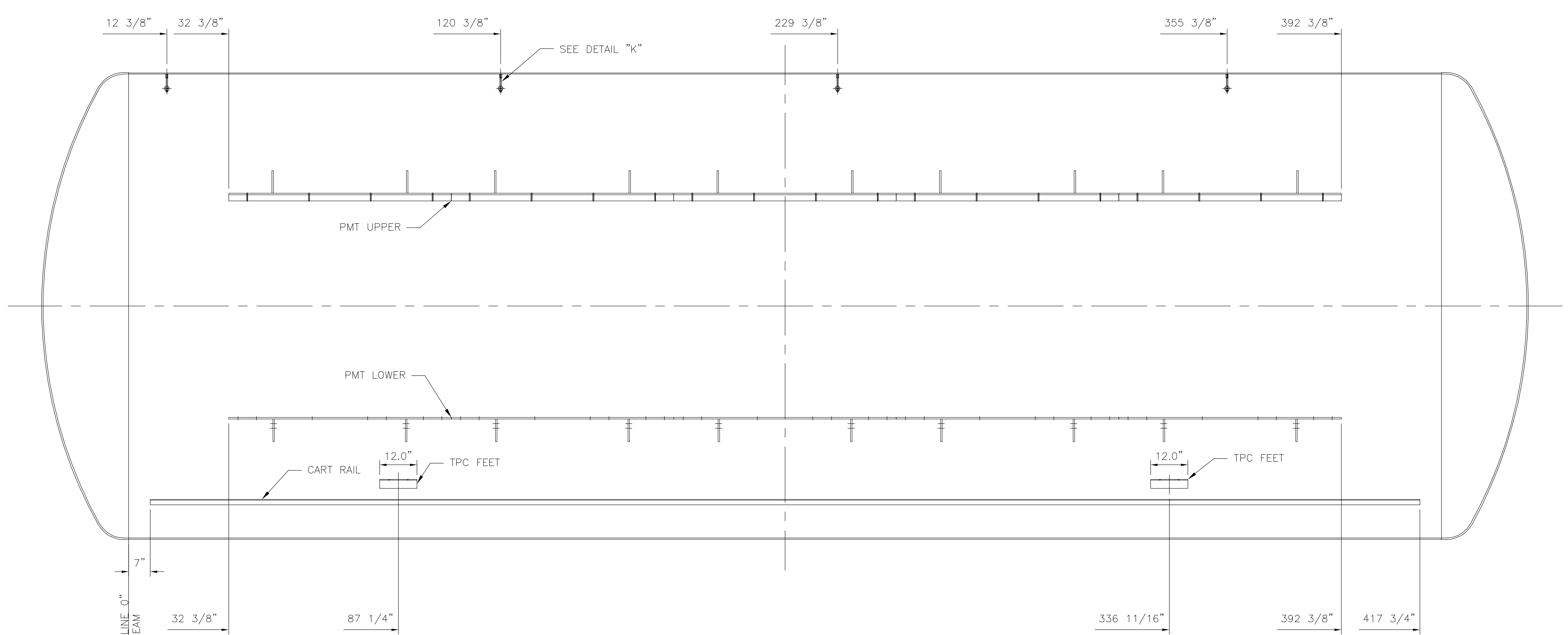


ELEVATION SECTION G-G

LOOKING AT CATHODE SIDE



SECTION H-H



ELEVATION SECTION F-F

LOOKING AT ANODE SIDE

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12'-6" ID x 35'-5" T/T
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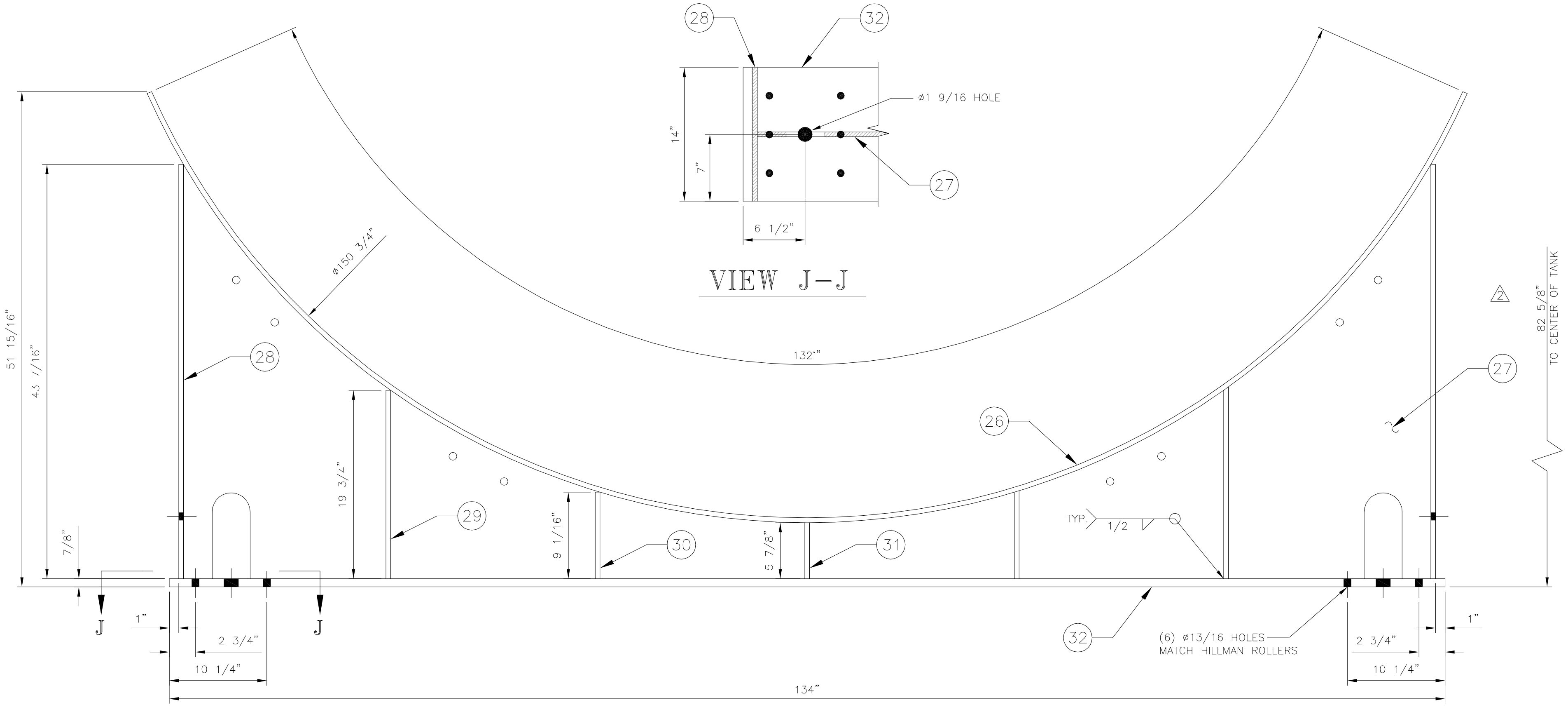
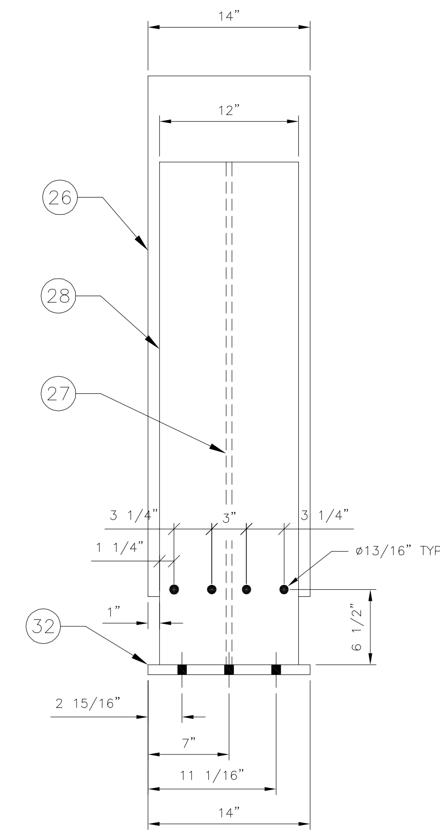
DWN BY: BCR	CHK'D & APRV'D BY:	D-SIZE SHEET	JOB: 1203-727
DATE: 06/25/12	CUST PO: 606341	DWG: 1203-727 S4	REV: 4
SCALE: 1 = 4			

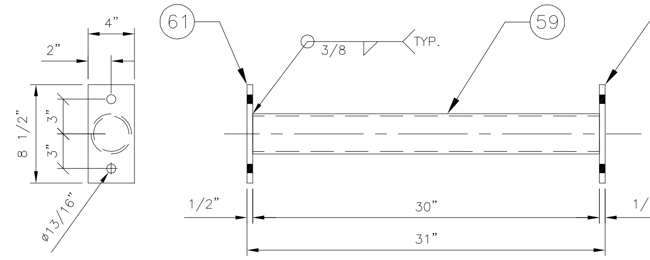


SUPPORT SADDLE DETAIL

(2) REQ'D
(1) AS SHOWN (1) SUPPORT W/ ALLIGNMENT NOTCH

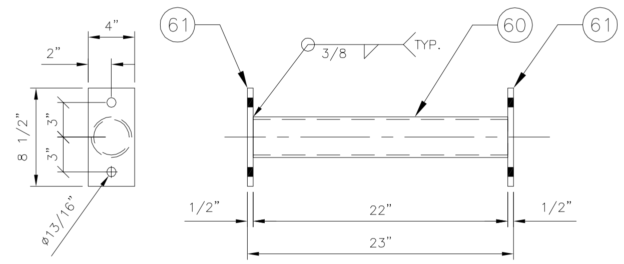


SUPPORT SADDLE RIGHT SIDE VIEW



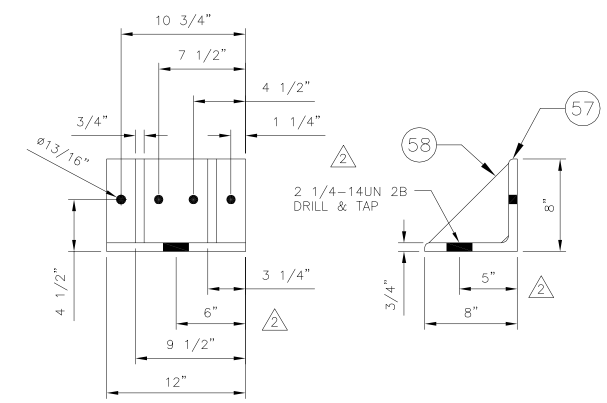
SADDLE BRACE-SB1

(4) REQ'D



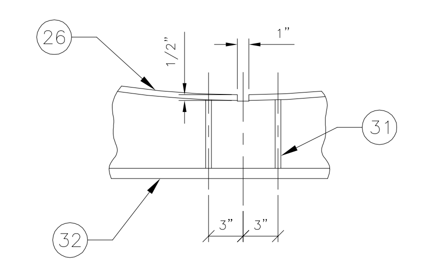
SADDLE BRACE-SB2

(4) REQ'D



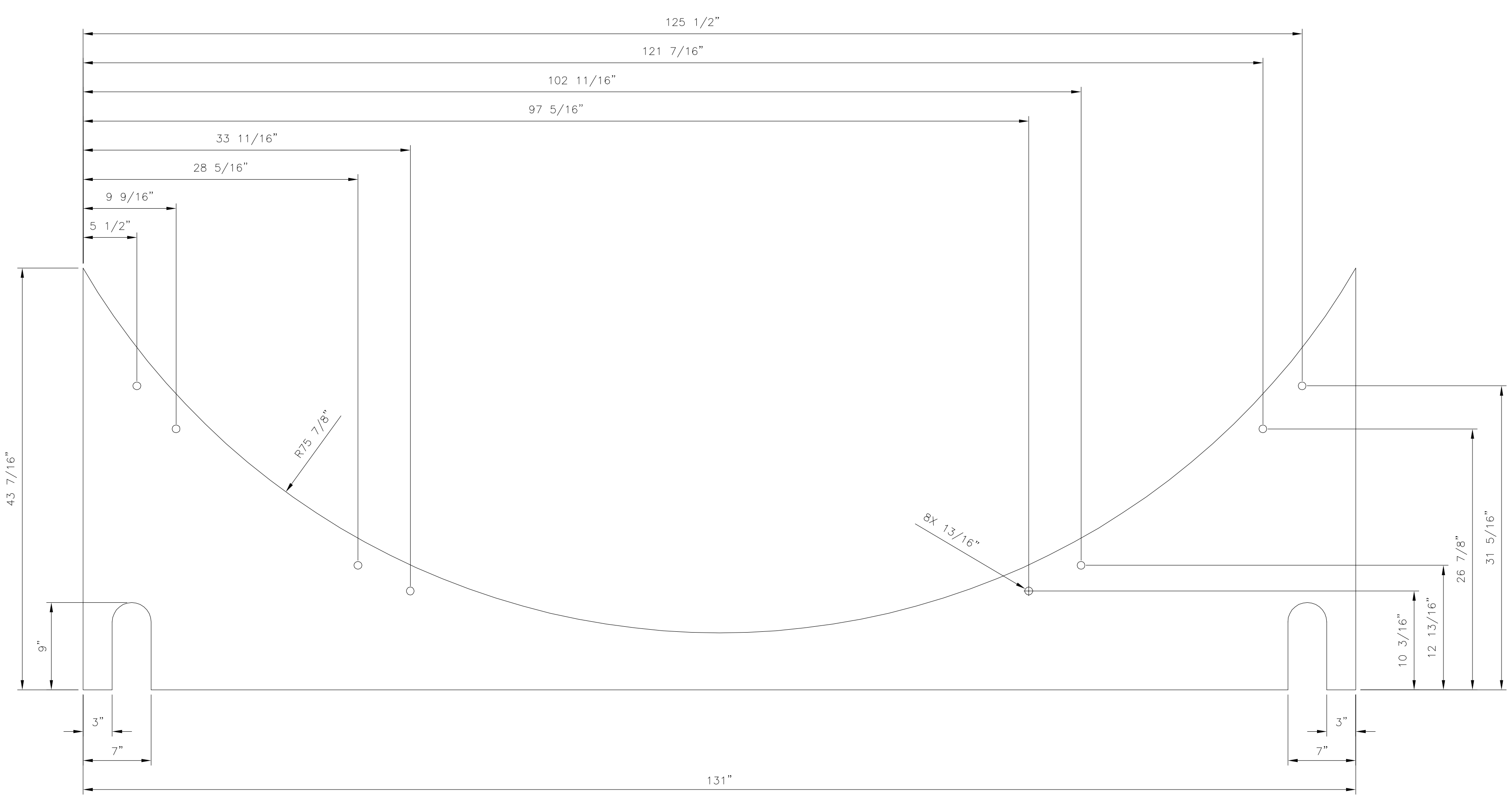
JACKING ANGLE DETAIL

(4) REQ'D



ALIGNMENT NOTCH DETAIL

TO FIT ALIGNMENT BAR



SADDLE RIB PLATE DETAIL- 27

(2) REQ'D

VAL-FAB, Inc.
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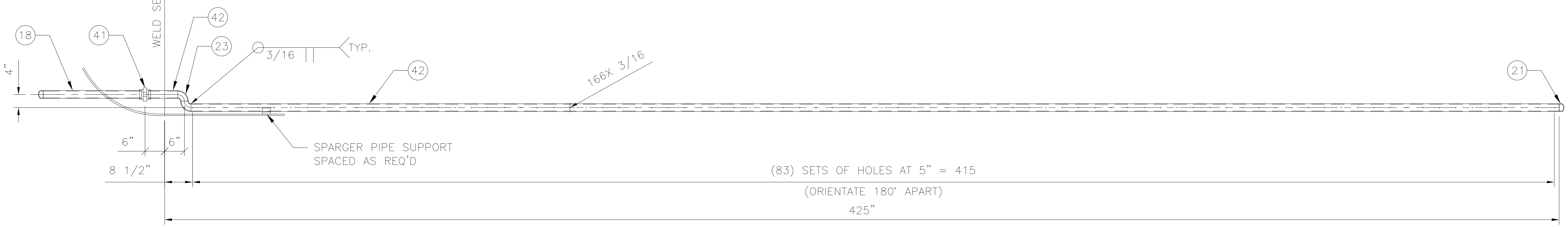
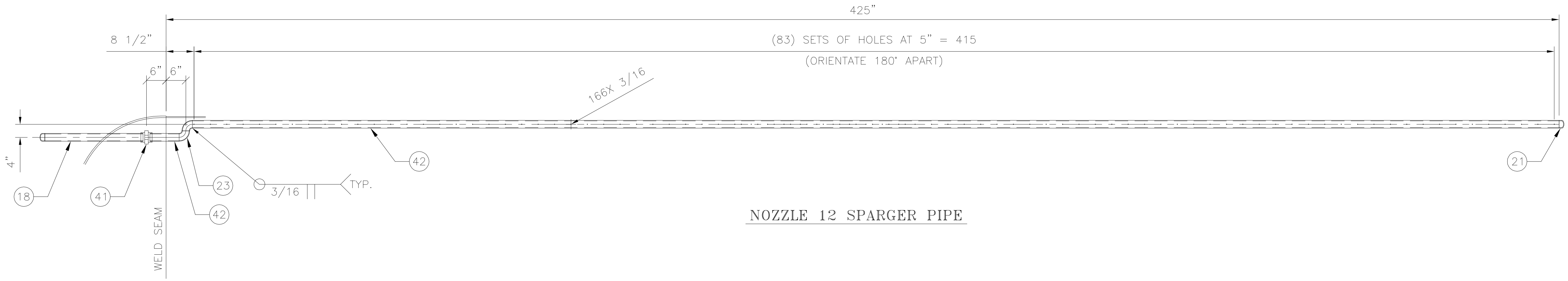
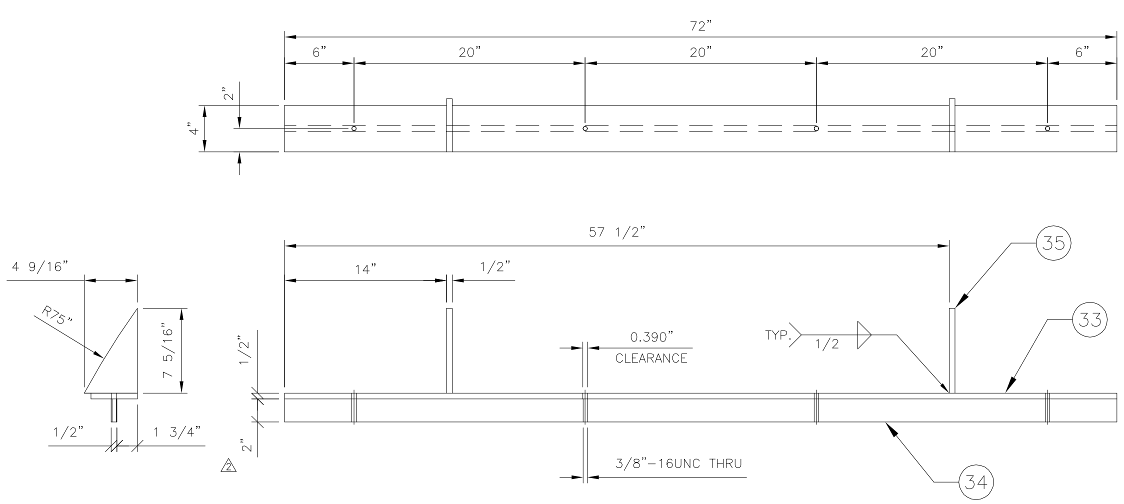
CUSTOMER NAME: FERMI NATIONAL ACCELERATOR LABORATORY			
TITLE: MicroBooNE VESSEL 12'-6" ID x 35'-5" T/T BATAVIA, IL			
DWN BY: BCR	CHK'D & APRV'D BY:	D-SIZE SHEET	JOB: 1203-727
DATE: 06/25/12	CUST PO: 606341	DWG: 1203-727 S5	REV: 4
SCALE: 1 = 4			



