FESHM 5031.1 PIPING ENGINEERING NOTE FORM

Prepared by: Mark Adamowski & Terry Tope   Preparation Date: July 18th, 2011

Piping System Title: LAPD LN2 and LAr Supply Piping

Lab Location: PC4   Lab Location code: 701030125

Purpose of system / System description: To supply liquid nitrogen and liquid argon to LAPD.

Piping System ID Number:

Appropriate governing piping code: ASME B31.3 - 2010

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

Fluid Contents: Liquid & Gaseous Nitrogen and Argon

Design Pressure: 100 psig and 60 psig.

Design Temperature: -320 °F (77 K),

Piping Materials: See Note.

Drawing Numbers (PID's, weldments, etc.): See note.

Designer/Manufacturer: FERMILAB

Test Pressure: See note.

Test Fluid: pneumatic   Test Date: See note.

Statements of Compliance

Piping system conforms to FESHM 5031.1, installation ***is not*** exceptional: Yes / No

Piping system conforms to FESHM 5031.1, installation ***is*** exceptional and has been designed, fabricated, inspected, and tested using sound engineering principles: Yes / No

Reviewer's Signature: Roger Rabehl ROGER RABEHL Date: 9/7/11

D/S Head's Signature: [signature] Date: 9/12/2011

ES&H Director's Signature: NA________________________ Date:

(if exceptional)

Director's Signature or Designee: NA____________________ Date:

(if exceptional)

Pipe Characteristics

Size: See note for full details. Primary sections are 1" Type K Copper with foam insulation.

Length: See note for full details. LN2 supply 150 feet. LAr supply 70 feet.

Volume: 40 liters

Relief Valve Information

Type: See Note

Manufacturer:

Set Pressure:

Relief Capacity:

Relief Design Code:

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

Fabrication Quality Verification

System Documentation

Process and Instrumentation diagram appended? **Yes** (circled) / No

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

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

Exceptional Piping System

Is the piping system or any part of it in the above category? Yes / **No** (circled)

If “Yes”, follow the requirements for an extended engineering note for Exceptional Piping Systems.

Quality Assurance

List vendor(s) for assemblies welded/brazed off site: No assemblies were fabricated off site.

List welder(s) for assemblies welded/brazed in-house: See Note.

Append welder qualification records for in-house welded/brazed assemblies. See note appendix.

Append all quality verification records required by the identified code (e.g. examiner's certification, inspector's certification, test records, etc.)

http://lartpc-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=639

Statements of Compliance for Amendment #1

Prepared by: Terry Tope

Preparation Date: June 25, 2012

Piping system conforms to FESHM 5031.1, installation ***is not*** exceptional: Yes / No

Piping system conforms to FESHM 5031.1, installation ***is*** exceptional and has been designed, fabricated, inspected, and tested using sound engineering principles: Yes / No

Reviewer's Signature: Roger Rabehl ROGER RABEHL Date: 11/9/12

D/S Head's Signature: [signature] Date: 11/12/2012

ES&H Director's Signature: NA________ Date: ________
(if exceptional)

Director's Signature or Designee: NA________ Date: ________
(if exceptional)

Fermilab

Particle Physics Division

Mechanical Department Engineering Note

Number: LArTPC DOC-553 Date: 06/25/12

Project Internal Reference:

Project: LAPD

Title: LAPD LN2 Supply and LAr Supply Piping Engineering Note

Author(s): Mark Adamowski, Terry Tope

Reviewer(s): Key Words: LAPD, LN2, LAr, Piping

Abstract Summary:

This note documents the liquid nitrogen, gaseous nitrogen, and liquid argon supply piping for LAPD. The note has been amended to document the changes implemented in preparation for LAPD Run 2.

Applicable Codes:

1. *Fermilab Piping Systems, FESHM Chapter 5031.1, Rev. 11/ 2007*
2. *ASME B31.3-2010*

1. INTRODUCTION

Nitrogen liquid and gas are used for LAPD, located in PC4. Liquid nitrogen is used as a coolant for the Argon condenser. A nitrogen phase separator is used to vent off any boil-off nitrogen before the argon condenser. The nitrogen gas from the condenser is vented outside.

Nitrogen gas is generated outside with an ambient vaporizer. The vaporized nitrogen gas is supplied to the filter regeneration system. This demand for nitrogen gas is expected to be sporadic as needed based on filter life.

The nitrogen will also provide foam insulation purges. Total maximum purge rate is 5 SCFH.

The design pressure for the majority of the N2 piping is 100 psig which is the highest differential pressure for the solenoid valves. A small portion of the piping has a design pressure of 60 psig due to the 60 psig MAWP of the condenser vessel which makes pressure testing the attached piping at 100 psig impossible. All calculations are performed for 100 psig, thus they are adequate for the 60 psig portions. The LN2 supply trailer has a MAWP of 50 psig thus the nitrogen source cannot over pressurize the system.

The liquid argon supply piping for filling the LAPD tank is constructed in the same manner as the liquid nitrogen supply piping and is also included in this note. The liquid argon supply contract stipulates that the vendor tanker will have an MAWP less than or equal to 75 psig and the tanker liquid pump can be locked out. Thus a 100 psig design pressure for the liquid argon supply piping ensures it cannot be over pressurized by the source.

A tie in to supply liquid nitrogen to the LBNE 35T cryostat has been added to the LAPD liquid nitrogen supply inside PC4. The flow schematic in Appendix 1 notes these additions. The addition includes two liquid nitrogen isolation valves, four room temperature instrument isolation valves, two pressure gauges, a pressure transmitter, a strainer, and two trapped volume reliefs.

2. FLOW SCHEMATIC

The N2 and LAr supply piping and instrumentation is part of the LAPD P&ID[1]. The N2 piping appears on P&ID sheet 1, rows G, H columns 2 through 8, and sheet 2, rows F through H and columns 4 through 8. The LAr supply piping appears on P&ID sheet 3, rows G and F and

[1] Liquid Argon Purity Demonstration (LAPD) Cryogenic Safety Report, Section 1.2, LArTPC-Docdb-553.

columns 1 thru 3. In Appendix 1 the relevant piping sections are highlighted on the flow schematic along with their design and test pressures. The new components associated with the amendment are boxed on sheet 1 of the annotated flow schematic.

3. DESIGN CODE

The N2 and LAr supply piping to LAPD must meet the requirements of FESHM 5031.1. Cryogenic liquid is covered by ASME B31.3, Normal Fluid Service. Nitrogen vapor piping downstream of SV-144-N2 is considered Category D Fluid Service and outside of the scope of this note because its design temperature is above –20 F (and its design pressure is less then 150 psig). TE-146-N located at the outlet of the ambient liquid nitrogen vaporizer is monitored by the PLC. The PLC will close SV-144-N2 if TE-146-N drops below –20 F. The ambient vaporizer is rated to deliver 5,200 SCFH at 70 F for 8 hours with a 20 F approach to ambient. Nitrogen system demand is not expected to exceed 500 SCFH nor is demand at the 500 SCFH level expected to exceed 8 hours such that its unlikely that the vaporizer will deliver gas colder than –20 F at its outlet. The piping from SV-144-N2 is considered in the flexibility analysis up to the 1st hard fixed point inside PC4.

4. MATERIALS

The majority of the LN2 and LAr supply piping is fabricated from pre-insulated type K copper tubing. Some of the connecting components are bronze and some are 304/316 stainless steel. Of the materials involved, the copper tubing has the lowest allowable stress of 6000 psi[2].

The N2 gas supply piping is fabricated from un-insulated copper tubing.

The lowest temperature for LN2 is 77 K and 87 K is the lowest for LAr. This temperature is above the minimum temperature for copper (4.3 K) and 304/316 (19.3 K).

The Nitrogen and Argon valves and instruments are included in the LAPD valve and instrument list, which is available in Appendix 1.

Components not conforming to the standards in B31.3 Table 326.1 are listed in Table 1.

The amendment does not introduce additional unlisted components.

[2] Per B31.3, Table A-1.

Table 1: Unlisted Components

Component	Manufacturer	Classification	Pressure rating	System design pressure	Comments
			psig	psig	
Braided metal flexible hose - 1 in. dia.	Hosemaster	Unlisted	718	100	See note 1
VCR fittings	Swagelok	Unlisted	1900	100	See note 2
Tube weld fittings	Swagelok	Unlisted	2400	100	See note 3
Compression fittings	Swagelok	Unlisted	1450	100	See note 4
Vaporizer	Thermax	Unlisted	600	100	See note 5
Tube socket weld elbows - 3/4 in. dia.	Truly Tubular	Unlisted	8285	100	See note 6
Fermilab 1/2" cryo control valve	FNAL	Unlisted	350	100	See note 7

Notes

1 Hosemaster supplies a pressure rating for these Masterflex hoses and extensive service experience exists for both liquid nitrogen and liquid argon.

2 The lowest pressure rating of any Swagelok VCR fitting is 1900 psi. Extensive service experience exists for Swagelok VCR fittings in liquid argon service at pressures up to 415 psid.

3 The lowest pressure rating of any Swagelok tube weld fitting is 2400 psi. Extensive service experience exists for Swagelok tube weld fittings in liquid argon service at pressures up to 415 psid.

4 The lowest pressure rating of any Swagelok compression fitting is 1813 psi.

5 The manufacturer supplied pressure rating is 600 psi for a Thermax SG50HF with male pipe thread fittings.

6 Truly Tubular pressure ratings are defined as the minimum pressure which would cause permanent deformation.

7 Fermilab 1/2" cryogenic control valves have been operated on 350 psi systems extensively.

5. DESIGN PRESSURE AND MINIMUM TUBE WALL

Solenoids are used in the nitrogen supply piping. The largest pressure differential for under which these solenoid can still open / close is 100 psig. This will be used as the design pressure for the both the nitrogen and argon piping.

The liquid nitrogen supply and liquid argon supply piping are fabricated from pre-insulated 1 inch, type K, copper tubing. The vapor supply nitrogen piping is fabricated from bare 1 inch, type K copper tubing.

The required tubing wall thickness is 0.009 inch for the 100 psig design pressure. The minimum wall thickness calculations are detailed in the Appendix 2. Type K, 1" copper has a rated working pressure of 655 psig[3].

The 0.065 inch wall thickness of type K copper tubing exceeds the minimum required for the 100 psig design pressure.

Stainless steel tubing and pipe is also used in the nitrogen piping. The calculations for minimum wall thickness are the same as the copper calculations shown in the appendix. All copper and stainless steel tubing and pipe used is summarized in Table 2 with the physical property data used in determining the minimum wall thickness.

The amendment does not introduce any new materials or additional pipe/tube sizes.

[3] The Copper Tube Handbook, Copper Development Association, A4015-04/06, Table 3a.

Table 2: Minimum Tube / Pipe Wall Thickness

OD (in)	Wall Thk (in)	matl	SA1 (psi)	Ycoef	Wfact.	Efact.	Ea (psi)	Design P (psig)	tmin (in)	wall thk > tmin	note
1.125	0.065	copper, k	6000	0.4	1.0	1.0	1.70E+07	100	0.009	**YES**	tubing
3.500	0.120	SS	16700	0.4	1.0	1.0	2.83E+07	100	0.010	**YES**	3" sch 10
1.315	0.109	SS	16700	0.4	1.0	1.0	2.83E+07	100	0.004	**YES**	1" sch 10
1.000	0.049	SS	16700	0.4	1.0	1.0	2.83E+07	100	0.003	**YES**	tubing
0.750	0.035	SS	16700	0.4	1.0	1.0	2.83E+07	100	0.002	**YES**	tubing
0.250	0.035	SS	16700	0.4	1.0	1.0	2.83E+07	100	0.001	**YES**	tubing

OVER PRESSURE PROTECTION

The liquid nitrogen and liquid argon piping will have trapped volumes, requiring overpressure relief. Fire and thermal overpressure are significant sources of overpressure. The largest relief rate is 43 SCFM air at 110 psig (10% over pressure). Circle-seal 5100 series relief valves with a 4MP orifice provide 54 SCFM at 110 psig (10% over pressure). Details of the pressure relief calculations are in the Appendix 2. No adjustments are made for smaller trapped volumes and the same size relief valve is used. This allows for shared spares and eliminates the risk of error and installation of an undersized relief valve.

The nitrogen vent piping post condenser and post phase separator has no valves or trapped volumes.

The un-insulated ¼ inch copper tubing for the nitrogen insulation purges only contains liquid for a short distance until it vaporizes. After that short distance the copper tubing contains only nitrogen gas.

The existing relief valve calculations are valid for the amendment.

6. PIPING STRESS

The supply piping for the nitrogen liquid and gas piping is routed from a FERMLAB LN2 trailer positioned near between PS4 and an electrical substation. The liquid nitrogen piping is routed to a nearby nitrogen vaporizer and over a berm to PC4. The nitrogen gas comes from the nitrogen vaporizer and is also routed over the berm to PC4. The relative position of the trailer, vaporizer and PC4 can be seen in Figure 1.

The specific nitrogen supply pipe routing is documented by the ANSYS FEA flexibility analysis shown in Appendix 3. Piping supports are provided by blocks of plastic that allow the pipes to slide as they contract and expand.

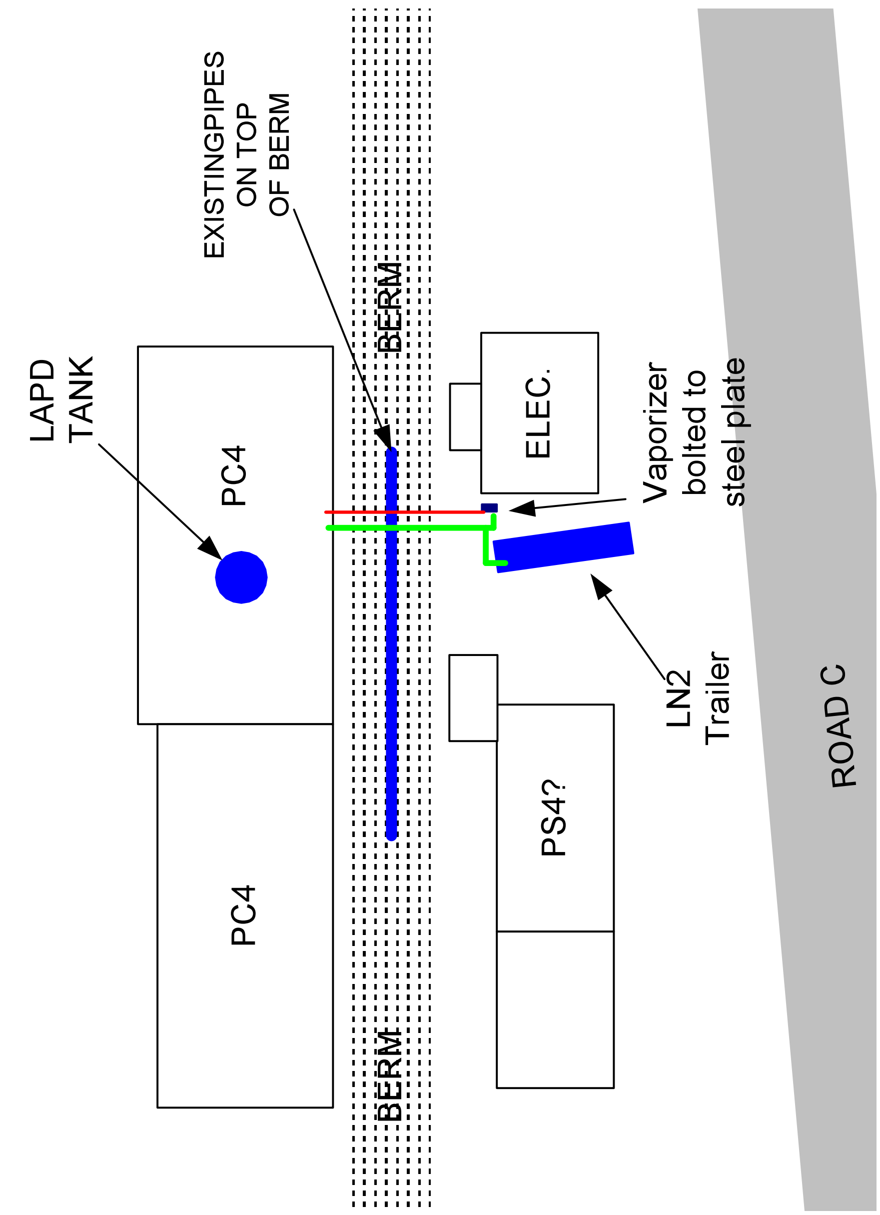
The components added in this amendment do not affect the flexibility of the piping.

All calculated thermal stresses are below the allowable displacement stress range SA as computed by 302.3.5(d):

$$S_A = f\left(1.25S_c + 0.25S_h\right) = 1\left[1.25(6{,}000) + 0.25(6{,}000)\right] = 9{,}000 \text{ psi}$$

The piping therefore has sufficient flexibility.

Figure 1: N2 SUPPLY PIPING ROUTE



7. CODE REQUIRED DOCUMENTATION

ASME B31.3 requires that the brazing/welding be done by qualified brazers/welders. Brazer/welder qualifications are documented in the appendix.

B31.3 also requires that a representative sampling of the fabrication be inspected, defined as not less than 5% of the fabrication. Inspection forms are available here:

http://lartpc-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=639

Any inspection forms required by the amendment will be added to the above link.

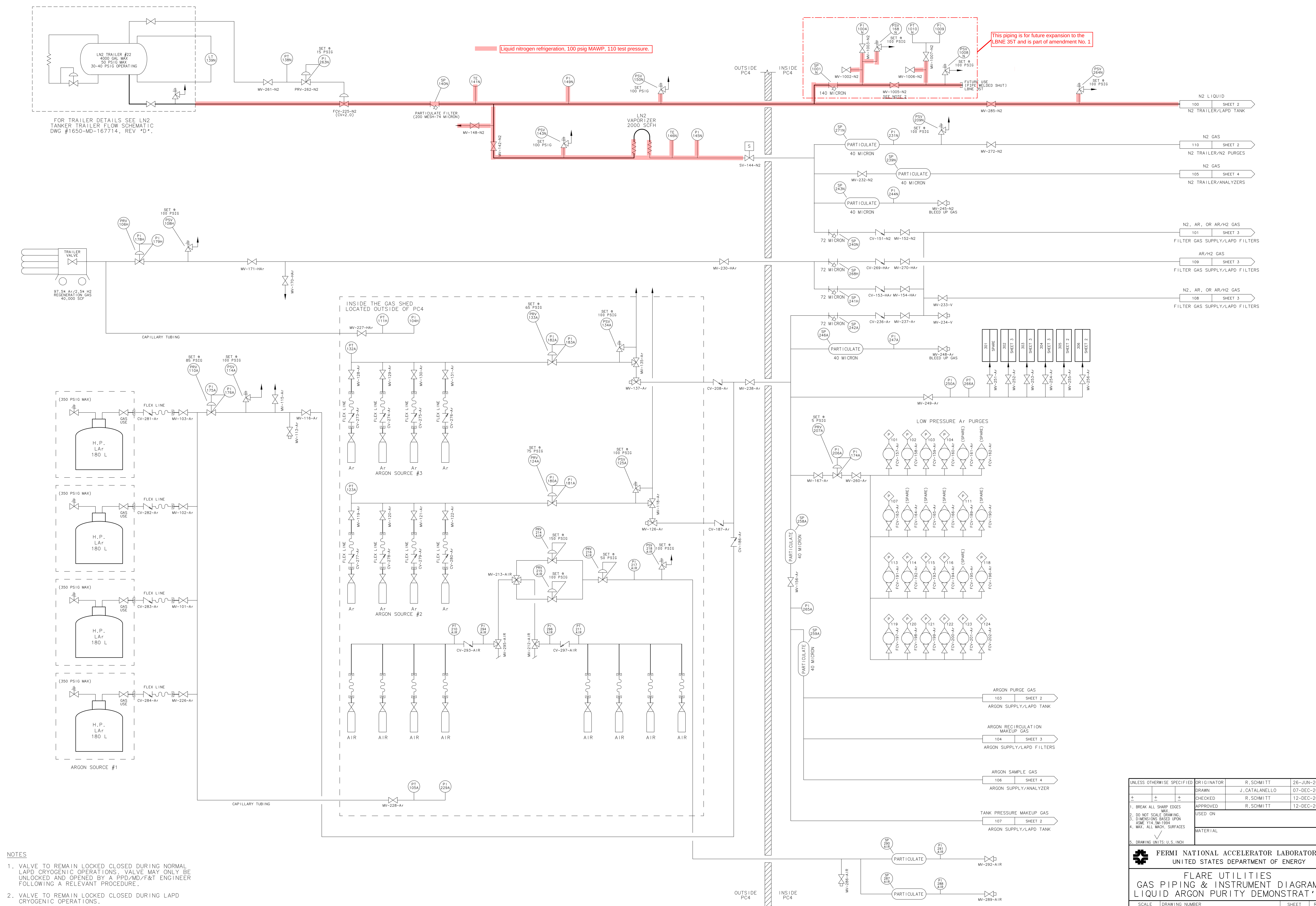
A leak test is required by B31.3. For the supply piping the test pressure is 110% of design or 110 psig. B31.3 allows for pneumatic testing and pneumatic testing was used. Test results are documented in the Appendix 4.

The required pressure tests for the amendment will be added to Appendix 4.

Appendix 1
Flow Schematics and Valve and Instrument List.

The flow schematic and valve and instrument list are updated for the amendment.

REV	DESCRIPTION	DRAWN / APPROVED	DATE
M	MISC. REVISIONS MADE.	J.CATALANELLO	22-MAY-2012
F	MISC. REVISIONS MADE.	J.CATALANELLO / M.ADAMOWSKI	26-FEB-2010 / 26-FEB-2010
G	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	10-JAN-2011 / 12-JAN-2012
H	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	10-JAN-2011 / 03-FEB-2011
J	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	23-FEB-2011 / 28-FEB-2011
K	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	04-MAR-2011 / 22-JUN-2011
L	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	11-JUL-2011 / 01-MAR-2012
A	ADDED TAG NUMBERS TO VALVE TYPES	V. MAJDANSKI / R. SCHMITT	25FEB08 / 26FEB08
B	MOVE CONDENSOR OUTSIDE TANK	J.CATALANELLO / R.SCHMITT	07-DEC-2008 / 10-DEC-2008
C	MISC. REVISIONS MADE.	J.CATALANELLO / R.SCHMITT	23-DEC-2008 / 06-JAN-2009
D	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	17-NOV-2009 / 14-DEC-2009
E	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	17-NOV-2009 / 15-JAN-2010



NOTES

1. VALVE TO REMAIN LOCKED CLOSED DURING NORMAL LAPD CRYOGENIC OPERATIONS. VALVE MAY ONLY BE UNLOCKED AND OPENED BY A PPD/MD/F&T ENGINEER FOLLOWING A RELEVANT PROCEDURE.
2. VALVE TO REMAIN LOCKED CLOSED DURING LAPD CRYOGENIC OPERATIONS.

UNLESS OTHERWISE SPECIFIED			
ORIGINATOR	R.SCHMITT	26-JUN-2007
DRAWN	J.CATALANELLO	07-DEC-2007
CHECKED	R.SCHMITT	12-DEC-2007
APPROVED	R.SCHMITT	12-DEC-2007
USED ON		
MATERIAL		

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

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UNITED STATES DEPARTMENT OF ENERGY

FLARE UTILITIES
GAS PIPING & INSTRUMENT DIAGRAM
LIQUID ARGON PURITY DEMONSTRAT'N

SCALE NONE | DRAWING NUMBER 3942.510-ME-444897 | SHEET 1 OF 4 | REV M

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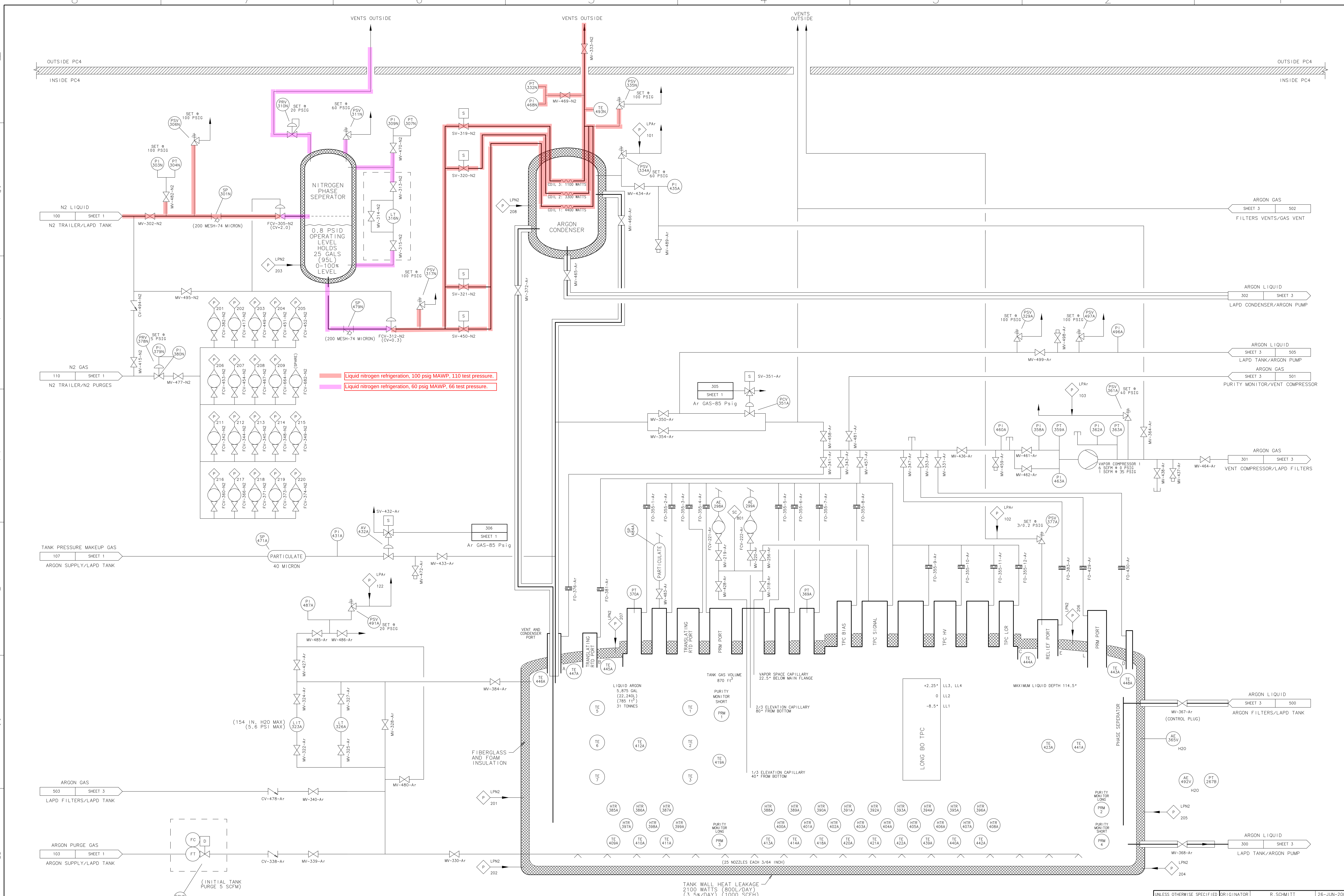

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	CHECKED	R.SCHMITT	12-DEC-2007
1. BREAK ALL SHARP EDGES	APPROVED	R.SCHMITT	12-DEC-2007
2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON ASME Y14.5M-1994 4. MAX. ALL MACH. SURFACES	USED ON		
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UNITED STATES DEPARTMENT OF ENERGY

FLARE UTILITIES
GAS PIPING & INSTRUMENT DIAGRAM
LIQUID ARGON PURITY DEMONSTRAT'N

SCALE	DRAWING NUMBER	SHEET	REV
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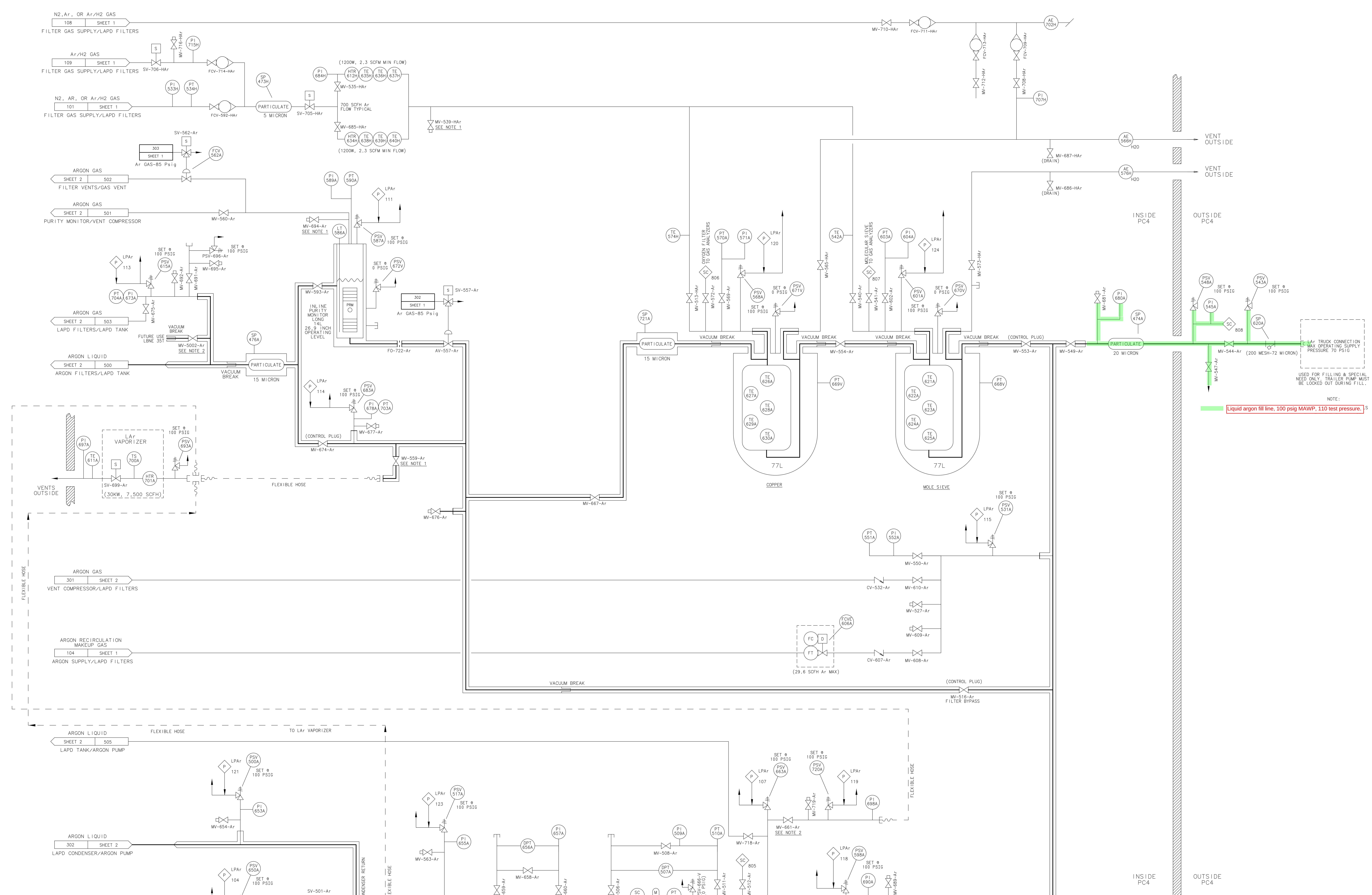

NOTES

1. VALVE TO REMAIN LOCKED CLOSED DURING NORMAL LAPD CRYOGENIC OPERATIONS. VALVE MAY ONLY BE UNLOCKED AND OPENED BY A PPD/MD/F&T ENGINEER FOLLOWING A RELEVANT PROCEDURE.
2. VALVE TO REMAIN LOCKED CLOSED DURING LAPD CRYOGENIC OPERATIONS.

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	R.SCHMITT	26-JUN-2007
	DRAWN	J.CATALANELLO	07-DEC-2007
	CHECKED	R.SCHMITT	12-DEC-2007
	APPROVED	R.SCHMITT	12-DEC-2007

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

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MATERIAL

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UNITED STATES DEPARTMENT OF ENERGY

FLARE UTILITIES
GAS PIPING & INSTRUMENT DIAGRAM
LIQUID ARGON PURITY DEMONSTRAT'N

SCALE	DRAWING NUMBER	SHEET	REV
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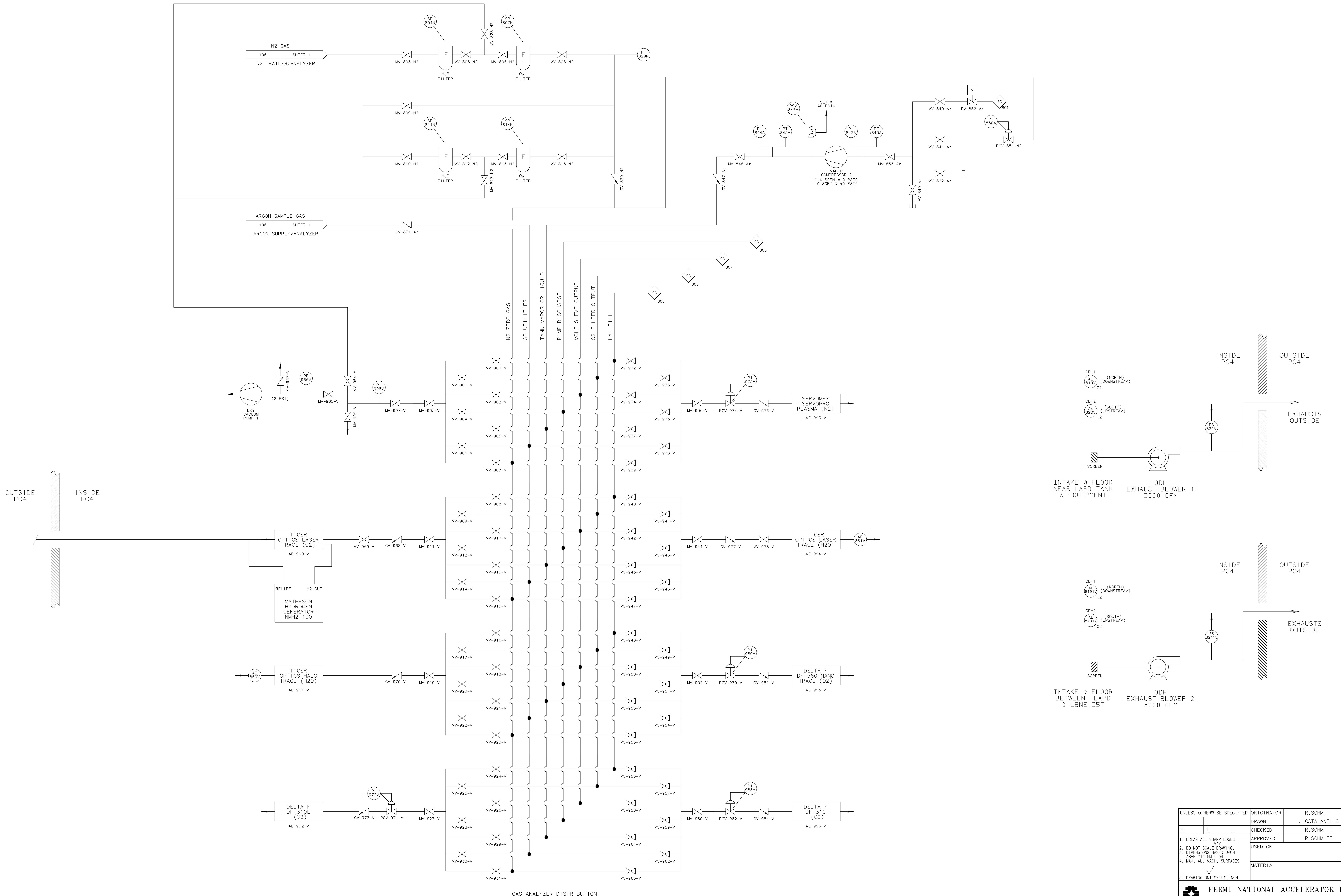

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	R.SCHMITT	26-JUN-2007
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1. BREAK ALL SHARP EDGES MAX. 2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON ASME Y14.5M-1994 4. MAX. ALL MACH. SURFACES 5. DRAWING UNITS: U.S. INCH	APPROVED	R.SCHMITT	12-DEC-2007
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UNITED STATES DEPARTMENT OF ENERGY

FLARE UTILITIES
GAS PIPING & INSTRUMENT DIAGRAM
LIQUID ARGON PURITY DEMONSTRAT'N

SCALE	DRAWING NUMBER	SHEET	REV
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Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
MV	101	Ar	SHT-1	7-	C	connection to HP Ar dewar #1	manual valve	NA	3000 psig	Matheson	53-48T
MV	102	Ar	SHT-1	7-	D	connection to HP Ar dewar #2	manual valve	NA	3000 psig	Matheson	53-48T
MV	103	Ar	SHT-1	7-	D	connection to HP Ar dewar #3	manual valve	NA	3000 psig	Matheson	53-48T
PI	104	Har	SHT-1	6-	E	regeneration gas trailer pressure	local pressure indicator	NA	3000 psig	Wika	NA
PT	105	Ar	SHT-1	6-	B	HP Ar header pressure	pressure transmitter	0 - 3000 psig	3750 psig	Setra	C280E
PRV	106	HAr	SHT-1	7-	F	Ar/H2 from trailer	pressure regulator	50	3000 psig	Matheson	3201
PSV	108	HAr	SHT-1	7-	F	Ar/H2 from trailer relief	relief valve	100 psig	400 psig	Rockwood Swendeman	710NBEF-A
PRV	110	Ar	SHT-1	7-	E	header from HP Ar dewars	pressure regulator	85 psig	3000 psig	Victor	VTS 450 E 580
PT	111	Ar	SHT-1	6-	E	Ar/H2 trailer pressure	pressure transmitter	0 - 3000 psia	3000 psia	Setra	225130CPAC411B1
MV	113	Ar	SHT-1	7-	D	HP Ar header	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
PSV	114	Ar	SHT-1	7-	E	header from HP Ar dewars	relief valve	100 psig	2400 psig	Circle-Seal	5100-4MP
MV	115	Ar	SHT-1	7-	E	HP Ar header blowdown	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
MV	116	Ar	SHT-1	7-	E	HP Ar supply to LAPD tank	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
MV	118	Ar	SHT-1	4-	D	Argon Source #2 vent valve	manual valve	NA	1500 psig	Swagelok	B-44XS6
MV	119	Ar	SHT-1	6-	D	Argon Source #2 hookup #1	manual valve	NA	3000 psig	Matheson	53-48T
MV	120	Ar	SHT-1	6-	D	Argon Source #2 hookup #2	manual valve	NA	3000 psig	Matheson	53-48T
MV	121	Ar	SHT-1	6-	D	Argon Source #2 hookup #3	manual valve	NA	3000 psig	Matheson	53-48T
MV	122	Ar	SHT-1	6-	D	Argon Source #2 hookup #4	manual valve	NA	3000 psig	Matheson	53-48T
PT	123	Ar	SHT-1	6-	D	Ar bottle header header	pressure transmitter	0 - 3000 psia	3000 psia	Setra	225130CPAC411B1
PRV	124	Ar	SHT-1	5-	D	Ar bottle header header	pressure regulator	75	3000 psig	Victor	VTS 450 E 580
PSV	125	Ar	SHT-1	4-	D	Ar bottle header header	relief valve	100 psig	2400 psig	Circle-Seal	5100-4MP
MV	126	Ar	SHT-1	4-	D	Argon source #2	manual valve	NA	1500 psig	Swagelok	B-44XS6
MV	128	Ar	SHT-1	6-	E	Argon Source #3 hookup #1	manual valve	NA	3000 psig	Matheson	53-48T
MV	129	Ar	SHT-1	6-	E	Argon Source #3 hookup #2	manual valve	NA	3000 psig	Matheson	53-48T
MV	130	Ar	SHT-1	6-	E	Argon Source #3 hookup #3	manual valve	NA	3000 psig	Matheson	53-48T
MV	131	Ar	SHT-1	6-	E	Argon Source #3 hookup #4	manual valve	NA	3000 psig	Matheson	53-48T
PT	132	Ar	SHT-1	6-	E	Argon Source #3 manifold pressure	pressure transmitter	0 - 3000 psia	3000 psia	Setra	225130CPAC411B1
PRV	133	Ar	SHT-1	5-	E	Argon source #3 header	pressure regulator	65	3000 psig	Victor	VTS 450 E 580
PSV	134	Ar	SHT-1	4-	E	Argon source #3 header	relief valve	100 psig	2400 psig	Circle-Seal	5100-4MP
MV	135	Ar	SHT-1	4-	E	Argon Source #3 vent valve	manual valve	NA	1500 psig	Swagelok	B-44XS6
MV	137	Ar	SHT-1	4-	E	Argon Source #3	manual valve	NA	1500 psig	Swagelok	B-44XS6
PT	138	N2	SHT-1	7-	G	N2 trailer	pressure transmitter	0-100 psig	>150 psig	Setra	C206, 100 psig, top mounted bayonet
LT	139	N2	SHT-1	7-	G	N2 trailer	press diff (level) transmitter	0-100 "wc	3000 psig	Cameron (formally Barton)	9A-IND224-GC-LA IT
SP	140	N2	SHT-1	5-	G	liq. N2 from N2 trailer to phase sep. outdoor section	Y-strainer (particulate filter)	NA	400 psig	McMASTER-CARR	44125K45 - 200 mesh
TE	141	N2	SHT-1	5-	G	liq. N2 from N2 trailer to phase sep. outdoor section	temperature element	70-400K	>200 psig	OMEGA	Platinum RTD PR-18-2-100-1/4-9-E
MV	142	N2	SHT-1	5-	G	liq. N2 from N2 trailer to vaporizer	manual shutoff valve	NA	600 psig	CPC-Cryolab	ES4-088-TPG standard length bonnet, 1", NPT, globe body
PSV	143	N2	SHT-1	4-	G	liq. N2 from N2 trailer to vaporizer	relief valve trapped volume	100 psig	2400 psig	Circle-Seal	5180B-4M-100
SV	144	N2	SHT-1	3-	G	GN2 supply to Pc4	solenoid valve	NA	300 psig	Magnatrol	16L44Z, 24 VDC
PI	145	N2	SHT-1	4-	G	N2 gas from vaporizer to regen gas header / outdoor section	local pressure indicator	0-160 psig	>200 psig	US Gauge	US Gauge Series P1535 - 2.5" Dial Gauge 110795
TE	146	N2	SHT-1	4-	G	N2 gas from vaporizer to regen gas header / outdoor section	temperature element	70-400K	>200 psig	OMEGA	Platinum RTD PR-18-2-100-1/4-9-E
MV	148	N2	SHT-1	5-	G	liq. N2 from N2 trailer to phase sep. blowdown / outdoor section	manual valve	NA	600 psig	CPC-Cryolab	ES4-088-TPG standard length bonnet, 1", NPT, globe body
PI	149	N2	SHT-1	4-	G	liq. N2 from N2 trailer to phase sep. outdoor section	local pressure indicator	0-160 psig	>200 psig	US Gauge	US Gauge Series P1535 - 2.5" Dial Gauge 110795
PSV	150	N2	SHT-1	4-	G	liq. N2 from N2 trailer to phase sep. outdoor section	relief valve trapped volume	100 psig	2400 psig	Circle-Seal	5180B-4M-100
CV	151	N2	SHT-1	3-	F	N2 gas from vaporizer to regen gas header / indoor section	check valve	1 psig spring	1600 psig	Check-All Valve	BU-125-BR-BN-1.00-SS
MV	152	N2	SHT-1	3-	G	N2 gas from vaporizer to regen gas header / indoor section	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
CV	153	HAr	SHT-1	3-	F	Ar/H2 from trailer to LAPD filtration indoor section	check valve	1 psig spring	1600 psig	Check-All Valve	BU-125-BR-BN-1.00-SS
MV	154	HAr	SHT-1	3-	F	Ar/H2 from trailer to LAPD filtration indoor section	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
MV	156	Ar	SHT-1	3-	C	HP Ar supply to LAPD tank	inside manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
FCV	157	Ar	SHT-1	3-	D	Ar purge header to purge #101	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	158	Ar	SHT-1	3-	D	Ar purge header to purge #102	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	159	Ar	SHT-1	3-	D	Ar purge header to purge #103	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	160	Ar	SHT-1	3-	D	Ar purge header to purge #104	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	161	Ar	SHT-1	3-	D	Ar purge header spare	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	162	Ar	SHT-1	2-	D	Ar purge header spare	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	163	Ar	SHT-1	2-	D	Ar purge header to purge #107	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	164	Ar	SHT-1	2-	D	Ar purge header spare	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	165	Ar	SHT-1	2-	D	Ar purge header spare	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	166	Ar	SHT-1	2-	D	Ar purge header spare	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
MV	167	Ar	SHT-1	3-	D	Ar bottle gas to Ar purge header	manual valve	NA	1000 psig	Swagelok	B-4HK
PSV	168	N2	SHT-1	3-	G	LN2 supply	relief valve trapped volume	100 psig	2400 psig	Circle-Seal	5100-4MP
MV	170	HAr	SHT-1	6-	F	Ar/H2 from trailer blowdown	manual valve	NA	1000 psig	Sharpe	84-6-6-P-G-SW
MV	171	HAr	SHT-1	7-	F	Ar/H2 from trailer	manual valve	NA	1000 psig	Sharpe	84-6-6-P-G-SW
PI	174	Ar	SHT-1	3-	D	Ar bottle gas to Ar purge header	pressure indicator	0 - 10 psig	10 psig	Matheson	0 - 10 psig gauge
PI	175	Ar	SHT-1	7-	E	header from HP Ar dewars	pressure indicator on regulator	0 - 3000 psig	3000 psig	Victor	Supplied with regulator
PI	176	Ar	SHT-1	7-	E	header from HP Ar dewars	pressure indicator on regulator	0 - 400 psig	400 psig	Victor	Supplied with regulator
PI	178	HAr	SHT-1	7-	F	Ar/H2 from trailer	pressure indicator on regulator	0 - 4000 psig	4000 psig	Wika	111.11.68.4000
PI	179	HAr	SHT-1	7-	F	Ar/H2 from trailer	pressure indicator on regulator	vac - 200 psig	200 psig	Matheson	Supplied with regulator
PI	180	Ar	SHT-1	5-	D	Ar bottle header header	pressure indicator on regulator	0 - 3000 psig	3000 psig	Victor	Supplied with regulator
PI	181	Ar	SHT-1	5-	D	Ar bottle header header	pressure indicator on regulator	0 - 400 psig	400 psig	Victor	Supplied with regulator
PI	182	Ar	SHT-1	5-	E	Ar bottle header header	pressure indicator on regulator	0 - 3000 psig	3000 psig	Victor	Supplied with regulator
PI	183	Ar	SHT-1	5-	E	Ar bottle header header	pressure indicator on regulator	0 - 400 psig	400 psig	Victor	Supplied with regulator
CV	186	Ar	SHT-1	3-	C	HP Ar supply to LAPD tank	check valve	1 psig spring	1600 psig	Check-All Valve	BU-125-BR-BN-1.00-SS
CV	187	Ar	SHT-1	4-	C	Ar bottle gas to PC4	check valve	1 psig spring	1600 psig	Check-All Valve	BU-125-BR-BN-1.00-SS
FCV	189	Ar	SHT-1	3-	D	Ar purge header to purge #111	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV

Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
FCV	190	Ar	SHT-1	3-	D	Ar purge header spare	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	191	Ar	SHT-1	3-	D	Ar purge header to purge #113	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	192	Ar	SHT-1	3-	D	Ar purge header to purge #114	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	193	Ar	SHT-1	3-	D	Ar purge header to purge #115	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	194	Ar	SHT-1	2-	D	Ar purge header to purge #116	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	195	Ar	SHT-1	2-	D	Ar purge header spare	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	196	Ar	SHT-1	2-	D	Ar purge header to purge #118	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	197	Ar	SHT-1	2-	C	Ar purge header spare	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	198	Ar	SHT-1	2-	C	Ar purge header to purge #120	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	199	Ar	SHT-1	2-	C	Ar purge header to purge #121	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	200	Ar	SHT-1	2-	C	Ar purge header spare	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	201	Ar	SHT-1	2-	C	Ar purge header to purge #123	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	202	Ar	SHT-1	2-	C	Ar purge header to purge #124	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
PI	206	Ar	SHT-1	3-	D	low pressure ar purge line pressure	local pressure indicator	0 - 100 psig	100 psig	US Gauge	162988
PRV	207	Ar	SHT-1	3-	D	low pressure ar purge line pressure regulator	pressure regulator	0.5 - 5 psi	250 psig	Matheson	3702
CV	208	Ar	SHT-1	4-	D	argon supply	check valve	1 psig spring	1600 psig	Check-All Valve	BU-125-BR-BN-1.00-SS
PSV	209	N2	SHT-1	3-	G	trapped volume relief inside PC4	relief valve	100 psig	2400 psig	Circle -Seal	5100-4MP
PT	210	Air	SHT-1	6-	C	air bottle manifold	pressure transmitter	0-3000 psig	3000 psig	Ashcroft	K1
PT	211	Air	SHT-1	5-	C	air bottle manifold	pressure transmitter	0-3000 psig	3000 psig	Ashcroft	K1
MV	212	Air	SHT-1	5-	C	air bottle manifold	manual valve	NA	2500 psig	Swagelok	B-42XF2
MV	213	Air	SHT-1	5-	C	air bottle manifold	manual valve	NA	2500 psig	Swagelok	B-43YF2
PRV	214	Air	SHT-1	5-	C	air bottle manifold	pressure regulator	NA	> 2000 psig	Scott	Part of commercially purchased switchover manifold
PRV	215	Air	SHT-1	5-	C	air bottle manifold	pressure regulator	NA	> 2000 psig	Scott	Part of commercially purchased switchover manifold
PRV	216	Air	SHT-1	5-	C	air bottle manifold	pressure regulator	NA	> 2000 psig	Scott	Part of commercially purchased switchover manifold
PI	217	Air	SHT-1	5-	C	air bottle manifold	pressure indicator	0 - 400 psig	400 psig	Wika	NA
PSV	218	Air	SHT-1	5-	C	air bottle manifold	relief valve	100 psig	2400 psig	Circle-Seal	5100-4MP
MV	219	Ar	SHT-2	4-	D	Tank purge gas analyzers	manual valve	NA	1000 psig	Swagelok	SS-4BG-V47
MV	220	Ar	SHT-2	4-	D	Tank purge gas analyzers	manual valve	NA	1000 psig	Swagelok	SS-4BG-V47
FCV	221	Ar	SHT-2	4-	D	Tank purge gas analyzers	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
FCV	222	Ar	SHT-2	4-	D	Tank purge gas analyzers	rotameter	5-50 sccm	100 psig	Dwyer Instruments	RMA-151-SSV
AV	225	N2	SHT-1	6-	G	LN2 supply	automatic valve	NA	> 100 psig	Fermilab	Fermilab extended stem cryogenic control valve
MV	226	Ar	SHT-1	7-	B	connection to HP Ar dewar #3	manual valve	NA	3000 psig	Matheson	53-48T
MV	227	Ar	SHT-1	6-	E	H2/Ar pressure instrumentation	manual valve	NA	3500 psig	Swagelok	6LV-DLBW4
MV	228	Har	SHT-1	6-	B	Ar supply pressure instrumentation	manual valve	NA	3500 psig	Swagelok	6LV-DLBW4
PI	229	Ar	SHT-1	6-	B	argon dewar gas supply pressure instrumentation	pressure indicator	0 - 3000 psig	3000 psig	Wika	NA
MV	230	Har	SHT-1	4-	F	regeneration gas isolation	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
PI	231	N2	SHT-1	3-	G	nitrogen gas supply	pressure indicator	vac - 150 psig	150 psig	US Gauge	vac - 150 psig pressure gauge
MV	232	N2	SHT-1	3-	F	nitrogen gas supply	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
MV	233	V	SHT-1	2-	F	regeneration gas header	manual valve	NA	1000 psig	Swagelok	B-4HK
MV	234	V	SHT-1	2-	F	regeneration gas header	manual valve	NA	1000 psig	Swagelok	B-4HK
CV	236	Ar	SHT-1	3-	F	argon gas supply @ regen header	check valve	1 psig spring	1600 psig	Check-All Valve	BU-125-BR-BN-1.00-SS
MV	237	Ar	SHT-1	3-	F	argon gas supply @ regen header	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
MV	238	Ar	SHT-1	4-	E	argon supply isolation	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
SP	239	N2	SHT-1	3-	F	nitrogen gas supply	particulate filter	NA	500 psig	McMASTER-CARR	4414K35
SP	240	N2	SHT-1	3-	F	nitrogen gas supply	Y-strainer (particulate filter)	NA	200 psig	McMASTER-CARR	43935K556
SP	241	Har	SHT-1	3-	F	hydrogen argon gas supply	Y-strainer (particulate filter)	NA	200 psig	McMASTER-CARR	43935K556
SP	242	Ar	SHT-1	3-	F	argon gas supply @ regen header	Y-strainer (particulate filter)	NA	200 psig	McMASTER-CARR	43935K556
SP	243	N2	SHT-1	2-	F	nitrogen gas supply	particulate filter	NA	500 psig	McMASTER-CARR	4414K35
PI	244	N2	SHT-1	2-	F	nitrogen gas supply	pressure indicator	vac - 150 psig	150 psig	US Gauge	FNAL Stock Item 1050-003500
MV	245	N2	SHT-1	2-	G	nitrogen gas supply	manual valve	NA	3000 psig	Swagelok	B-1VM4
SP	246	Ar	SHT-1	3-	E	argon supply	particulate filter	NA	500 psig	McMASTER-CARR	4414K35
PI	247	Ar	SHT-1	3-	E	argon supply	pressure indicator	vac - 150 psig	150 psig	US Gauge	FNAL Stock Item 1050-003500
MV	248	Ar	SHT-1	3-	E	argon supply	manual valve	NA	3000 psig	Swagelok	B-1VM4
MV	249	Ar	SHT-1	3-	E	pneumatic valve actuation	manual valve	NA	2200 psig	Swagelok	B-43S6
PI	250	Ar	SHT-1	2-	E	pneumatic valve actuation	prssure indicator	vac - 150 psig	150 psig	US Gauge	FNAL Stock Item 1050-003500
MV	251	Ar	SHT-1	2-	E	pneumatic valve actuation	manual valve	NA	2200 psig	Swagelok	B-43S6
MV	252	Ar	SHT-1	2-	E	pneumatic valve actuation	manual valve	NA	2200 psig	Swagelok	B-43S6
MV	253	Ar	SHT-1	2-	E	pneumatic valve actuation	manual valve	NA	2200 psig	Swagelok	B-43S6
MV	254	Ar	SHT-1	2-	E	pneumatic valve actuation	manual valve	NA	2200 psig	Swagelok	B-43S6
MV	255	Ar	SHT-1	2-	E	pneumatic valve actuation	manual valve	NA	2200 psig	Swagelok	B-43S6
MV	256	Ar	SHT-2	4-	D	TPC signal purge	manual valve	NA	1000 psig	Swagelok	SS-4BG-V47
SP	258	Ar	SHT-1	3-	D	argon supply	particulate filter	NA	500 psig	McMASTER-CARR	4414K35
SP	259	Ar	SHT-1	3-	C	argon supply	particulate filter	NA	500 psig	McMASTER-CARR	4414K35
MV	260	Ar	SHT-1	3-	D	argon purges	manual valve	NA	250 psig	Matheson	100-S
MV	261	N2	SHT-1	7-	G	LN2 trailer instrumentation	manual valve	NA	1000 psig	Swagelok	B-4HK
PRV	262	N2	SHT-1	6-	G	LN2 trailer automatic shut off valve	pressure regulator	15 psig	300 psig	McMASTER-CARR	4289K21
PI	263	N2	SHT-1	6-	G	LN2 trailer automatic shut off valve	pressure indicator	0 - 30 psig	30 psig	McMASTER-CARR	gauge included with PRV-262-N2
PSV	264	N2	SHT-1	2-	G	trapped volume relief inside PC4	relief valve	100 psig	2400 psig	Circle -Seal	5100-4MP
PI	265	Ar	SHT-1	3-	C	argon utility gas	pressure indicator	vac - 150 psig	150 psig	US Gauge	FNAL Stock Item 1050-003500
PT	266	Ar	SHT-1	2-	E	argon utility gas	pressure transmitter	0 - 300 psig	300 psig	Setra	C206
PT	267	B	SHT-2	2-	C	barometric pressure	pressure transmitter	800 - 1100 mpa	1100 mpa	Setra	C278
SP	268	Har	SHT-1	3-	F	H2/Ar dilution	particulate filter	NA	200 psig	McMASTER-CARR	43935K556
CV	269	Har	SHT-1	3-	F	H2/Ar dilution	check valve	1 psig spring	1600 psig	Check-All Valve	BU-125-BR-BN-1.00-SS
MV	270	Har	SHT-1	3-	F	H2/Ar dilution	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100

Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
SP	271	N2	SHT-1	3-	G	nitrogen purge supply	particulate filter	NA	500 psig	McMASTER-CARR	4414K35
MV	272	N2	SHT-1	3-	G	nitrogen purge supply	manual valve	NA	600 psig	Quadrant	M1FNSRRSLTT-100
CV	273	Ar	SHT-1	5-	E	Argon Source #3	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	274	Ar	SHT-1	5-	E	Argon Source #3	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	275	Ar	SHT-1	5-	E	Argon Source #3	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	276	Ar	SHT-1	5-	E	Argon Source #3	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	277	Ar	SHT-1	5-	C	Argon Source #2	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	278	Ar	SHT-1	5-	C	Argon Source #2	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	279	Ar	SHT-1	5-	C	Argon Source #2	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	280	Ar	SHT-1	5-	C	Argon Source #2	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	281	Ar	SHT-1	8-	E	Argon Source #1	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	282	Ar	SHT-1	8-	D	Argon Source #1	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	283	Ar	SHT-1	8-	C	Argon Source #1	check valve	NA	3000 psig	Matheson	580-CV-4-BP
CV	284	Ar	SHT-1	8-	C	Argon Source #1	check valve	NA	3000 psig	Matheson	580-CV-4-BP
MV	285	N2	SHT-1	2-	G	N2 liquid to LAPD	manual valve	NA	870 psig	Worcester	#C4466 PM SW
MV	286	AIR	SHT-1	3-	A	breathable air	manual valve	NA	250 psig	Worcester	1/4-416N
SP	287	AIR	SHT-1	3-	A	breathable air	particulate filter	NA	500 psig	McMASTER-CARR	4414K3
PI	288	AIR	SHT-1	3-	A	breathable air	pressure gauge	vac - 150 psig	150 psig	US Gauge	FNAL Stock Item 1050-003500
MV	289	AIR	SHT-1	3-	A	breathable air	manual valve	NA	250 psig	Worcester	1/4-416N
SP	290	AIR	SHT-1	3-	A	breathable air	particulate filter	NA	500 psig	McMASTER-CARR	4414K3
PI	291	AIR	SHT-1	3-	A	breathable air	pressure gauge	vac - 150 psig	150 psig	US Gauge	FNAL Stock Item 1050-003500
MV	292	AIR	SHT-1	3-	A	breathable air	manual valve	NA	250 psig	Worcester	1/4-416N
CV	293	AIR	SHT-1	6-	C	breathable air	check valve	10 psid	3000 psig	Nupro	B-4CP4
PI	294	AIR	SHT-1	6-	C	breathable air	pressure indicator	0 - 3000 psig	3000 psig	Wiki	NA
MV	295	AIR	SHT-1	5-	C	breathable air	manual valve	NA	2500 psig	Swagelok	B-42XF2
PI	296	AIR	SHT-1	5-	C	breathable air	pressure indicator	0 - 3000 psig	3000 psig	Wiki	NA
CV	297	AIR	SHT-1	5-	C	breathable air	check valve	10 psid	3000 psig	Nupro	B-4CP4
AE	298	Ar	SHT-2	4-	D	piston purge	oxygen sensor 1/3 elevation	0-25% O2	ambient	MSA	A-ULTIMAX-XP-E-14-U1S0-0010-100
AE	299	Ar	SHT-2	4-	D	piston purge	oxygen sensor 2/3 elevation	0-25% O2	ambient	MSA	A-ULTIMAX-XP-E-14-U1S0-0010-100
FCVE	300	Ar	SHT-2	7-	B	argon purge gas from HP Ar	gas mass flow control valve	0-6.5 SCFM	160 psia	Alicat Scientific Inc	MCR-250SLPM-D
SP	301	N2	SHT-2	7-	G	liq. N2 from N2 trailer to phase sep. indoor section	Y-strainer	NA	400 psig	McMASTER-CARR	44125K45 - 200 mesh
MV	302	N2	SHT-2	8-	G	liq. N2 from N2 trailer to phase sep. indoor section	manual shutoff valve	NA	600 psig	CPC-Cryolab	ES4-088-TPG standard length bonnet, 1", NPT, globe body
PI	303	N2	SHT-2	7-	G	liq. N2 from N2 trailer to phase sep. indoor section	local pressure indicator	0-160 psig	>200 psig	US Gauge	0-100 psig
PT	304	N2	SHT-2	7-	G	liq. N2 from N2 trailer to phase sep. indoor section	pressure transmitter	0-100 psig	>150 psig	Setra	C206, 100 psig, top mounted bayonet
FCV	305	N2	SHT-2	7-	G	liq. N2 from N2 trailer to phase sep. indoor section	solenoid valve	NA	300 psig	Magnatrol	16L44Z, 24 VDC
PSV	306	N2	SHT-2	7-	G	vacinity of phase sep	relief valve trapped volume	100 psig	2400 psig	Circle-Seal	5180B-4MP-100
PT	307	N2	SHT-2	6-	G	phase sep vent to vent header	pressure transmitter	0-100 psig	>150 psig	Setra	C206, 100 psig, top mounted bayonet
PI	309	N2	SHT-2	6-	G	phase sep vent to vent header	pressure indicator	0-100 psig	100 psig	US Gauge	162988
PRV	310	N2	SHT-2	7-	H	phase sep vent to vent header	back pressure regulator	20 psig	400 psig	Cash Valve	FR, 13782 (1/2"), 0-20 psig, cryogenic N2 gas
PSV	311	N2	SHT-2	7-	G	phase separator vessel	vessel overpressure relief valve	60 psig	2400 psig	Rockwood Swendeman	710-N-B-D-E-A-060 ASME Bronze RXSO, plain cap, B orifice, 3/4" inlet, 1" outlet, gas sect VIII, set at 60 psig
FCV	312	N2	SHT-2	6-	F	liq N2 from phase separator condenser	control valve	0 - 100 %	>300 psig	Fermilab	std Fermi LN2 valve w/badger actuator
MV	313	N2	SHT-2	6-	G	phase separator vessel	manual valve	NA	250 psig	see LT-316	NA
MV	314	N2	SHT-2	7-	G	phase separator vessel	manual valve	NA	250 psig	see LT-316	NA
MV	315	N2	SHT-2	6-	G	phase separator vessel	manual valve	NA	250 psig	see LT-316	NA
LT	316	N2	SHT-2	6-	G	phase separator vessel	level transmitter (pressure differential)	0-100%, 0-2psid	250 psig	Setra	2301-002PD-3V-11-A
PSV	317	N2	SHT-2	6-	F	liq N2 from phase separator condenser	relief valve trapped volume	100 psig	2400 psig	Circle-Seal	5180B-4MP-100
MV	318	Ar	SHT-2	4-	D	LAPD nozzle ar impurity purge vent	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
SV	319	N2	SHT-2	6-	G	liq N2 from phase separator condenser coil #3	solenoid valve	NA	300 psig	Magnatrol	16L44Z, 24 VDC
SV	320	N2	SHT-2	6-	F	liq N2 from phase separator condenser coil #2	solenoid valve	0 - 100 %	>300 psig	Fermilab	std Fermi LN2 valve w/badger actuator
SV	321	N2	SHT-2	6-	F	liq N2 from phase separator condenser coil #1	solenoid valve	NA	300 psig	Magnatrol	14L42, 24 VDC
MV	322	Ar	SHT-2	7-	C	LAPD tank level	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
LIT	323	Ar	SHT-2	7-	C	LAPD tank level	differential pressure indicator	0-10 psid (0-16.67 ft)	50 psid	Setra	231MS1
MV	324	Ar	SHT-2	7-	C	LAPD tank level	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
MV	325	Ar	SHT-2	6-	C	LAPD tank level	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
LT	326	Ar	SHT-2	6-	C	LAPD tank liquid level	differential pressure transmitter	0-10 psid (0-16.67 ft)	500 psi	GP:50	316DPJLC
MV	327	Ar	SHT-2	6-	C	LAPD tank level	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
MV	328	Ar	SHT-2	6-	C	LAPD tank level	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
PSV	329	Ar	SHT-2	4-	F	Pump cool down trapped volume	relief valve	100 psig	2400 psig	Circle-Seal	5100-4MP
MV	330	Ar	SHT-2	5-	B	argon purge gas from HP Ar to LAPD tank	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
MV	331	Ar	SHT-2	3-	E	LAPD pressure control vent	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
PT	332	N2	SHT-2	5-	G	N2 vent from condenser	pressure transmitter	0-100 psig	>150 psig	Setra	C206, 100 psig, top mounted bayonet
MV	333	N2	SHT-2	5-	G	N2 vent from condenser	manual valve	NA	600 psig	CPC-Cryolab	ES4-088-TPG standard length bonnet, 1", NPT, globe body
PSV	334	Ar	SHT-2	4-	G	condenser	vessel overpressure relief valve	60 psig	2400 psig	Rockwood Swendeman	710-N-A-D-E-A-060 ASME Bronze RXSO, plain cap, A orifice, 3/4" inlet, 1" outlet, gas sect VIII, set at 60 psig
PSV	335	N2	SHT-2	5-	G	condenser	relief valve	60 psig	2400 psig	Circle-Seal	5180B-4M-100
CV	338	Ar	SHT-2	7-	B	argon purge gas from HP Ar	check valve	2 psi crack	3000 psig	Swagelok	6L-CW4VR8
MV	339	Ar	SHT-2	6-	B	argon purge gas from HP Ar	manual valve	NA	300 psig	Swagelok	6L-ELD8-CCXX
MV	340	Ar	SHT-2	6-	B	argon purge gas from HP Ar blowdown	manual valve	NA	300 psig	Swagelok	6L-ELD8-CCXX
MV	341	Ar	SHT-2	4-	E	LAPD nozzle ar impurity purge vent	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
FCV	342	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
MV	343	Ar	SHT-2	4-	E	LAPD nozzle ar impurity purge vent	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
FCV	344	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
FCV	345	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
MV	346	Ar	SHT-2	4-	D	LAPD nozzle ar impurity purge vent	manual valve	NA	375 psig	Carten	MD-250
MV	347	Ar	SHT-2	3-	E	LAPD nozzle ar impurity purge vent	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW

Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
FCV	348	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
FCV	349	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
MV	350	Ar	SHT-2	4-	E	tank vent	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8134
PCV	351	Ar	SHT-2	4-	E	LAPD pressure control vent	pressure control valve	NA	165 psid	Eden Cryogenics	BC-02146-8135
SV	351	Ar	SHT-2	4-	E	PCV-351-Ar	solenoid valve	NA	150 psig	ASCO	EF8327G041
MV	353	Ar	SHT-2	4-	E	LAPD pressure control vent	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
MV	354	Ar	SHT-2	4-	E	LAPD pressure control vent	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8119
FO	355-1	Ar	SHT-2	5-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.067"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-2	Ar	SHT-2	5-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.067"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-3	Ar	SHT-2	4-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.140"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-4	Ar	SHT-2	4-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.200"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-5	Ar	SHT-2	4-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.140"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-6	Ar	SHT-2	4-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.067"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-7	Ar	SHT-2	4-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.067"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-8	Ar	SHT-2	4-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.09"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-9	Ar	SHT-2	3-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.200"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-10	Ar	SHT-2	3-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.200"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-11	Ar	SHT-2	3-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.200"	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	355-12	Ar	SHT-2	3-	D	tank riser diffusion purge	orifice (drilled blind VCR seal)	0.200"	3500 psig	Swagelok	SS-8-VCR-2-BL
PI	358	Ar	SHT-2	3-	E	suction line to vent purge bellows pump	local pressure indicator	vac - 60 psig	60 psig	Wika	230.15-B-PV352-Z-WI-UZ-ZZZ ZZ P/N 50328794
PT	359	Ar	SHT-2	3-	E	suction line to vent purge bellows pump	pressure transmiter	0-100 psia	150 psig	Setra	2251-100P-A-D4-11-B1
FCV	360	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
PSV	361	Ar	SHT-2	3-	E	vent purge bellows pump outlet	relief valve	40 psig	2400 psig	Circle-Seal	5100-2MP
PI	362	Ar	SHT-2	2-	E	vent purge bellows pump outlet	local pressure indicator	vac - 60 psig	60 psig	Wika	230.15-B-PV352-Z-WI-UZ-ZZZ ZZ P/N 50328794
PT	363	Ar	SHT-2	2-	E	vent purge bellows pump outlet	pressure transmiter	0-100 psia	150 psig	Setra	2251-100P-A-D4-11-B1
MV	364	Ar	SHT-2	2-	E	vent purge bellows pump discharge to vent header	manual valve	NA	300 psig	Swagelok	6L-ELD8-CCXX
AE	365	V	SHT-2	3-	C	LAPD tank insulation	moisture analyzer and temperature sensor	0-100% RH -40 to +80 C	external to process	Vaisala	HMT100A12A621A2A1CB00
FCV	366	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
MV	367	Ar	SHT-2	2-	C	argon liquid return from filtration to tank	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8118
MV	368	Ar	SHT-2	3-	B	LAPD tank liquid to filtration pump	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8119
PT	369	Ar	SHT-2	4-	D	LAPD tank vapor pressure transmitter #1	pressure transmitter	0-5 psid	500 psi	GP:50	316DPJLC
PT	370	Ar	SHT-2	5-	D	LAPD tank vapor pressure transmitter #2	pressure transmitter	0-5 psid	500 psi	GP:50	316DPJLC
FCV	371	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
MV	372	Ar	SHT-2	5-	F	condenser liq overflow to LAPD tank	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8122
FCV	373	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
FCV	374	N2	SHT-2	7-	E	insulation purges	rotameter	0 - 20 SCFH	100 psig	Dwyer Instruments	RMA-6-SSV
MV	375	Ar	SHT-2	4-	D	LAPD nozzle ar impurity purge vent	manual valve	NA	375 psig	Carten	MD-250
FO	376	Ar	SHT-2	4-	E	tank riser diffusion purge	orifice	3/32" (~Cv=0.2)	3500 psig	Swagelok	SS-8-VCR-2-BL
PSV	377	Ar	SHT-2	3-	D	LAPD tank relief vent	relief valve	3 psid internal / 0.2 psid external	25 psig	Anderson Greenwood	9399C06SSTC
PRV	378	N2	SHT-2	7-	F	nitrogen to tank insulation	pressure regulator	0.5 - 5 psig	250 psig	Matheson	3702
PI	379	N2	SHT-2	7-	F	nitrogen to tank insulation	pressure indicator on regulator	0 - 100 psig	100 psig	US Gauge	0 - 100 psig gauge
PI	380	N2	SHT-2	7-	F	nitrogen to tank insulation	pressure indicator on regulator	0 - 10 psig	10 psig	Matheson	0 - 10 psig gauge
FO	381	Ar	SHT-2	4-	E	tank riser diffusion purge	orifice	3/32" (~Cv=0.2)	3500 psig	Swagelok	SS-8-VCR-2-BL
FCV	382	N2	SHT-2	7-	F	nitrogen to tank insulation	rotometer	30-240 sccm	100 psig	Dwyer Instruments	RMA-11-SSV
FO	383	Ar	SHT-2	2-	D	tank riser diffusion purge	orifice	3/32" (~Cv=0.2)	3500 psig	Swagelok	SS-8-VCR-2-BL
MV	384	Ar	SHT-2	5-	C	LAPD tank vapor isolation	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
HTR	385	Ar	SHT-2	5-	B	LAPD tank	tank heater #1	NA	external to process	Watlow	K020100C3-0009B
HTR	386	Ar	SHT-2	5-	B	LAPD tank	tank heater #2	NA	external to process	Watlow	K020100C3-0009B
HTR	387	Ar	SHT-2	4-	B	LAPD tank	tank heater #3	NA	external to process	Watlow	K020100C3-0009B
HTR	388	Ar	SHT-2	4-	B	LAPD tank	tank heater #4	NA	external to process	Watlow	K020100C3-0009B
HTR	389	Ar	SHT-2	4-	B	LAPD tank	tank heater #5	NA	external to process	Watlow	K020100C3-0009B
HTR	390	Ar	SHT-2	4-	B	LAPD tank	tank heater #6	NA	external to process	Watlow	K020100C3-0009B
HTR	391	Ar	SHT-2	4-	B	LAPD tank	tank heater #7	NA	external to process	Watlow	K020100C3-0009B
HTR	392	Ar	SHT-2	4-	B	LAPD tank	tank heater #8	NA	external to process	Watlow	K020100C3-0009B
HTR	393	Ar	SHT-2	4-	B	LAPD tank	tank heater #9	NA	external to process	Watlow	K020100C3-0009B
HTR	394	Ar	SHT-2	4-	B	LAPD tank	tank heater #10	NA	external to process	Watlow	K020100C3-0009B
HTR	395	Ar	SHT-2	4-	B	LAPD tank	tank heater #11	NA	external to process	Watlow	K020100C3-0009B
HTR	396	Ar	SHT-2	5-	B	LAPD tank	tank heater #12	NA	external to process	Watlow	K020100C3-0009B
HTR	397	Ar	SHT-2	5-	B	LAPD tank	tank heater #13	NA	external to process	Watlow	K020100C3-0009B
HTR	398	Ar	SHT-2	5-	B	LAPD tank	tank heater #14	NA	external to process	Watlow	K020100C3-0009B
HTR	399	Ar	SHT-2	3-	B	LAPD tank	tank heater #15	NA	external to process	Watlow	K020100C3-0009B
HTR	400	Ar	SHT-2	4-	B	LAPD tank	tank heater #16	NA	external to process	Watlow	K020100C3-0009B
HTR	401	Ar	SHT-2	4-	B	LAPD tank	tank heater #17	NA	external to process	Watlow	K020100C3-0009B
HTR	402	Ar	SHT-2	4-	B	LAPD tank	tank heater #18	NA	external to process	Watlow	K020100C3-0009B
HTR	403	Ar	SHT-2	4-	B	LAPD tank	tank heater #19	NA	external to process	Watlow	K020100C3-0009B
HTR	404	Ar	SHT-2	4-	B	LAPD tank	tank heater #20	NA	external to process	Watlow	K020100C3-0009B
HTR	405	Ar	SHT-2	4-	B	LAPD tank	tank heater #21	NA	external to process	Watlow	K020100C3-0009B
HTR	406	Ar	SHT-2	4-	B	LAPD tank	tank heater #22	NA	external to process	Watlow	K020100C3-0009B
HTR	407	Ar	SHT-2	3-	B	LAPD tank	tank heater #23	NA	external to process	Watlow	K020100C3-0009B
HTR	408	Ar	SHT-2	3-	B	LAPD tank	tank heater #24	NA	external to process	Watlow	K020100C3-0009B
TE	409	Ar	SHT-2	5-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	410	Ar	SHT-2	5-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	411	Ar	SHT-2	5-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	412	Ar	SHT-2	4-	C	LAPD tank (midpoint)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon

Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
TE	413	Ar	SHT-2	4-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	414	Ar	SHT-2	4-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
MV	415	N2	SHT-2	7-	F	nitrogen to tank insulation	manual valve	NA	1000 psig	Swagelok	B-4HK
FCV	417	N2	SHT-2	7-	F	nitrogen to tank insulation	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
TE	418	Ar	SHT-2	4-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	419	Ar	SHT-2	4-	C	LAPD tank (midpoint	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	420	Ar	SHT-2	4-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	421	Ar	SHT-2	4-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	422	Ar	SHT-2	4-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	423	Ar	SHT-2	3-	C	LAPD tank (midpoint)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
MV	427	Ar	SHT-2	6-	C	LAPD tank level	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
MV	428	Ar	SHT-2	4-	D	LAPD tank sample line	manual valve	NA	1000 psig	Swagelok	SS-4BG-V47
FO	429	Ar	SHT-2	3-	D	tank riser diffusion purge	orifice	3/32" (~Cv=0.2)	3500 psig	Swagelok	SS-8-VCR-2-BL
FO	430	Ar	SHT-2	2-	D	tank riser diffusion purge	orifice	3/32" (~Cv=0.2)	3500 psig	Swagelok	SS-8-VCR-2-BL
PI	431	Ar	SHT-2	6-	E	tank pressure makeup	pressure indicator	vac - 150 psig	150 psig	US Gauge	vac - 150 psig pressure gauge
AV	432	Ar	SHT-2	6-	E	tank pressure makeup	automatic valve	NA	1000 psig	Swagelok	SS-6UW-V19-TF-6C
SV	432	Ar	SHT-2	6-	E	AV-432-Ar	solenoid valve	NA	150 psig	ASCO	EF8327G041
MV	433	Ar	SHT-2	5-	E	tank pressure makeup	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
MV	434	Ar	SHT-2	4-	F	LAPD tank vent to condenser	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
PI	435	Ar	SHT-2	4-	F	LAPD tank vent to condenser	manual valve	vac - 60 psig	60 psig	Ashcroft	25-1009SWXVKLL
MV	436	Ar	SHT-2	3-	E	bellows pump isolation	manual valve	NA	300 psig	Swagelok	6L-ELD8-CCXX
MV	437	Ar	SHT-2	2-	E	vent purge bellows pump sample	manual valve	NA	375 psig	Carten	MD-250
MV	438	Ar	SHT-2	2-	E	vent purge bellows pump discharge	manual valve	NA	300 psig	Swagelok	6L-ELD8-CCXX
TE	439	Ar	SHT-2	3-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	440	Ar	SHT-2	3-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	441	Ar	SHT-2	3-	C	LAPD tank (midpoint)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	442	Ar	SHT-2	3-	B	LAPD tank (base)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	443	Ar	SHT-2	3-	C	LAPD tank (top - L)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	444	Ar	SHT-2	4-	C	LAPD tank (top - E)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	445	Ar	SHT-2	4-	C	LAPD tank (top -C)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	446	Ar	SHT-2	5-	C	LAPD tank (top - A)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	447	Ar	SHT-2	5-	C	LAPD tank (top - B)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
TE	448	Ar	SHT-2	3-	C	LAPD tank (top - D)	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
FCV	449	N2	SHT-2	7-	F	phase separator insulaton purge	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
SV	450	N2	SHT-2	6-	F	liq N2 from phase separator condenser coil #1	solenoid valve	NA	300 psig	Magnatrol	14L42, 24 VDC
FCV	451	N2	SHT-2	7-	F	nitrogen to tank insulation	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
FCV	452	N2	SHT-2	7-	F	nitrogen to tank insulation	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
FCV	453	N2	SHT-2	7-	E	nitrogen to tank insulation	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
FCV	454	N2	SHT-2	7-	E	nitrogen to tank insulation	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
MV	455	Ar	SHT-2	4-	D	LAPD nozzle ar impurity purge vent	manual valve	NA	375 psig	Carten	MD-250
MV	456	Ar	SHT-2	4-	D	LAPD nozzle ar impurity purge vent	manual valve	NA	375 psig	Carten	MD-250
MV	457	Ar	SHT-2	3-	E	LAPD nozzle ar impurity purge vent	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
MV	458	Ar	SHT-2	4-	E	LAPD nozzle ar impurity purge vent	manual valve	NA	2500 psig	Swagelok	SS-12UAW-TW
MV	459	Ar	SHT-2	3-	E	LAPD nozzle ar impurity purge vent	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
PI	460	Ar	SHT-2	3-	E	bellows pump suction	local pressure indicator	vac - 60 psig	60 psig	Wika	230.15-B-PV352-Z-WI-UZ-ZZZ ZZ P/N 50328794
MV	461	Ar	SHT-2	3-	E	bellows pump suction	manual valve	NA	300 psig	Swagelok	6L-ELD8-CCXX
MV	462	Ar	SHT-2	3-	E	bellows pump suction metering valve	manual valve	NA	700 psig	Swagelok	SS-4BMRW-TW
PI	463	Ar	SHT-2	3-	E	bellows pump suction	local pressure indicator	vac - 60 psig	60 psig	Wika	230.15-B-PV352-Z-WI-UZ-ZZZ ZZ P/N 50328794
MV	464	Ar	SHT-2	2-	E	bellows pump dishcarge	manual valve	NA	300 psig	Swagelok	6L-ELD8-CCXX
MV	465	Ar	SHT-2	5-	F	condenser liquid to pump suction	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8122
MV	466	Ar	SHT-2	4-	F	vapor from tank to condenser	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8131
FCV	467	N2	SHT-2	7-	E	nitrogen to condenser insulation	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
PI	468	N2	SHT-2	5-	H	nitrogen to condenser	pressure indicator	0 - 100 psig	100 psig	US Gauge	162988
MV	469	N2	SHT-2	5-	G	nitrogen vent	manual valve	NA	1000 psig	Swagelok	B-4HK
MV	470	N2	SHT-2	6-	G	phase separator vent pressure	manual valve	NA	1000 psig	Swagelok	B-4HK
SP	471	Ar	SHT-2	6-	E	tank make up gas	particulate filter	NA	500 psig	McMASTER-CARR	4414K35
MV	472	Ar	SHT-2	5-	E	tank make up gas vent	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
SP	473	Har	SHT-3	7-	H	regeneration gas	particulate filter	NA	1177 psig	GKN and FNAL	GKN tool # 9111/2
SP	474	Ar	SHT-3	2-	F	liquid argon fill	particulate filter	NA	1177 psig	GKN and FNAL	GKN tool # 9111/1
SP	475	Ar	SHT-3	5-	B	liquid argon pump suction	particulate filter	NA	820 psig	GKN and FNAL	GKN tool # 9111/5
SP	476	Ar	SHT-3	7-	F	liquid return to tank	particulate filter	NA	820 psig	GKN and FNAL	GKN tool # 9111/5
MV	477	N2	SHT-2	7-	F	nitrogen purges	manual valve	NA	250 psig	Matheson	100-S
CV	478	Ar	SHT-2	6-	B	argon for tank purge	check valve	2 psi crack	3000 psig	Swagelok	6L-CW4VR8
SP	479	N2	SHT-2	6-	F	LN2 for condenser	Y-strainer (particulate filter)	NA	400 psig	McMASTER-CARR	44125K45 - 200 mesh
MV	480	Ar	SHT-2	6-	B	tank dp valving vent	manual valve	NA	1000 psig	Swagelok	SS-4BG-V47
MV	481	Ar	SHT-2	3-	E	purity monitor diffusion purge	manual valve	NA	1000 psig	Swagelok	SS-8BG-V51
MV	482	N2	SHT-2	7-	G	LN2 for condenser	manual valve	NA	1000 psig	Swagelok	B-4HK
MV	483	Ar	SHT-2	4-	D	breather isolation	manual valve	NA	15 psid	Varian	Bellows sealed conflat vacuum valve
SP	484	Ar	SHT-2	4-	D	tank atmospheric breather	particulate filter - sintered metal filter	NA	175 psig	McMASTER-CARR	440K56
MV	485	Ar	SHT-2	6-	D	tank pressure instrumentation valving	manual valve	NA	375 psig	Carten	MD 250
MV	486	Ar	SHT-2	6-	D	tank pressure instrumentation valving	manual valve	NA	375 psig	Carten	MD 250
PI	487	Ar	SHT-2	6-	D	tank vapor pressure	pressure indicator	0 - 35 psia	35 psig	Wallace & Tiernan	61A-1A-0035
MV	489	Ar	SHT-2	4-	F	condenser Argon side	manual valve	NA	1000 psig	Swagelok	SS-8BG-V51
PSV	491	Ar	SHT-2	6-	D	tank pressure instrumentation	relief valve	20 psig	2400 psig	Circle-Seal	5100-2MP

Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
AE	492	V	SHT-2	2-	C	ambient	dewpoint transmitter	0-100% RH -40 to +80 C	external to process	Vaisala	HMT120KA1A2B12A1C0A
TE	493	N2	SHT-2	5-	G	N2 coil vent	100 ohm platinum RTD	NA	external to process	Minco	S651PDZ36A thermal ribbon
CV	494	N2	SHT-2	8-	F	N2 insulation purges	check valve	1/3 psia	3000 psig	Swagelok	B-4CP4-1/3
MV	495	N2	SHT-2	8-	F	N2 on/off to FCV	manual valve	NA	1000 psig	Swagelok	B-4HK
PI	496	Ar	SHT-2	4-	F	Pump cool down	pressure indicator	vac - 150 psig	150 psig	Ashcroft	25HPGG4FMVCRLXLL30IMV&150#
PSV	497	Ar	SHT-2	4-	F	Pump cool down trapped volume	relief valve	100 psig	2400 psig	Generant	CRV8-8V-K-100-PSI
MV	498	Ar	SHT-2	4-	F	Pump cool down	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
MV	499	Ar	SHT-2	4-	F	Pump cool down	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
PSV	500	Ar	SHT-3	7-	C	from LAPD tank to LAPD particulate filter before pump	relief valve	100 psig	2400 psig	Circle Seal	5100-2MP
AV	501	Ar	SHT-3	6-	B	from LAPD tank to LAPD particulate filter before pump (normally closed)	automatic valve (act'd by SV-641-N2	NA	165 psid	Eden Cryogenics	ECV-70-Y-20-B-VJ
SV	501	Ar	SHT-3	6-	B	AV-501-Ar	solenoid valve	NA	100 psig	ASCO	EF8327G041
MV	502	Ar	SHT-3	6-	B	LAPD condenser to LAPD particulate filter before pump	manual valve	NA	165 psid	Eden Cryogenics	EVC-60-Y-10-B-VJ
SC	504	Ar	SHT-3	5-	B	argon pump	motor speed control	NA	external to process	Toshiba	VFS11-4007PL-WN(r5)
PT	505	Ar	SHT-3	5-	B	argon pump vacuum jacket	pressure transmitter	0 - 1 Torr	1 atm	Granville-Phillips	275851-EU
MV	506	Ar	SHT-3	5-	C	pressure differential line on pump	manual valve	NA	375 psig	Carten	MD 250
DPT	507	Ar	SHT-3	5-	C	pressure differential across pump	pressure differential transmitter	0-100 psid	500 psi	GP:50	316DPJLC
MV	508	Ar	SHT-3	5-	B	pressure differential line on pump	manual valve	NA	375 psig	Carten	MD 250
PI	509	Ar	SHT-3	5-	C	pressure differential line on pump	local pressure indicator	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
PT	510	Ar	SHT-3	5-	C	pressure differential line on pump	pressure transmitter	0-250 psia	250 psia	Setra	2251250PAD41106
MV	511	Ar	SHT-3	4-	B	pressure differential line on pump	manual valve	NA	375 psig	Carten	MD 250
MV	512	Ar	SHT-3	4-	B	pump dishcharge	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
MV	513	Har	SHT-3	4-	F	regen gas to O2 filter	manual valve	NA	2500 psig	Swagelok	SS-12UAW-TW
MV	514	Ar	SHT-3	4-	B	from argon pump to flow transmitter, pump isolation	manual valve	NA	165 psig	Eden Cryogenics	BC-02146-8101
MV	516	Ar	SHT-3	3-	C	from argon pump to LAPD tank / filter bypass	manual valve	NA	165 psig	Eden Cryogenics	BC-02146-8122
PSV	517	Ar	SHT-3	6-	C	liquid argon from tank and condenser to particulate filter before pump	relief valve	100 psig	2400 psig	Circle Seal	5100-4MP
MV	527	Ar	SHT-3	3-	D	argon filtration	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
PSV	531	Ar	SHT-3	3-	E	from argon pump to first filter	relief valve	100 psig	2400 psig	Circle Seal	5100-4MP
CV	532	Ar	SHT-3	3-	D	vapor recirculation	check valve	2 psi crack	3000 psig	Swagelok	6L-CW4VR8
PI	533	Har	SHT-3	7-	H	regen gas from heater to filters	local pressure indicator	vac - 150 psig	150 psig	US Gauge	FNAL stock item 1050-003500
PT	534	Har	SHT-3	7-	H	regen gas from heater to filters	pressure transmitter	0 - 100 psig	300 psig	Setra	C206, 100 psig, top mounted bayonet
MV	535	Har	SHT-3	7-	H	regen gas from heater to filters	manual valve	NA	1000 psig	Sharpe	84-6-6-P-G-SW
MV	539	Har	SHT-3	6-	H	regen gas to filter one	manual valve	NA	1000 psig	Sharpe	84-6-6-P-G-SW
MV	540	Ar	SHT-3	4-	F	regen gas to filter one	manual valve	NA	2500 psig	Swagelok	SS-12UAW-TW
MV	541	Ar	SHT-3	3-	F	filter one sample connection	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
TE	542	Ar	SHT-3	4-	G	regen gas to molecular sieve	Type K TC	NA	100 psig	Omega	TC-K-NPT-G-72
PSV	543	Ar	SHT-3	1-	F	bulk liquid argon supply line	relief valve	100 psig	2400 psig	Circle-Seal	5180B-4M-100
MV	544	Ar	SHT-3	1-	F	bulk liquid argon supply line	manual valve	NA	600 psig	CPC-Cryolab	ES4-088-TPG standard length bonnet, 1", NPT, globe body
PI	545	Ar	SHT-3	1-	F	bulk liquid argon supply line	local pressure indicator	vac - 150 psig	150 psig	Ashcroft	25HPGG4FMVCRLXLL30IMV&150#
MV	547	Ar	SHT-3	2-	F	bulk liquid argon supply line	manual valve	NA	600 psig	CPC-Cryolab	ES4-088-TPG standard length bonnet, 1", NPT, globe body
PSV	548	Ar	SHT-3	2-	F	bulk liquid argon supply line	relief valve	100 psig	2400 psig	Circle-Seal	5180B-4M-100
MV	549	Ar	SHT-3	2-	F	bulk liquid argon supply line	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8122
MV	550	Ar	SHT-3	3-	D	liquid recirculation mole sieve input	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
PT	551	Ar	SHT-3	3-	D	liquid recirculation mole sieve input	pressure transmitter	0 - 500 psia	500 psia	Setra	2251250PAD41106
PI	552	Ar	SHT-3	3-	D	liquid recirculation mole sieve input	local pressure indicator	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
MV	553	Ar	SHT-3	2-	F	line from pump and bulk argon suppy to first filter	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8129
MV	554	Ar	SHT-3	4-	F	filter one to filter two	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8101
AV	557	Ar	SHT-3	6-	F	filter three to purity monitor	automatic valve (act'd by SV-557-Ar)	NA	165 psid	Eden Cryogenics	BC-02146-8119
SV	557	Ar	SHT-3	6-	F	AV-557-Ar	solenoid valve	NA	150 psig	ASCO	EF8327G041
MV	559	Ar	SHT-3	6-	E	filter loop vent to argon vaporizer and atmosphere	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8129
MV	560	Ar	SHT-3	7-	G	purity monitor vent to vent compressor	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
FCV	562	Ar	SHT-3	7-	G	purity monitor vent	automatic valve (act'd by SV562-Ar)	NA	1000 psig	Swagelok	SS-6UW-V19-TF-6C
SV	562	Ar	SHT-3	7-	G	FCV-552-Ar	solenoid valve	NA	150 psig	ASCO	EF8327G041
MV	563	Ar	SHT-3	6-	C	liquid argon from tank and condenser to particulate filter before pump	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
PSV	564	Ar	SHT-3	3-	B	from argon pump to first filter	relief valve	100 psig	2400 psig	Circle Seal	5100-4MP
MV	565	Har	SHT-3	4-	G	O2 filter regen vent to water analyzer	manual valve	NA	2500 psig	Swagelok	SS-12UAW-TW
AE	566	Har	SHT-3	2-	G	O2 filter regeneration vent	Dewpoint meter	-80 to +20 C	290 psia	Vaisala	DMT242A1A1A1B
PSV	568	Ar	SHT-3	4-	G	filter two	relief valve	100 psig	400 psig	Rockwood Swendeman	710NBEF-A
MV	569	Ar	SHT-3	4-	G	filter two	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
PT	570	Ar	SHT-3	4-	G	oxygen filter	pressure transmitter	0-250 psia	250 psia	Setra	2251250PAD41106
PI	571	Ar	SHT-3	4-	G	filter two	local pressure indicator	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
MV	572	Ar	SHT-3	4-	F	filter two sample connection		NA	160 psig	Swagelok	6LVV-DPBW4-P
MV	573	Har	SHT-3	3-	G	filter one to anlyzer	manual valve	NA	250 psig	Swagelok	SS-12UAW-TW
TE	574	Har	SHT-3	5-	G	regen gas to oxygen filter	Type K TC	NA	2500 psig	Omega	TC-K-NPT-G-72
AE	576	Har	SHT-3	2-	G	molecular sieve regeneration vent	Dewpoint meter	-80 to +20 C	290 psia	Vaisala	DMT242A1A1A1B
LT	586	Ar	SHT-3	6-	G	purity monitor liquid level	capacitance probe	0 - 44.6 inches	100 psig	American Magnetics	Model 185 Liquid Level Monitor
PSV	587	Ar	SHT-3	6-	G	purity monitor	relief valve	100 psig	400 psig	Rockwood Swendeman	710NBEF-A
PI	589	Ar	SHT-3	6-	H	purity monitor	local pressure indicator	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
PT	590	Ar	SHT-3	6-	H	purity monitor	pressure transmitter	0 - 250 psia	250 psia	Setra	2251250PAD41106
FCV	592	Har	SHT-3	7-	H	regen gas from heater to filters	Variable Area Flowmeter	0 - 1,000 SCFH	100 psig	Dwyer Instruments	RMC-106-SSV
MV	593	Ar	SHT-3	6-	G	purity monitor to LAPD tank	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8101
MV	594	Ar	SHT-3	3-	B	from argon pump to first filter, flowmeter isolation	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8101
FT	595	Ar	SHT-3	3-	B	from argon pump to first filter	coriolis flow transmitter	0 - 15 GPM	285 psig	Emerson Process Management	Micro Motion flowmeter CMF100M328NQBUEZZZ and transmitter 1700R12ABUEZZZ
MV	596	Ar	SHT-3	3-	B	from argon pump to first filter	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8101
MV	597	Ar	SHT-3	3-	B	from argon pump to first filter, blowdown	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47

Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
PSV	598	Ar	SHT-3	4-	B	from argon pump to first filter (trapped volume relief)	relief valve	100 psig	1000 psig	Circle Seal	5100-4MP
MV	599	Ar	SHT-3	3-	B	from argon pump to first filter, flowmeter bypass	manual valve	NA	2400 psig	Eden Cryogenics	BC-02146-8101
PSV	601	Ar	SHT-3	3-	F	filter one	relief valve	100 psig	400 psig	Rockwood Swendeman	710NBEF-A
MV	602	Ar	SHT-3	3-	F	filter one	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
PT	603	Ar	SHT-3	3-	G	molecular sieve	pressure transmitter	0-250 psia	250 psig	Setra	2251250PAD41106
PI	604	Ar	SHT-3	3-	G	filter one	local pressure indicator	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
FCVE	606	Ar	SHT-3	4-	D	makeup argon gas to pump loop	flow control valve	0 - 10,000 sccm	150 psig	MKS	1480
CV	607	Ar	SHT-3	3-	D	makeup argon gas to pump loop	check valve	1 / 3 psi crack	150 psig	Hylok	CVWBVM-4-SM6L
MV	608	Ar	SHT-3	3-	D	makeup argon gas to pump loop	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
MV	609	Ar	SHT-3	3-	D	makeup argon gas to pump loop	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
MV	610	Ar	SHT-3	3-	D	from vent compressor to pump loop	manual valve	NA	300 psig	Swagelok	6L-ELD8-CCXX
TE	611	Ar	SHT-3	8-	E	filter loop vent to argon vaporizer and atmosphere	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-4-E-SL RTD
HTR	612	Har	SHT-3	6-	H	regen gas from heater to filters	Circulation heater	NA	100 psig	Omega	AHPF-122
PSV	615	Ar	SHT-3	8-	F	liquid return to tank	relief valve	100 psig	external to process	Circle Seal	5100-4MP
SP	620	Ar	SHT-3	1-	F	bulk liquid argon supply line	y-strainer	NA	400 psig	McMASTER-CARR	44125K45 - 200 mesh
TE	621	Ar	SHT-3	3-	F	molecular sieve	100 ohm platinum RTD	NA	400 psig	Omega	PR-18-2-100-1/4-6-E-SL RTD
TE	622	Ar	SHT-3	3-	F	molecular sieve	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-4-E-SL RTD
TE	623	Ar	SHT-3	3-	F	molecular sieve	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-6-E-SL RTD
TE	624	Ar	SHT-3	3-	F	molecular sieve	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-4-E-SL RTD
TE	625	Ar	SHT-3	3-	F	molecular sieve	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-6-E-SL RTD
TE	626	Ar	SHT-3	4-	F	oxygen filter	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-6-E-SL RTD
TE	627	Ar	SHT-3	4-	F	oxygen filter	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-4-E-SL RTD
TE	628	Ar	SHT-3	4-	F	oxygen filter	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-6-E-SL RTD
TE	629	Ar	SHT-3	4-	F	oxygen filter	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-4-E-SL RTD
TE	630	Ar	SHT-3	4-	F	oxygen filter	100 ohm platinum RTD	NA	external to process	Omega	PR-18-2-100-1/4-6-E-SL RTD
MV	633	Ar	SHT-3	6-	B	LAPD TANK TO Argon vaporizer	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8101
HTR	634	Har	SHT-3	6-	H	regen gas from heater to filters	Circulation heater	NA	165 psid	Omega	AHPF-122
TE	635	Har	SHT-3	6-	H	regen gas heater (gas flow)	Type K TC	NA	100 psig	Omega	TC-K-NPT-G-72
TE	636	Har	SHT-3	6-	H	regen gas heater (heater surface)	Type K TC	NA	100 psig	Watlow	75XKFGA120A
TE	637	Har	SHT-3	6-	H	regen gas heater (gas flow)	Type K TC	NA	external to process	Omega	TC-K-NPT-G-72
TE	638	Har	SHT-3	7-	H	regen gas heater (gas flow)	Type K TC	NA	100 psig	Omega	TC-K-NPT-G-72
TE	639	Har	SHT-3	6-	H	regen gas heater (heater surface)	Type K TC	NA	100 psig	Watlow	75XKFGA120A
TE	640	Har	SHT-3	6-	H	regen gas heater (gas flow)	Type K TC	NA	external to process	Omega	TC-K-NPT-G-72
PSV	650	Ar	SHT-3	7-	B	liquid line to pump	relief valve	100 psig	150 psig	Circle Seal	5100-2MP
PI	651	Ar	SHT-3	7-	B	liquid line to pump	pressure gauge	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
MV	652	Ar	SHT-3	7-	B	liquid line to pump	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
PI	653	Ar	SHT-3	7-	C	condenser to pump suction	pressure gauge	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
MV	654	Ar	SHT-3	7-	C	condenser to pump suction	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
PI	655	Ar	SHT-3	6-	C	liquid line to pump	pressure gauge	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
DPT	656	Ar	SHT-3	5-	C	liquid line to pump across filter	differential pressure transmitter	0 - 5 psid	160 psig	Setra	C239
PI	657	Ar	SHT-3	5-	C	liquid line to pump	pressure gauge	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
MV	658	Ar	SHT-3	5-	C	liquid line to pump	manual valve	NA	375 psig	Carten	MD 250
MV	659	Ar	SHT-3	6-	B	liquid line to pump	manual valve	NA	375 psig	Carten	MD 250
MV	660	Ar	SHT-3	5-	B	liquid line to pump	manual valve	NA	375 psig	Carten	MD 250
MV	661	Ar	SHT-3	4-	C	liquid line pump discharge	manual valve	NA	375 psig	Carten	MD 250
TE	662	Ar	SHT-3	5-	B	liquid pump temperature	100 ohm platinum RTD	NA	375 psig	Minco	S651PDZ36A thermal ribbon
PSV	663	Ar	SHT-3	4-	C	pump discharge trapped volume relief	relief valve	100 psig	2400 psig	Circle Seal	5100-4MP
FCV	664	N2	*SHT-2*	7-	E	nitrogen purge to liquid argon flowmeter foam insulaton	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
PI	665	Ar	SHT-3	3-	B	liquid argon flowmeter inlet pressure	pressure gauge	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
PSV	666	V	SHT-3	5-	B	tank to pump vacuum jacket relief	relief valve (vacuum pumpout)	~ 0 psig	160 psig	CVI	V-1046-31 (spring removed)
LT	667	Ar	489659	4-	C	Liquid argon supply trailer liquid level	Level transmitter	0 - 100 "H2O		Ashcroft C	C1
MV	667	Ar	SHT-3	5-	E	future filter bypass isolation	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8101
PT	668	V	SHT-3	3-	F	molecular sieve vacuum	pressure transmitter	0 - 1 Torr	1 atm	Granville-Phillips	275851-EU
PT	669	V	SHT-3	4-	F	Cu filter vacuum	pressure transmitter	0 - 1 Torr	1 atm	Granville-Phillips	275851-EU
PSV	670	V	SHT-3	3-	F	molecular sieve vacuum	parallel plate relief	~0.25 psid	1 atm	Eden Cryogenics	Eden dwg # BC-02128-5815
PSV	671	V	SHT-3	4-	F	oxygen filter vacuum	parallel plate relief	~0.25 psid	1 atm	Eden Cryogenics	Eden dwg # BC-02128-5815
PSV	672	V	SHT-3	6-	F	inline purity monitor vacuum	parallel plate relief	~0.64 psid	1 atm	Fermilab	MB-106391
PI	673	Ar	SHT-3	8-	F	liquid return to tank	pressure gauge	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
PT	673	Ar	489659	4-	C	Liquid argon supply trailer	pressure transmitter	0 - 100 psig	100 psig	Ashcroft	Duratran #2279
MV	674	Ar	SHT-3	6-	F	inline purity monitor bypass	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8101
MV	675	Ar	SHT-3	7-	F	liquid return to tank	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
MV	676	Ar	SHT-3	6-	E	filter bypass	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
MV	677	Ar	SHT-3	6-	F	inline purity monitor bypass	manual valve	NA	1000 psig	Swagelok	SS-8BG-TW
PI	678	Ar	SHT-3	6-	F	inline purity monitor bypass	pressure gauge	vac - 160 psig	160 psig	WIKA	230.15 2" P/N 50328808
PI	680	Ar	SHT-3	2-	F	Lar supply	local pressure indicator	vac - 150 psig	150 psig	Ashcroft	25HPGG4FMVCRLXLL30IMV&150#
MV	681	Ar	SHT-3	2-	F	Lar supply	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
FCV	682	N2	*SHT-2*	7-	E	nitrogen purge - spare	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
PSV	683	Ar	SHT-3	6-	F	liquid return to tank	relief valve	100 psig	2400 psig	Circle Seal	5100-4MP
PI	684	Har	SHT-3	7-	H	regeneration gas heater inlet	pressure gauge	vac - 150 psig	150 psig	US Gauge	FNAL stock item 1050-003500
MV	685	Har	SHT-3	7-	H	regeneration gas heater inlet	manual valve	NA	1000 psig	Sharpe	84-6-6-P-G-SW
MV	686	Har	SHT-3	3-	G	regeneration vent drain	manual valve	NA	1000 psig	Swagelok	B-4HK-2
MV	687	Har	SHT-3	3-	G	regeneration vent drain	manual valve	NA	1000 psig	Swagelok	B-4HK-2
MV	688	Ar	SHT-3	3-	B	post pump Lar trapped volume	manual valve	NA	1000 psig	Swagelok	SS-4BG-V47
MV	689	Ar	SHT-3	3-	B	post pump Lar trapped volume	manual valve	NA	300 psig	Swagelok	6L-ELD8-CCXX

Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
PI	690	Ar	SHT-3	3-	B	post pump Lar trapped volume	pressure gauge	vac - 150 psig	150 psig	Ashcroft	25HPGG4FMVCRLXLL30IMV&150#
MV	691	Ar	SHT-3	7-	F	tank liquid return trapped volume	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
MV	692	Ar	SHT-3	7-	F	tank liquid return trapped volume	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
PSV	693	Ar	SHT-3	7-	E	trapped volume relief	relief valve	100 psig	2400 psig	Generant	CRV8-8V-K-100-PSI
MV	694	Ar	SHT-3	7-	G	inline purity monitor	manual valve	NA	100 psig	Varian	951-5017
MV	695	Ar	SHT-3	7-	G	liquid return to tank	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
PSV	696	Ar	SHT-3	7-	G	cool pump cool down valving	relief valve	100 psig	2400 psig	Generant	CRV8-8V-K-100-PSI
PI	697	Ar	SHT-3	8-	E	vaporizer outlet	pressure gauge	0 - 15 psig	15 psig	USG	NA
PI	698	Ar	SHT-3	7-	G	pump discharge	pressure gauge	vac - 150 psig	150 psig	Ashcroft	25HPGG4FMVCRLXLL30IMV&150#
SV	699	Ar	SHT-3	8-	E	LAr electric vaporizer	solenoid valve	NA	500 psig	included with vaporizer package	NA
TS	700	Ar	SHT-3	8-	E	LAr electric vaporizer	temperature switch	- 20 F	500 psig	included with vaporizer package	NA
HTR	701	Ar	SHT-3	8-	E	LAr electric vaporizer	heater	NA	500 psig	included with vaporizer package	NA
AE	702	Har	SHT-3	3-	G	Regeneration gas vent	Hydrogen analyzer	0 - 10% H2	atm	Beacon	110
PT	703	Ar	SHT-3	6-	F	O2 filter discharge	pressure transmitter	0 - 250 psia	250 psia	Setra	2251250PAD41106
PT	704	Ar	SHT-3	8-	F	Tank side of return particulate filter	pressure transmitter	0 - 250 psia	250 psia	Setra	2251250PAD41106
SV	705	Har	SHT-3	7-	H	Regen gas to filters	solenoid valve	NA	100 psig	Asco	8210B054
SV	706	Har	SHT-3	7-	H	H2/Ar dilution shutoff	solenoid valve	NA	100 psig	Asco	8210B054
PI	707	Har	SHT-3	3-	H	O2 filter regeneration vent H2 analyzer	pressure gauge	vac - 30 psig	30 psig	USG	FNAL stock item 1050-002500
MV	708	Har	SHT-3	3-	H	O2 filter regeneration vent H2 analyzer	manual valve	NA	1000 psig	Swagelok	B-4HK
FCV	709	Har	SHT-3	3-	H	O2 filter regeneration vent H2 analyzer	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
MV	710	Har	SHT-3	3-	H	H2 analyzer	manual valve	NA	1000 psig	Swagelok	B-4HK
FCV	711	Har	SHT-3	3-	H	H2 analyzer	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
MV	712	Har	SHT-3	3-	H	H2 analyzer	manual valve	NA	1000 psig	Swagelok	B-4HK
FCV	713	Har	SHT-3	3-	H	H2 analyzer	rotometer	30-240 sccm	100 psig	Dwyer	RMA-11-SSV
FCV	714	Har	SHT-3	7-	H	H2/Ar dilution	rotometer	10 - 1000 SCFH	100 psig	Dwyer	RMC-102-SSV
PI	715	Har	SHT-3	7-	H	H2/Ar dilution	pressure gauge	vac - 150 psig	150 psig	US Gauge	FNAL stock item 1050-003500
MV	716	Har	SHT-3	7-	H	H2/Ar dilution	manual valve	NA	1000 psig	Swagelok	B-4HK
MV	717	Ar	SHT-3	5-	B	pump strainer vent	manual valve	NA	1000 psig	Swagelok	SS-4BG-V47
MV	718	Ar	SHT-3	4-	C	pump discharge cooldown	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
MV	719	Ar	SHT-3	4-	C	pump discharge	manual valve	NA	1000 psig	Swagelok	SS-8BG-V47
PSV	720	Ar	SHT-3	3-	C	pump discharge trapped volume relief	relief valve	100 psig	2400 psig	Generant	CRV8-8V-K-100-PSI
SP	721	Ar	SHT-3	5-	F	Post filter particulate	particulate filter	NA	820 psig	GKN and FNAL	GKN tool # 9111/5
FO	722	Ar	SHT-3	6-	F	inline purity monitor	orifice	3/8" (~Cv = 2)	NA	Fermilab	NA
MV	803	N2	SHT-4	6-	G	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
SP	804	N2	SHT-4	6-	G	gas analyzers	H2O filter	NA	350	Matheson	460 (housing) + 461 (cartridge)
MV	805	N2	SHT-4	5-	G	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	806	N2	SHT-4	5-	G	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
SP	807	N2	SHT-4	5-	G	gas analyzers	O2 filter	NA	150 psig	Airgas	Y40-RES0010K with Y40-RES0301 oxygen cartridge
MV	808	N2	SHT-4	5-	G	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	809	N2	SHT-4	6-	G	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	810	N2	SHT-4	6-	F	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
SP	811	N2	SHT-4	6-	F	gas analyzers	H2O filter	NA	350 psig	Matheson	460 (housing) + 461 (cartridge)
MV	812	N2	SHT-4	5-	F	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	813	N2	SHT-4	5-	F	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
SP	814	N2	SHT-4	5-	F	contaminant gas to analyzers	O2 filter	NA	150 psig	Airgas	Y40-RES0010K with Y40-RES0301 oxygen cartridge
MV	815	N2	SHT-4	5-	F	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
AE	819	V	SHT-4	2-	E	vicinity of LAPD tank	ODH O2 sensor	0-25% O2	atm	MSA	A-ULTIMAX-PL-A-14-03D2-0000-100
AE	820	V	SHT-4	2-	D	vicinity of LAPD tank	ODH O2 sensor	0-25% O2	atm	MSA	A-ULTIMAX-PL-A-14-03D2-0000-100
FS	821	V	SHT-4	1-	D	ODH blower inlet duct	pressure differential switch	100-1000 cm/sec	atm	Efector	SL5101
MV	822	Ar	SHT-3		F	analyzer pump input	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
MV	827	N2	SHT-4	5-	F	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	828	N2	SHT-4	5-	G	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
PI	829	N2	SHT-4	5-	G	gas analyzers	pressure indicator	vac - 160 psig	160 psig	Wika	230.15-B-PV412-Z-WI-UZ-ZZZ ZZ
CV	830	N2	SHT-4	5-	F	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4
CV	831	Ar	SHT-4	6-	F	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4
MV	840	Ar	SHT-4	3-	F	gas analyzers	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
MV	841	Ar	SHT-4	3-	F	gas analyzers	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
PI	842	Ar	SHT-4	4-	F	gas analyzers	pressure indicator	vac - 60 psig	60 psig	Wika	230.15-B-PV352-Z-WI-UZ-ZZZ ZZ
PT	843	Ar	SHT-4	4-	F	gas analyzers	pressure transmitter	0 - 100 psia	150 psig	Setra	2251100PAC411B1
PI	844	Ar	SHT-4	4-	F	gas analyzers	pressure indicator	vac - 60 psig	60 psig	Wika	230.15-B-PV352-Z-WI-UZ-ZZZ ZZ
PT	845	Ar	SHT-4	4-	F	gas analyzers	pressure transmitter	0 - 100 psia	150 psig	Setra	2251100PAC411B1
PSV	846	Ar	SHT-4	4-	F	gas analyzers	relief valve	40 psig	2400 psig	Circle Seal	5100-2MP
CV	847	Ar	SHT-4	4-	F	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4
MV	848	Ar	SHT-4	4-	F	gas analyzers	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
MV	849	Ar	SHT-4	4-	F	gas analyzers	manual valve	NA	250 psig	Swagelok	6LVV-DPBW4-P
PI	850	Ar	SHT-4	3-	F	gas analyzers	pressure indicator	vac - 60 psig	60 psig	Wika	230.15-B-PV352-Z-WI-UZ-ZZZ ZZ
PCV	851	N2	SHT-4	3-	F	gas analyzers	pressure control valve	0 - 30 psig	300 psig	Matheson	9332-3-V4FF
EV	852	Ar	SHT-4	3-	F	gas analyzers	control valve	Cv max = 0.02	750 psig	Swagelok	SS-4BMG-V51 w/actuator (Custom part # OS-FERMI-004)
MV	853	Ar	SHT-4	3-	F	gas analyzers	manual valve	NA	1000 psig	Swagelok	SS-4BG-TW
AE	860	V	SHT-4	3-	D	gas analyzers	Dewpoint meter	-80 to +20 C	290 psia	Vaisala	DMT242A1A1A1B
AE	861	V	SHT-4	6-	C	gas analyzers	Dewpoint meter	-80 to +20 C	290 psia	Vaisala	DMT242A1A1A1B
MV	900	V	SHT-4	5-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	901	V	SHT-4	5-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	902	V	SHT-4	5-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250

Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
MV	903	V	SHT-4	6-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	904	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	905	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	906	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	907	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	908	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	909	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	910	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	911	V	SHT-4	6-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	912	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	913	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	914	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	915	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	916	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	917	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	918	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	919	V	SHT-4	6-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	920	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	921	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	922	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	923	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	924	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	925	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	926	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	927	V	SHT-4	6-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	928	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	929	V	SHT-4	5-	A	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	930	V	SHT-4	5-	A	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	931	V	SHT-4	5-	A	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	932	V	SHT-4	5-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	933	V	SHT-4	5-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	934	V	SHT-4	5-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	935	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	936	V	SHT-4	4-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	937	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	938	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	939	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	940	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	941	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	942	V	SHT-4	5-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	943	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	944	V	SHT-4	4-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	945	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	946	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	947	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	948	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	949	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	950	V	SHT-4	5-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	951	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	952	V	SHT-4	4-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	953	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	954	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	955	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	956	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	957	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	958	V	SHT-4	5-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	959	V	SHT-4	5-	A	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	960	V	SHT-4	4-	B	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	961	V	SHT-4	5-	A	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	962	V	SHT-4	5-	A	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	963	V	SHT-4	5-	A	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	964	V	SHT-4	6-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
MV	965	V	SHT-4	6-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
PE	966	V	SHT-4	6-	E	gas analyzers	pressure element	NA	~ 1 atm	Granville Phillips	275 Convectron Gauge
CV	967	V	SHT-4	6-	E	gas analyzers	check valve	2 psig	3000 psig	Circle Seal	249T14PP-2 psi
CV	968	V	SHT-4	6-	D	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4
MV	969	V	SHT-4	6-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
CV	970	V	SHT-4	6-	C	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4
PCV	971	V	SHT-4	6-	B	gas analyzers	pressure control valve	0 - 30 psig	300 psig	Matheson	9332-3-V4FF
PI	972	V	SHT-4	6-	B	gas analyzers	pressure indicator	30"-0-60 psig	60 psig	Matheson	supplied with regulator
CV	973	V	SHT-4	6-	B	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4
PCV	974	V	SHT-4	4-	D	gas analyzers	pressure control valve	0 - 30 psig	300 psig	Matheson	9332-3-V4FF
PI	975	V	SHT-4	4-	D	gas analyzers	pressure indicator	30"-0-60 psig	60 psig	Matheson	supplied with regulator
CV	976	V	SHT-4	4-	D	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4

Instr Code	Tag #	Serv. Code	PID	GRID	LOC	Service Description	Instrument Type	Operating Range or Setpoint	Pressure Rating	Manufacturer	Model No.
CV	977	V	SHT-4	4-	C	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4
MV	978	V	SHT-4	4-	C	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
PCV	979	V	SHT-4	4-	C	gas analyzers	pressure control valve	0 - 30 psig	300 psig	Matheson	9332-3-V4FF
PI	980	V	SHT-4	4-	C	gas analyzers	pressure indicator	30"-0-60 psig	60 psig	Matheson	supplied with regulator
CV	981	V	SHT-4	4-	C	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4
PCV	982	V	SHT-4	4-	B	gas analyzers	pressure control valve	0 - 30 psig	300 psig	Matheson	9332-3-V4FF
PI	983	V	SHT-4	4-	B	gas analyzers	pressure indicator	30"-0-60 psig	60 psig	Matheson	supplied with regulator
CV	984	V	SHT-4	4-	B	gas analyzers	check valve	2 psig	3000 psig	Swagelok	6L-CW4FR4
AE	990	V	SHT-4	7-	D	gas analyzers	oxygen analyzer	0 - 2.5 ppm	125 psig	Tiger Optics	LaserTrace O2
AE	991	V	SHT-4	7-	C	gas analyzers	water analyzer	0 - 20 ppm	125 psig	Tiger Optics	HaloTrace H2O
AE	992	V	SHT-4	7-	B	gas analyzers	oxygen analyzer	0 - 50 ppm	30 psig	Delta-F	DF-310E
AE	993	V	SHT-4	4-	D	gas analyzers	nitrogen analyzer	0 - 100 ppm	30 psig	Servomex/Kontrol Analytik	K2001
AE	994	V	SHT-4	4-	D	gas analyzers	water analyzer	0 - 5 ppm	125 psig	Tiger Optics	LaserTrace H2O
AE	995	V	SHT-4	4-	B	gas analyzers	oxygen analyzer	0 - 100 ppm	30 psig	Delta-F	NanoTrace II DF-560
AE	996	V	SHT-4	4-	A	gas analyzers	oxygen analyzer	0 - 5000 ppm	30 psig	Delta-F	DF-310
MV	997	V	SHT-4	6-	E	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
PI	998	V	SHT-4	6-	E	gas analyzers	pressure indicator	vac - 60 psig	60 psig	Wika	230.15-B-PV352-Z-WI-UZ-ZZZ ZZ
MV	999	V	SHT-4	6-	D	gas analyzers	manual valve	NA	375 psig	Carten	MD-250
SP	1001	N2	SHT-1	3-	G	N2 liquid to LBNE 35T	particulate filter	NA	1400 psig	McMaster	4745K555
MV	1002	N2	SHT-1	3-	G	N2 liquid to LBNE 35T instrumentation	manual valve	NA	1000 psig	Swagelok	B-4HK2
MV	1003	N2	SHT-1	3-	G	N2 liquid to LBNE 35T instrumentation	manual valve	NA	1000 psig	Swagelok	B-4HK2
PI	1004	N2	SHT-1	3-	G	N2 liquid to LBNE 35T instrumentation	pressure indicator	vac - 150 psig	150 psig	US Gauge	FNAL STK 1050-003500
MV	1005	N2	SHT-1	3-	G	N2 liquid to LBNE 35T	manual valve	NA	870 psig	Worcester	1" #C4466 PM SW
MV	1006	N2	SHT-1	3-	G	N2 liquid to LBNE 35T instrumentation	manual valve	NA	1000 psig	Swagelok	B-4HK2
MV	1007	N2	SHT-1	3-	G	N2 liquid to LBNE 35T instrumentation	manual valve	NA	1000 psig	Swagelok	B-4HK2
PSV	1008	N2	SHT-1	3-	G	N2 liquid to LBNE 35T	relief valve	100 psig	2400 psig	Circle Seal	5100-4MP
PI	1009	N2	SHT-1	3-	G	N2 liquid to LBNE 35T instrumentation	pressure gauge	vac - 150 psig	150 psig	US Gauge	FNAL STK 1050-003500
PT	1010	N2	SHT-1	3-	G	N2 liquid to LBNE 35T	pressure transmitter	vac - 135 psig	135 psig	Setra	5161-135P-C-2M-11-B1-H
MV	5001	Ar	SHT-3	4-	A	LBNE 35T to filter (isolation)	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8101
MV	5002	Ar	SHT-3	7-	F	LBNE 35T from filters (isolation)	manual valve	NA	165 psid	Eden Cryogenics	BC-02146-8101

Appendix 2 MathCad Wall Thickness, Trapped Volume Relief Sizing, and Ambient Vaporizer Wind Loading Calculations

LAPD N2 Supply Piping
Min Wall Thickness

rev. 09-06-10

The minimum thickness of the piping is dictated by ASME B31.3, 304.1.2(a), Straight Pipe Under Internal Pressure.

The solenoids used for the nitrogen service can operate up to a maximum pressure differential of 100 psig. The 100 psig will be used as the design pressure.

Piping / Tubing Design Gage Pressure

$P_{design} := 100 \cdot psi$ g

LN2 Density @100 psig per refprop

$LN2_{dens} := 50.5 \cdot \frac{lbm}{ft^3}$

Basic Brazed (Socket) Copper Tubing Data

Allowable Copper Tubing Stress, Table A-1

$S_{A1} := 6000 \cdot psi$

ref: ASME B31.3-2008

SIF, stress intensification factor, B31.3 Table D300, note (13)

$SIF := 2.1$

Y coefficient from B31.3, Table 304.1.1

$Y_{coeff} := 0.4$

Weld strength reduction factor, B31.3, 302.3.5(e)

$W_{factor} := 1.00$

Quality factor, Table A-1B

$E_{factor} := 1.00$

reference modulus of elasticity at 70 F, Table C-6

$E_a := 17 \cdot 10^6 \cdot psi$

Tubing Data, Type K Copper Tubing

The largest copper tube size used is 1". Smaller 3/4" and 1/2" tubing is also used.

Nominal Tube Wall Thickness	Tube Outside Diameter
$TWall_{th.1} := 0.065 \cdot in$	$Tube_{OD.1} := 1.125 \cdot in$
$TWall_{th.3Q} := 0.065 \cdot in$	$Tube_{OD.3Q} := 0.875 \cdot in$
$TWall_{th.half} := 0.049 \cdot in$	$Tube_{OD.half} := 0.625 \cdot in$

ref: The Copper Tube Handbook, Copper Development Association, A4015-04/06, Table 2a.

Minimum Wall Thickness

per B31.3-2008 eqn 3.

$$\frac{Tube_{OD.1}}{6} = 0.188 \cdot in$$

wall thickness of the largest tube size is less than D/6 therefore B31.3, equation 3a applies.

For 1" tubing

$$t_{min.req.1} := \frac{P_{design} \cdot Tube_{OD.1}}{2 \cdot \left(S_{A1} \cdot E_{factor} \cdot W_{factor} + P_{design} \cdot Y_{coeff}\right)} = 0.0093 \cdot in$$

actual tube wall thickness $TWall_{th.1} = 0.065 \cdot in$

For 3/4" tubing

The 3/4" tubing has the same wall thickness as the 1" tubing. B31.3 minimum wall thickness goes down with decreasing diameter. Therefore the 3/4" tube wall also exceeds the minimum required.

For 1/2" tubing

$$t_{min.req.half} := \frac{P_{design} \cdot Tube_{OD.half}}{2 \cdot \left(S_{A1} \cdot E_{factor} \cdot W_{factor} + P_{design} \cdot Y_{coeff}\right)} = 0.0052 \cdot in$$

actual tube wall thickness $TWall_{th.half} = 0.049 \cdot in$

Actual wall thickness exceeds the minimum wall thickness called for by B31.3 for the 1", 3/4" and 1/2" type K copper tubing selected.

N2 Supply Piping
Trapped Volume Relief Sizing

This calculation is for sizing the relief rate for trapped volumes in the LN2 supply piping for LAPD. The formulas and factors are per CGA S-1.3-2005, piping pressure relief.

The outdoor piping will pass over a grassy berm. Since the grass is flammable, fire case is evaluated with part of the pipe exposed to fire. It is assumed that that a 10 ft section of pipe could be exposed to fire.

There are no flammables that could engulf the pipe and LN2 is not flammable so the required relief capacity will be reduced to 30% of calculated as allowed for in CGA S-1.3-2005, section 6.3.

The LN2 piping is pre-insulated in polyurathane with a PVC jacket.

Fire Relief

Pipe outside diameter, 1" copper

$Pipe_{dia} := Tube_{OD.1} = 1.125 \cdot in$

Pipe Length

$Pipe_{l.fire} := 10 \cdot ft$

Total Outside Pipe Surface Area

$Area_{pipe} := 2\pi \frac{Pipe_{dia}}{2} \cdot Pipe_{l.fire}$

$Area_{pipe} = 2.9 \cdot ft^2$

Area for CGA formula, converted into unitless value from Area in ft2

$A := \frac{Area_{pipe}}{ft^2} = 2.9$

N2 Uninsulated Gas Factor, CGA S-1.3-2005, Table 1

$G_U := 59.0$ @ min working pressure of 100 psig

CGA S-1.3-2005 has a error in Table 1 where the data is shifted. The correct value is used here and verifed from the 2008 version.

Correction Factor per CGA S-1.3-2005, sec. 6.1.4 (inlet to RV is less than 2 ft so correction factor is 1)

$F := 1$

Required CGA Fire Relief Rate (sec 6.3.2)

$Q_{a.fire} := 30\% F \cdot G_U \cdot A^{0.82} \cdot \frac{ft^3}{min} = 42.9 \cdot \frac{ft^3}{min}$ SCFM air @ 60 F (cap. at 21% overpres.)

Relief size check for other than fire

Pipe outside diameter

$Pipe_{dia} = 1.125 \cdot in$

Insulation outside diameter

$Insul_{dia} := 6 \cdot in$

Arithmetic mean of surface diameters

$$Avg_{dia} := \frac{(Pipe_{dia} + Insul_{dia})}{2} = 3.6 \cdot in$$

Relief T

$T := -320$ F

Pipe Length

$Pipe_{l.sect} := 200 \cdot ft$

Area based on arithmetic mean surface diameter

$$Area := 2\pi \frac{Avg_{dia}}{2} \cdot Pipe_{l.sect}$$

$Area = 186.5 \cdot ft^2$

Area for CGA formula, converted into unitless value from Area in ft2

$$A := \frac{Area}{ft^2} = 186.5$$

Insulation thickness

$$Insul_{thick} := \frac{(Insul_{dia} - Pipe_{dia})}{2} = 2.4 \cdot in$$

Insulation thermal conductivity

$$k := 0.5 \cdot \frac{BTU \cdot in}{hr \cdot ft^2 \cdot F}$$

N2 Uninsulated Gas Factor, CGA S-1.3-2005, Table 1

$G_i := 10.2$ @ min working pressure of 100 psig

CGA S-1.3-2005 has a error in Table 1 where the data is shifted. The correct value is used here and verifed from the 2008 version.

Overall U based on

$$U_{insul} := \frac{k}{Insul_{thick}} = 0.2 \cdot \frac{BTU}{hr \cdot ft^2 \cdot F}$$

$$U := \frac{U_{insul}}{\frac{BTU}{hr \cdot ft^2 \cdot F}} = 0.2$$

make unitless U for CGA formula

Correction Factor per CGA S-1.3-2005, sec. 6.1.4
(inlet to RV is less than 2 ft so correction factor is 1)

$F := 1$

Required CGA Thermal Heating (non-fire) Relief Rate (sec 6.2.2)

$$Q_a := \frac{[590 - (T + 459.67)]}{4\cdot[1660 - (T + 459.67)]}\cdot F\cdot G_i\cdot U\cdot A\cdot\frac{ft^3}{min} = 28.9\cdot\frac{ft^3}{min}$$

SCFM air @ 60 F (cap.at 10% overpres.)

$$Q_{a.fire} = 42.9\cdot\frac{ft^3}{min}$$ SCFM air @ 60 F (cap. at 21% overpres.)

The thermal heating scenario is the larger rate and this rate will be used in selecting the relief device. Use of this rate for shorter lengths of the same or smaller diameter insulated pipe would be conservative.

From the Circle Seal line of relief valves, the 4MP size will be used. The 4MP

Air Flow Rates (5100–MP)

Inline valves, ⅛"–1"

Crack Pressure PSIG	Percent Over Pressure Beyond Cracking (SCFM air at room temperature)						
	10%				25%		
	1MP	2MP/3MP	4MP	6MP/8MP	1MP	2MP/3MP	4MP
15	1.0	1.5	5.0	9.0	3.0	5.0	50
20	1.5	2.0	10	12	4.0	5.0	60
25	2.0	2.7	25	27	5.4	6.5	65
30	2.4	4.6	30	36	6.2	13	68
40	3.0	5.5	34	55	6.5	25	72
50	3.0	10.5	40	65	8.0	29	74
75	4.2	14	50	70	13	38	80
100	6.0	25	54	90	17	55	90
125	8.5	32	70	120	22	58	110
150	10	36	72	150	27	78	115

N2 Ambient Vaporizer Wind Load

The LAPD N2 ambient vaporizer will be bolted to a steel plate as part of the temporary N2 supply system to LAPD. This calculation determines the additional weight needed to keep the vaporizer from tipping over in a gust of wind.

Vaporizer Data:

Vaporizer Largest Profile Area

$V_{area} := (45 \cdot in - 3 \cdot 4 \cdot in) \cdot 120 \cdot in = 27.5 \cdot ft^2$

The largest profile area is the widest side minus the three open space between fins.

Vaporizer Empty Weight

$V_{wt} := 275 \cdot lb$

Ballast in form of plate and additional weights

$ballast := 700 \cdot lb$ approx. 5ft x 7 ft x 0.5 in steel plate

The vaporizer is treated as a simple vertical structure against a horizontal wind against the largest flat profile.