NOZZLE 11 SPARGER PIPE

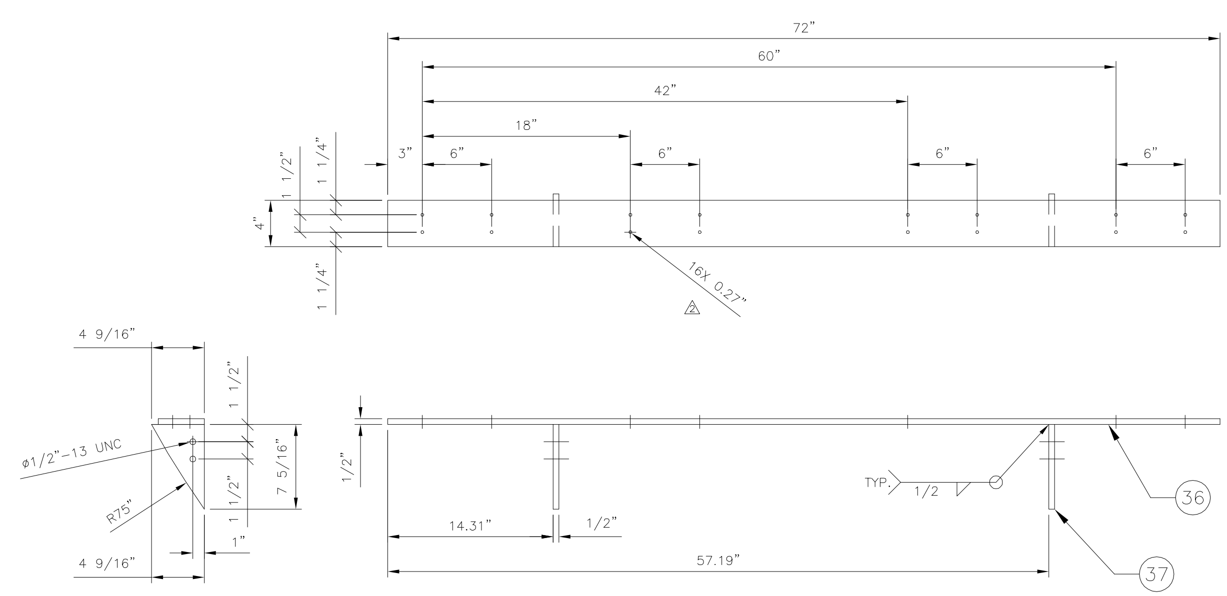


NOZZLE 12 SPARGER PIPE



PMT UPPER SUPPORT

(5) REQ'D



PMT LOWER SUPPORT

(5) REQ'D

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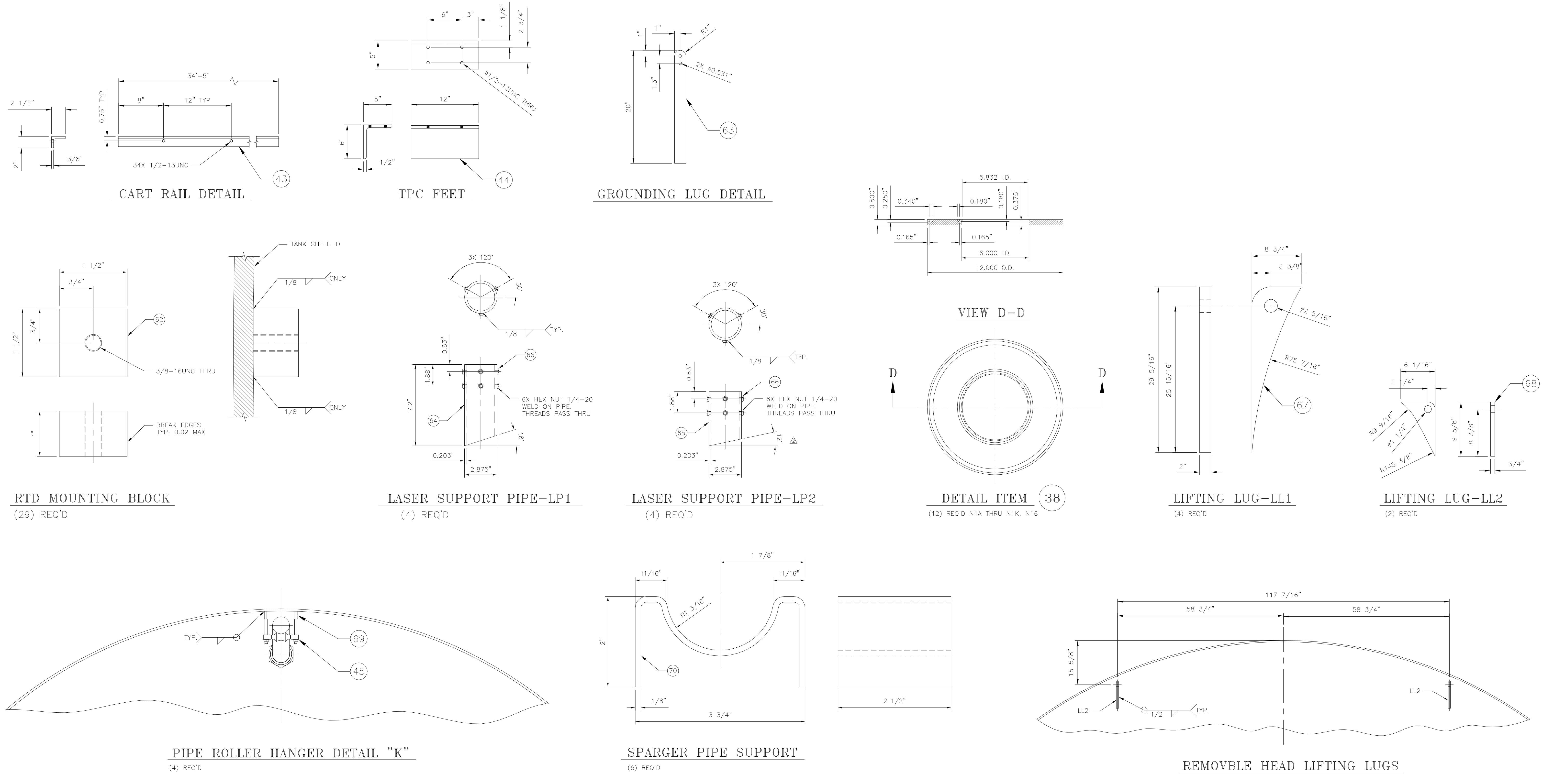
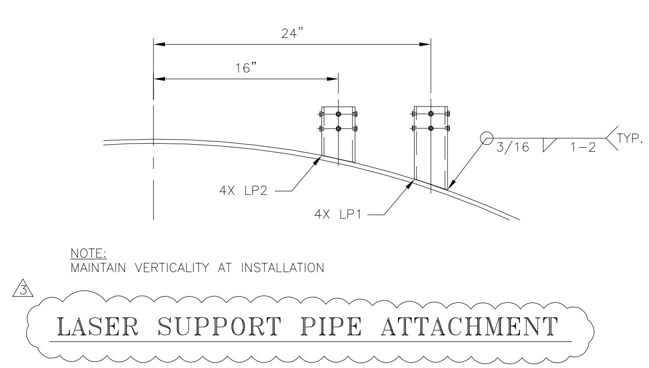
DATE: 06/25/12	CUST PO: 606341	DWG: 1203-727 S6	REV: 4
SCALE: 1 = 4			





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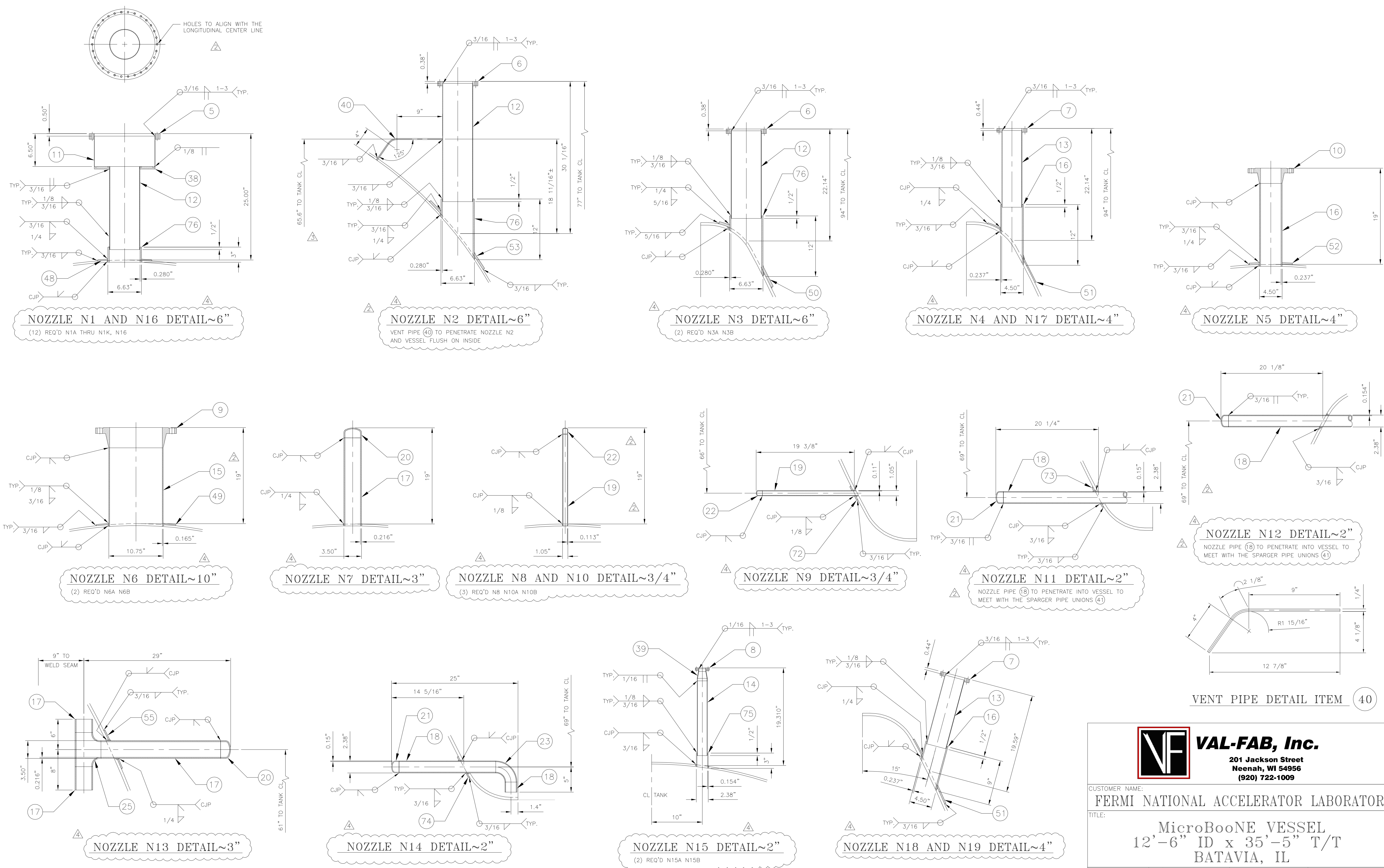
DATE: 06/25/12	CUST PO: 606341	DWG: 1203-727 S7	REV: 4
SCALE: 1 = 4			



VAL-FAB, Inc.
201 Jackson Street
Neenah, WI 54956
(920) 722-1009

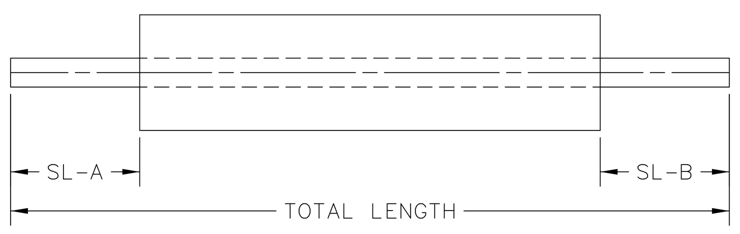
CUSTOMER NAME:
FERMI NATIONAL ACCELERATOR LABORATORY

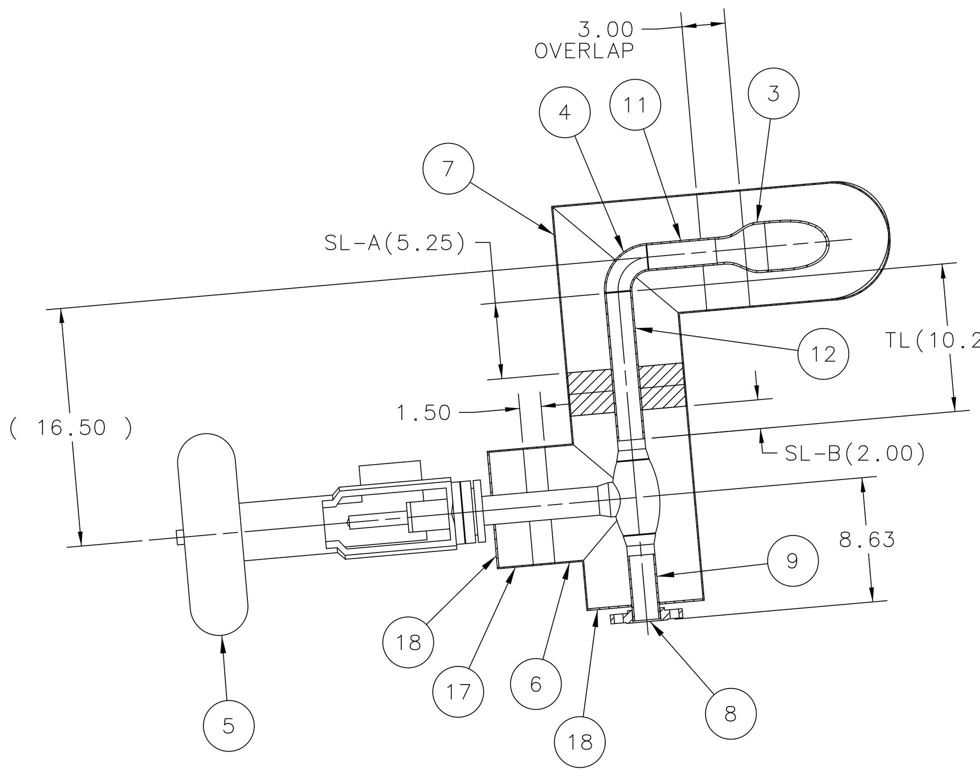
TITLE:
MicroBooNE VESSEL
12'-6" ID x 35'-5" T/T
BATAVIA, IL

DWN BY: BCR	CHK'D & APRV'D BY:	D-SIZE SHEET	JOB: 1203-727
DATE: 06/25/12	CUST PO: 606341	DWG: 1203-727 S8	REV: 4
SCALE: 1 = 4			

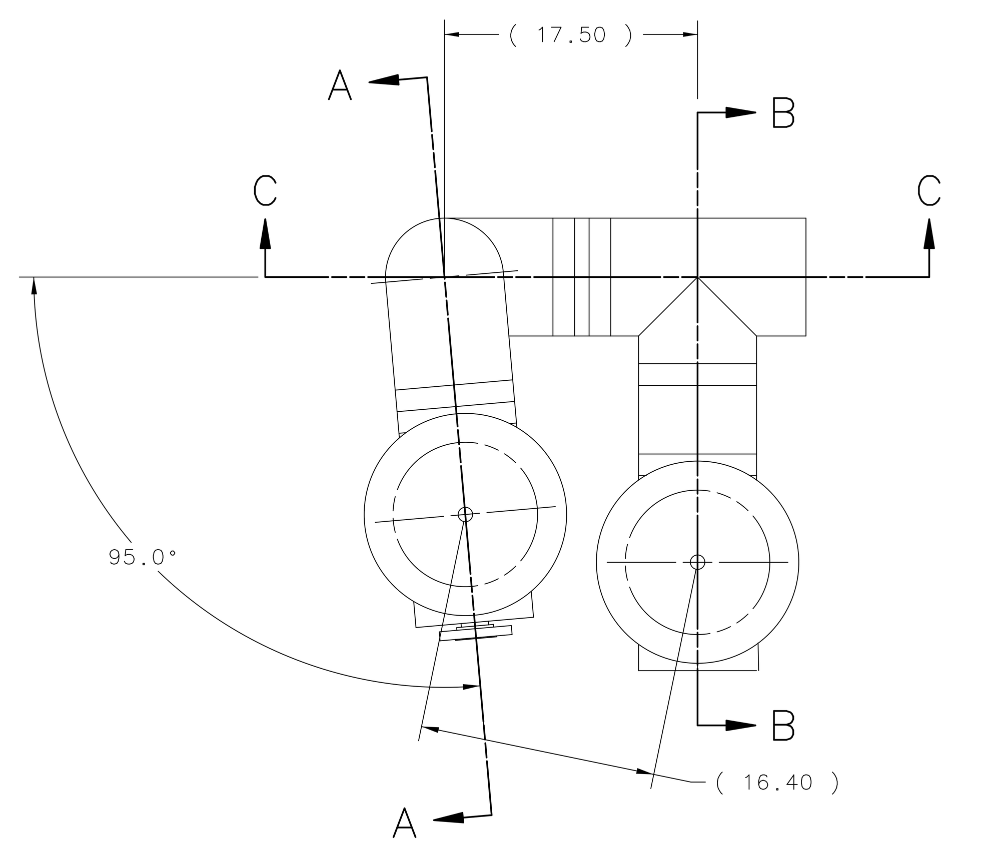
REV	DESCRIPTION	DRAWN / APPROVED	DATE / DATE

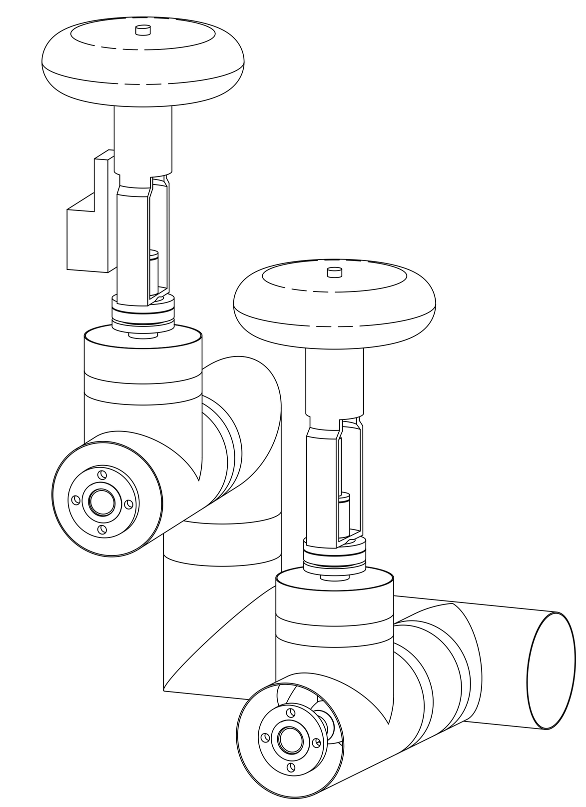
INSUL. PIPE LENGTH CHART			
PART#-ITEM#	TOTAL LG. (TL)	STRIP LG. (SL-A)	STRIP LG. B (SL-B)
489995-12	10.25	5.25	2.00
489995-13	12.87	3.12	2.00
489995-14	9.63	3.00	2.62



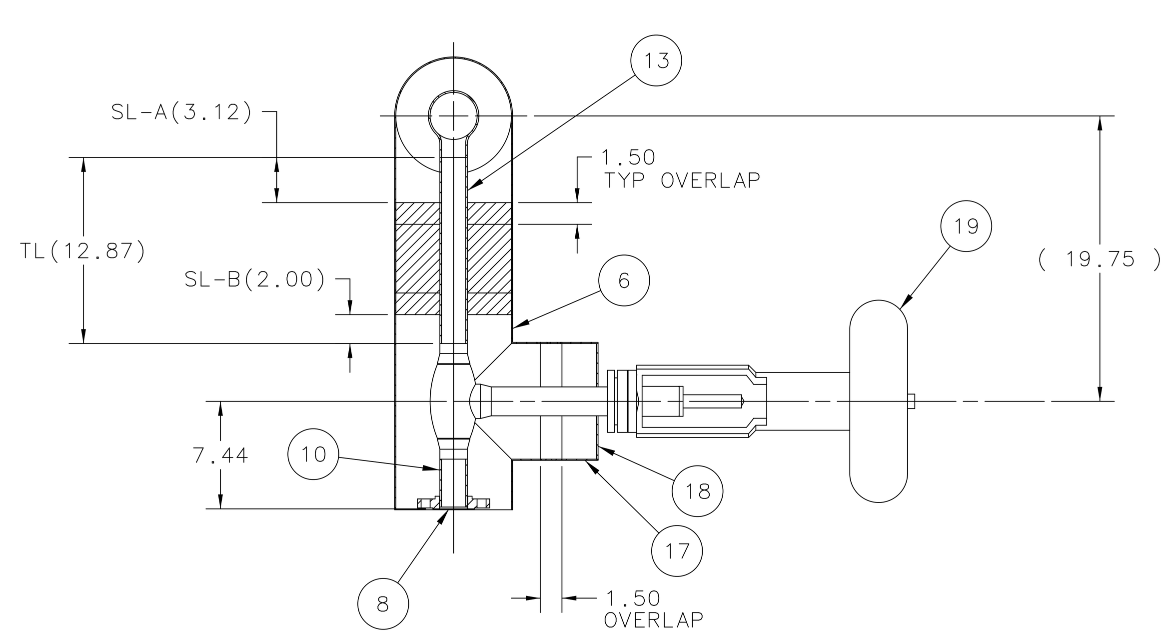


SECTION A-A

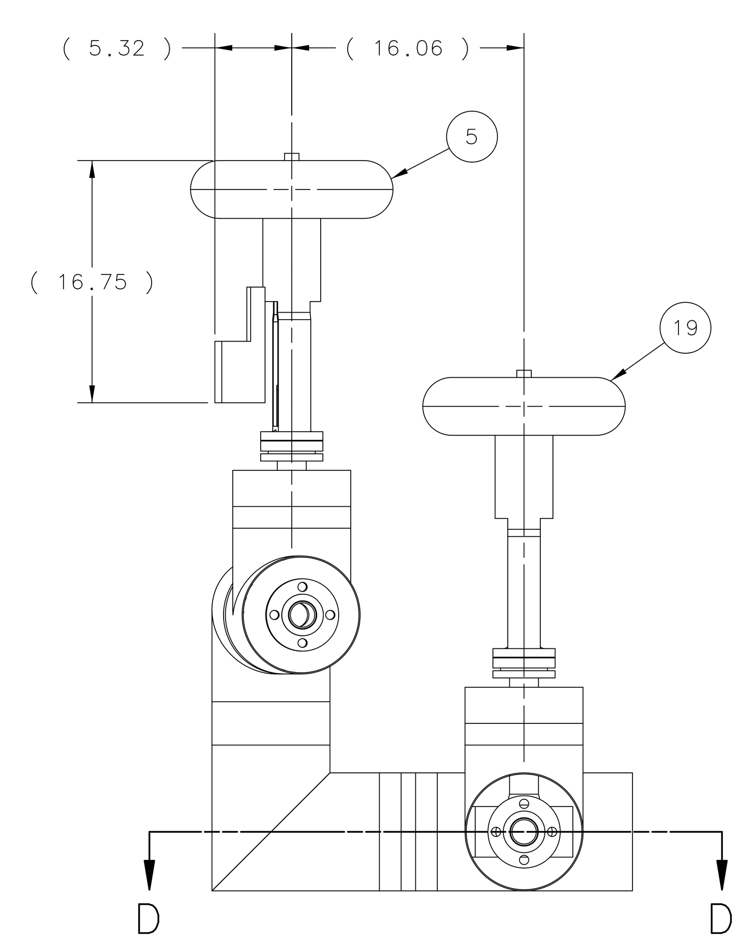


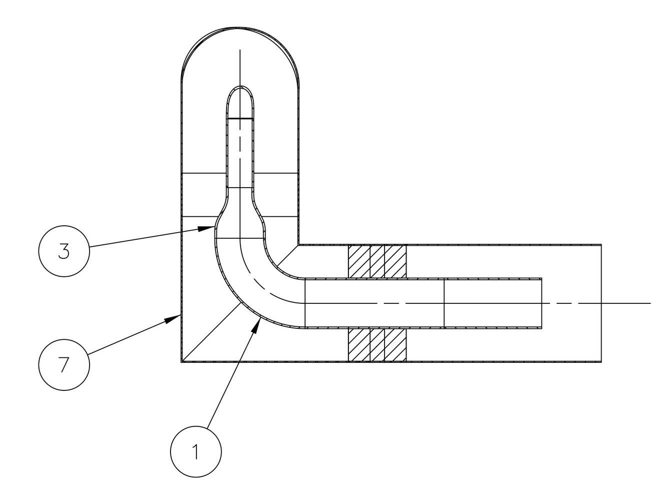


ISOMETRIC VIEW

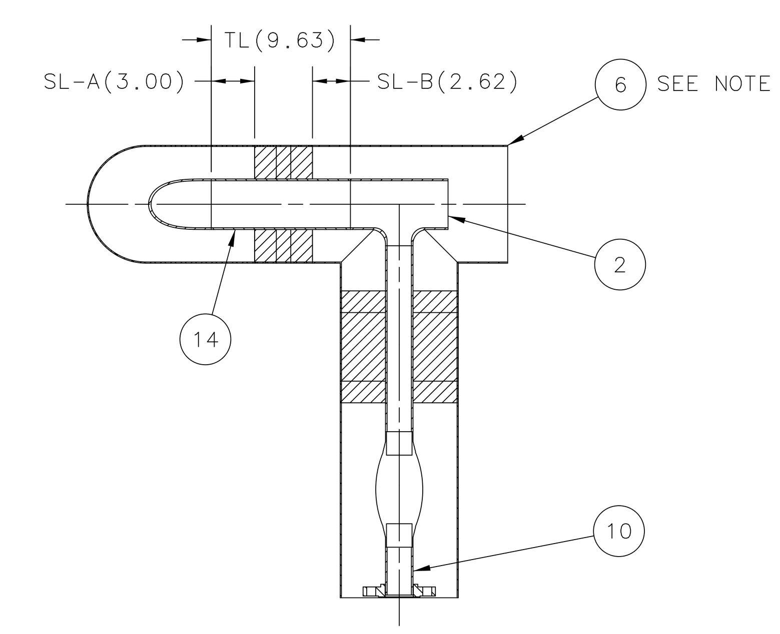


SECTION B-B





SECTION C-C



SECTION D-D

NOTES:

1. INSTALL FITTING COVERS PER MANUFACTURERS RECOMMENDATIONS (ROVANCO;DOC.INS-FFC). APPLY AND ADDITIONAL 2 LAYERS OF ITEM 15 OVER ALL TAPED JOINTS.
2. SEAL ALL ENDPLATES AND CRYOGEL TRANSITIONS WITH 2 LAYERS OF ITEM 15. ENSURE THAT NO GAPS OR CRACKS EXIST.
3. WELDMENT MUST BE FREE OF DIRT, GREASE, OIL AND CHIPS. SEE "MICROBOONE COMPONENT CLEANING PROCEDURE" - DOC. DB#2141.
4. ALL WELDS AS PER ASME B31.3 FOR NORMAL FLUID SERVICE.
5. ON BUTT WELDS PERFORM IN-PROCESS EXAMINATION PER ASME B31.3-344.7. SEE "WELD INSPECTION GUIDELINES AND INSPECTION FORM"-DOC.DB#2136.
6. PRESSURE TEST THIS ASSEMBLY TO 110 PSIG WITH DRY NITROGEN GAS AS PER FESHM 5034.
7. ALL WELDS TO BE VACUUM LEAK TIGHT. LEAK TEST PER "MICROBOONE ASSEMBLY PROCEDURE FOR CRYOGENIC SYSTEM"-DOC.DB#2147.
8. IN PROCESS EXAMINATION PER ASME B31.3-344.7. SEE "WELD INSPECTION GUIDELINES AND INSPECTION FORM" - DOC. DB#2136.
9. ITEM 6 (QTY 1) TO BE APPLIED AFTER FINAL ASSEMBLY IN ENCLOSURE.