Basic Wind Speed, ASCE 7-05, Fig 6-1

$W_{speed.basic} := 90 \cdot mph$

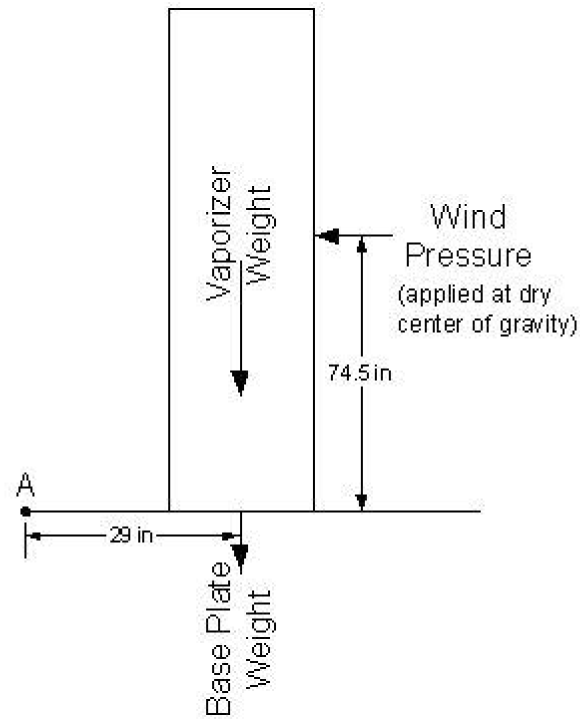
per ASCE 7-05, Minimum Design Loads for Buildings and Other Structures.

Minimum Wind Design Pressure for above basic wind speed, ASCE 7-05, Fig 6-2

$$P_{wind} := 12.8 \cdot \frac{lbf}{ft^2}$$

Wind Load on side with largest profile

$$Wind_{load} := V_{area} \cdot \frac{P_{wind}}{g} = 352 \cdot lb$$



The moments around the edge of the plate, point A, are calculated counter clockwise per the vaporizer figure shown.

$$Moment_A := Wind_{load} \cdot (74.5 \cdot in) - (V_{wt} \cdot 29 \cdot in) - (ballast \cdot 29 \cdot in)$$

$$Moment_A = -172.7 \cdot lb \cdot ft$$

The total of moments is negative, indicating that the wind load is insufficient to tip over the empty vaporizer.

The resistance to tipping increases when the vaporizer is used due to the additional weight of LN2 and ice.

Appendix 3
ANSYS Flexibility Analysis

Figure A3.1: LN2 Supply Piping FEA Model Details

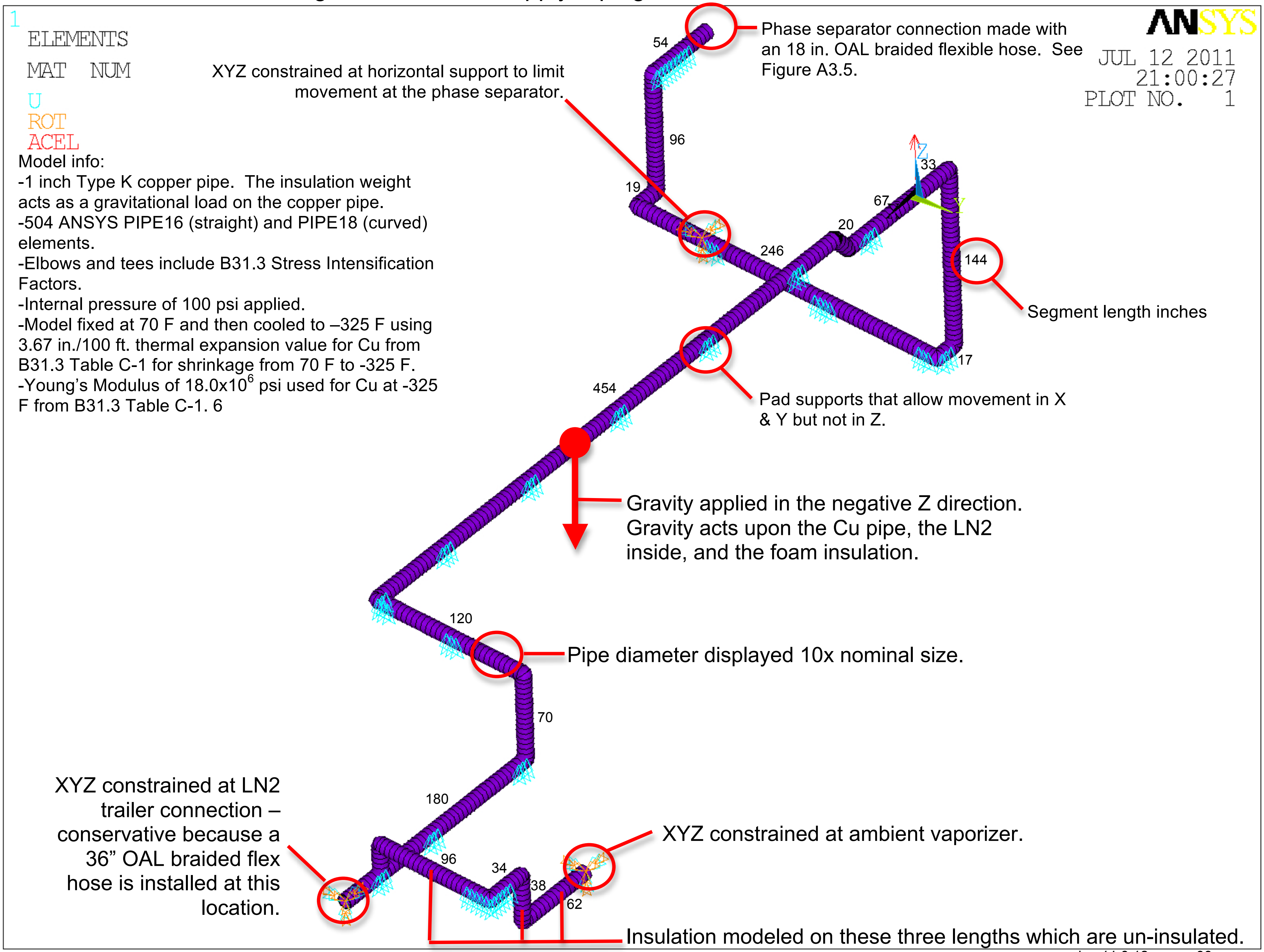


Figure A3.2: LN2 Supply Piping FEA Deformed Shape

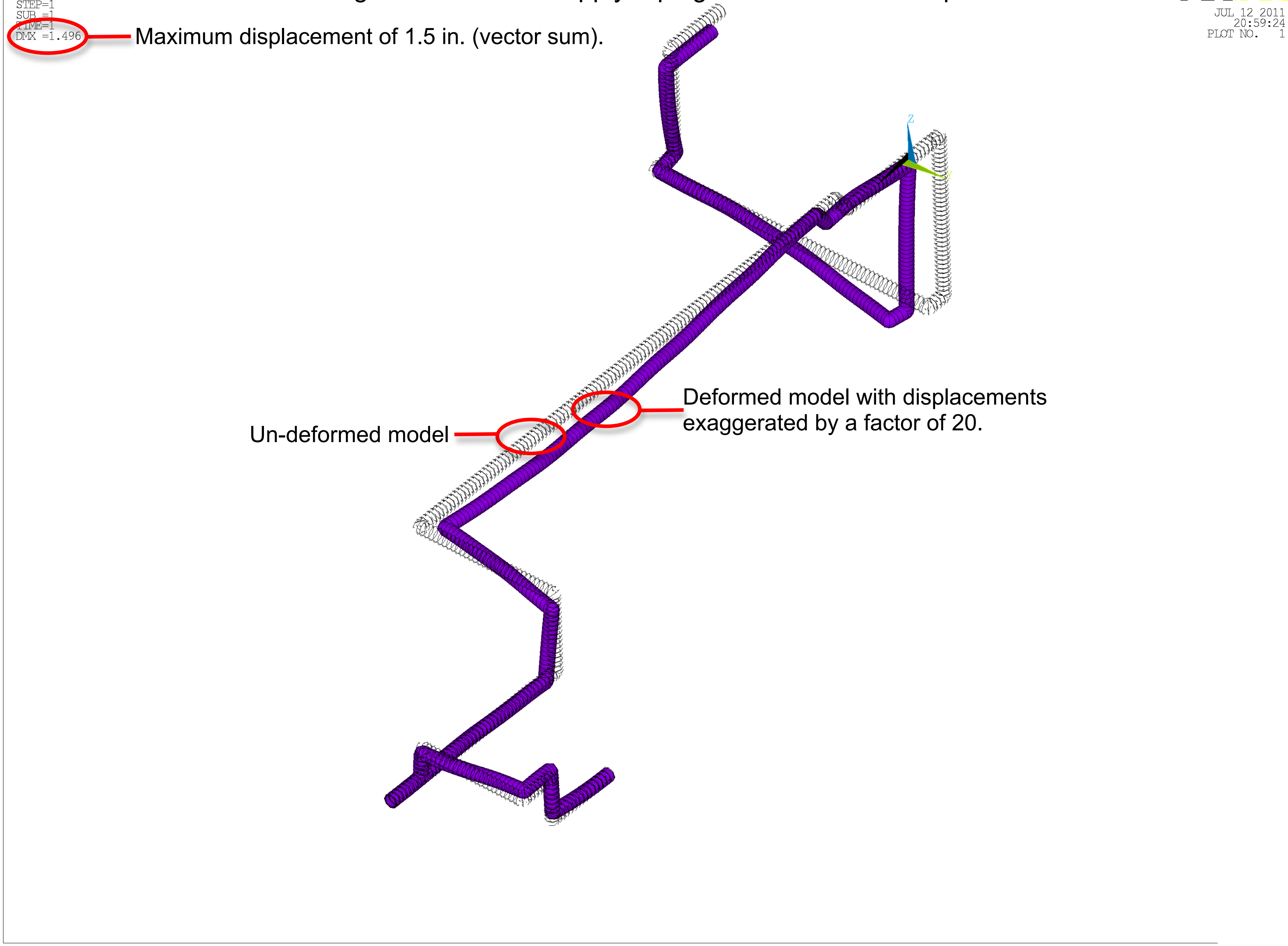
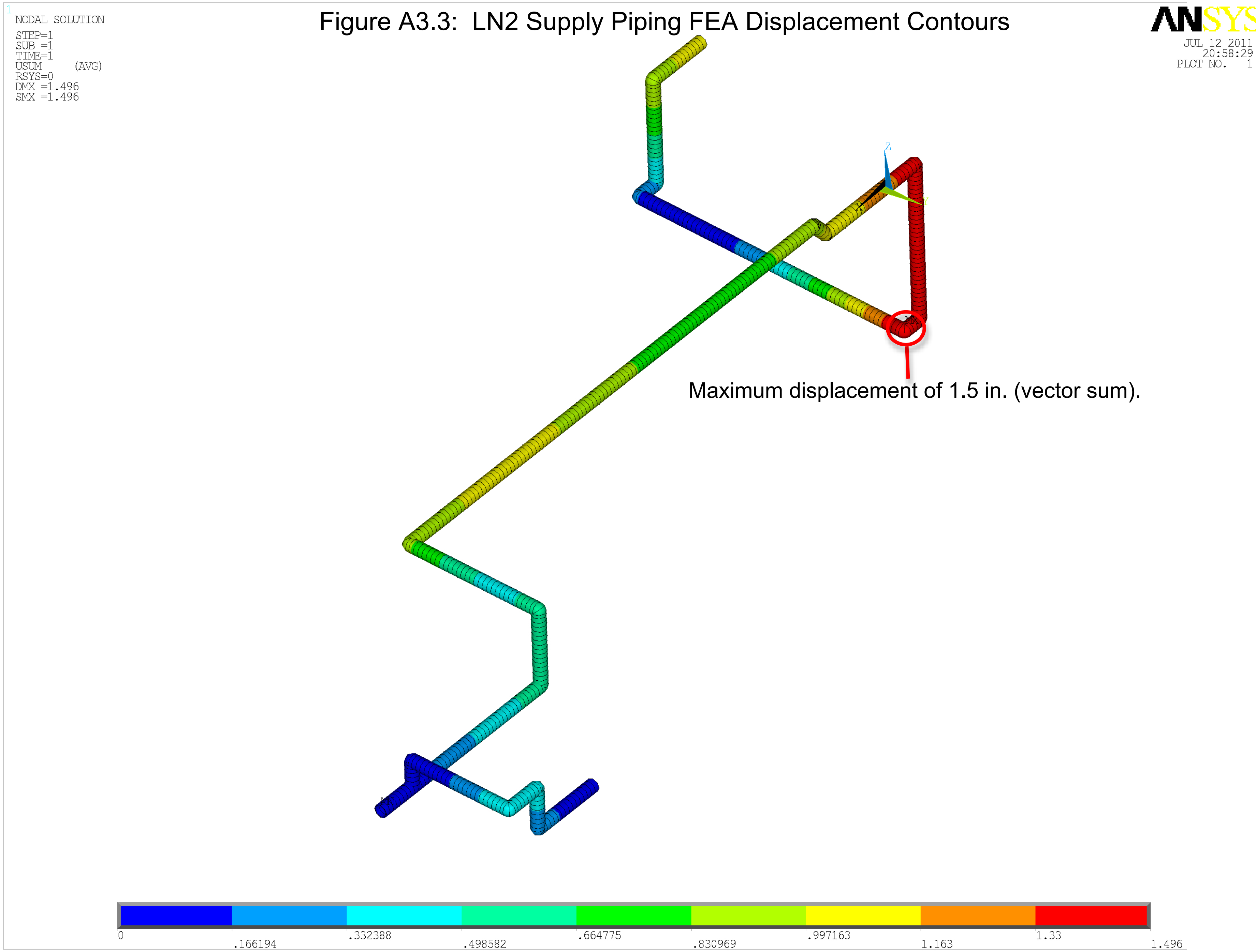
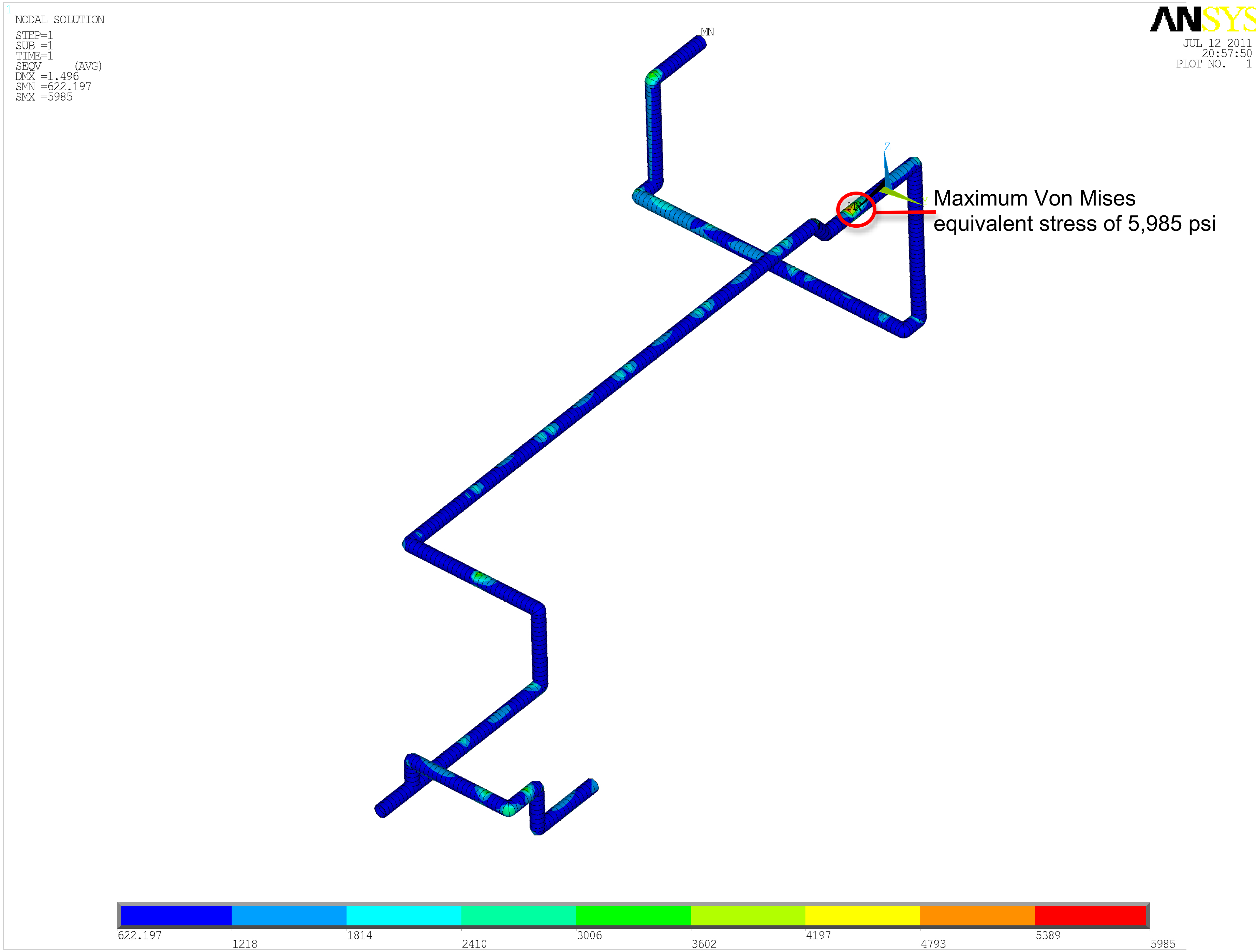


Figure A3.3: LN2 Supply Piping FEA Displacement Contours



Displacement vector sum contours (inches).

Figure A3.4: LN2 Supply Piping FEA Von Mises Stress Contours



Von Mises equivalent stress contours (psi).

Figure A3.5: LN2 Supply Piping Phase Separator and Condenser View (side)

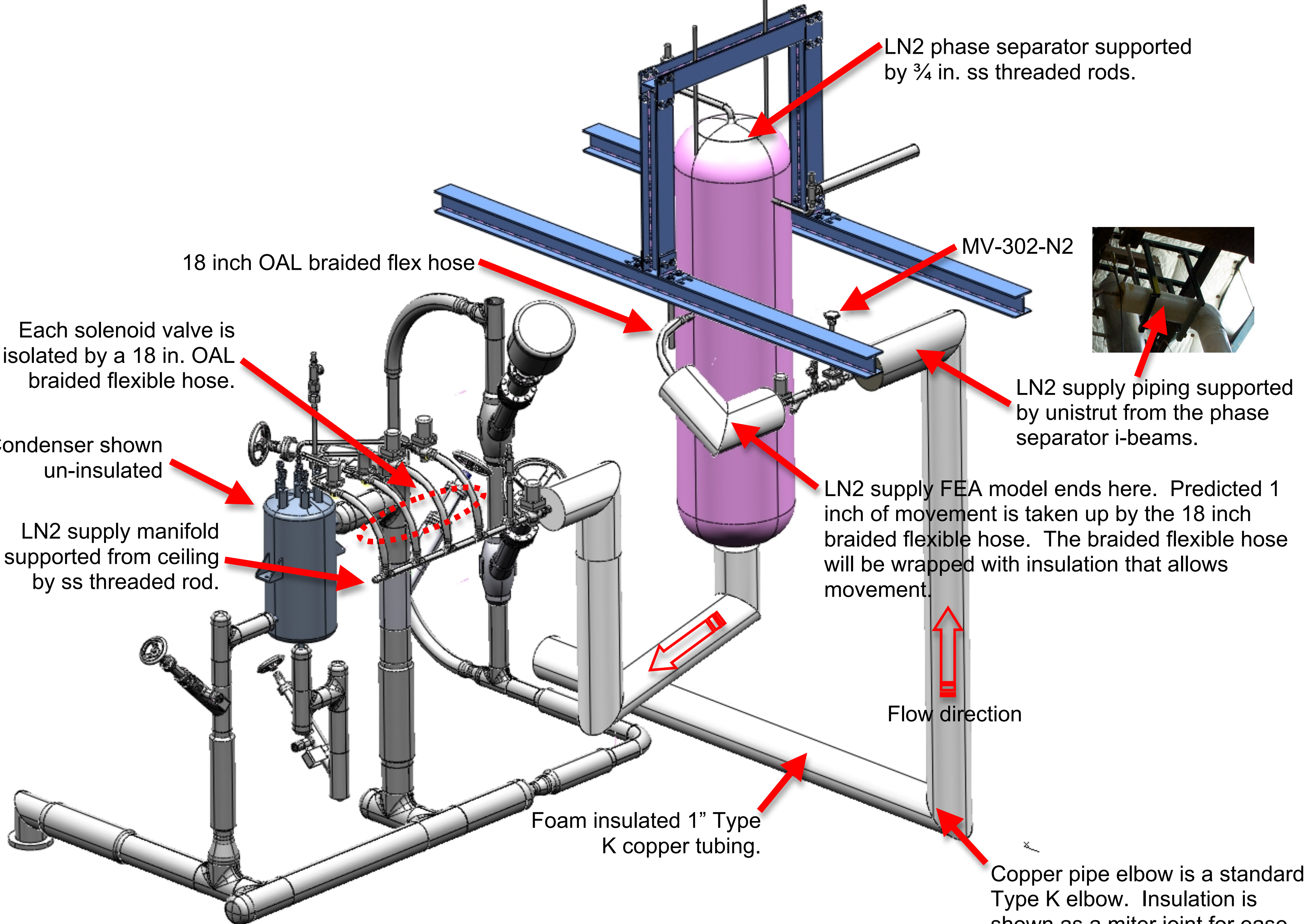


Figure A3.6: LN2 Supply Piping Phase Separator and Condenser View (top)