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
19	COML	GLOBE VALVE, 1-1/2 NPS, BUTT-WELD, ACME P/N CV15NOHAROP10EA, TAG #PV-256, LOCATION 7C	1
18	MB-489852	MICBN FOAM JACKET ENDPLATE C	3
17	COML	SPLICE KIT, 8.00" O.D. x 4.00" LG, ROVANCO	2
16	COML	FOAM KIT - INSULATION, 2-PART, POLYURETHANE, ROVANCO	AS REQ'D
15	COML	ASJ FACING TAPE, GTA-NHT, INC. P/N VENTURE TAPE 1540 CW	AS REQ'D
14	COML	INSULATED PIPE, SCH 10, 3" NPS x 8" O.D. INSUL x 9.63" LG, ROVANCO	1
13	COML	INSULATED PIPE, SCH 10, 1-1/2 NPS x 8" O.D. INSUL x 12.87" LG, ROVANCO	1
12	COML	INSULATED PIPE, SCH 10, 1-1/2 NPS x 8" O.D. INSUL x 10.25" LG, ROVANCO	1
11	COML	PIPE, SCH 10, 304 S.S., 1-1/2" x 4.75" LG	1
10	COML	PIPE, SCH 10, 304 S.S., 1-1/2" x 3.31" LG	1
9	COML	PIPE, SCH 10, 304 S.S., 1-1/2" x 4.50" LG	1
8	COML	FLANGE, SLIP-ON, RAISED FACE, 150 LB, 1-1/2 NOM PIPE SIZE, 304 S.S.	2
7	COML	ELBOW, 90°, #18-8" O.D., PVC PLASTIC,	2
6	COML	TEE, COVER, #18-8" O.D., PVC PLASTIC, ROVANCO P/N ZET18	2
5	COML	GLOBE VALVE, 1-1/2 NPS, BUTT-WELD, ACME P/N CV15SPHAROP10EA, TAG #FCV-191, LOCATION 7D	1
4	COML	ELBOW, 90°, 1-1/2" NOM PIPE SIZE, SCH 10, LONG RADIUS, 304 S.S.	1
3	COML	CONCENTRIC PIPE REDUCER, 3" x 1-1/2", SCH 10, 304 S.S.	1
2	COML	TEE, REDUCING, 3 x 1-1/2 NPS, SCH 10, 304 S.S.	1
1	COML	ELBOW, 90°, 3" NOM PIPE SIZE, SCH 10, LONG RADIUS, 304 S.S.	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED					
.XX	.XXX	ANGLES	ORIGINATOR	R.SANDERS	09-JUL-2012
± .06	± - -	± 1°	DRAWN	T.SPERRY	10-OCT-2012
			CHECKED	J.TILLMAN	31-OCT-2012
			APPROVED	M.ZUCKERBROT	05-NOV-2012

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. MAX. ALL MACH. SURFACES 250
5. DRAWING UNITS: U.S. INCH

USED ON

MATERIAL
SEE PARTS LIST ABOVE

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

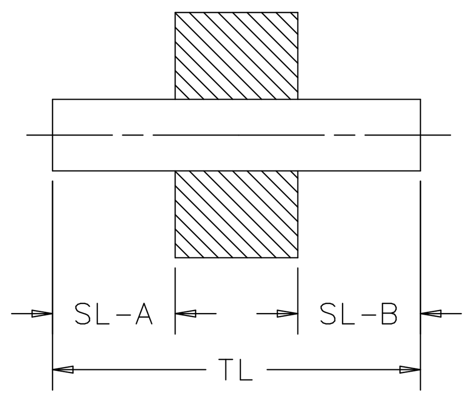
E974-MICROBOONE - INFRASTRUCTURE SERVICE EQUIPMENT MCRBN PLMNG VESSEL INLET SECTION

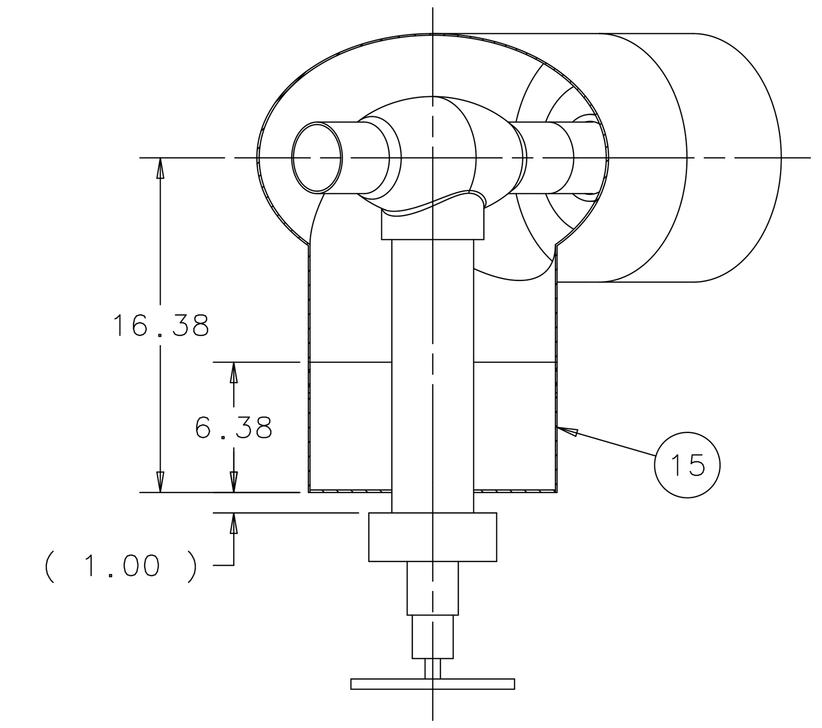
SCALE	DRAWING NUMBER	SHEET	REV
1:8	3974.110-ME-489995	1 OF 1	

CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

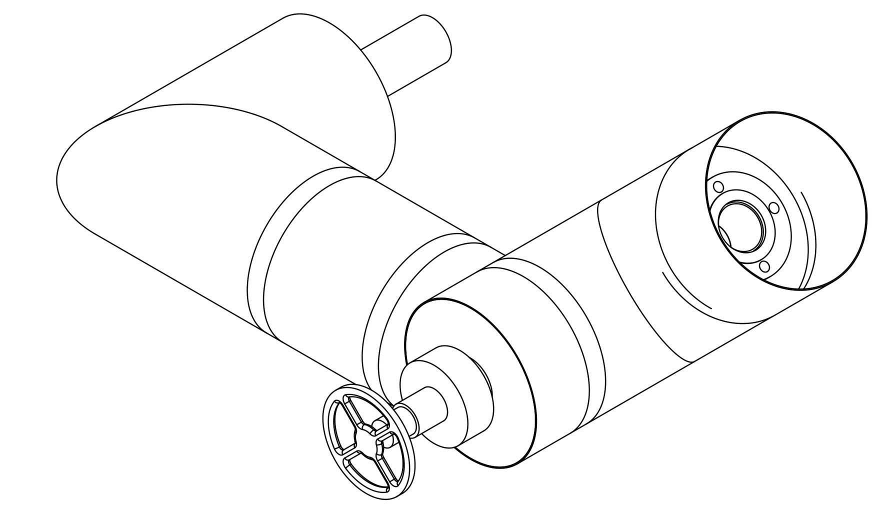
REV	DESCRIPTION	DRAWN / APPROVED	DATE
A	REVISED VENDOR P/N, ITEM 10 REVISED NOTE 4.	B.CYKO / J.TILLMAN	12-DEC-2012 / 12-DEC-2012

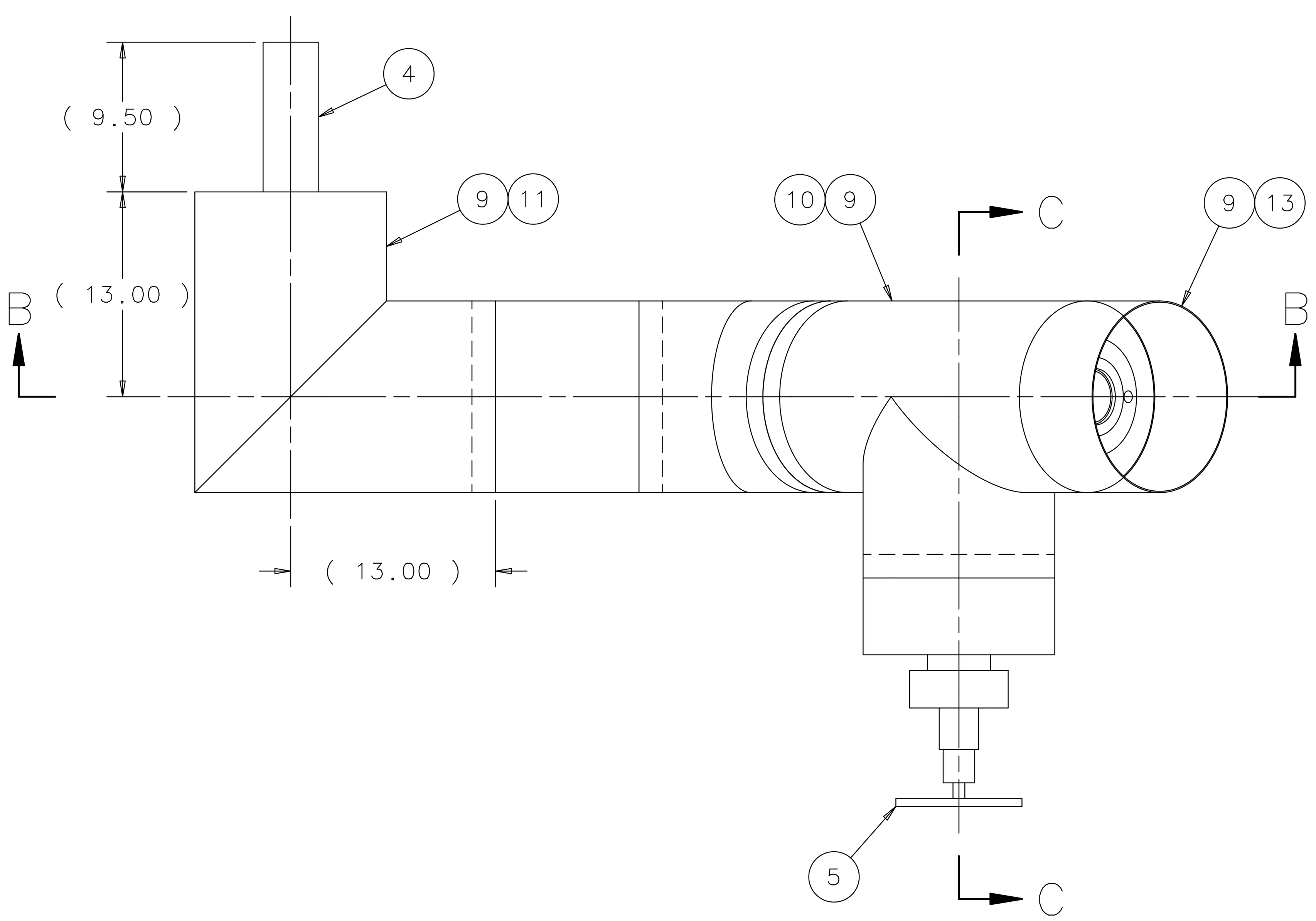
PART#-ITEM#	TOTAL LG. (TL)	STRIP LG. A (SL-A)	STRIP LG. B (SL-B)
493111-1	22.86	7.00	3.75
493111-2	8.77	3.77	2.00

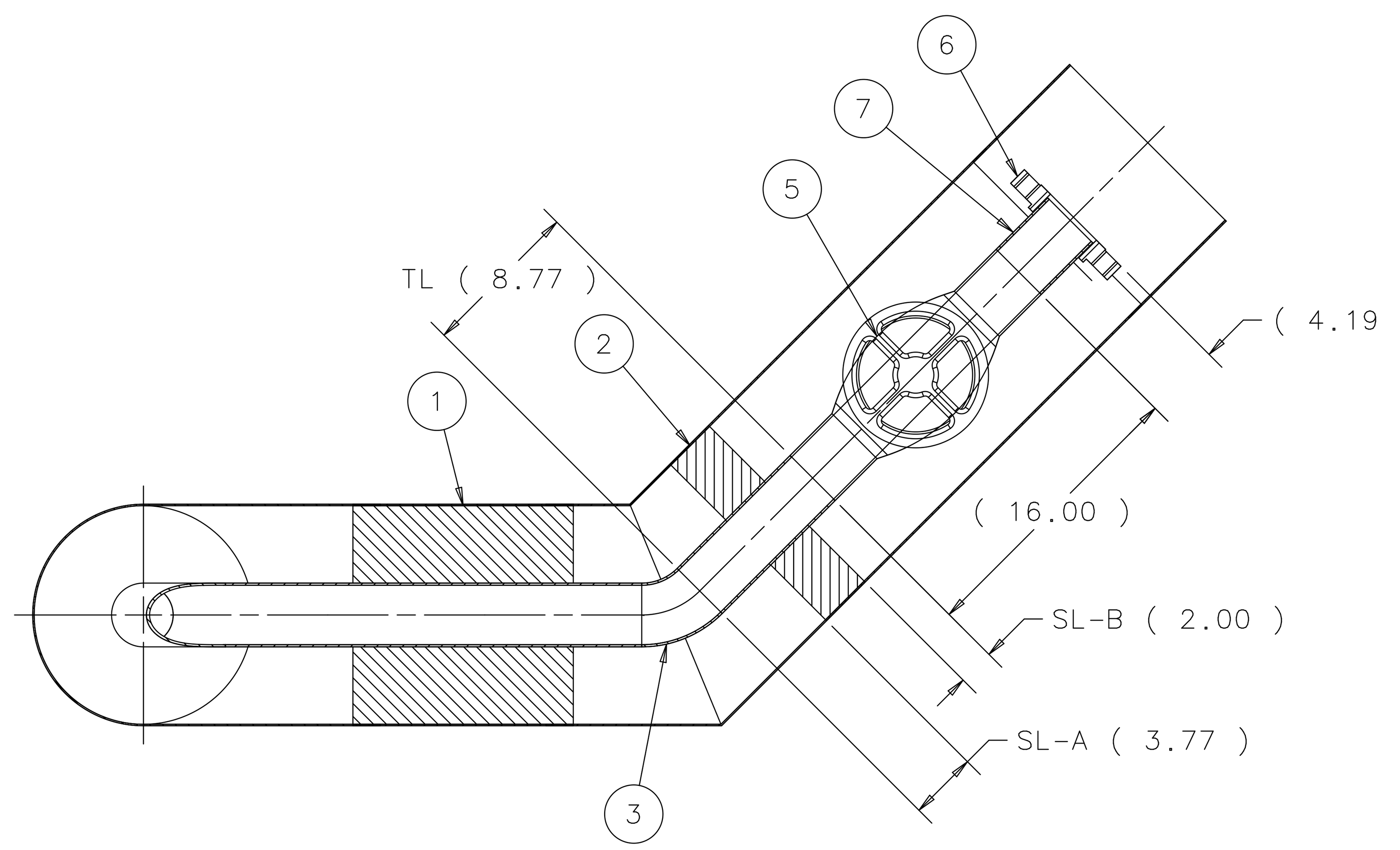




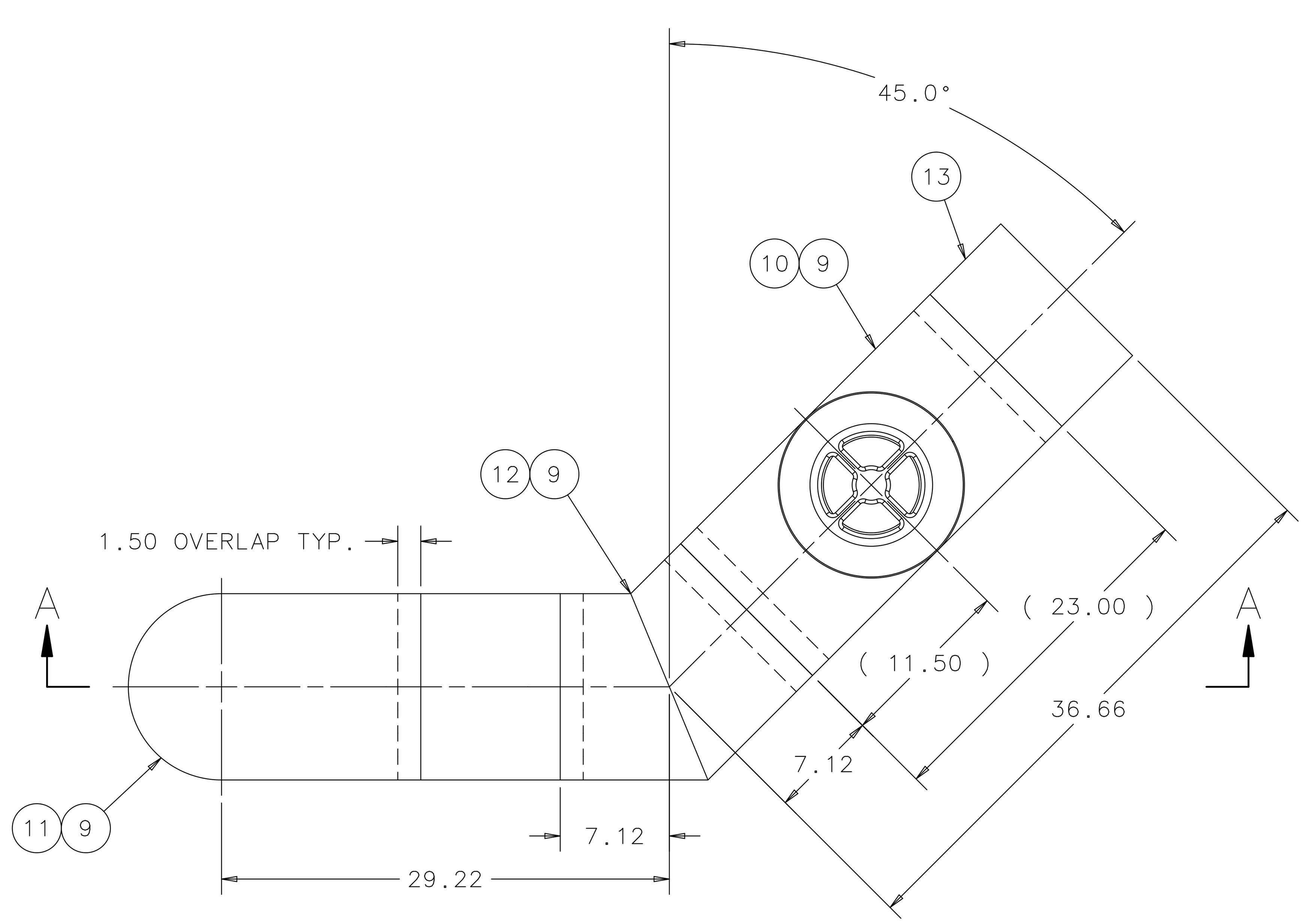
SECTION C-C

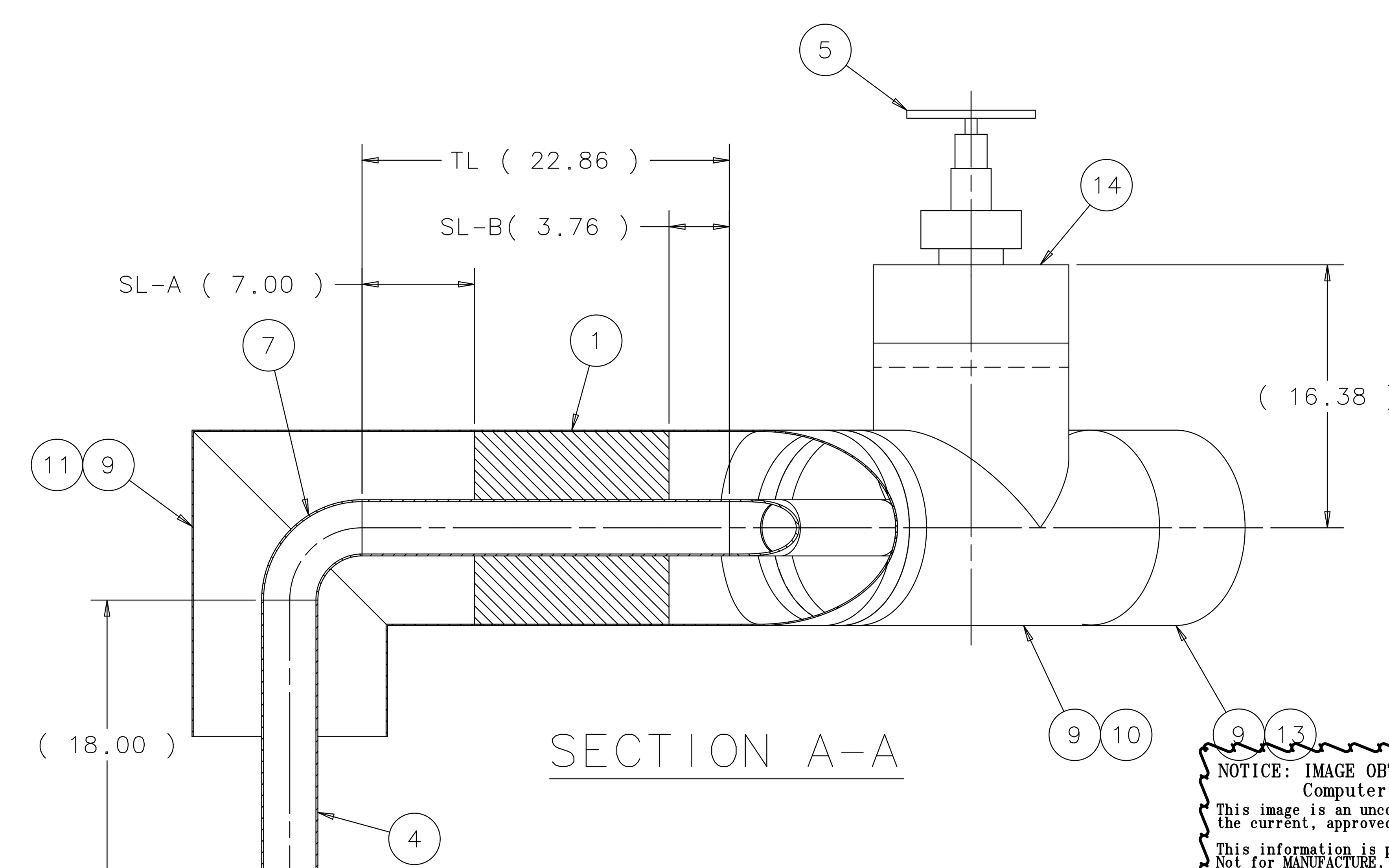






SECTION B-B





SECTION A-A

NOTES:

1. INSTALL FITTING COVERS PER MANUFACTURERS RECOMMENDATIONS (ROVANCO;DOC.INS-FFC). APPLY AN ADDITIONAL 2 LAYERS OF ITEM 16 OVER ALL TAPED JOINTS.
2. SEAL ALL ENDPLATES AND CRYOGEL TRANSITIONS WITH 2 LAYERS OF ITEM 16. ENSURE THAT NO GAPS OR CRACKS EXIST.
3. WELDMENT MUST BE FREE OF DIRT, GREASE, OIL AND CHIPS. SEE "MICROBOONE COMPONENT CLEANING PROCEDURE" - DOC. DB#2141.
4. (A) ALL WELDS AS PER MD-493176.
5. ON BUTT WELDS PERFORM IN-PROCESS EXAMINATION PER ASME B31.3-344.7. SEE "WELD INSPECTION GUIDELINES AND INSPECTION FORM"-DOC.DB#2136.
6. PRESSURE TEST THIS ASSEMBLY TO 110 PSIG WITH DRY NITROGEN GAS AS PER FESHM 5034.
7. ALL WELDS TO BE VACUUM LEAK TIGHT. LEAK TEST PER "MICROBOONE ASSEMBLY PROCEDURE FOR CRYOGENIC SYSTEM"-DOC.DB#2147.
8. ALL NPT CONNECTIONS TO BE SEALED WITH EPOXY PER "MICROBOONE ASSEMBLY PROCEDURE FOR CRYOGENIC SYSTEM" - DOC.DB#2147.
9. ITEM 13 (QTY 1) TO BE APPLIED AFTER FINAL ASSEMBLY IN ENCLOSURE.