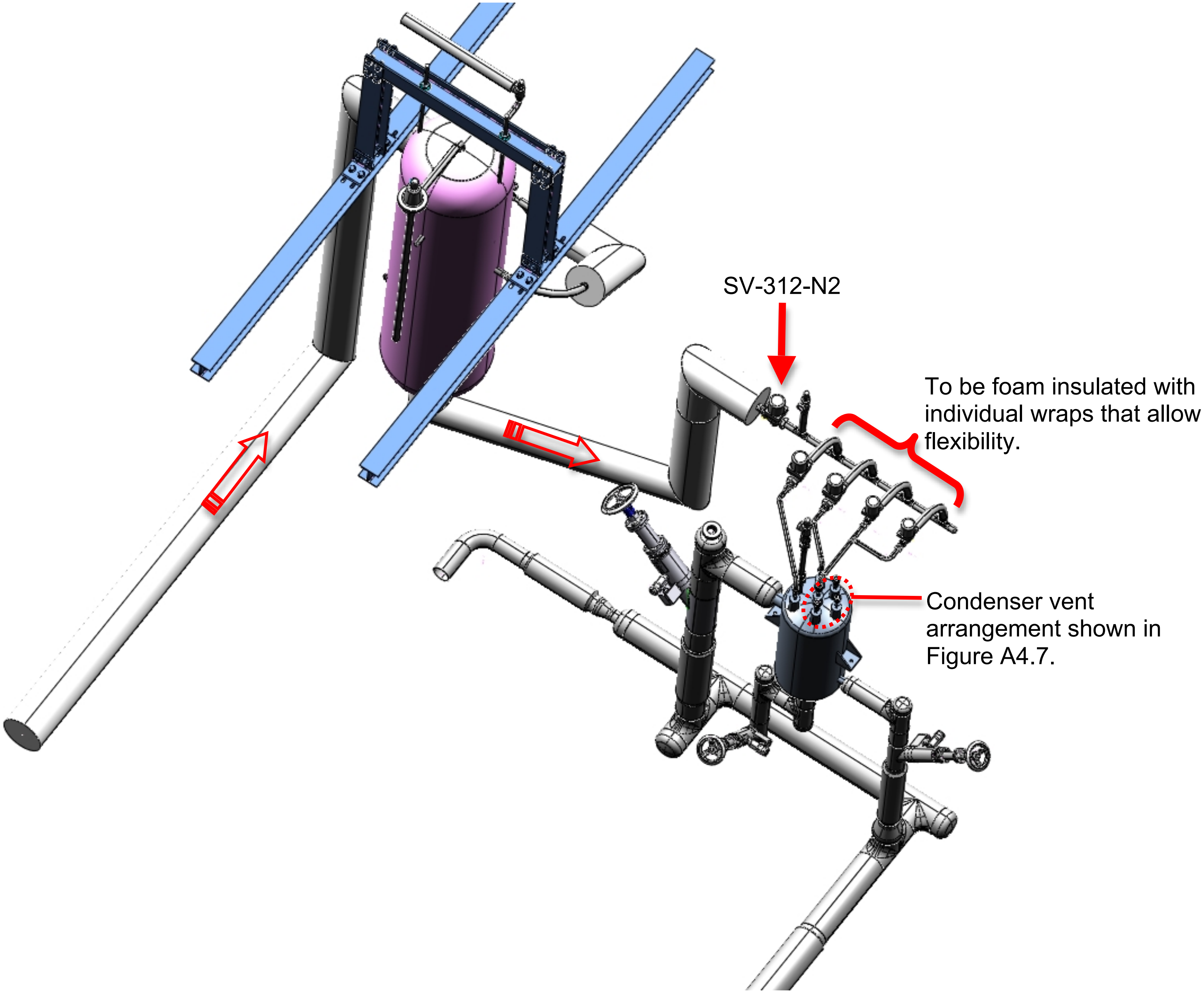


Figure A3.7: Condenser Vent Arrangement

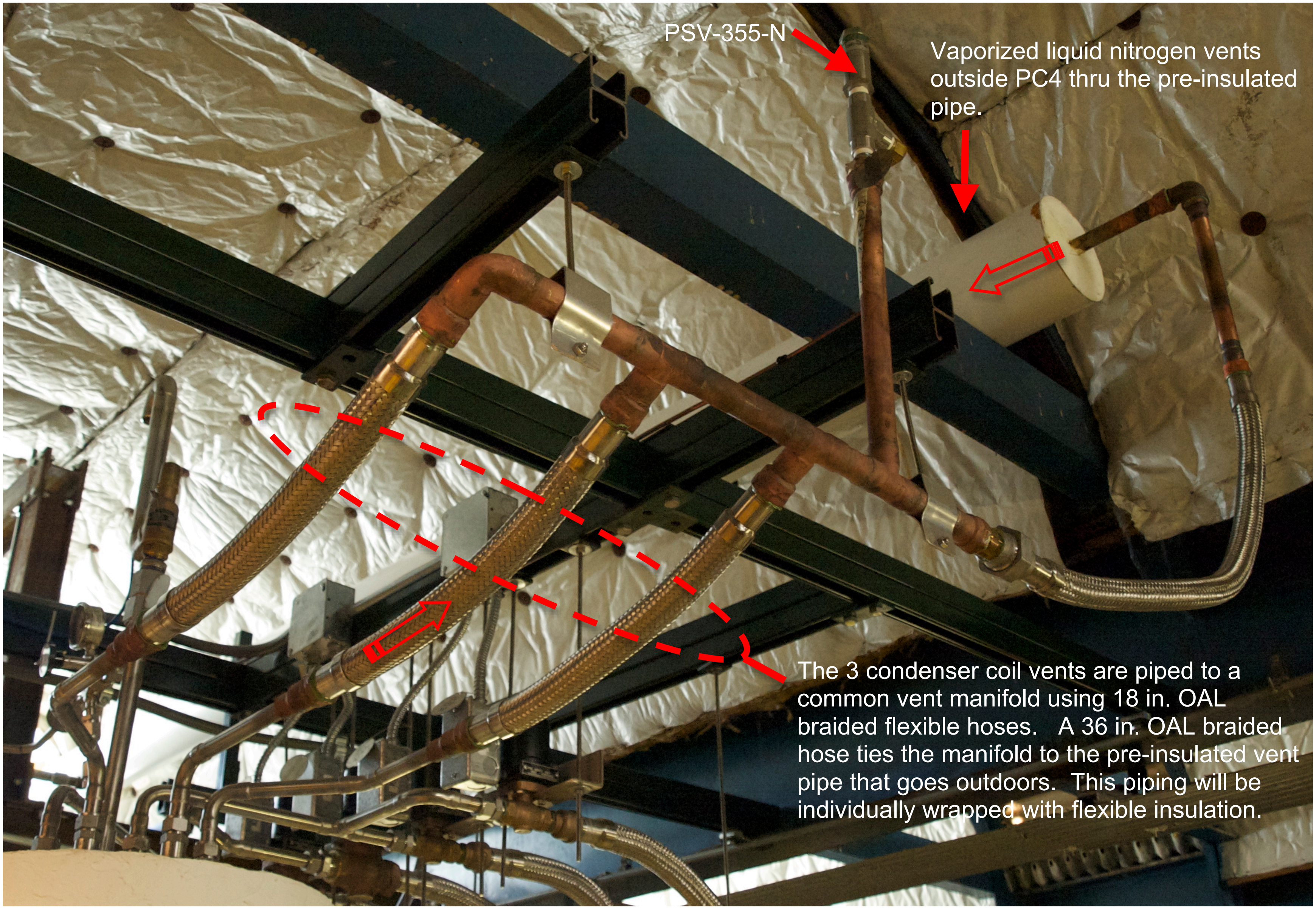
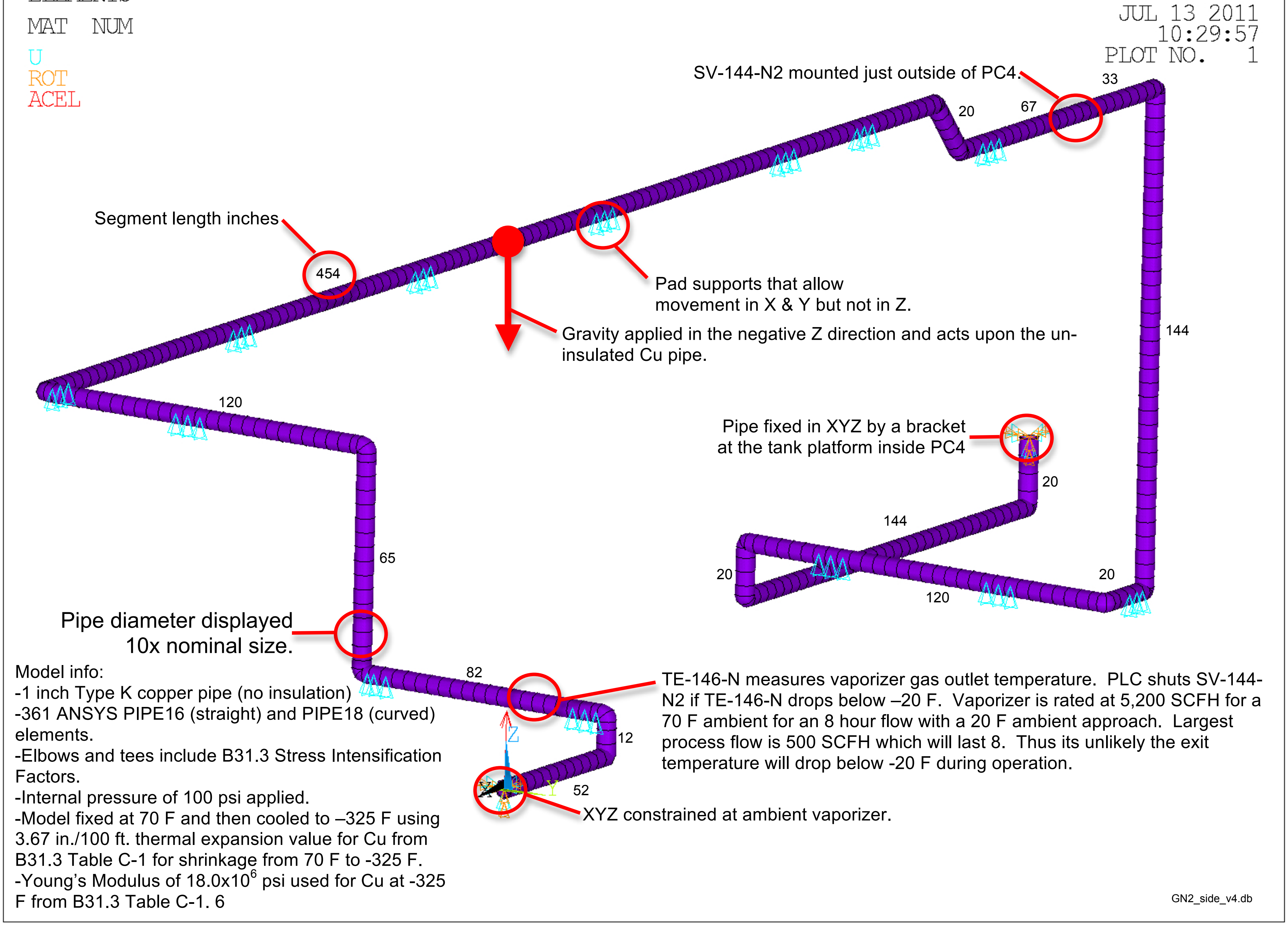


Figure A3.8: GN2 Supply Piping FEA Model Details



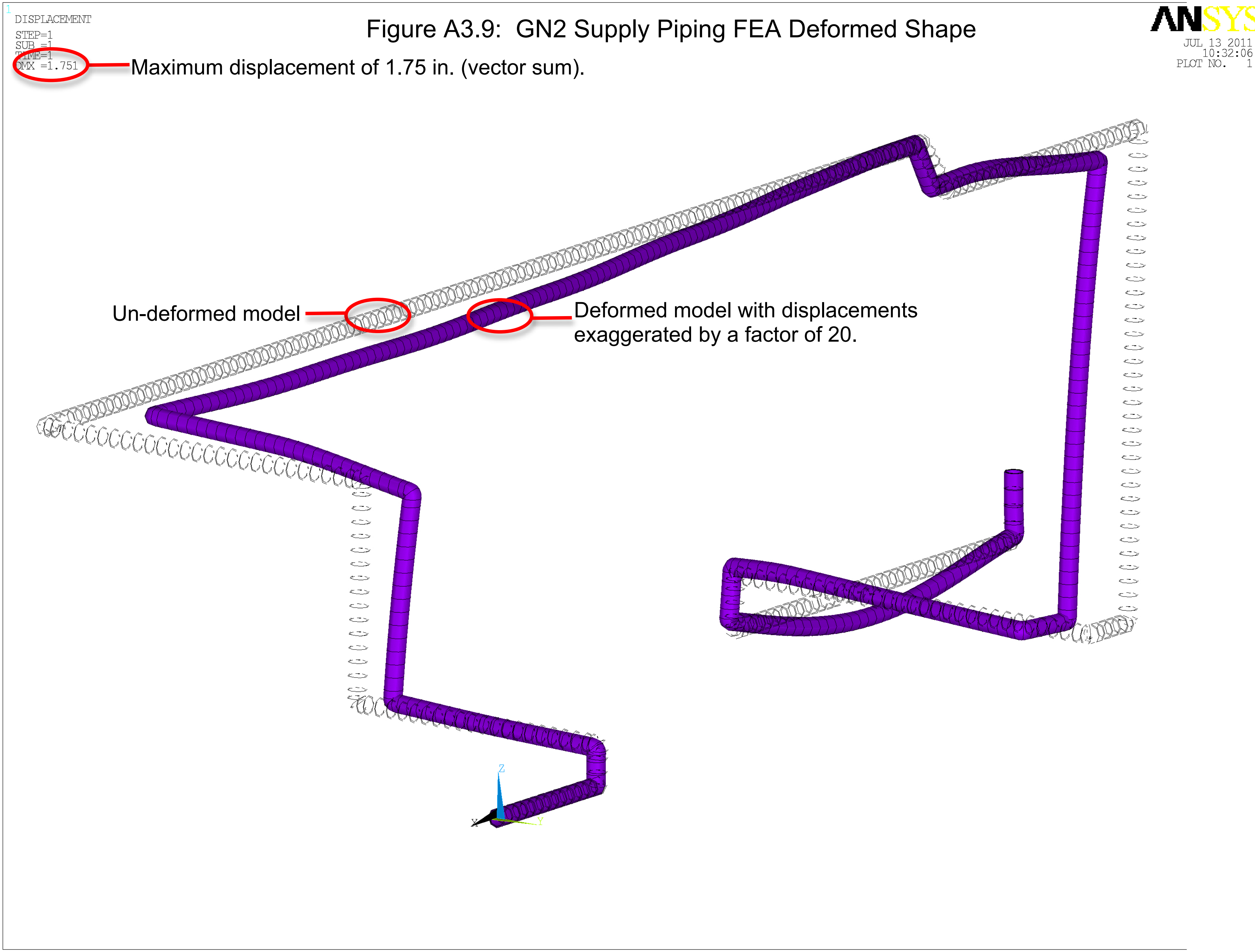
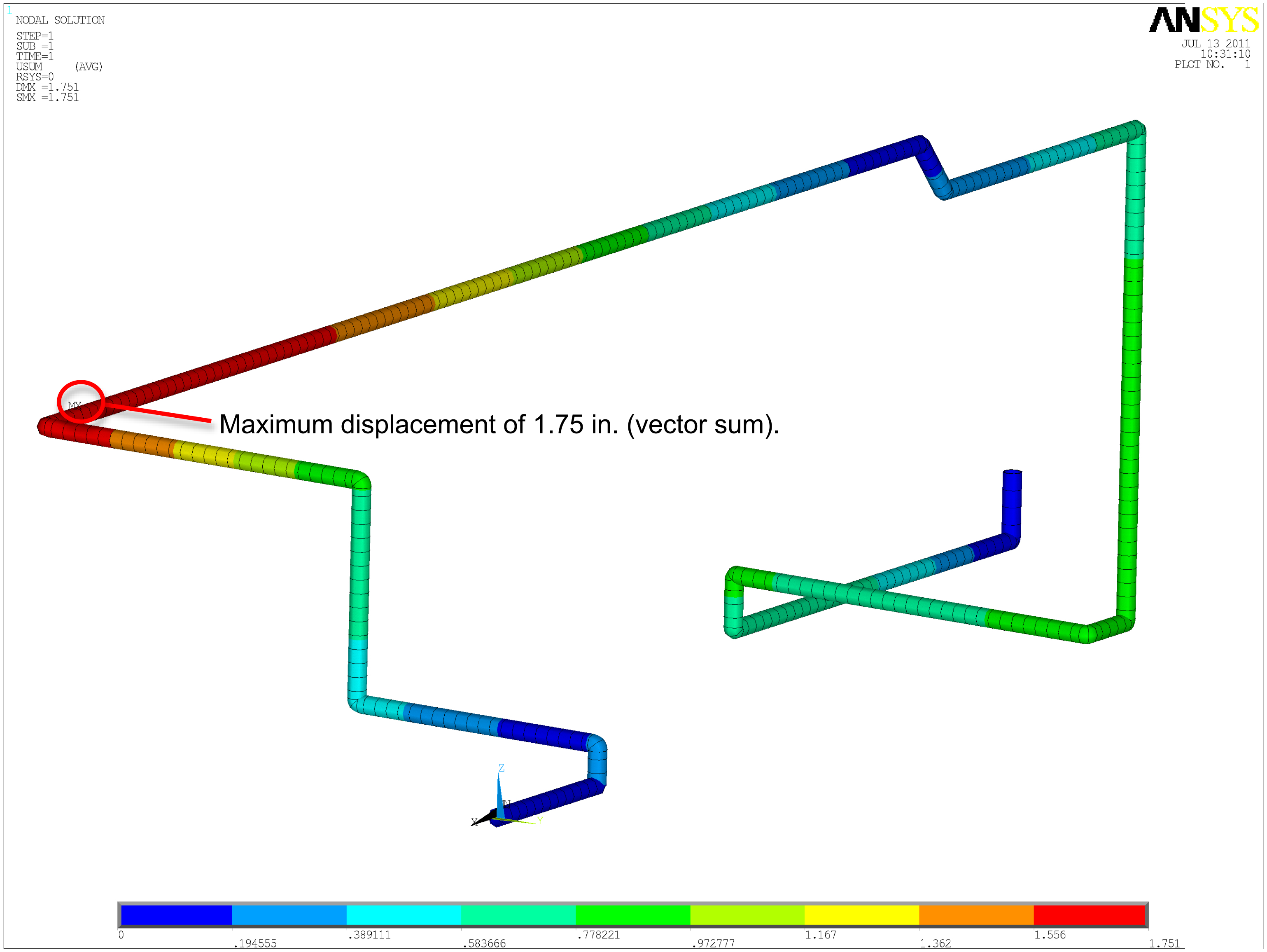


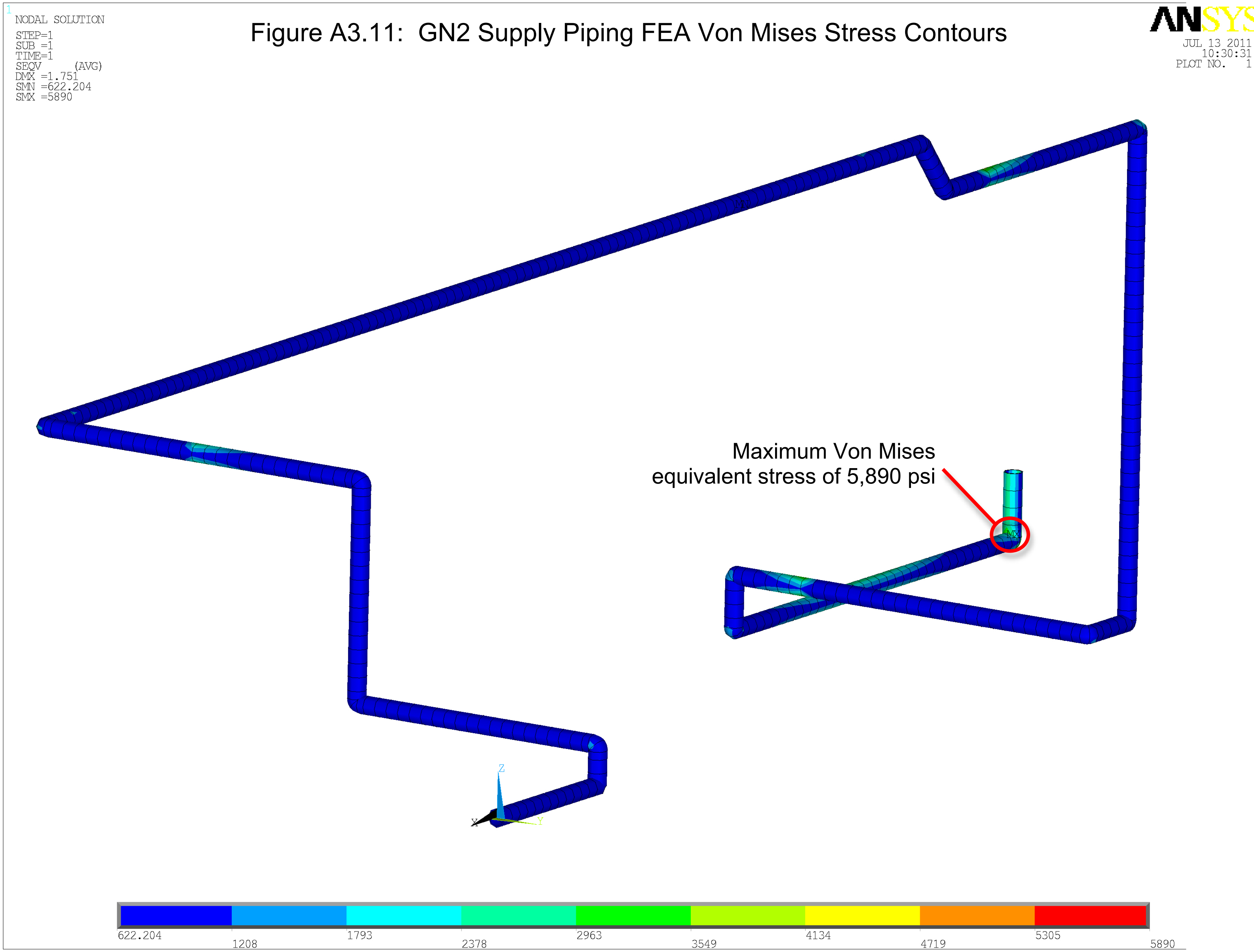
Figure A3.9: GN2 Supply Piping FEA Deformed Shape

Figure A3.10: GN2 Supply Piping FEA Displacement Contours



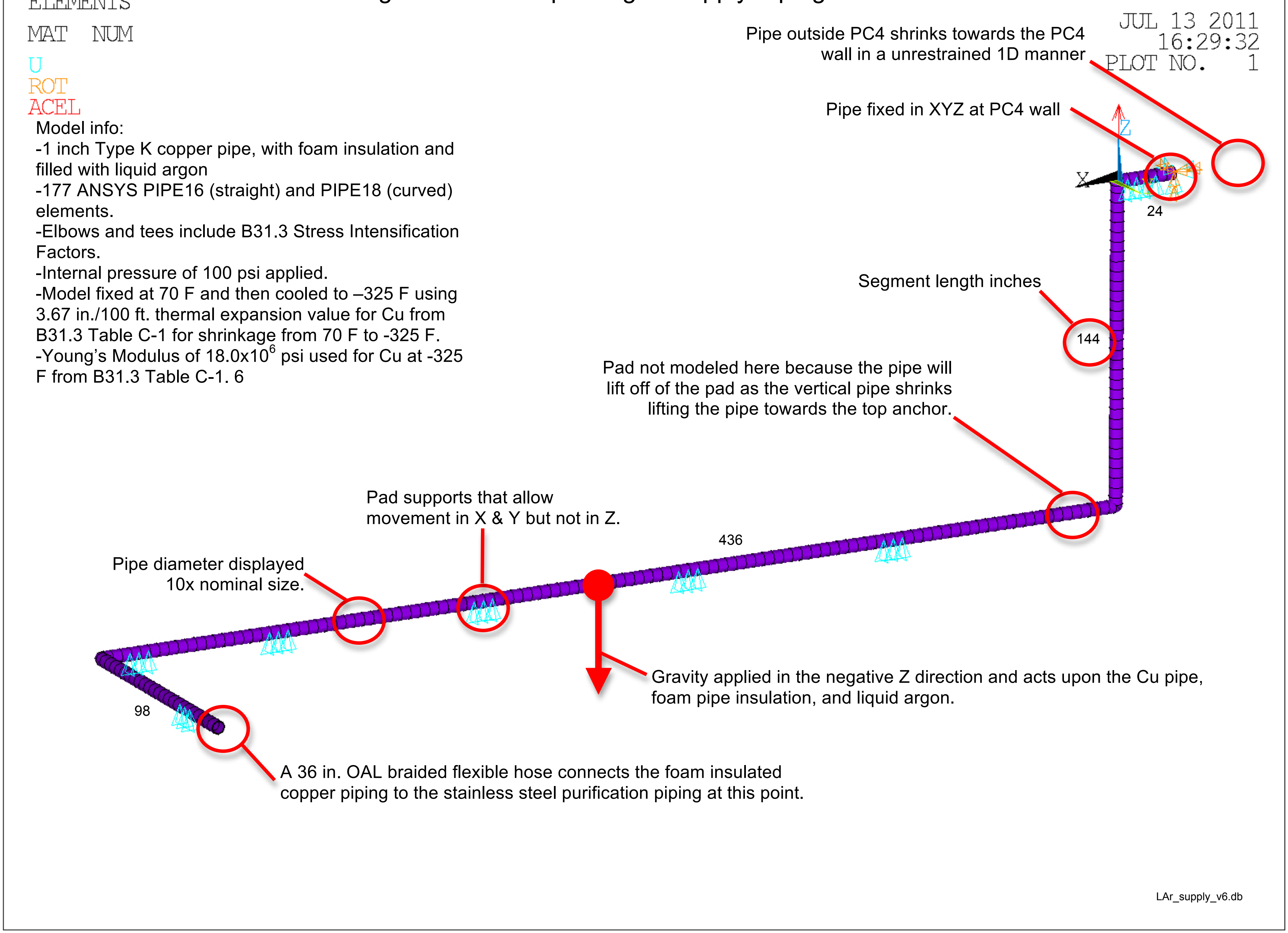
Displacement vector sum contours (inches).

Figure A3.11: GN2 Supply Piping FEA Von Mises Stress Contours



Von Mises equivalent stress contours (psi).