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
16	COML.	ASJ FACING TAPE, GTA-NHT, INC., P/N VENTURE TAPE 1540 CW	AS REQD.
15	COML.	SPLICE KIT, 12" O.D. X 6.25 LG., ROVANCO	1
14	MB-493118	MICBN FOAM ENDPLATE 12 OD X 4 ID	1
13	COML.	SPLICE KIT, 12" O.D. X 8.00 LG., ROVANCO	1
12	COML.	MITERED CORNER, 45°, 12" O.D.,PVC PLASTIC, ROVANCO	1
11	COML.	ELBOW, 90° #22-12" O.D. PVC PLASTIC ROVANCO ZE922	1
(A) 10	COML.	TEE, COVER #22-12" O.D. PVC PLASTIC ROVANCO ZET22	1
9	COML.	FOAM KIT, INSULATION, 2-PART POLYURETHANE ROVANCO P/N ROV-FM-KT	AS REQD.
8	COML.	ELBOW, 90°, LONG R.,3"SCH. 10, 304 S.S.	1
7	COML.	PIPE, 3" SCH. 10 X 4.00 LG., 304 S.S.	1
6	COML.	FLANGE, 3" NPS, 150# RF SLIP-ON, 304 S.S.	1
5	COML.	VALVE, GLOBE, ACME, 3" NPS, P/N V1060300SLX10 TAG #MV-240 LOCATION 7G	1
4	COML.	PIPE, 3" SCH. 10 X 18.00 LG., 304 S.S.	1
3	COML.	ELBOW, 45°, LONG R.,3" SCH. 10 304 S.S.	1
2	COML.	INSUL. PIPE, 3" SCH. 10 X 12" O.D. X 8.77 LG., 304 S.S.	1
1	COML.	INSUL. PIPE, 3" SCH. 10 X 12" O.D. X 22.86 LG., 304 S.S.	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED					
.X	.XX	ANGLES	DRAWN	W.CYKO	31-OCT-2012
± - -	± 0.06	±1.0°	CHECKED	J.TILLMAN	02-NOV-2012
			ORIGINATOR	R.SANDERS	31-OCT-2012
			APPROVED	M.ZUCKERBROT	07-NOV-2012

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. MAX. ALL MACH. SURFACES
5. DRAWING UNITS: U.S. INCH

USED ON

MATERIAL: SEE PARTS LIST ABOVE

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

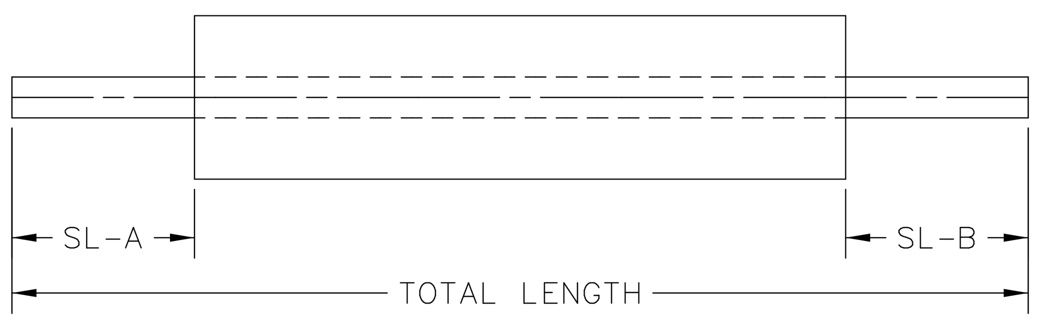
E974-MICROBOONE - INFRASTRUCTURE SERVICE EQUIPMENT MCRBN VESSEL TO CONDENSER SECT A

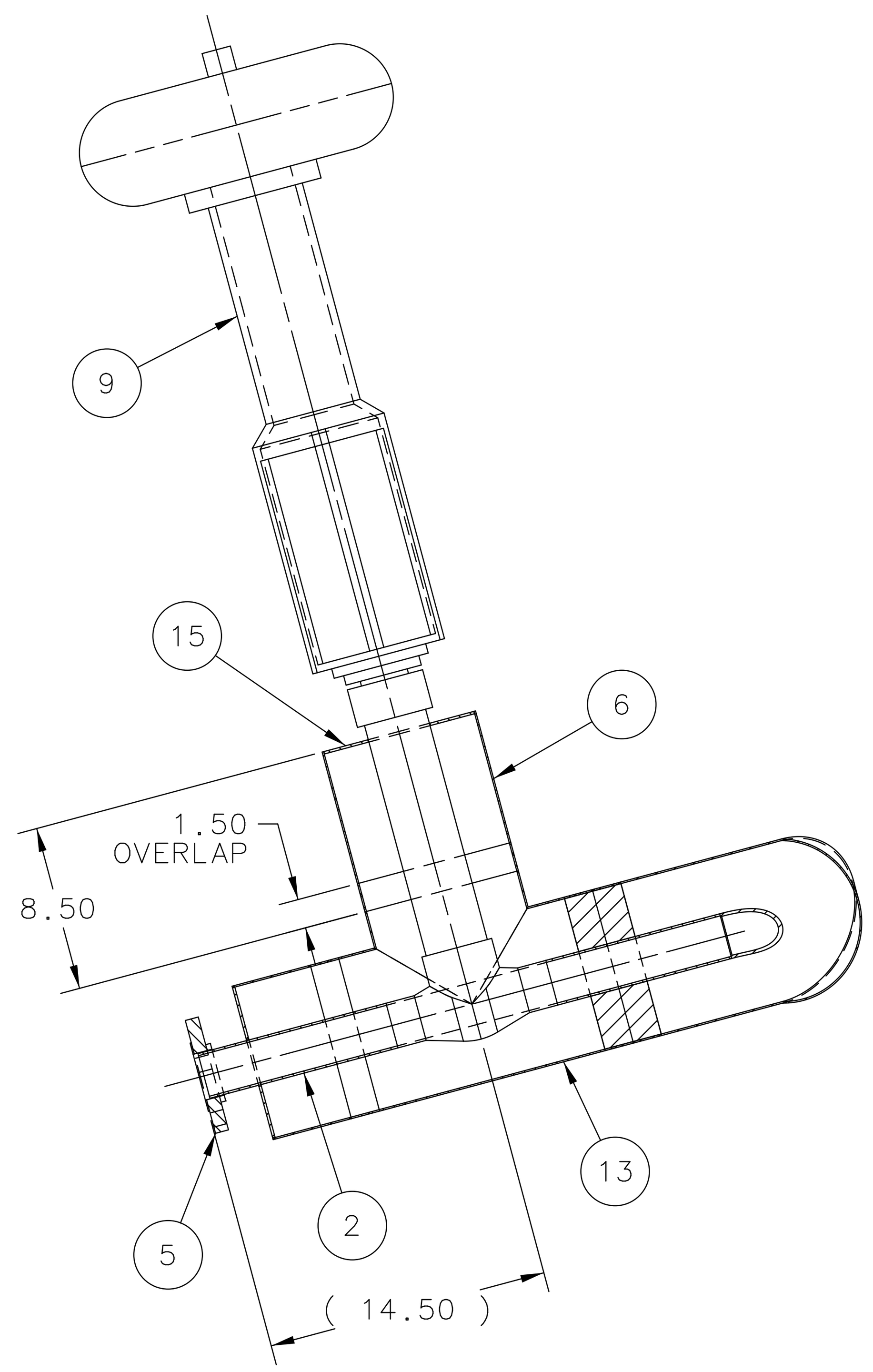
SCALE	DRAWING NUMBER	SHEET	REV
1:8	3974.110-MD-493111	1 OF 1	A

CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

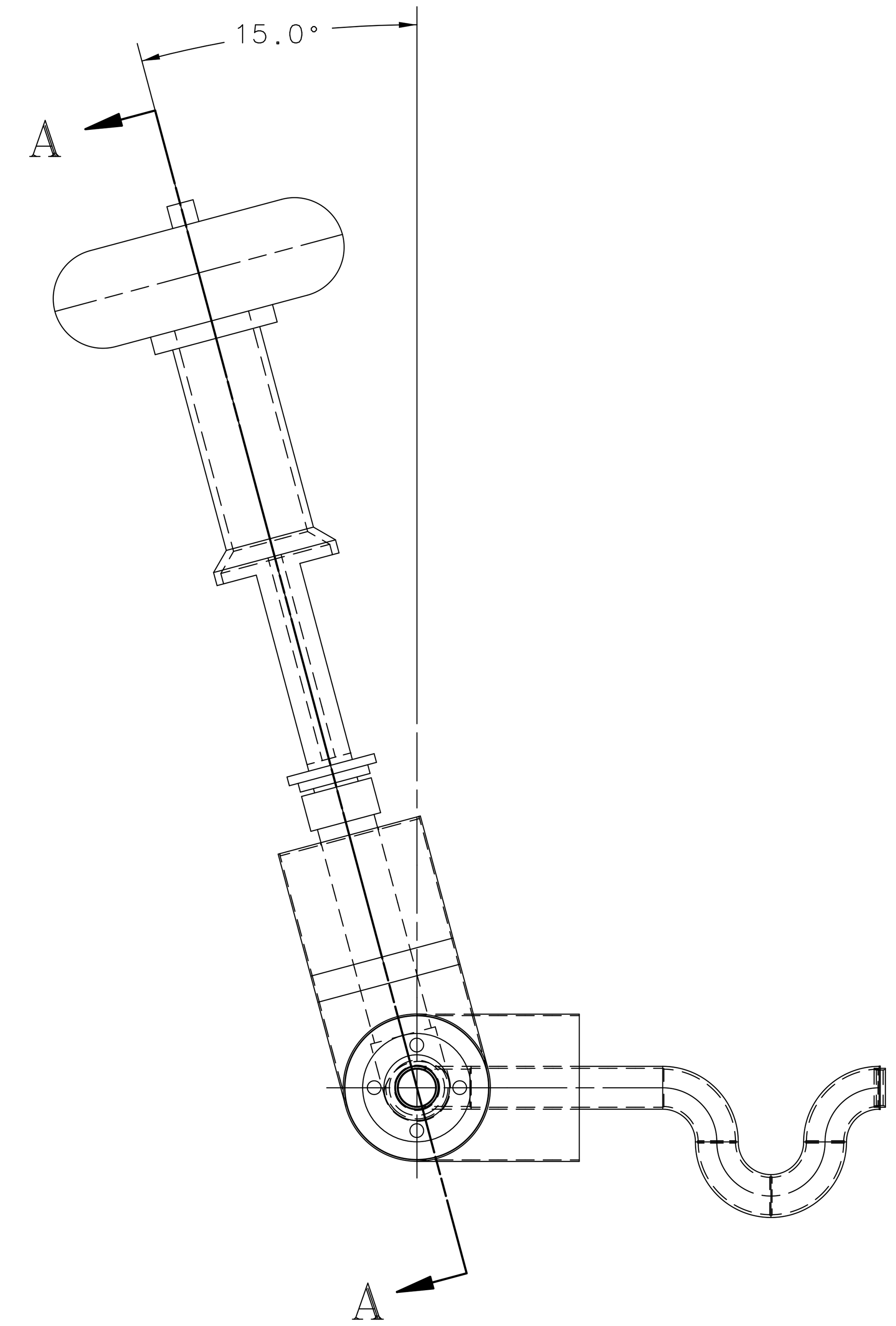
REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE

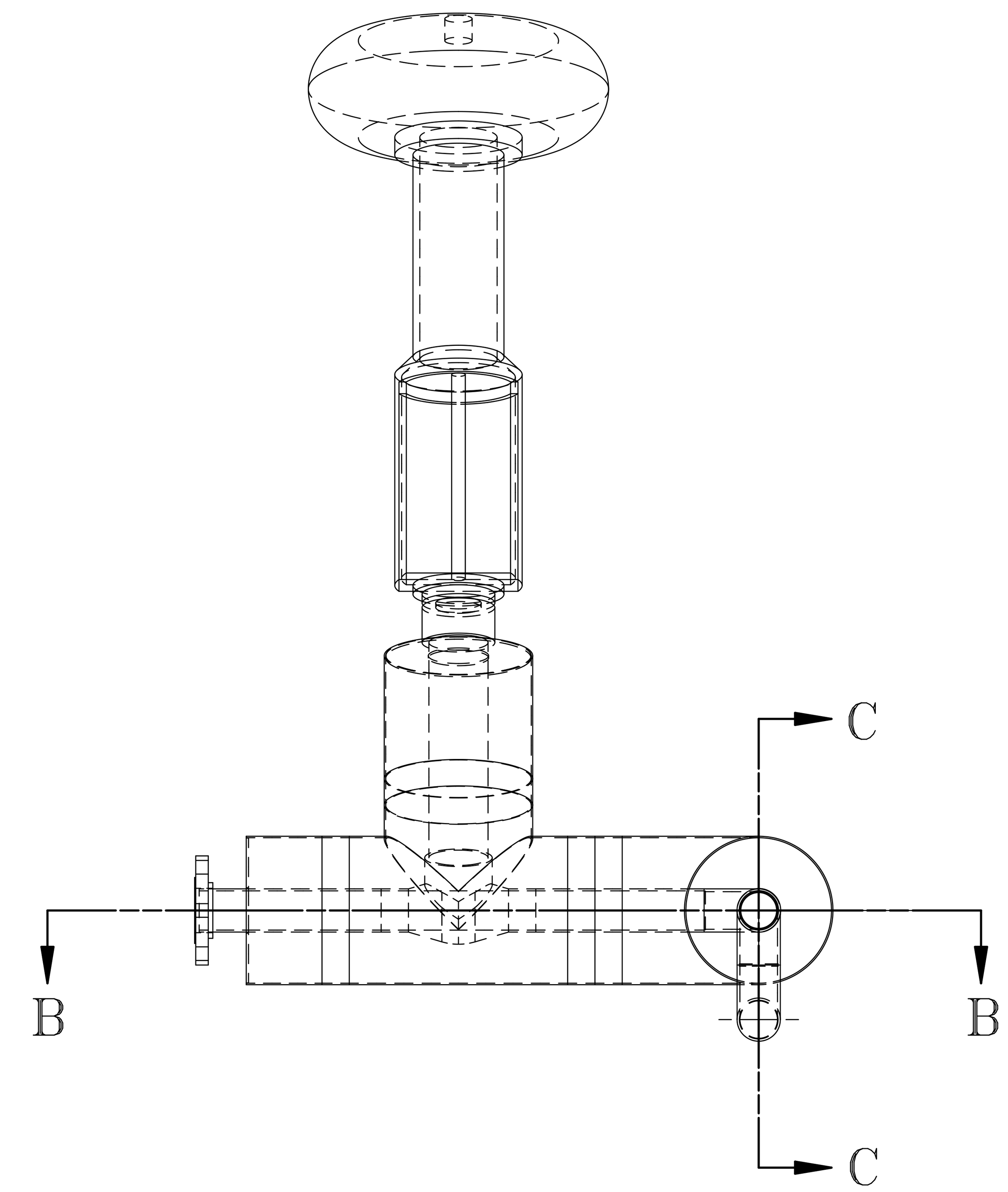
INSUL. PIPE LENGTH CHART			
PART#-ITEM#	TOTAL LG. (TL)	STRIP LG. (SL-A)	STRIP LG. B (SL-B)
493136-1	9.25	1.75	4.50

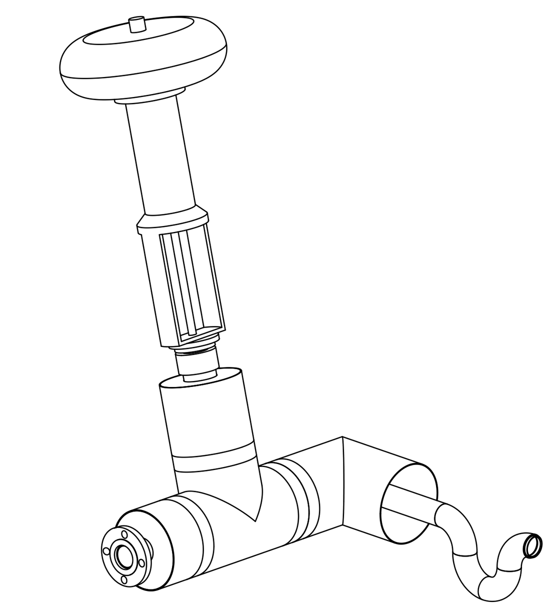




SECTION A-A

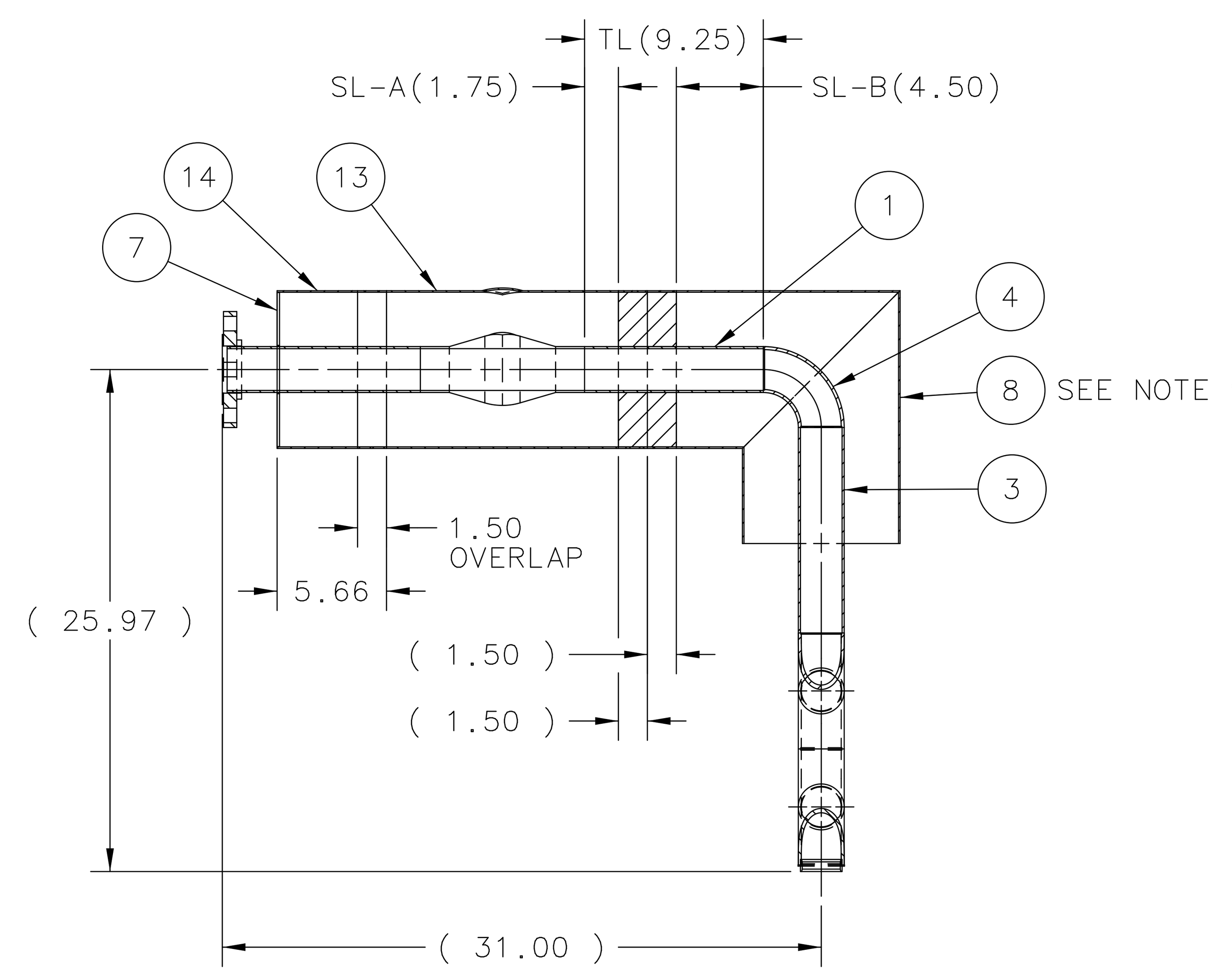




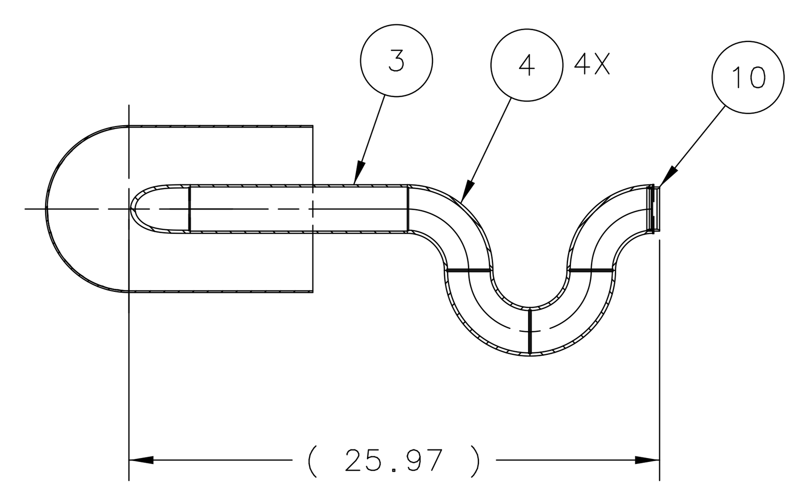


ISOMETRIC VIEW

SCALE 1:16



SECTION B-B



SECTION C-C

NOTES:

1. INSTALL FITTING COVERS PER MANUFACTURERS RECOMMENDATIONS (ROVANCO;DOC.INS-FFC). APPLY AND ADDITIONAL 2 LAYERS OF ITEM 12 OVER ALL TAPED JOINTS.
2. SEAL ALL ENDPLATES AND CRYOGEL TRANSITIONS WITH 2 LAYERS OF ITEM 12. ENSURE THAT NO GAPS OR CRACKS EXIST.
3. WELDMENT MUST BE FREE OF DIRT, GREASE, OIL AND CHIPS. SEE "MICROBOONE COMPONENT CLEANING PROCEDURE" - DOC. DB#2141.
4. ALL WELDS AS PER ASME B31.3 FOR NORMAL FLUID SERVICE.
5. ON BUTT WELDS PERFORM IN-PROCESS EXAMINATION PER ASME B31.3-344.7. SEE "WELD INSPECTION GUIDELINES AND INSPECTION FORM"-DOC.DB#2136.
6. PRESSURE TEST THIS ASSEMBLY TO 110 PSIG WITH DRY NITROGEN GAS AS PER FESHM 5034.
7. ALL WELDS TO BE VACUUM LEAK TIGHT. LEAK TEST PER "MICROBOONE ASSEMBLY PROCEDURE FOR CRYOGENIC SYSTEM"-DOC.DB#2147.
8. ALL NPT CONNECTIONS TO BE SEALED WITH EPOXY PER "MICROBOONE ASSEMBLY PROCEDURE FOR CRYOGENIC SYSTEM" - DOC.DB#2147.
9. ITEM 8 TO BE APPLIED AFTER FINAL ASSEMBLY IN ENCLOSURE.

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
15	MB-493133	FOAM JACKET ENDPLATE 3.31 I.D.	1
14	COML	SPLICE KIT, 8" O.D. x 5.66" LG, ROVANCO	1
13	COML	TEE-COVER, #18-8" O.D., PVC PLASTIC, ROVANCO P/N ZET18	1
12	COML	AJS FACING TAPE, GTA-NHT, INC., VENTURE TAPE 1540 CW	AS REQ'D
11	COML	FOAM KIT - INSULATION, 2-PART, POLYURETHANE, ROVANCO #ROV-FM-KT	AS REQ'D
10	COML	CONSPACER, 2" NPS, SCH 10, 304 S.S., ROBVON	1
9	COML	GLOBE VALVE, 2" NPS, BUTT-WELD, ACME P/N CV2000HAROP10EA, TAG: PV-300, LOCATION: 6A	1
8	COML	ELBOW, 90°, #18-8" O.D., PVC PLASTIC, ROVANCO P/N ZE918	1
7	MB-493134	MICBN FOAM JACKET ENDPLATE B	1
6	COML	SPLICE KIT, 8" O.D. x 8.50" LG, ROVANCO	1
5	COML	FLANGE, SLIP-ON, RAISED FACE, 150 LB CLASS, STAINLESS STEEL, 2" NPS	1
4	COML	ELBOW, 90°, 2" NPS, SCH 10, LONG RADIUS, 304 S.S.	5
3	COML	PIPE, SCH 10, 304 S.S., 2" NPS x 10.62" LG	1
2	COML	PIPE, SCH 10, 304 S.S., 2" NPS x 10.00" LG	1
1	COML	INSULATED PIPE, SCH 10, 2" NPS x 8" O.D. INSULATION x 9.25 LG, ROVANCO	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED					
.XX	.XXX	ANGLES	ORIGINATOR	R.SANDERS	09-JUL-2012
± .06	± - -	± 1°	DRAWN	T.SPERRY	09-NOV-2012
			CHECKED	J.TILLMAN	19-NOV-2012
			APPROVED	M.ZUCKERBROT	19-NOV-2012

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. MAX. ALL MACH. SURFACES 250√
5. DRAWING UNITS:U.S.INCH

USED ON

MATERIAL
SEE PARTS LIST ABOVE

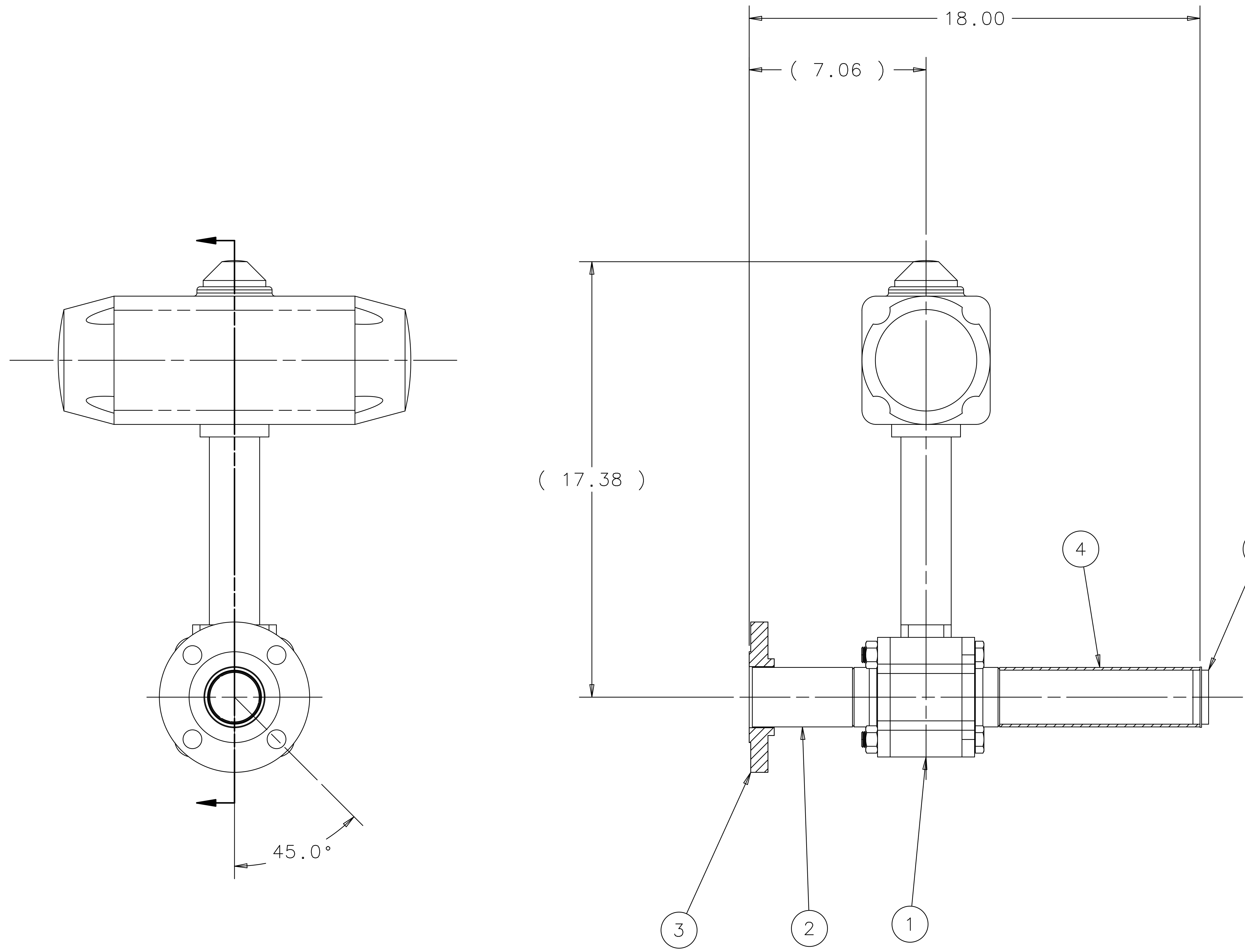
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

E974-MICROBOONE - INFRASTRUCTURE SERVICE EQUIPMENT MICROBOONE VES TO PUMP SECTION A

SCALE	DRAWING NUMBER	SHEET	REV
1:8 & AS NOTED.	3974.110-MD-493136	1 OF 1	

CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

REV	DESCRIPTION	DRAWN / APPROVED	DATE / DATE



5	COML	CONSPACER, 2" NPS, 304 S.S. SCH 10, ROBVON	1
4	COML	PIPE, 2" SCH. 10 x 8.00 LG., 304 S.S.	1
3	COML	FLANGE, SLIP-ON, RAISED FACE, 150 LBS, 2 NOM PIPE SIZE, 304 S.S	1
2	COML	PIPE, SCH 10, 304 S.S 2" X 4.00" LG	1
1	COML	VALVE, 2"NPS, 3 PIECE BALL, TAG #PV-816, LOC. 10 SHARPE:2-C99-6-6-R-T-BW10-SR-NC	1
ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.

PARTS LIST

NOTES:

1. WELDMENT MUST BE FREE OF DIRT, GREASE, OIL AND CHIPS. SEE "MICROBOONE COMPONENT CLEANING PROCEDURE" - DOC. DB#2141.
2. ALL WELDS AS PER MD-493176.
3. ON BUTT WELDS PERFORM IN-PROCESS EXAMINATION PER ASME B31.3-344.7. SEE "WELD INSPECTION GUIDELINES AND INSPECTION FORM"-DOC.DB#2136.
4. PRESSURE TEST THIS ASSEMBLY TO 55 PSIG WITH DRY NITROGEN GAS AS PER FESHM 5034.
5. ALL WELDS TO BE VACUUM LEAK TIGHT. LEAK TEST PER "MICROBOONE ASSEMBLY PROCEDURE FOR CRYOGENIC SYSTEM"-DOC.DB#2147.
6. IN PROCESS EXAMINATION PER ASME B31.3-344.7. SEE "WELD INSPECTION GUIDELINES AND INSPECTION FORM" - DOC. DB#2136.

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	R.SANDERS	13-NOV-2012
.X	.XX	ANGLES	DRAWN	J.RAUCH	13-NOV-2012
± --	± .06	±1.0°	CHECKED	J.TILLMAN	02-JAN-2013
			APPROVED	M.ZUCKERBROT	02-JAN-2013

1. BREAK ALL SHARP EDGES .02 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. MAX. ALL MACH. SURFACES 250
5. DRAWING UNITS: U.S. INCH

USED ON

MATERIAL: SEE PARTS LIST ABOVE

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

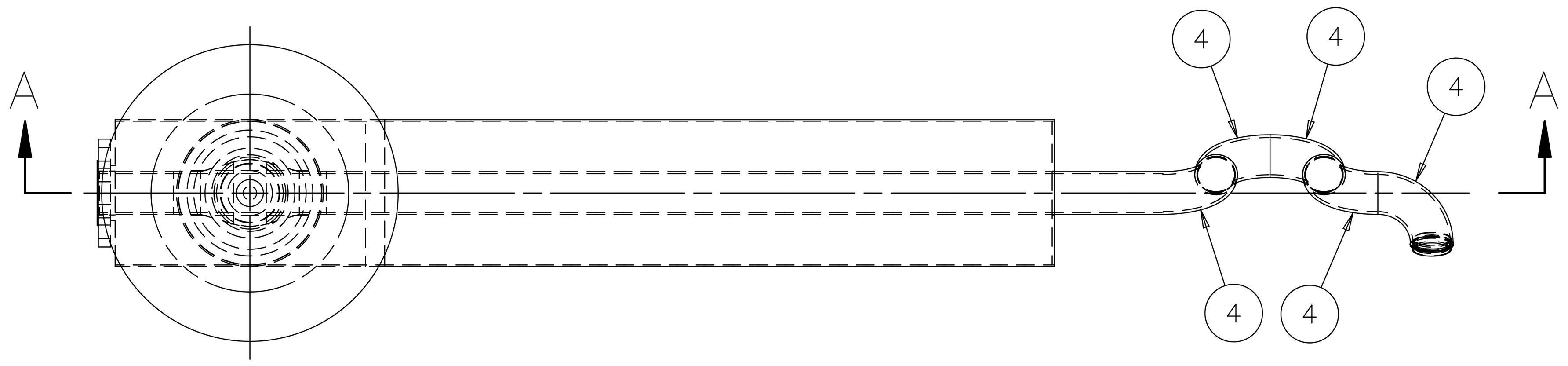
E974-MICROBOONE - INFRASTRUCTURE SERVICE EQUIPMENT
UBOONE PLMNG VES 2 HTXR SEC A

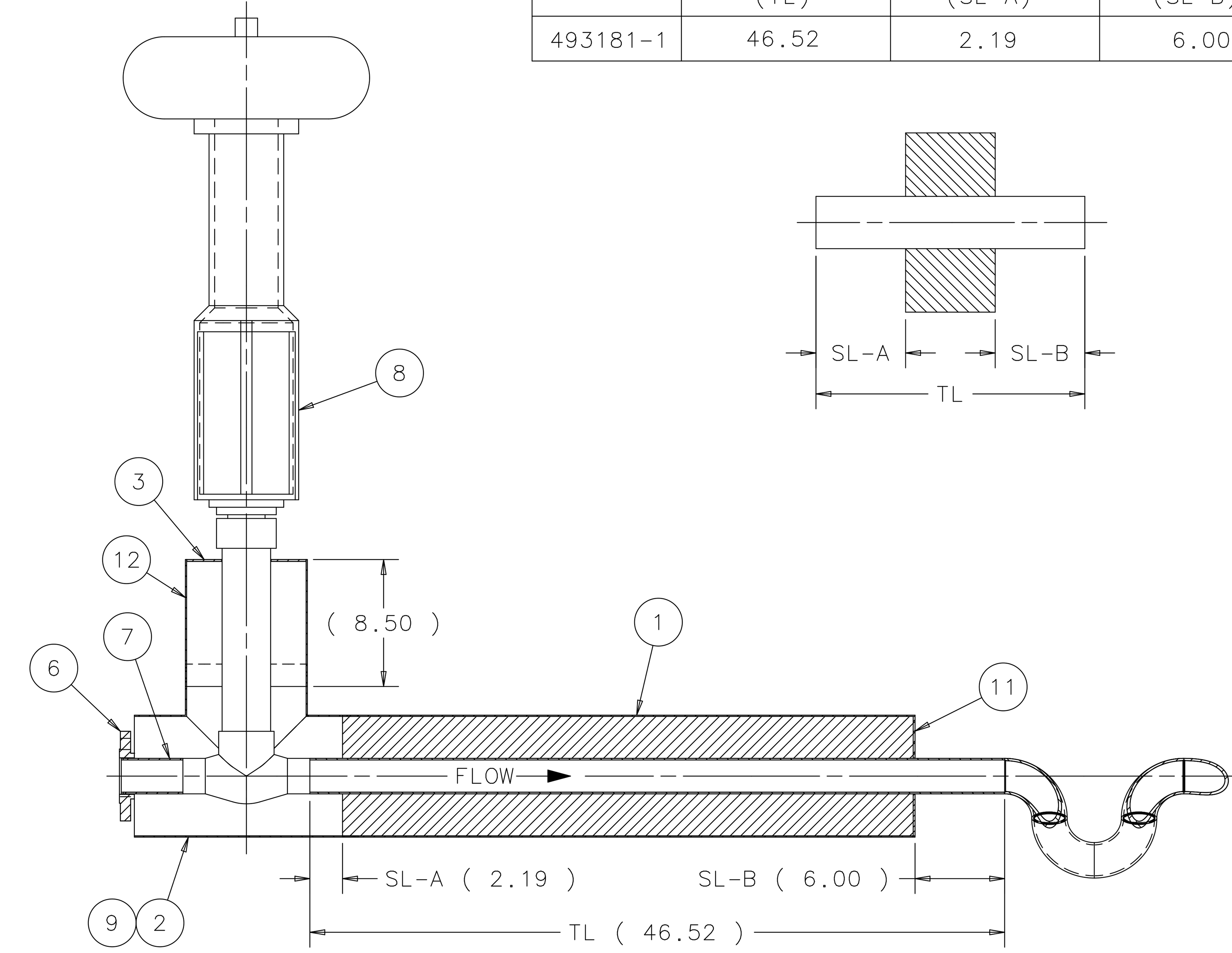
SCALE	DRAWING NUMBER	SHEET	REV
1:4	3974.110-MC-493144	1 OF 1	

CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

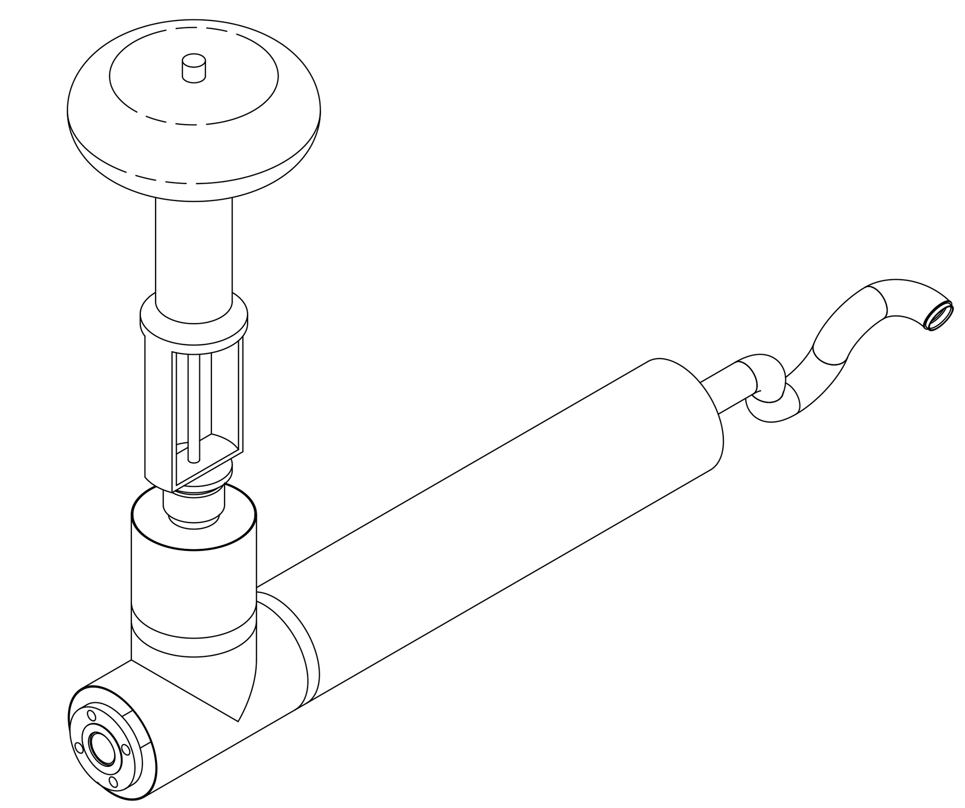
REV	DESCRIPTION	DRAWN / APPROVED	DATE / DATE

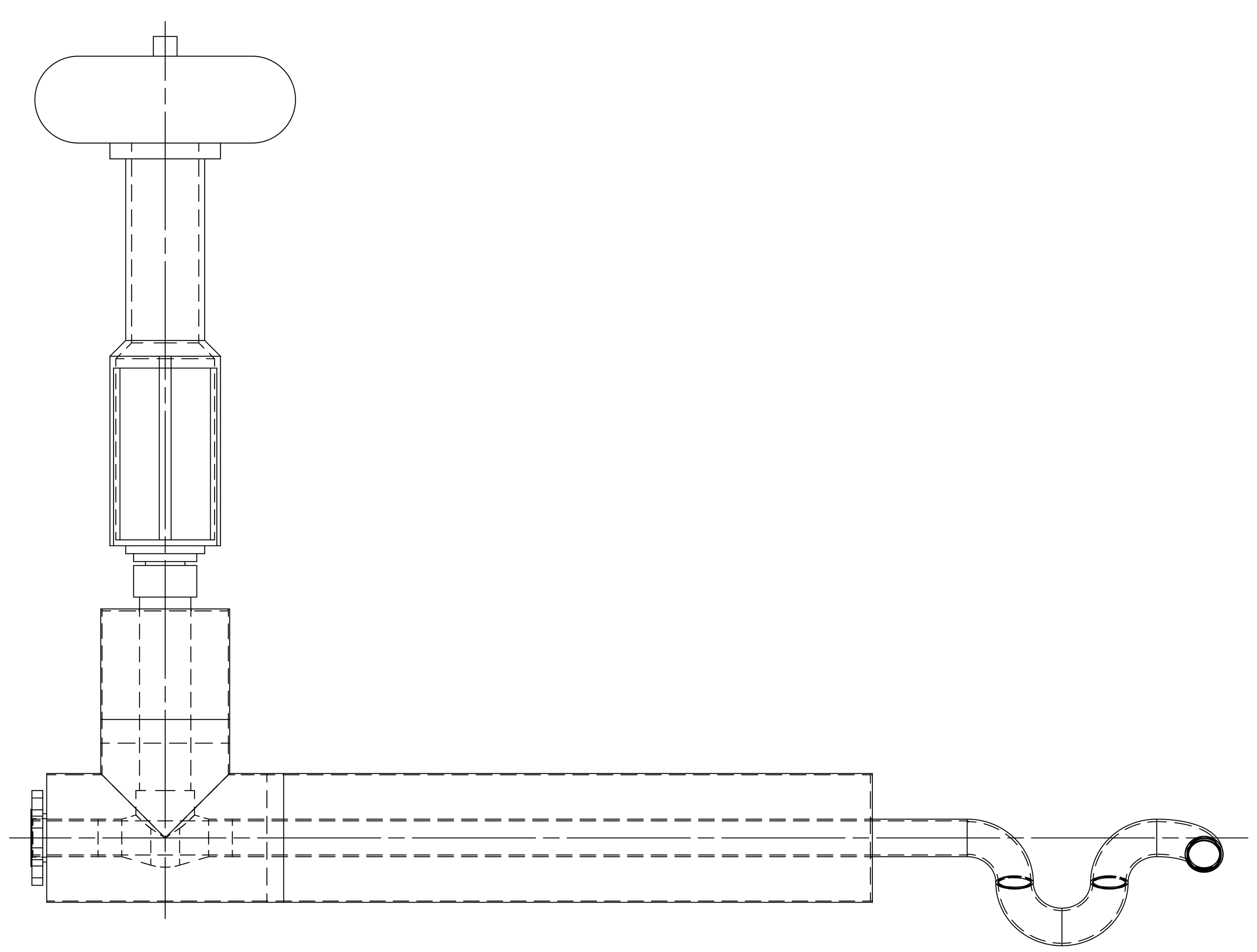
PART#-ITEM#	TOTAL LG. (TL)	STRIP LG. A (SL-A)	STRIP LG. B (SL-B)
493181-1	46.52	2.19	6.00

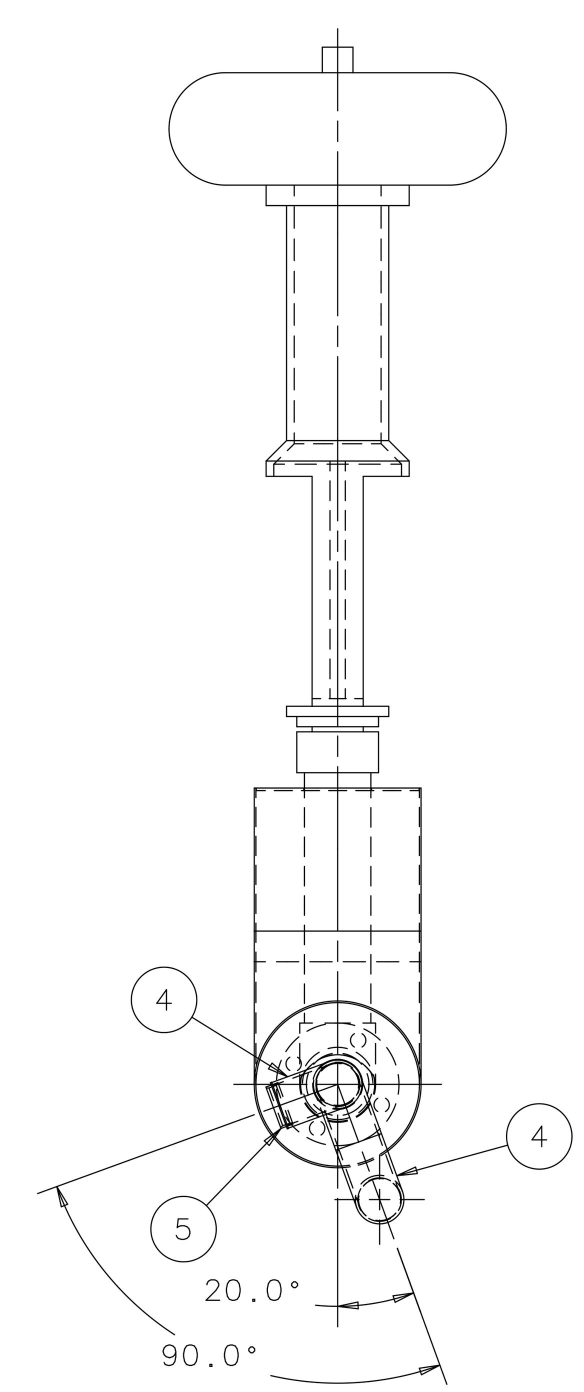




SECTION A-A







NOTES:

1. INSTALL FITTING COVERS PER MANUFACTURERS RECOMMENDATIONS (ROVANCO;DOC.INS-FFC). APPLY AN ADDITIONAL 2 LAYERS OF ITEM 10 OVER ALL TAPED JOINTS.
2. SEAL ALL ENDPLATES AND CRYOGEL TRANSITIONS WITH 2 LAYERS OF ITEM 10. ENSURE THAT NO GAPS OR CRACKS EXIST.
3. WELDMENT MUST BE FREE OF DIRT, GREASE, OIL AND CHIPS. SEE "MICROBOONE COMPONENT CLEANING PROCEDURE" - DOC. DB#2141.
4. ALL WELDS AS PER MD-493176.
5. ON BUTT WELDS PERFORM IN-PROCESS EXAMINATION PER ASME B31.3-344.7. SEE "WELD INSPECTION GUIDELINES AND INSPECTION FORM"-DOC.DB#2136.
6. PRESSURE TEST THIS ASSEMBLY TO 110 PSIG WITH DRY NITROGEN GAS AS PER FESHM 5034.
7. ALL WELDS TO BE VACUUM LEAK TIGHT. LEAK TEST PER "MICROBOONE ASSEMBLY PROCEDURE FOR CRYOGENIC SYSTEM"-DOC.DB#2147.
8. ITEMS 3, 9 & 12 TO BE APPLIED AFTER FINAL ASSEMBLY IN ENCLOSURE.

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
12	COML.	SPLICE KIT, 8" O.D. X 8.50 LG., ROVANCO	1
11	MB-493192	FOAM ENDPLATE 8" O.D. X 2.44" I.D.	1
10	COML.	ASJ FACING TAPE, GTA-NHT, INC., P/N VENTURE TAPE 1540 CW	AS REQD.
9	COML.	FOAM KIT INSULATION, 2-PART POLYURETHANE ROVANCO P/N ROV-FM-KT	AS REQD.
8	COML.	VALVE, GLOBE, ACME, 2" NPS, ACT, P/N CV2000HAROP10EA, TAG: PV-815 LOC: 6A	1
7	COML.	PIPE, 2" SCH. 10 X 4.13 LG., 304 S.S.	1
6	COML.	FLANGE, SLIP-ON, 150# RF, 2" NPS, 304 S.S.	1
5	COML.	CON SPACER, 2" SCH. 10, ROBVON	1
4	COML.	ELBOW, 90°, LONG R., 2" SCH. 10, 304 S.S.	5
3	MB-493133	FOAM JACKET END PLATE, 8" OD X 3.13 ID	1
2	COML.	TEE, COVER, #18-8" O.D. PVC PLASTIC, ROVANCO P/N ZET 18	1
1	MD-493181-1	INSUL PIPE, 2" SCH. 10 X 8" O.D. X 46.52 LG., 304 S.S.	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED					
.X	.XX	ANGLES	ORIGINATOR	R.SANDERS	04-DEC-2012
± - - -	± .06	± 1°	DRAWN	W.CYKO	04-DEC-2012
			CHECKED	J.TILLMAN	06-DEC-2012
			APPROVED	M.ZUCKERBROT	12-DEC-2012

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M 1994
4. MAX. ALL MACH. SURFACES 250
5. DRAWING UNITS: INCHES

USED ON

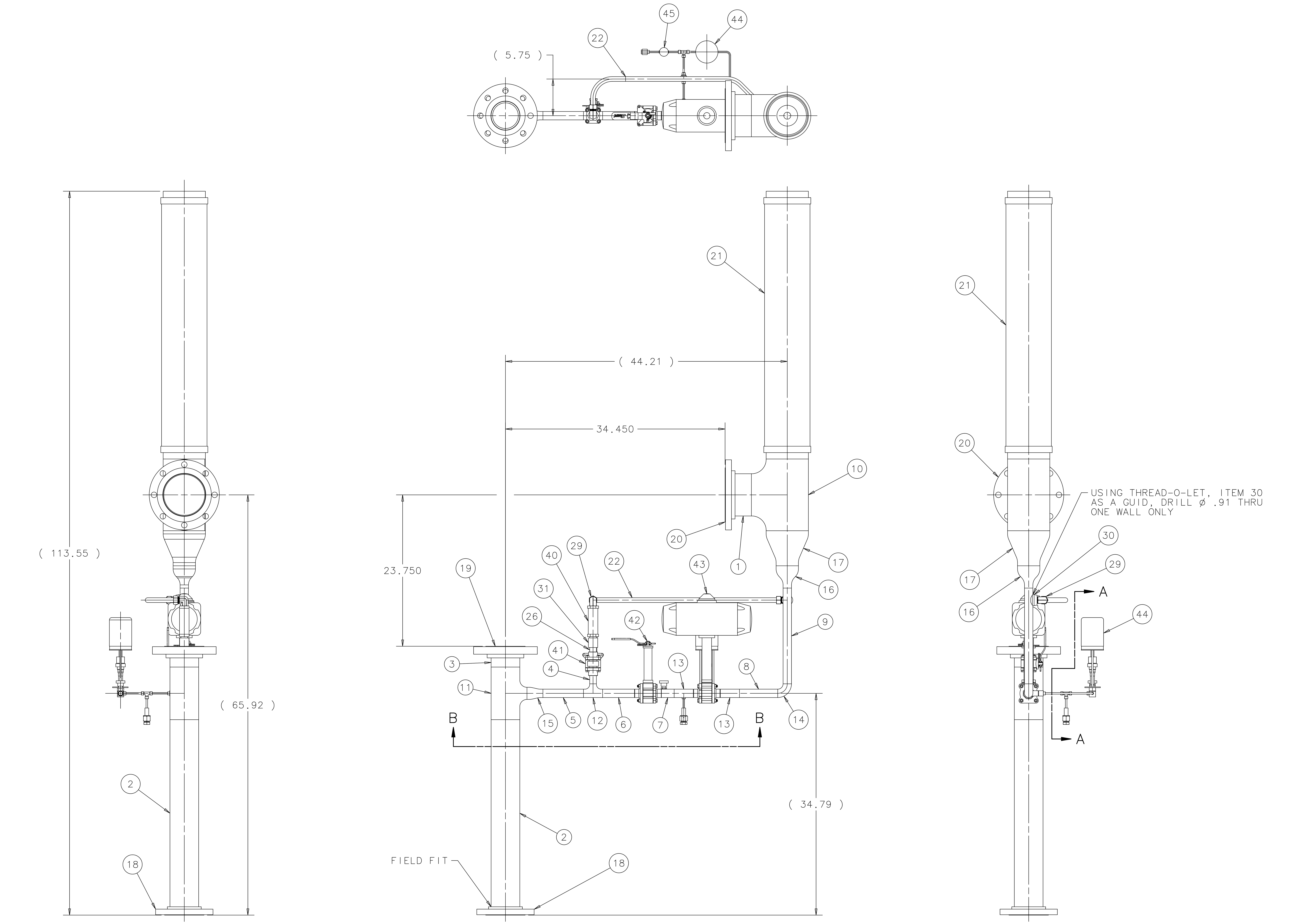
MATERIAL: SEE PARTS LIST ABOVE

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

E974-MICROBOONE - INFRASTRUCTURE SERVICE EQUIPMENT UBOONE PLMNG HTXR 2 VES SEC D

SCALE	DRAWING NUMBER	SHEET	REV
1:8	3974.110-MD-493181	1 OF 1	

CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT



PARTS LIST CONTINUED ON SHEET 2

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
29	COML	ELBOW; .75 COMP. X .75 MNPT MCMASTER CARR: 50915K35	2
28	COML	ADAPTER. .50 NPS X .25 TUBE S.W. SWAGELOK: SS-8-MPW-A-4TSW	2
27	COML	TEE. .25 TUBE SOCKET WELD; 316SS SWAGELOK: SS-4-TSW-3	2
26	COML	TUBING; 1/4 X .035 WALL X 2.42 LG; 304 SS	1
25	COML	TUBING; 1/4 X .035 WALL X 2.00 LG; 304 SS	3
24	COML	TUBING; 1/4 X .035 WALL X 3.00 LG; 304 SS	2
23	COML	TUBE; .25 .035 WALL 304 SS	A/R
22	COML	TUBE; .75 TYPE K COPPER	A/R
21	COML	FLEX HOSE; MASTERFLEX; SNGL BRD; 42", 6" SCH10 X 1" LG ENDS; 304SS	1
20	COML	FLANGE; 6" 150# R.F.S.O.; 304SS	1
19	COML	FLANGE, 4" 300# R.F.S.O.; 304SS	1
18	COML	FLANGE; 4" 150# R.F.S.W. 304SS	1
17	COML	CONCENTRIC REDUCER; 6" X 3" SCH.10 304SS	1
16	COML	CONCENTRIC REDUCER; 3" X 1" SCH.10 304SS	1
15	COML	CONCENTRIC REDUCER; 1.5 X 1.0 SCH.40 304SS	1
14	COML	ELBOW, 90DEG L.R. 1 SCH10; 304SS	1
13	COML	TEE, RED. 1 X .50 SCH10; 304SS	2
12	COML	TEE, RED. 1 X .75 SCH10; 304SS	1
11	COML	TEE, RED. 4 X 1.5 SCH40; 304SS	1
10	COML	TEE, STRAIGHT' 6" SCH10; 304SS	1
9	COML	PIPE, 1" SCH10 X 15.03 LG; 304SS	1
8	COML	PIPE, 1" SCH10 X 6.00 LG; 304SS	1
7	COML	PIPE, 1" SCH10 X 2.00 LG; 304SS	1
6	COML	PIPE, 1" SCH10 X 5.00 LG; 304SS	1
5	COML	PIPE, 1" SCH10 X 6.37 LG; 304SS	1
4	COML	PIPE, .75" SCH10 X 2.00 LG; 304SS	1
3	COML	PIPE, 4" SCH40 X 3.03 LG; 304SS	1
2	COML	PIPE, 4" SCH40 X 30.29 LG; 304SS	1
1	COML	PIPE, 6" SCH10 X 4.00 LG; 304SS	1

PARTS LIST

REV	DESCRIPTION	DRAWN / APPROVED	DATE

UNLESS OTHERWISE SPECIFIED			
ORIGINATOR	R.SANDERS	14-JAN-2014
DRAWN	J.TILLMAN	14-JAN-2014
CHECKED	J.TILLMAN	12-FEB-2014
APPROVED	M.ZUCKERBROT	12-FEB-2014

.XX ± .06 | .XXX ± .032 | ANGLES ± ---

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. MAX. ALL MACH. SURFACES 250
5. DRAWING UNITS: U.S. INCH

USED ON

MATERIAL: SEE PARTS LIST ABOVE

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

E974-MICROBOONE - INFRASTRUCTURE SERVICE EQUIPMENT UBOONE CRYOSTAT VENT ASSY A

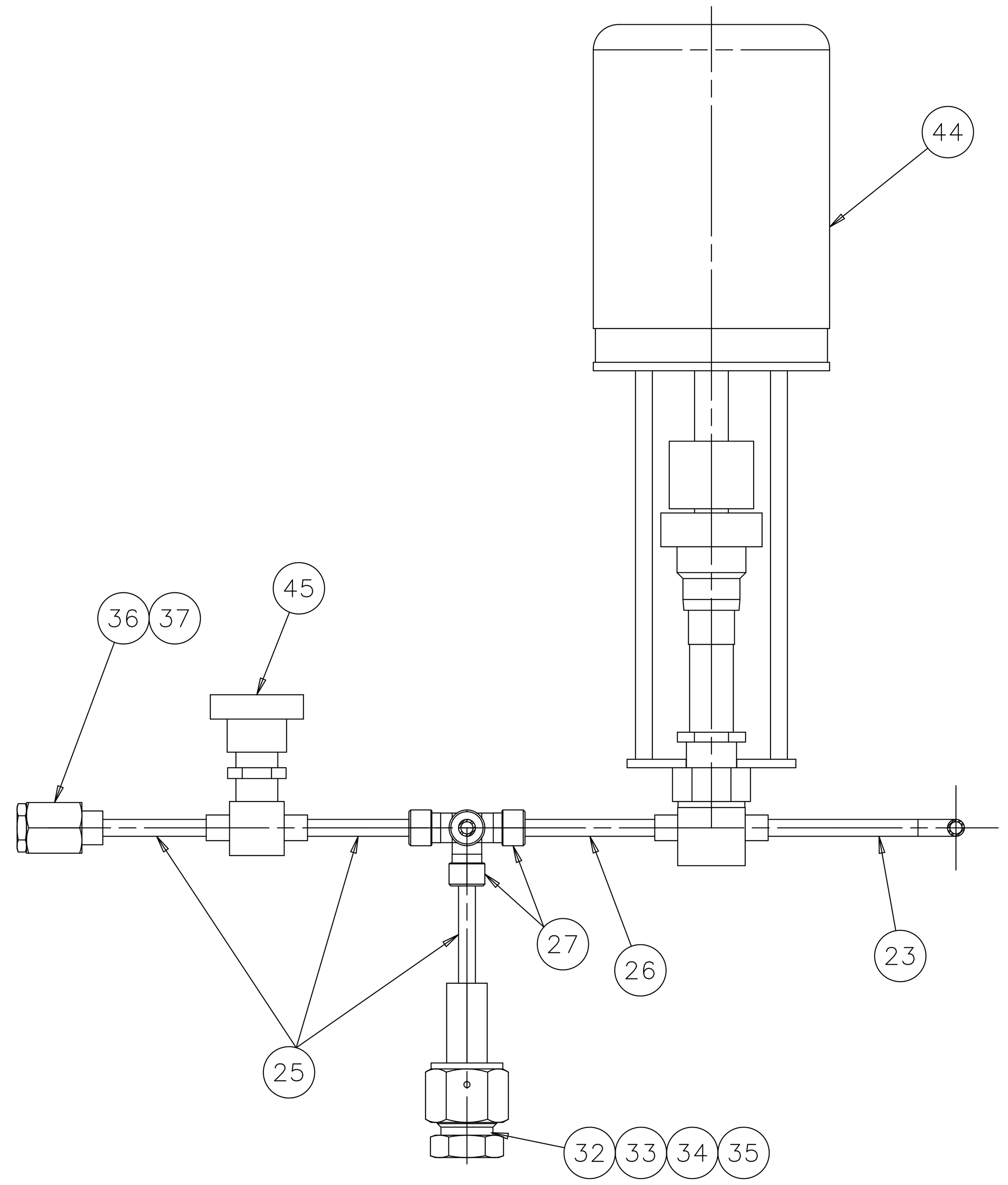
SCALE 1:8 & NOTED | DRAWING NUMBER 3974.110-MD-497340 | SHEET 1 OF 2 | REV

CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

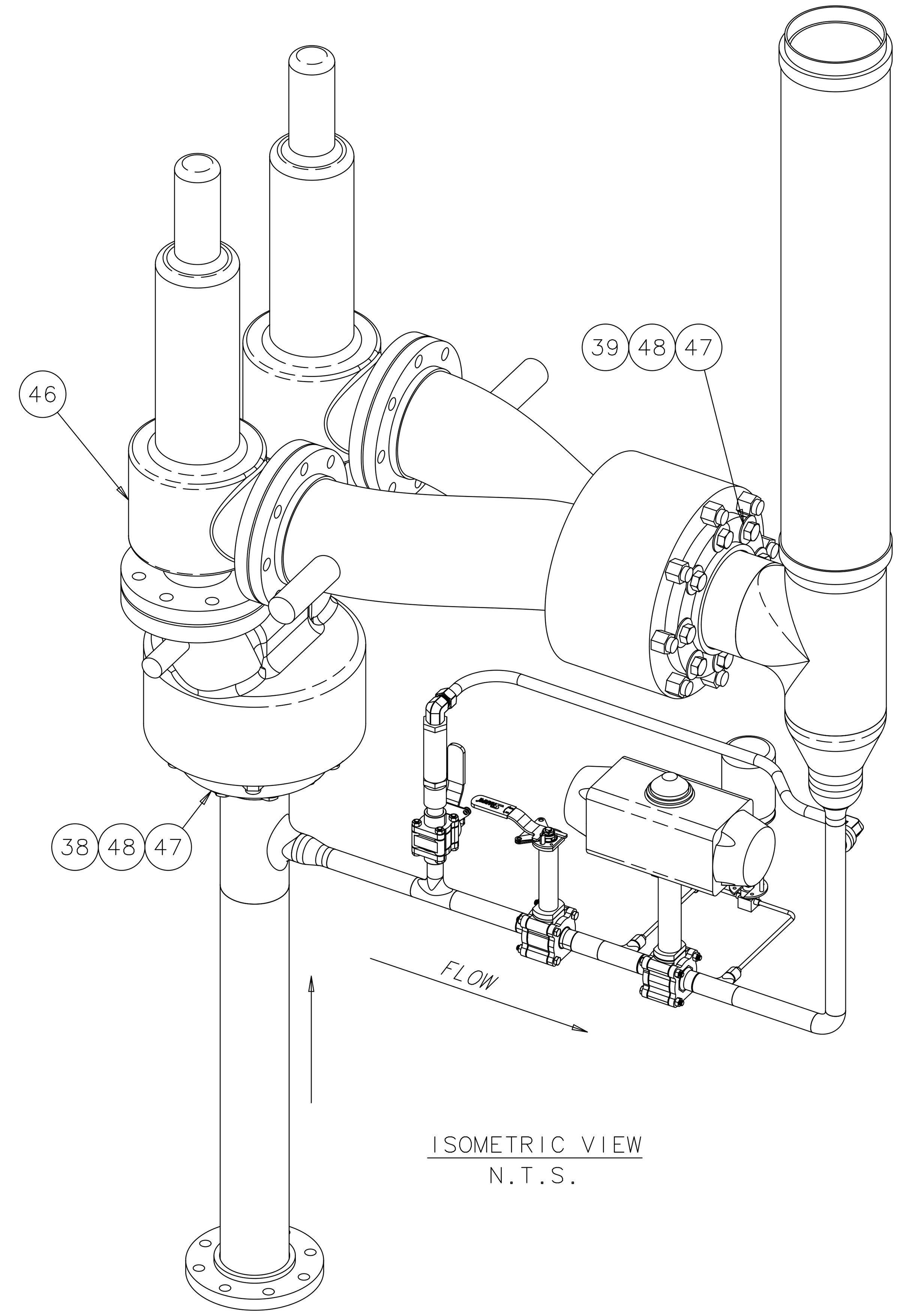
NOTES:
1. ALL WELDS AS PER MD-493176
2. SEAL ALL OPENINGS & PRESSURIZE TO 5 PSIG WITH NITROGEN. SNOOP WELDS & FITTINGS. NO REPORT REQUIRED.
3. TEFLON TAPE TO BE USED ON ALL PIPE THREADS.
4. SAFETY SELECTOR VALVE (ITEM 46) NOT SHOWN IN ORTHOGRAPHIC VIEWS FOR CLARITY.

Created: 08:33:12 on 13-02-14 (D-M-Y) By: jtillman State: 1-INITIAL

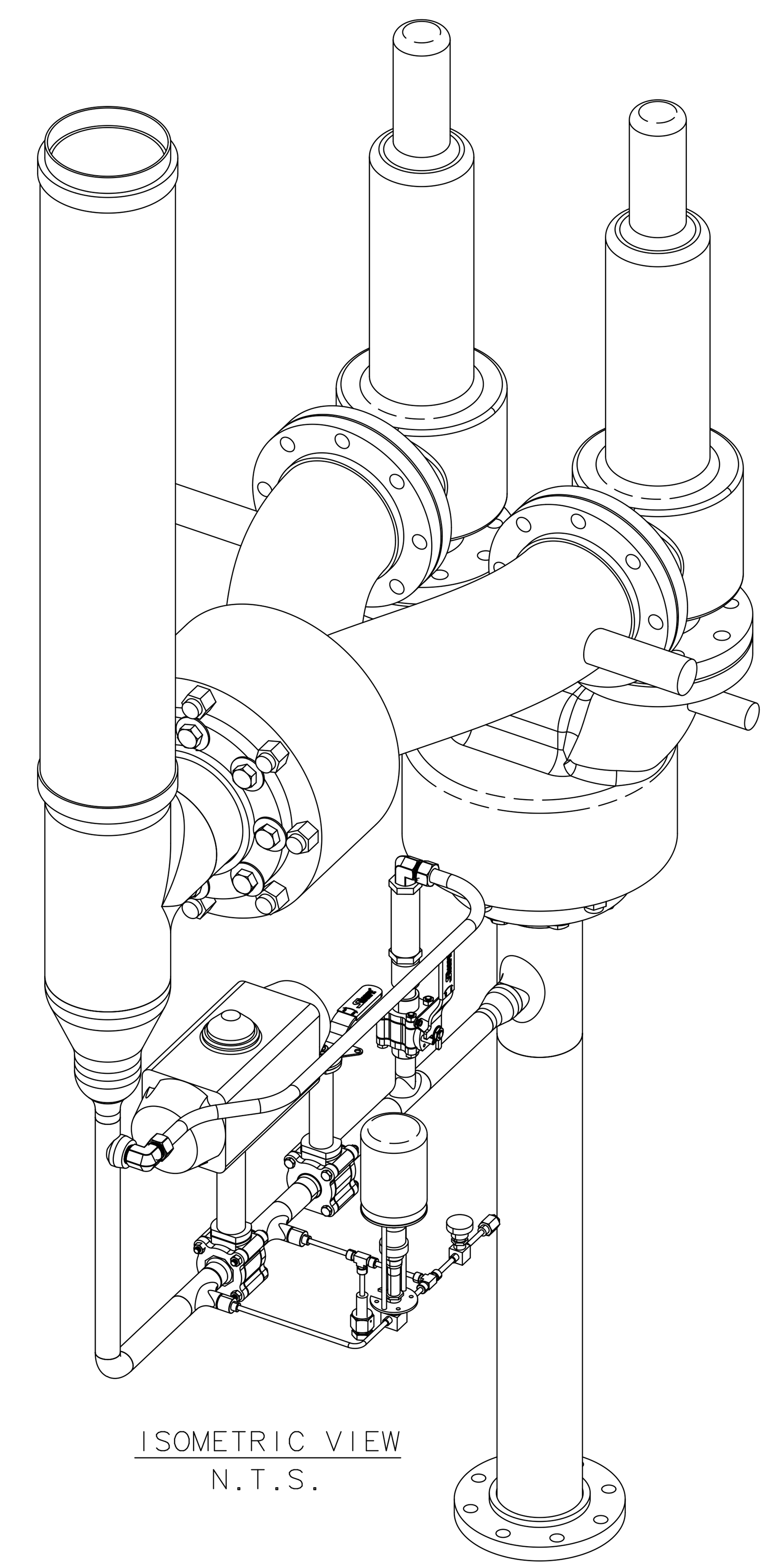
REV	DESCRIPTION	DRAWN / APPROVED	DATE / DATE



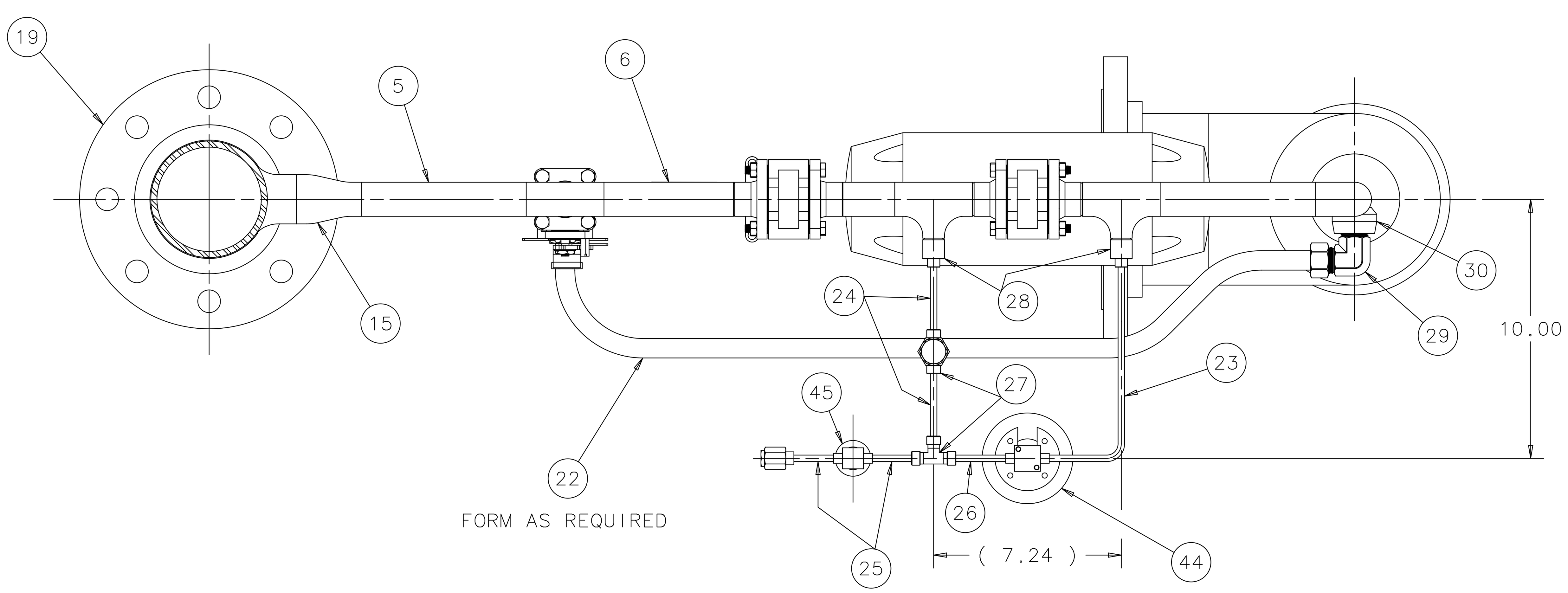
SECTION A-A
SCALE: 1:2



ISOMETRIC VIEW
N.T.S.



ISOMETRIC VIEW
N.T.S.



SECTION B-B
SCALE: 1:4

TAG / LOCATION	ITEM		DESCRIPTION	QTY
	48	COML	WASHER; 3/4" SAE; 18-8 SS	16
	47	COML	HHCS; 3/4-10 X 2.25 LG; 18-8 SS	16
	46	COML.	TANDEM SAFETY SELECTOR RELIEF VALVE ASSY ANDERSON GREENWOOD/CROSBY:	1
TAG# MV-141 LOCATION: 3J	45	COML.	VALVE; 1/4" BELLOWS SEALED SWAGELOK: SS-4H-TW	1
TAG# FCV-151 LOCATION: 3M	44	COML.	VALVE; 1/4" FLOW CONTROL; ACUATED SWAGELOK: SS-4BMRG-TW-XXXX	1
TAG# PV-142 LOCATION: 10	43	COML.	VALVE; 1" CRYO BALL; F.P. ACUATED SHARPE: 1-C99-6-6-R-T-BW10/SR/NC	1
TAG# MV-140 LOCATION: 10	42	COML.	VALVE; 1" CRYO BALL; F.P. B.W. SHARPE: 1-C99-6-6-R-T-BW10	1
TAG# MV-136 LOCATION: NA	41	COML.	VALVE; BALL, F.P. SOCKET WELD SHARPE: 3/4-99-6-6-M-T-SW	1
TAG# PSV-152 LOCATION: NA	40	COML.	VALVE; INLINE RELIEF, 3/4" CIRCLE SEAL: 5180B-6MP-10	1
	39	COML.	GASKET, 6" 150# SPIRAL WOUND PTFE McMASTER-CARR: 44955K472	1
	38	COML.	GASKET, 4" 300# SPIRAL WOUND PTFE McMASTER-CARR: 44955K485	1
	37	COML.	PIPE PLUG; .25 NPT; 304SS MCMASTER: 4464K252	1
	36	COML.	ADAPTER .25 T.S.W. X .25 MNPT 304SS; MCMASTER: 51255K302	1
	35	COML.	GLAND, .25" TUBE S. W. X 1/2" VCR 316 SST,SWAGELOK# SS-8-VCR-3_4TSW	1
	34	COML.	PLUG, .50" VCR 316 SST.,SWAGELOK#SS-8-VCR-P	1
	33	COML.	GASKET, VCR, .50", SILVER PLTD, 316L SST, SWAGELOK#SS-8-VCR-2	1
	32	COML.	NUT, VCR, .50" FEMALE 316 SST,SWAGELOK#SS-8-VCR-1	1
	31	COML	COUPLER; 3/4 NPT X 1.50 LG MCMASTER CARR: 4464K355	1
	30	COML	THREAD-O-LET; .75 MNPT BRANCH X 1"NPS RUN; 304SS	1
	29	COML	ELBOW; .75 COMP. X .75 MNPT MCMASTER CARR: 50915K35	2

UNLESS OTHERWISE SPECIFIED					
.XX	.XXX	ANGLES	ORIGINATOR	R.SANDERS	14-JAN-2014
± .06	± .032	± ---	DRAWN	J.TILLMAN	14-JAN-2014
			CHECKED	J.TILLMAN	12-FEB-2014
			APPROVED	M.ZUCKERBROT	12-FEB-2014

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. MAX. ALL MACH. SURFACES 250
5. DRAWING UNITS: U.S. INCH

USED ON

MATERIAL
SEE PARTS LIST ABOVE

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

E974-MICROBOONE - INFRASTRUCTURE SERVICE EQUIPMENT UBOONE CRYOSTAT VENT ASSY A

SCALE	DRAWING NUMBER	SHEET	REV
1:8 & NOTED	3974.110-MD-497340	2 OF 2	

CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

Appendix C

Pipe/Tube Pressure Rating Calculations

ASME B31.3 Required Wall Thickness and Listed Components

Robert Sanders
July 2, 2013

(1.0) Introduction

This document calculates the required wall thickness in straight pipe and tubes in accordance with ASME B31.3-2010 for pipe and tube sizes used in the MicroBooNE cryogenic system. Each section calculates the required wall thickness for a material type and design pressure and temperature range over range of sizes.

(1.1) Table of Contents:

This document is divided into the following sections:

(1.2) Equations and Functions Used

This document calculates the required wall thickness in straight pipe in accordance with ASME B31.3-2010. Use equation section 304.1.2 3a to determine the required wall thickness for straight pipe under internal pressure

$$t_{req} := \frac{P \times D}{2 \times (S \times E \times W + P \times Y)}$$

Where the
P = internal gage pressure
D = outside diameter of pipe
S = stress value for material from Table A-1
E = quality factor from Table A-1A or A-1B
W = weld joint strength reduction factor
Y = coefficient from Table 304.1.1
t_{req} = required wall thickness

In the calculation sections, the following function is used to flag any case where the actual wall thickness is insufficient.

IsItOK(true) := | "OK, actual wall thickness greater than required" **if true**
| "HOUSTON, WE HAVE A PROBLEM: INSUFFICIENT WALL THICKNESS" **otherwise**

(2.0) Stainless Steel 250 psig

The materials and design conditions are listed below

Material :	304SS or SS304L
Design Pressure:	$P := 250psi$
Minimum Temperature:	$T_{min} := -320F$
Maximum Temperature:	$T_{max} := 500F$

This section covers the pipe and tube used for the stainless steel pipe and tube in the following piping engineering notes. For each engineering note in the list, the design pressure is less than or equal to P; the minimum temperature is equal to or greater than T_{min} , and the maximum temperature is equal to or less than T_{max}.. The stainless steel pipe and tube in all of these piping notes have adequate wall thickness to satisfy the requirements of B31.3.

Class D Piping Engineering Note, DocDB#: 2580

Pump Suction/Discharge Piping Engineering Note, DocDB#: 2581

Cryostat Piping Engineering Note, DocDB#: 2582

Cooldown Piping Engineering Note, DocDB#: 2583

Liquid Nitrogen Piping Engineering Note, DocDB#: 2584

Filter Skid Piping Engineering Note, DocDB#: 2585

Hot Regeneration Gas Piping Engineering Note, DocDB#: 2586

Argon Gas Piping Engineering Note, DocDB#: 2588

(2.1) Values Used in Equations

Design pressure.	$P = 250\ psi$
For SS304L tube or pipe, from B31.3 Table A-1:	$S_{304L} := 14700psi$
For SS304 tube or pipe, from B31.3 Table A-1:	$S_{304} := 17500psi$
For the stress value, use the lower value, that of SS304L	$S := 14700psi$
Quality factor from Table A-1A or (worse case)	$E := 0.8$
Weld joint strength reduction factor, from table 302.3.5, for austenitic stainless less than 950F	$W := 1.0$
coefficient from Table 304.1.1, austenitic stainless less than 900F	$Y := 0.4$

(2.2) Range of Pipe and Tube Sizes

The calculations are for all pipe sizes range from 1/8" pipe to 10" pipe. The wall thickest used in all cases for the thinnest possible schedule. For pipe sizes 3/8" and smaller that is schedule 10S was used. For all other pipe sizes, schedule 5 was assumed. In all cases the available wall thickness exceeded the required wall thickness.

The tube calculations are for the smallest wall thickness for each outside diameter of tube used. The tubes OD's range from 1/8" to 12". The wall thickest used in all cases for the thinnest used at MicroBooNE. In all cases the available wall thickness exceeded the required wall thickness.

(2.3) Calculations for Pipe Sizes

1/8" Sch 10S pipe

Outside diameter: $D := 0.405\,\mathbf{in}$ Actual wall thickness: $t_a := 0.049\,\mathbf{in}$

Required wall thickness: $t_{req} := \dfrac{P \times D}{2 \times (S \times E + P \times Y)} = 0.00427 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req}) =$ "OK, actual wall thickness greater than required"

1/4" Sch 10S pipe

Outside diameter: $D := 0.540\,\mathbf{in}$ Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \dfrac{P \times D}{2 \times (S \times E + P \times Y)} = 0.00569 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req}) =$ "OK, actual wall thickness greater than required"

3/8" Sch 10S pipe

Outside diameter: $D := 0.675\,\mathbf{in}$ Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \dfrac{P \times D}{2 \times (S \times E + P \times Y)} = 0.00711 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req}) =$ "OK, actual wall thickness greater than required"

1/2" Sch 5S pipe

Outside diameter: $D := 0.840\,\mathbf{in}$ Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \dfrac{P \times D}{2 \times (S \times E + P \times Y)} = 8.853 \times 10^{-3} \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req}) =$ "OK, actual wall thickness greater than required"

3/4" Sch 5S pipe

Outside diameter: $D := 1.040\,\mathbf{in}$ Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \dfrac{P \times D}{2 \times (S \times E + P \times Y)} = 0.011 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req}) =$ "OK, actual wall thickness greater than required"

1" Sch 5S pipe

Outside diameter: $D := 1.315\,\mathbf{in}$ Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \dfrac{P \times D}{2 \times (S \times E + P \times Y)} = 0.014 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req}) =$ "OK, actual wall thickness greater than required"

---

1 1/4" Sch 5S pipe

Outside diameter: $D := 1.660\,\mathbf{in}$ Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \dfrac{P \times D}{2 \times (S \times E + P \times Y)} = 0.017 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req}) =$ "OK, actual wall thickness greater than required"

1 1/2" Sch 5S pipe

Outside diameter: $D := 1.90\mathbf{in}$

Actual wall thickness: $t_a := 0.065\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.02 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

2" Sch 5S pipe

Outside diameter: $D := 2.375\mathbf{in}$

Actual wall thickness: $t_a := 0.065\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.025 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

2 1/2" Sch 5S pipe

Outside diameter: $D := 2.875\mathbf{in}$

Actual wall thickness: $t_a := 0.083\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.03 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

3" Sch 5S pipe

Outside diameter: $D := 3.5\mathbf{in}$

Actual wall thickness: $t_a := 0.083\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.037 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

3 1/2" Sch 5S pipe

Outside diameter: $D := 4.00\mathbf{in}$

Actual wall thickness: $t_a := 0.083\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.042 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

4" Sch 5S pipe

Outside diameter: $D := 4.5\mathbf{in}$

Actual wall thickness: $t_a := 0.083\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.047 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

5" Sch 5S pipe

Outside diameter: $D := 5.563\mathbf{in}$

Actual wall thickness: $t_a := 0.083\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.059 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

6" Sch 5S pipe

Outside diameter: $D := 6.625\mathbf{in}$ Actual wall thickness: $t_a := 0.109\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.07 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

8" Sch 5S pipe

Outside diameter: $D := 8.625\mathbf{in}$ Actual wall thickness: $t_a := 0.109\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.091 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

10" Sch 5S pipe

Outside diameter: $D := 10.750\mathbf{in}$ Actual wall thickness: $t_a := 0.134\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.113 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

(2.4) Calculations for Tube Sizes

1/8" X 0.035" Tube

Outside diameter: $D := 0.125\mathbf{in}$ Actual wall thickness: $t_a := 0.035\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.00132 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

1/4" X 0.035" Tube

Outside diameter: $D := 0.25\mathbf{in}$ Actual wall thickness: $t_a := 0.035\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.00263 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

3/8" X 0.035" Tube

Outside diameter: $D := 0.375\mathbf{in}$ Actual wall thickness: $t_a := 0.035\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.00395 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

1/2" X 0.035" Tube

Outside diameter: $D := 0.5\,\mathbf{in}$ Actual wall thickness: $t_a := 0.035\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.00527 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

5/8" X 0.035" Tube

Outside diameter: $D := 0.625\,\mathbf{in}$ Actual wall thickness: $t_a := 0.035\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.00659 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

3/4" X 0.035" Tube

Outside diameter: $D := 0.75\,\mathbf{in}$ Actual wall thickness: $t_a := 0.035\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.0079 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

7/8" X 0.035" Tube

Outside diameter: $D := 0.875\,\mathbf{in}$ Actual wall thickness: $t_a := 0.035\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.00922 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

1" X 0.035" Tube

Outside diameter: $D := 1.000\,\mathbf{in}$ Actual wall thickness: $t_a := 0.035\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.01054 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

1 1/4" X 0.035" Tube

Outside diameter: $D := 1.25\,\mathbf{in}$ Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.01317 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

1 1/2" X 0.035" Tube

Outside diameter: $D := 1.5\,\mathbf{in}$ Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.01581 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

2" X 0.065" Tube

Outside diameter: $D := 2.000\,\mathbf{in}$

Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.02108 \times \mathbf{in}$

$\mathbf{IsItOK}\left(t_a > t_{req}\right)$ = "OK, actual wall thickness greater than required"

3" X 0.065" Tube

Outside diameter: $D := 3.0\,\mathbf{in}$

Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.03162 \times \mathbf{in}$

$\mathbf{IsItOK}\left(t_a > t_{req}\right)$ = "OK, actual wall thickness greater than required"

4" X 0.083" Tube

Outside diameter: $D := 1.25\,\mathbf{in}$

Actual wall thickness: $t_a := 0.083\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.01317 \times \mathbf{in}$

$\mathbf{IsItOK}\left(t_a > t_{req}\right)$ = "OK, actual wall thickness greater than required"

6" X 0.083" Tube

Outside diameter: $D := 6.0\,\mathbf{in}$

Actual wall thickness: $t_a := 0.083\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.06324 \times \mathbf{in}$

$\mathbf{IsItOK}\left(t_a > t_{req}\right)$ = "OK, actual wall thickness greater than required"

12" X 0.165" Tube

Outside diameter: $D := 12.000\,\mathbf{in}$

Actual wall thickness: $t_a := 0.165\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.12648 \times \mathbf{in}$

$\mathbf{IsItOK}\left(t_a > t_{req}\right)$ = "OK, actual wall thickness greater than required"

(3.0) Stainless Steel 2500 psig

The materials and design conditions are listed below

Material :	304SS or SS304L
Design Pressure:	$P := 2500\,psi$
Minimum Temperature:	$T_{min} := -20F$
Maximum Temperature:	$T_{max} := 100F$

This section covers the pipe and tube used for the stainless steel pipe and tube in the following piping engineering notes. For each engineering note in the list, the design pressure is less than or equal to P; the minimum temperature is equal to or greater than T_{min} , and the maximum temperature is equal to or less than T_{max}.. The stainless steel pipe and tube in all of these piping notes have adequate wall thickness to satisfy the requirements of B31.3.

Tube Trailer Piping Engineering Note, DocDB#: 2587

(3.1) Values Used in Equations

Design pressure.	$P = 2.5 \times 10^{3}\,psi$
For SS304L tube or pipe, from B3.13 Table A-1:	$S_{304L} := 16700\,psi$
For SS304 tube or pipe, from B3.13 Table A-1:	$S_{304} := 20000\,psi$
For the stress value, use the lower value, that of SS304L	$S := 16700\,psi$
Quality factor from Table A-1A or (worse case)	$E := 0.8$
Weld joint strength reduction factor, from table 302.3.5, for austenitic stainless less than 950F	$W := 1.0$
coefficient from Table 304.1.1, austenic stainless less than 900F	$Y := 0.4$

(3.2) Range of Pipe and Tube Sizes

The calculations are for 1/2" schedulue 10S pipe. Seamless pipe was used. The calculations conservatively assume there is a seam.

(3.3) Calculations for Pipe Sizes

1/2" Sch 10S pipe Outside diameter: $D := 0.840\,in$ Actual wall thickness: $t_a := 0.083\,in$

Required wall thickness: $t_{req} := \dfrac{P \times D}{2 \times (S \times E + P \times Y)} = 0.073 \times in$

$IsItOK(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

(4.0) Copper Pipe/Tube 250 psig

The materials and design conditions are listed below

Material :	Copper, ASTM spec B88 and B75
Design Pressure:	$P := 250\,\mathbf{psi}$
Minimum Temperature:	$T_{min} := -320\,\mathbf{F}$
Maximum Temperature:	$T_{max} := 100\,\mathbf{F}$

This section covers the coper pipe/tube for the following piping engineering notes. The copper pipe has adequet wall thickness to satisfy the requirements of B31.3.

Liquid Nitrogen Piping Engineering Note, DocDB#: 2584
Argon Gas Piping Note, DocDB# 2588
Pump Suction/Discharge Piping Note, DocDB# 2581

(4.1) Values Used in Equations

Design pressure.

For ASTM B75 tube, from B31.3 Table A-1: $S_{B75} := 6000\,\mathbf{psi}$

For ASTM B88 pipe, from B31.3 Table A-1: $S_{B88} := 6000\,\mathbf{psi}$

Both values are the same $S := 6000\,\mathbf{psi}$

Quality factor from Table A-1A ,seamless $E := 1.0$

coeffient from Table 304.1.1, other ductile materials $Y := 0.4$

(4.2) Range of Pipe and Tube Sizes

The calculations are for 1" and 1 1/2" Type K pipe.

(4.3) Calculations for Pipe Sizes

1" Type K Copper pipe

Outside diameter: $D := 1.250\,\mathbf{in}$ Actual wall thickness: $t_a := 0.065\,\mathbf{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.026 \times \mathbf{in}$

$\mathbf{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

1 1/2" Type K Copper pipe

Outside diameter: $D := 1.625\text{in}$

Actual wall thickness: $t_a := 0.072\text{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.033 \times \text{in}$

$\text{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

1/4" x 0.032" Copper Tube

Outside diameter: $D := 0.25\text{in}$

Actual wall thickness: $t_a := 0.032\text{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 5.123 \times 10^{-3} \times \text{in}$

$\text{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

1/2" x 0.032" Copper Tube

Outside diameter: $D := 0.5\text{in}$

Actual wall thickness: $t_a := 0.032\text{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.01 \times \text{in}$

$\text{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

3/4" x 0.032" Copper Tube

Outside diameter: $D := 0.75\text{in}$

Actual wall thickness: $t_a := 0.032\text{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.015 \times \text{in}$

$\text{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

1" x 0.032" Copper Tube

Outside diameter: $D := 1\text{in}$

Actual wall thickness: $t_a := 0.032\text{in}$

Required wall thickness: $t_{req} := \frac{P \times D}{2 \times (S \times E + P \times Y)} = 0.02 \times \text{in}$

$\text{IsItOK}(t_a > t_{req})$ = "OK, actual wall thickness greater than required"

Appendix D

Pressure Test Documents

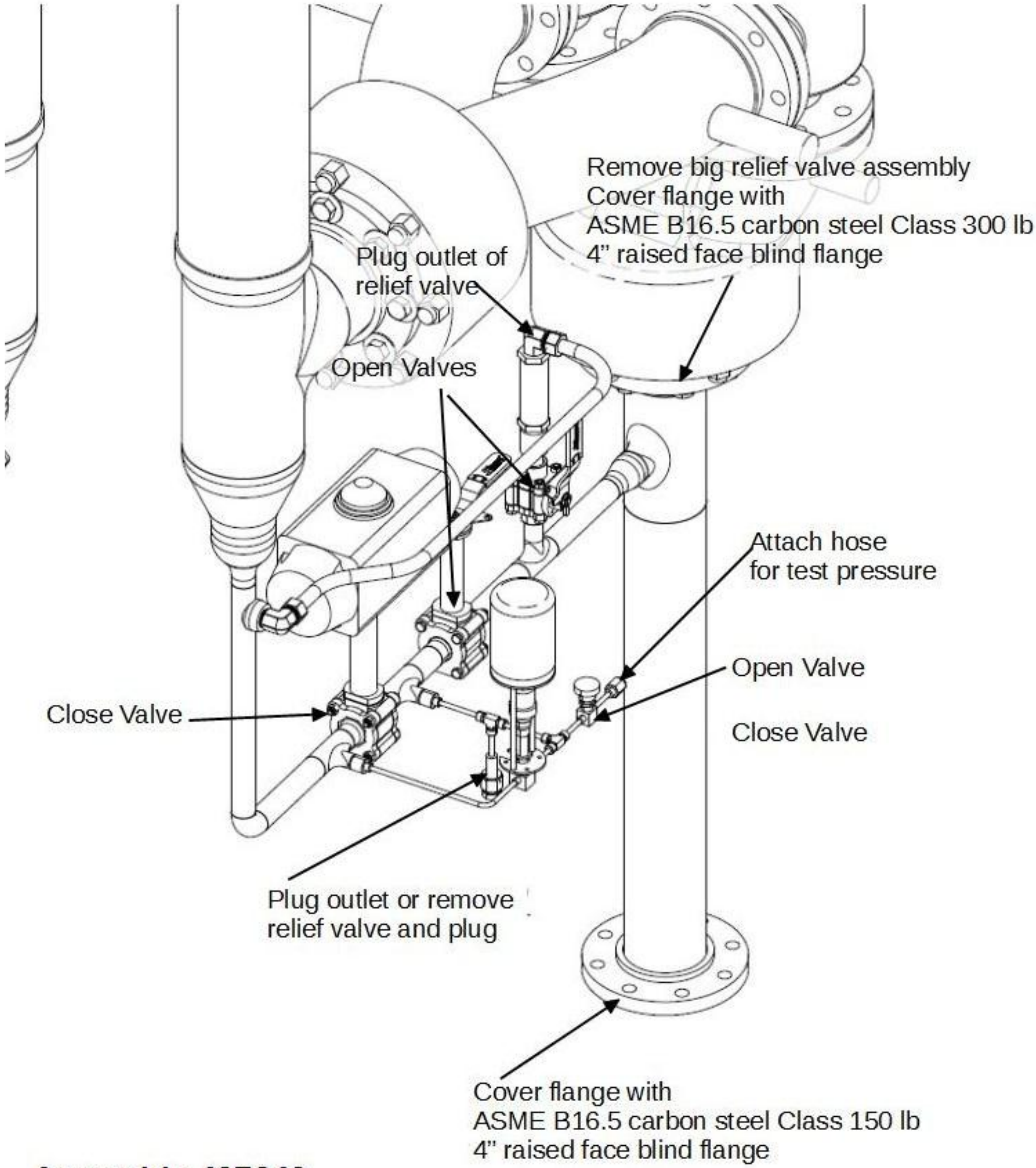
See following pages for:

- **Pressure Test Procedure**
- **Pressure Test Permits**

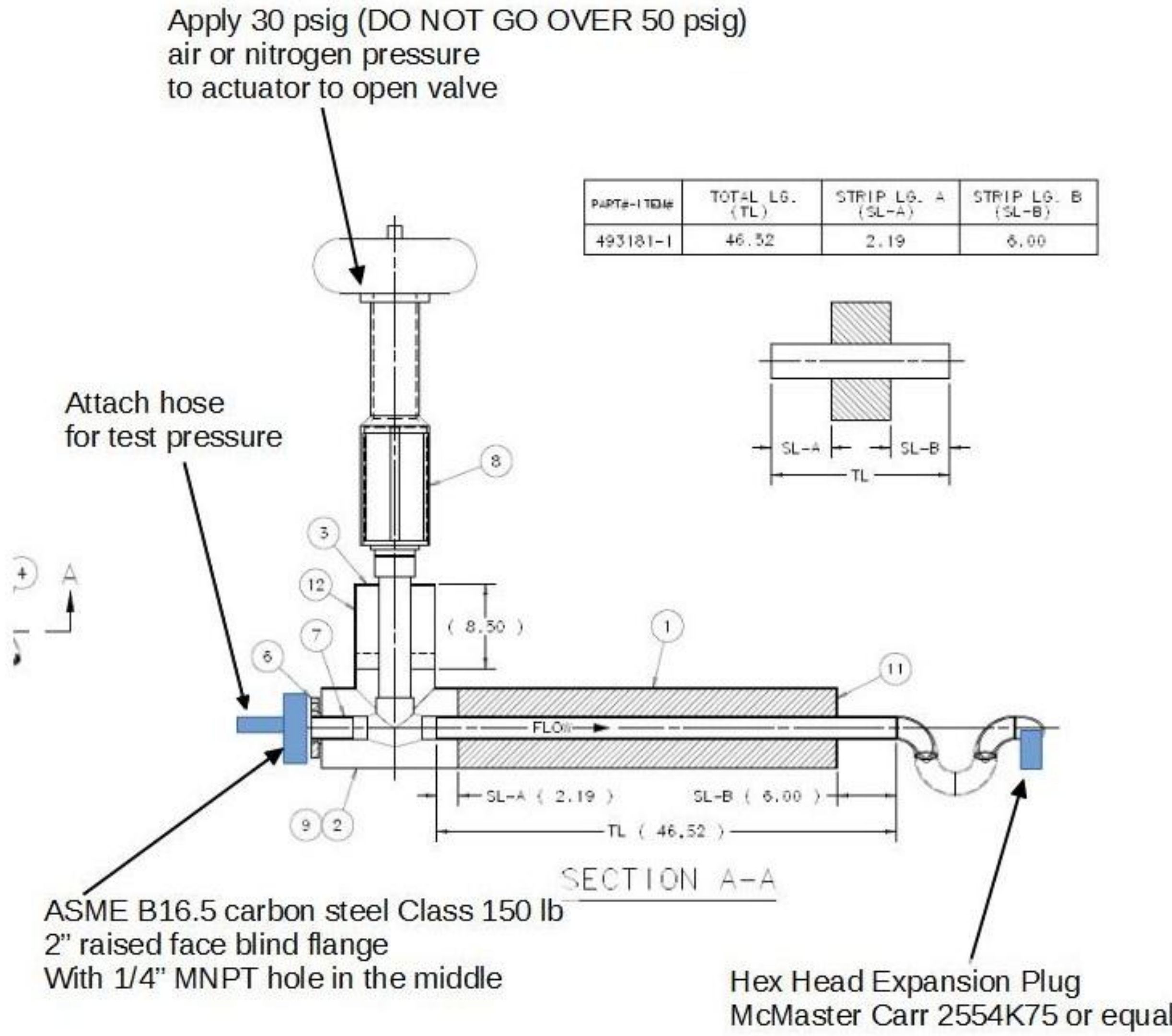
MicroBooNE Cryostat Piping Pressure Testing

There are six subassemblies for the cryostat piping that need pressure tested to 33 psig. The sub-assemblies are listed below. The pressure tests must be done before welding the subassemblies to the cryostat. The last weld, to the cryostat, will be radiographed and not pressure tested.

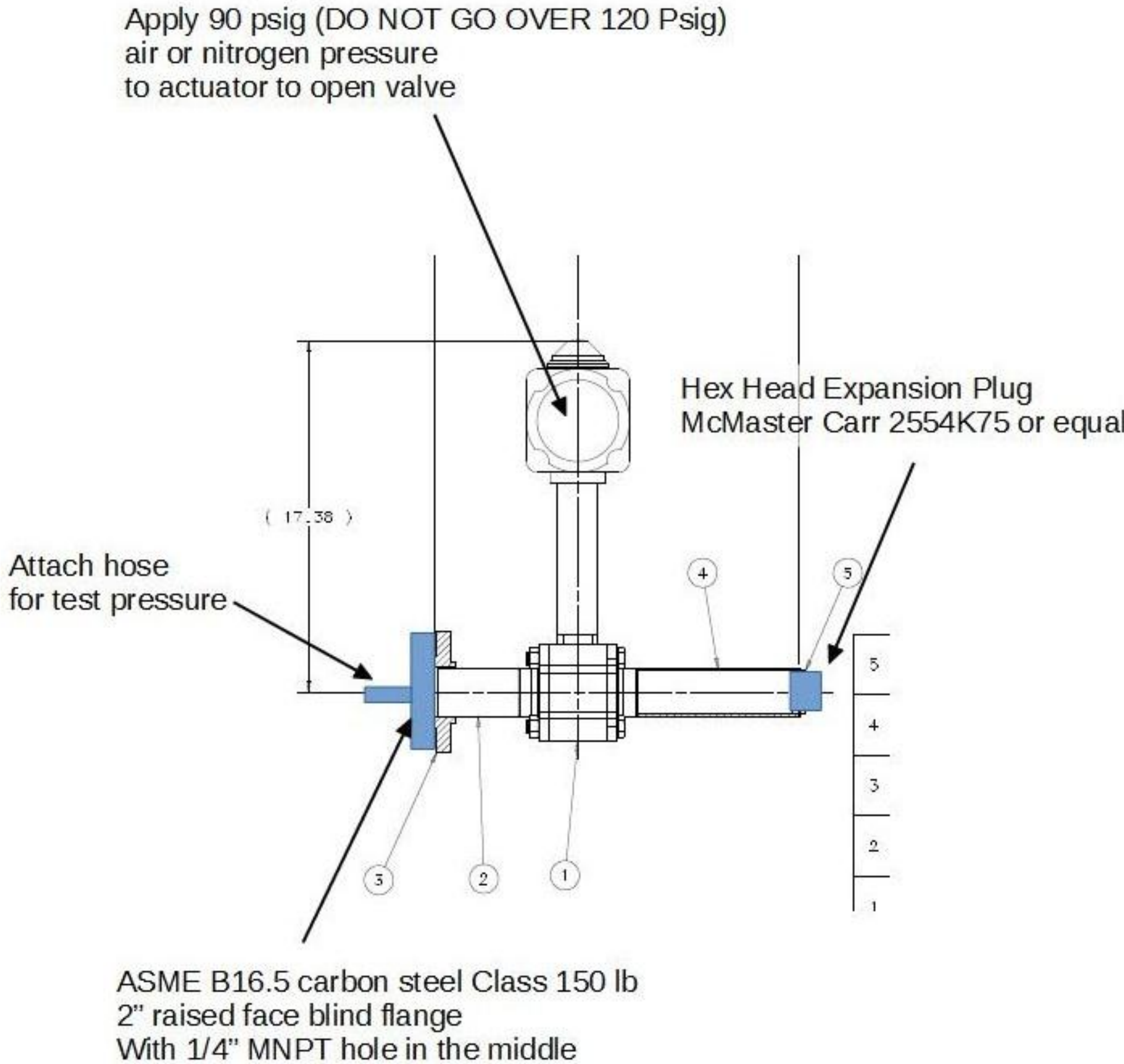
- See the sections below for descriptions and procedures.
- Always fill out a pressure test permit. ES&H signature required
- Place the sticker somewhere visible on the piping. Write valve numbers which contain the tested signature directly on the sticker



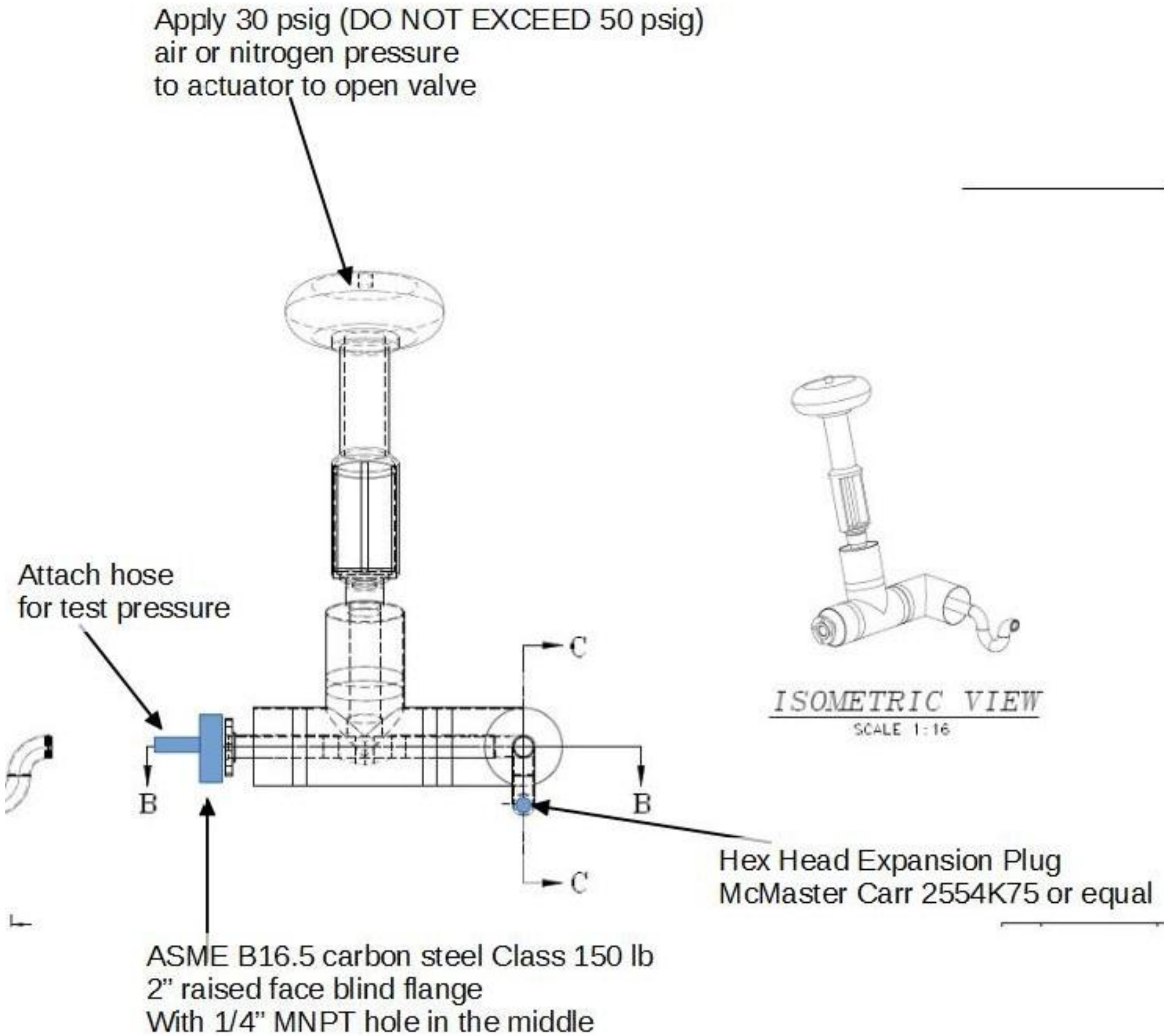
Assembly 497340



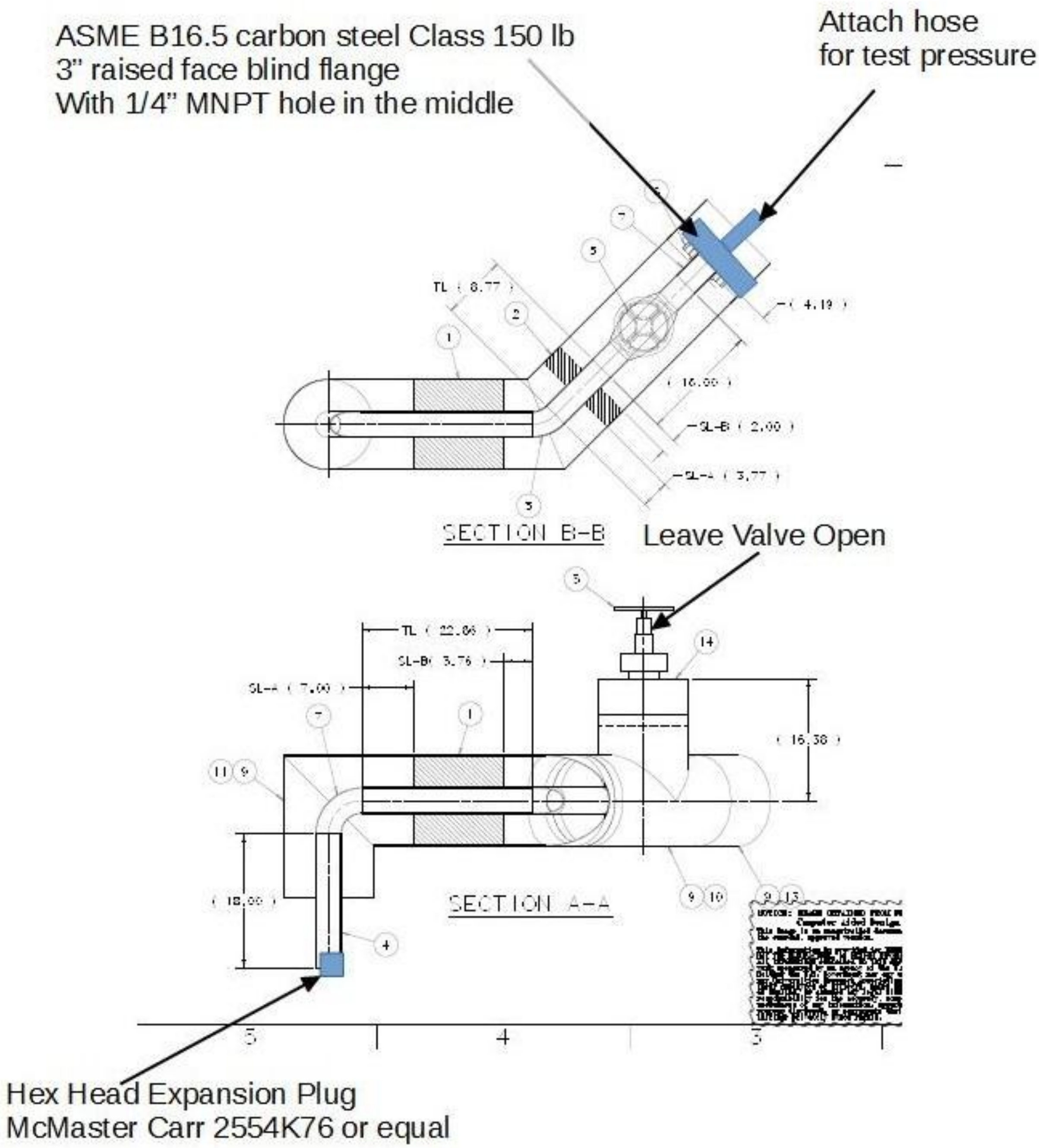
Assembly 493181



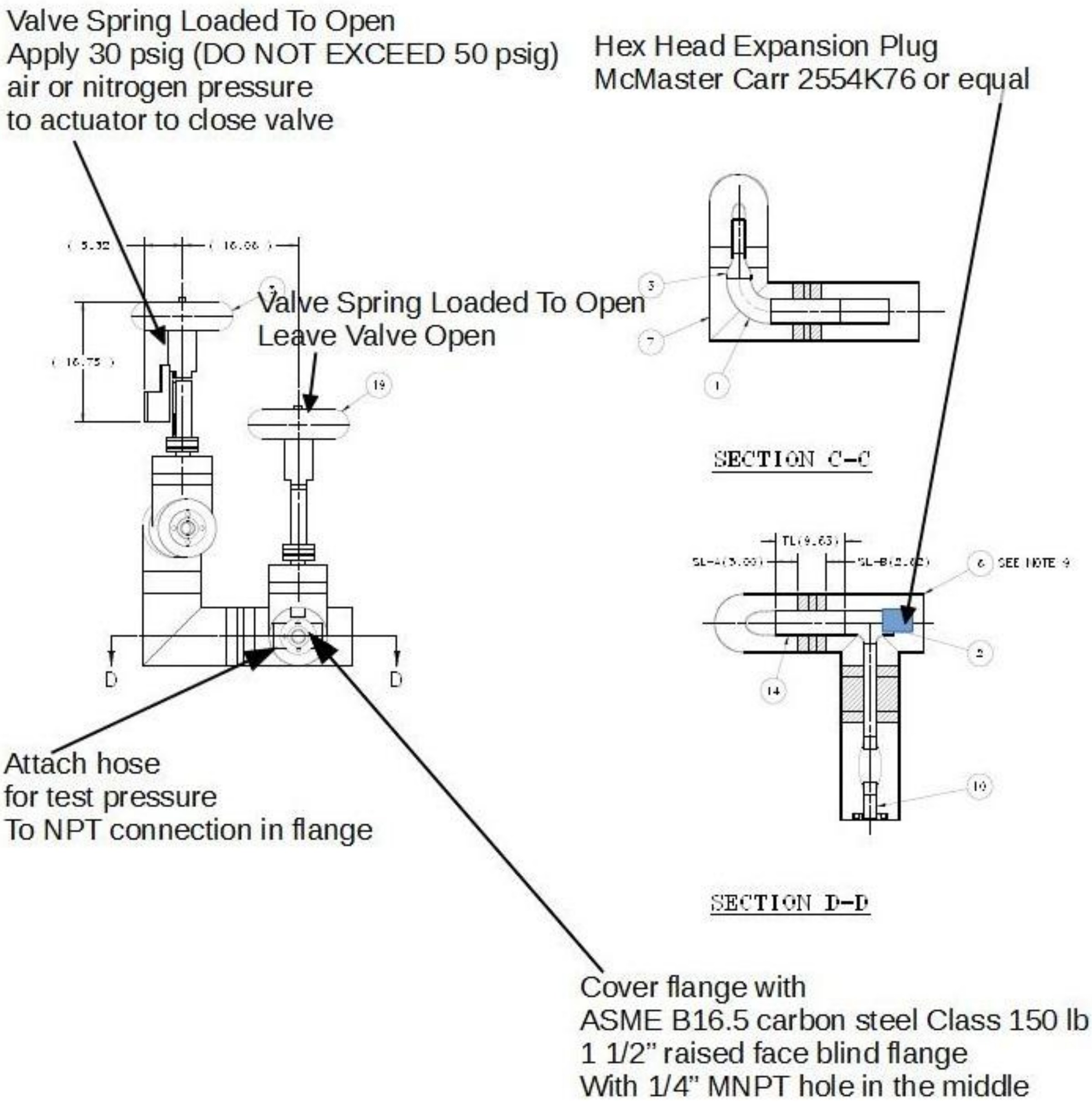
Assembly 493144



Assembly 493136



Assembly 493111



Assembly 489995

Fermilab

EXHIBIT B
Pressure Testing Perm

Date: 7/28/14

Type of Test: [ ]Hydrostatic [ ] Pneumatic

Test Pressure 33 psig Maximum Allowable Working Pressure 30 psig

Items to be Tested
Assemblies to be welded to vessel and Radiographed
493134 493111 493181 493144 489995

Location of Test LAB F Date and Time 7/23-5

Hazards Involved (use Hazard Analysis form FESHM 2060 if more space is required)

Safety Precautions Taken
Area Secure / Restricted access / Relief valve 40 psi

Special Conditions or Requirements N/A

Qualified Person and Test Coordinator Tim Griffin John Voirin
Dept/Date

Division/Section Safety Officer
Dept/Date

Results Ø pressure drop Ø leak w/ SNOOP

Witness [signature] Dept/Date 07/28/14
(Safety Officer or Designee)

* Must be signed by division/section safety officer prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

Fermilab

EXHIBIT B
Pressure Testing Perm

Date: 8/6/14

Type of Test: [ ]Hydrostatic [ ] Pneumatic

Test Pressure 33 psig **Maximum Allowable Working Pressure** 30 psig

Items to be Tested F 10026183

Location of Test LAB F **Date and Time** 1245 8/6/14

Hazards Involved (use Hazard Analysis form FESHM 2060 if more space is required)

Safety Precautions Taken

Special Conditions or Requirements

Qualified Person and Test Coordinator John Voirin
Dept/Date DPD/ET 8/6/14

Division/Section Safety Officer
Dept/Date

Results Passed

Fermilab

EXHIBIT B
Pressure Testing Perm

Date: 12/1/14

Type of Test: [ ]Hydrostatic x| Pneumatic

Test Pressure 33 psig **Maximum Allowable Working Pressure** 30 psig

Items to be Tested
Microboone Cryostat Piping isolated by PV816 (FC), PV815 (FC), PV300 (FC)
FCV191 (FO), PV256 (FO), MV240, MV224, MV104-115, MV159, and MV160

Location of Test LArTF **Date and Time** 12/1/14

Hazards Involved (use Hazard Analysis form FESHM 2060 if more space is required)
Pressurized lines and tank, large amount of stored energy in vessel

Safety Precautions Taken
Safety glasses, evacuate building of non-essential personnel, do
preliminary check at 1/3 or less of test pressure, follow HA

Special Conditions or Requirements
NA

Qualified Person and Test Coordinator John Voirin
Dept/Date PPD 12/1/14

Division/Section Safety Officer Angela Aparicio 15230N
Dept/Date PPD 12/1/14

Results
Cryostat piping welds inspected, no leaks

Witness [illegible] **Dept/Date** 12/2/14
(Safety Officer or Designee)

* Must be signed by division/section safety officer prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.