Figure A3.12: Liquid Argon Supply Piping FEA Model



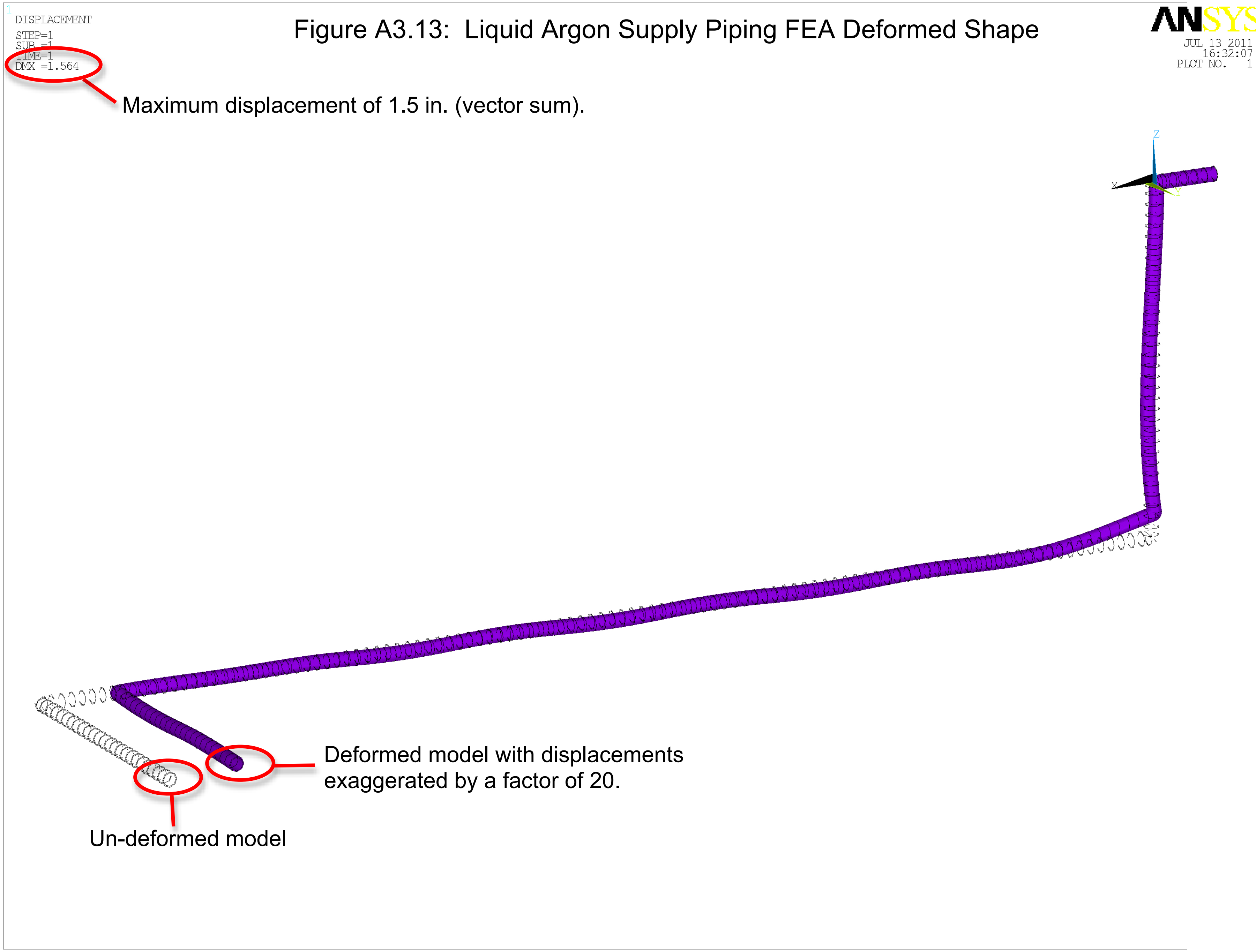
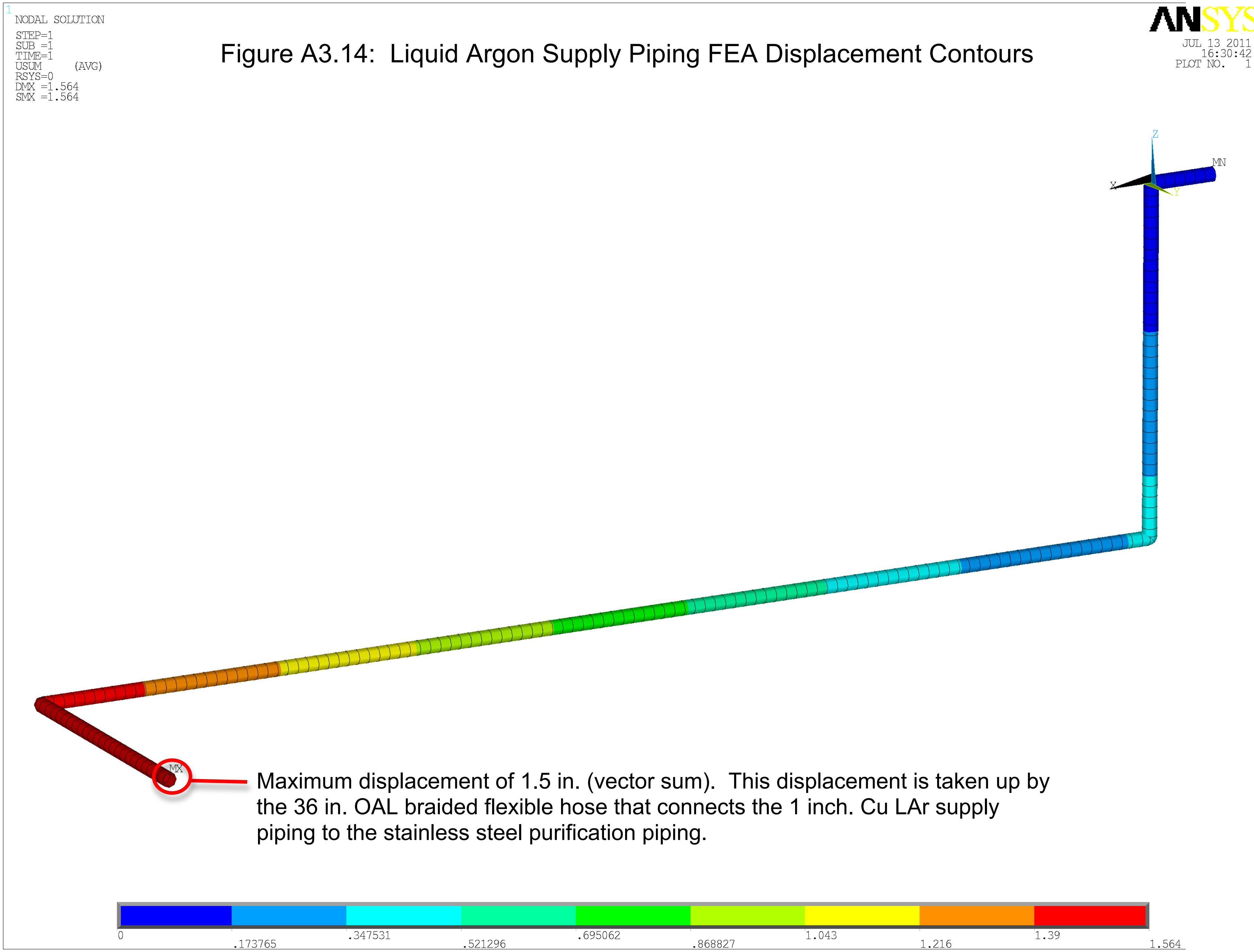
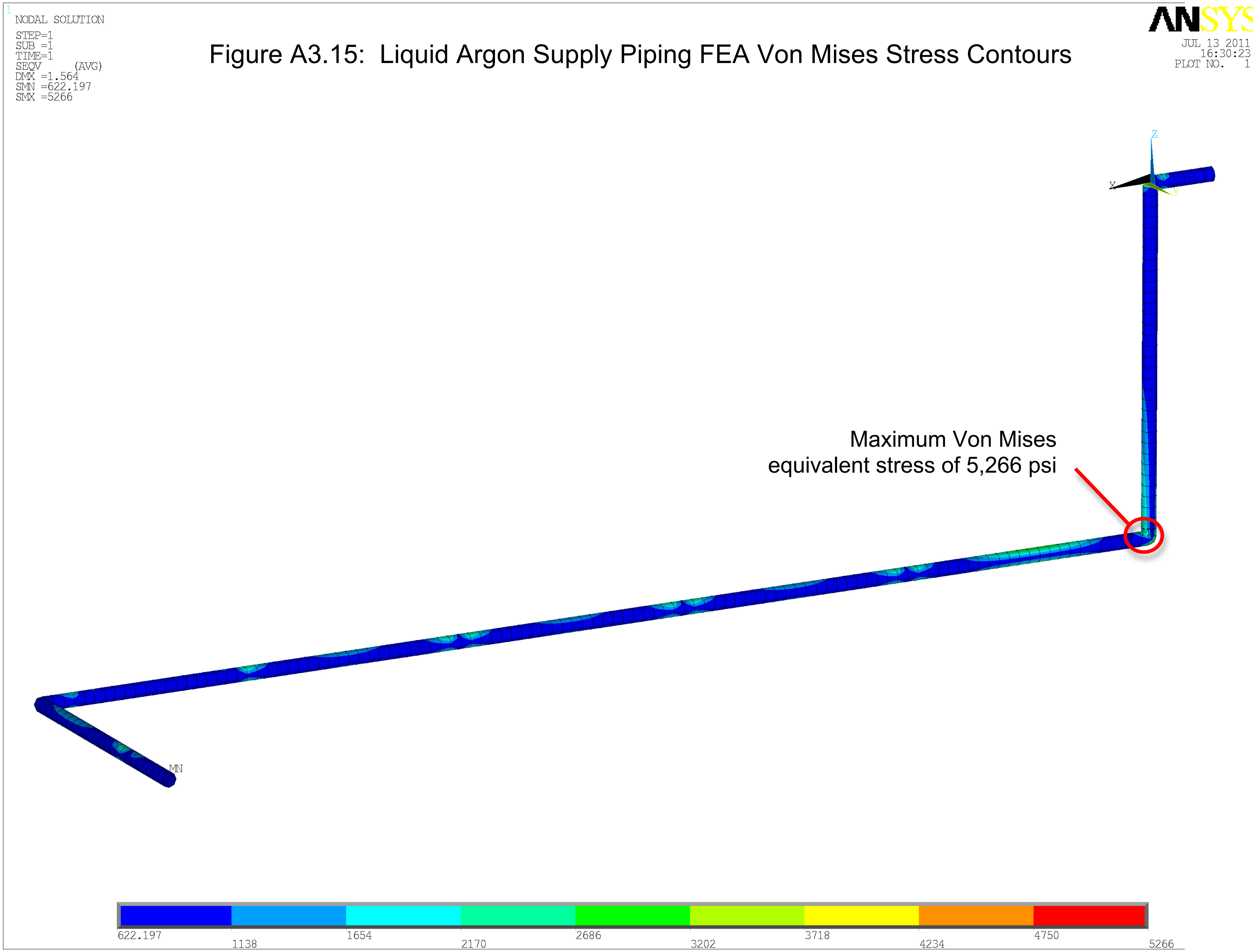


Figure A3.13: Liquid Argon Supply Piping FEA Deformed Shape

Figure A3.14: Liquid Argon Supply Piping FEA Displacement Contours



Displacement vector sum contours (inches).



Von Mises equivalent stress contours (psi).

Appendix 4
Pressure Test Documentation

The pressure tests required by the amendment will be added to this appendix.

Fermilab

Date: 7/14/11

EXHIBIT B
Pressure Testing Permit*

Type of Test: [ ]Hydrostatic [X] Pneumatic

Test Pressure 110 psig **Maximum Allowable Working Pressure** 100 psig
1.1 x 100 psig = 110 psig

Items to be Tested
LAPD liquid argon supply piping – see attached annotated flow schematic for highlighted test section. Component with the lowest pressure rating is a 150 psig pressure gauge. The piping is rated at 655 psig.

Location of Test PC4 **Date and Time**

Hazards Involved
Stored energy of compressed gas.

Safety Precautions Taken
Test personnel will wear eye protection.

Special Conditions or Requirements

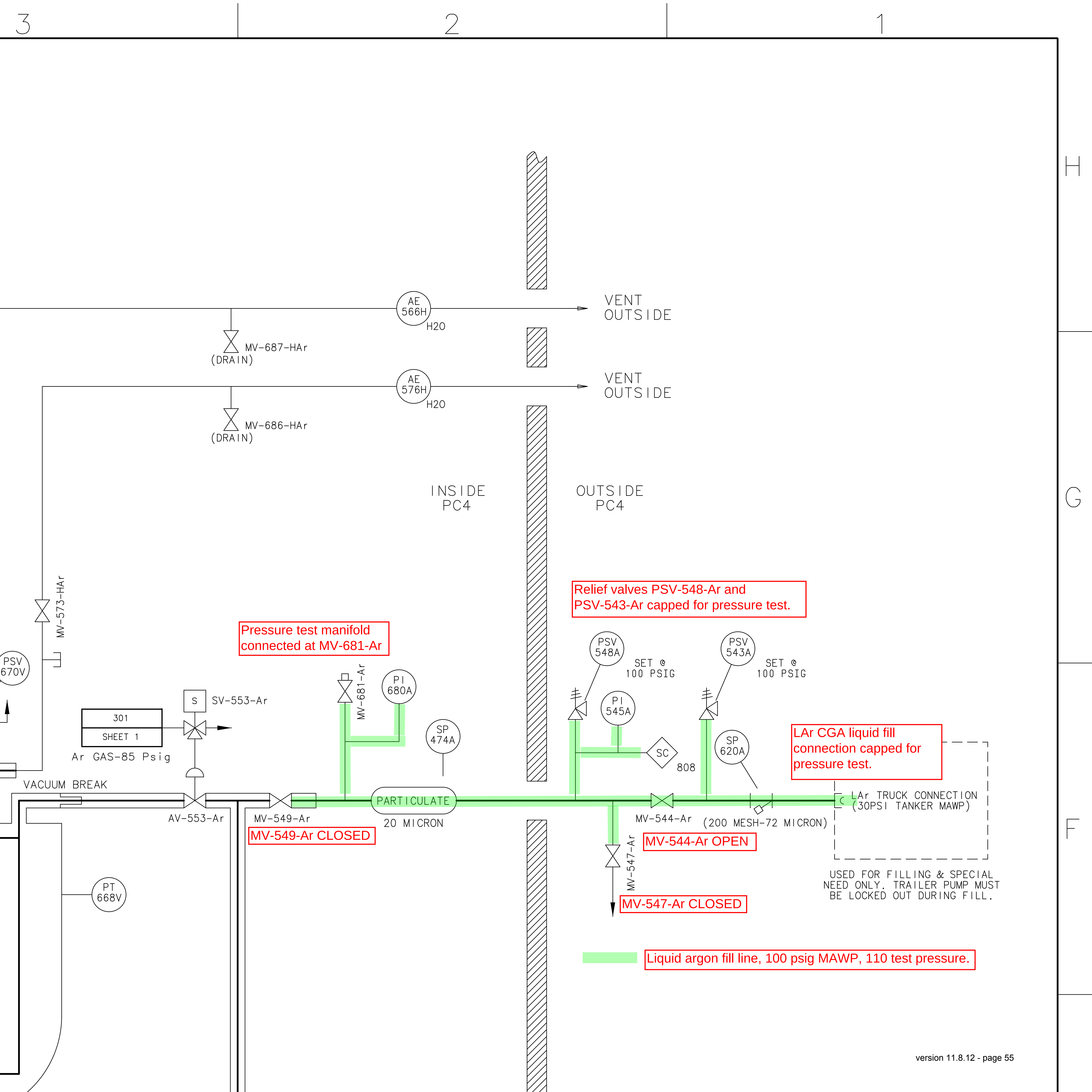
Qualified Person and Test Coordinator Terry Tope
Dept/Date PPD/MD/

Division/Section Safety Officer Ros Boshek
Dept/Date PD/ESH

Results
Held 110 psig for 10 min with no visible drop on the test gauge. [signature] 13329N

Witness [signature] (Safety Officer or Designee) **Dept/Date** 7-15-11

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


3
2
1
H
G
F
VENT OUTSIDE
VENT OUTSIDE
AE 566H
H2O
AE 576H
H2O
MV-687-HAr (DRAIN)
MV-686-HAr (DRAIN)
INSIDE PC4
OUTSIDE PC4
MV-573-HAr
PSV 670V
Relief valves PSV-548-Ar and PSV-543-Ar capped for pressure test.
Pressure test manifold connected at MV-681-Ar
PSV 548A
SET @ 100 PSIG
PSV 543A
SET @ 100 PSIG
PI 545A
PI 680A
MV-681-Ar
S
SV-553-Ar
301
SHEET 1
Ar GAS-85 Psig
SP 474A
SC
808
SP 620A
LAr CGA liquid fill connection capped for pressure test.
VACUUM BREAK
PARTICULATE
20 MICRON
AV-553-Ar
MV-549-Ar
MV-549-Ar CLOSED
MV-544-Ar
MV-544-Ar OPEN
(200 MESH-72 MICRON)
LAr TRUCK CONNECTION (30PSI TANKER MAWP)
MV-547-Ar
MV-547-Ar CLOSED
USED FOR FILLING & SPECIAL NEED ONLY. TRAILER PUMP MUST BE LOCKED OUT DURING FILL.
PT 668V
Liquid argon fill line, 100 psig MAWP, 110 test pressure.

Fermilab

Date: 7/19/11

EXHIBIT B
Pressure Testing Permit*

Type of Test: [ ]Hydrostatic [X] Pneumatic

Test Pressure 110 psig **Maximum Allowable Working Pressure** 100 psig
1.1 x 100 psig = 110 psig

Items to be Tested
LAPD liquid nitrogen supply piping – see attached annotated flow schematic for highlighted test section. The piping itself is rated at 655 psig – all other components are rated for at least 100 psig. Phase separator to be tested at a later date.

Location of Test PC4 **Date and Time**

Hazards Involved
Stored energy of compressed gas.

Safety Precautions Taken
Test personnel will wear eye protection.

Special Conditions or Requirements

Qualified Person and Test Coordinator Terry Tope
Dept/Date PPD/MD/

Division/Section Safety Officer Ros Buscher
Dept/Date PD/ESH 7-19-11

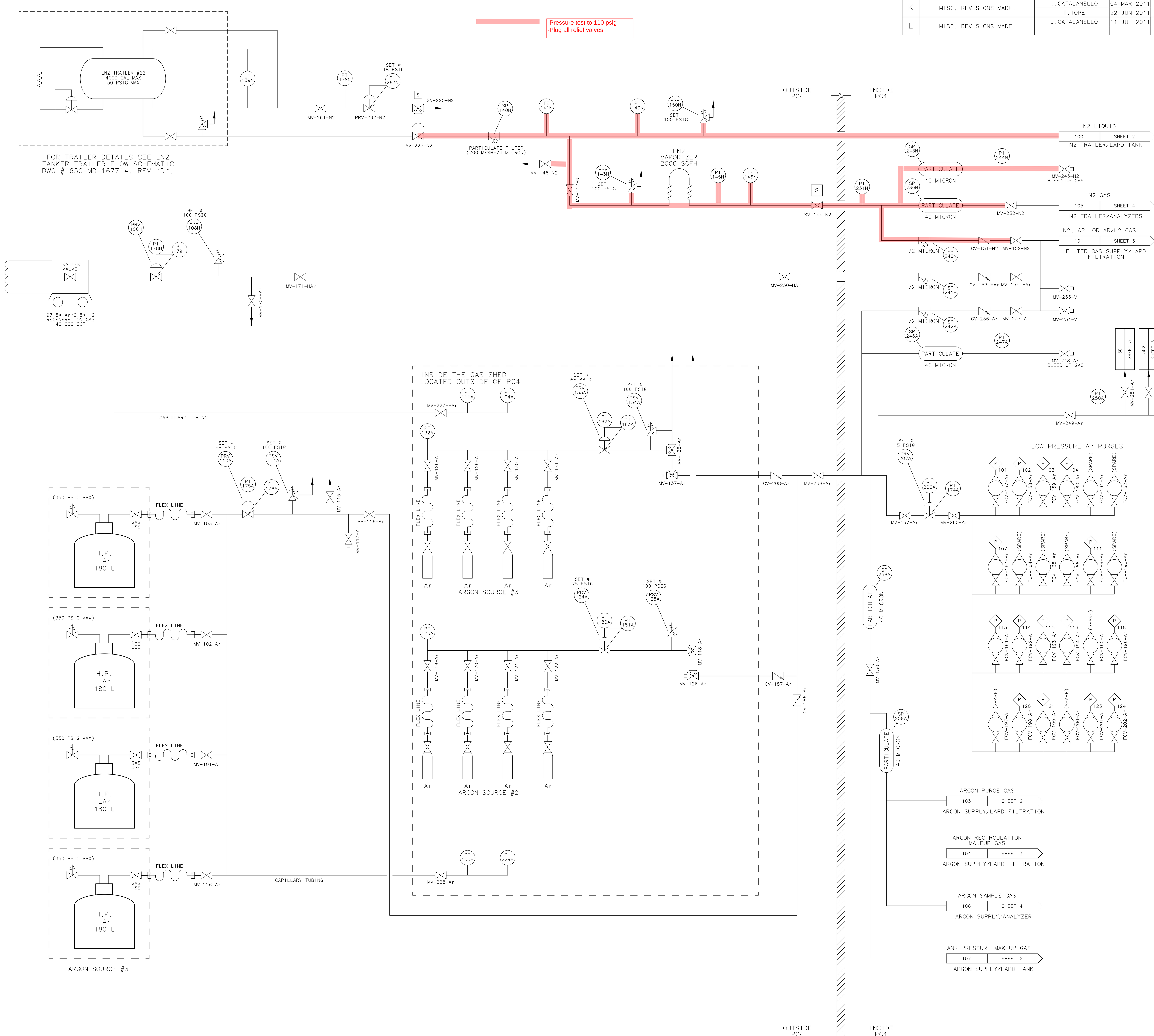
Results
Held 110 psig for 10 min. [signature]

Witness Ros Buscher 5007N (Safety Officer or Designee) **Dept/Date** PD/ESH 7-19-11

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

F	MISC. REVISIONS MADE.	J.CATALANELLO	26-FEB-2010	REV	DESCRIPTION	DRAWN	DATE
		M.ADAMOWSKI	26-FEB-2010			APPROVED	DATE
G	MISC. REVISIONS MADE.	J.CATALANELLO	10-JAN-2011	A	ADDED TAG NUMBERS TO VALVE TYPES	V. MAJDANSKI	25FEB08
		T.TOPE	12-JAN-2012			R. SCHMITT	26FEB08
H	MISC. REVISIONS MADE.	J.CATALANELLO	10-JAN-2011	B	MOVE CONDENSOR OUTSIDE TANK	J.CATALANELLO	07-DEC-2008
		T.TOPE	03-FEB-2011			R.SCHMITT	10-DEC-2008
J	MISC. REVISIONS MADE.	J.CATALANELLO	23-FEB-2011	C	MISC. REVISIONS MADE.	J.CATALANELLO	23-DEC-2008
		T.TOPE	28-FEB-2011			R.SCHMITT	06-JAN-2009
K	MISC. REVISIONS MADE.	J.CATALANELLO	04-MAR-2011	D	MISC. REVISIONS MADE.	J.CATALANELLO	17-NOV-2009
		T.TOPE	22-JUN-2011			T.TOPE	14-DEC-2009
L	MISC. REVISIONS MADE.	J.CATALANELLO	11-JUL-2011	E	MISC. REVISIONS MADE.	J.CATALANELLO	17-NOV-2009
						T.TOPE	15-JAN-2010

-Pressure test to 110 psig
-Plug all relief valves



UNLESS OTHERWISE SPECIFIED			ORIGINATOR	R.SCHMITT	26-JUN-2007
			DRAWN	J.CATALANELLO	07-DEC-2007
±	±	±	CHECKED	R.SCHMITT	12-DEC-2007
			APPROVED	R.SCHMITT	12-DEC-2007

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

FLARE UTILITIES
GAS PIPING & INSTRUMENT DIAGRAM
LIQUID ARGON PURITY DEMONSTRAT'N

SCALE	DRAWING NUMBER	SHEET	REV
NONE	3942.510-ME-444897	1 OF 4	L

CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

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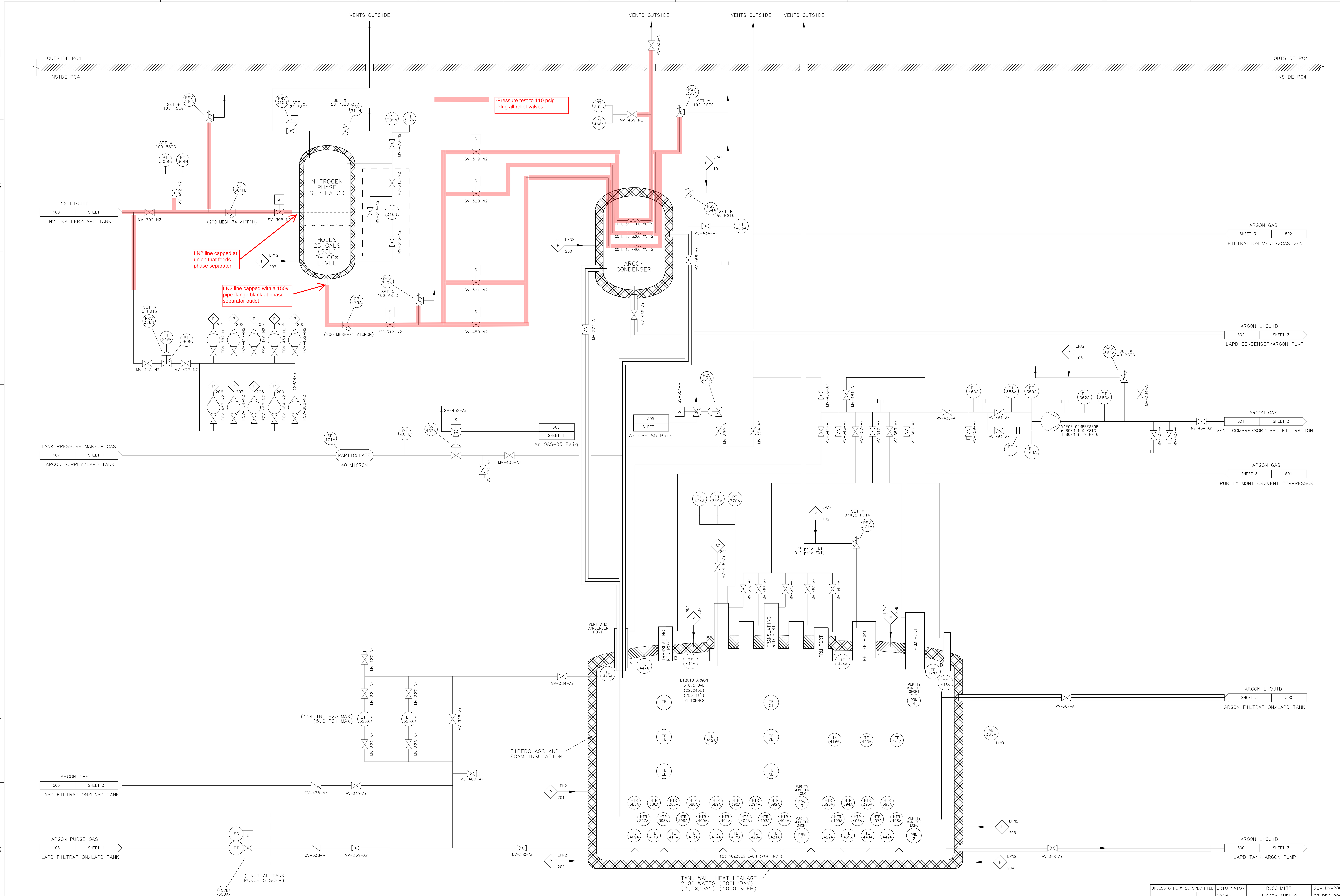


UNLESS OTHERWISE SPECIFIED			ORIGINATOR	R.SCHMITT	26-JUN-2007
			DRAWN	J.CATALANELLO	07-DEC-2007
±	±	±	CHECKED	R.SCHMITT	12-DEC-2007
			APPROVED	R.SCHMITT	12-DEC-2007

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

FLARE UTILITIES
GAS PIPING & INSTRUMENT DIAGRAM
LIQUID ARGON PURITY DEMONSTRAT'N

SCALE	DRAWING NUMBER	SHEET	REV
NONE	3942.510-ME-444897	2 OF 4	L

CREATED WITH : Ideas12NXSeries GROUP: PPD/MECHANICAL DEPARTMENT

Fermilab

Date: 7/20/11

EXHIBIT B
Pressure Testing Permit*

Type of Test: [ ]Hydrostatic [X] Pneumatic

Test Pressure 66 psig **Maximum Allowable Working Pressure** 60 psig
1.1 x 60 psig = 66 psig

Items to be Tested
LAPD liquid nitrogen supply piping at phase separator – see attached annotated flow schematic for highlighted test section.

Location of Test PC4 **Date and Time** 7/21/11

Hazards Involved
Stored energy of compressed gas.

Safety Precautions Taken
Test personnel will wear eye protection.

Special Conditions or Requirements

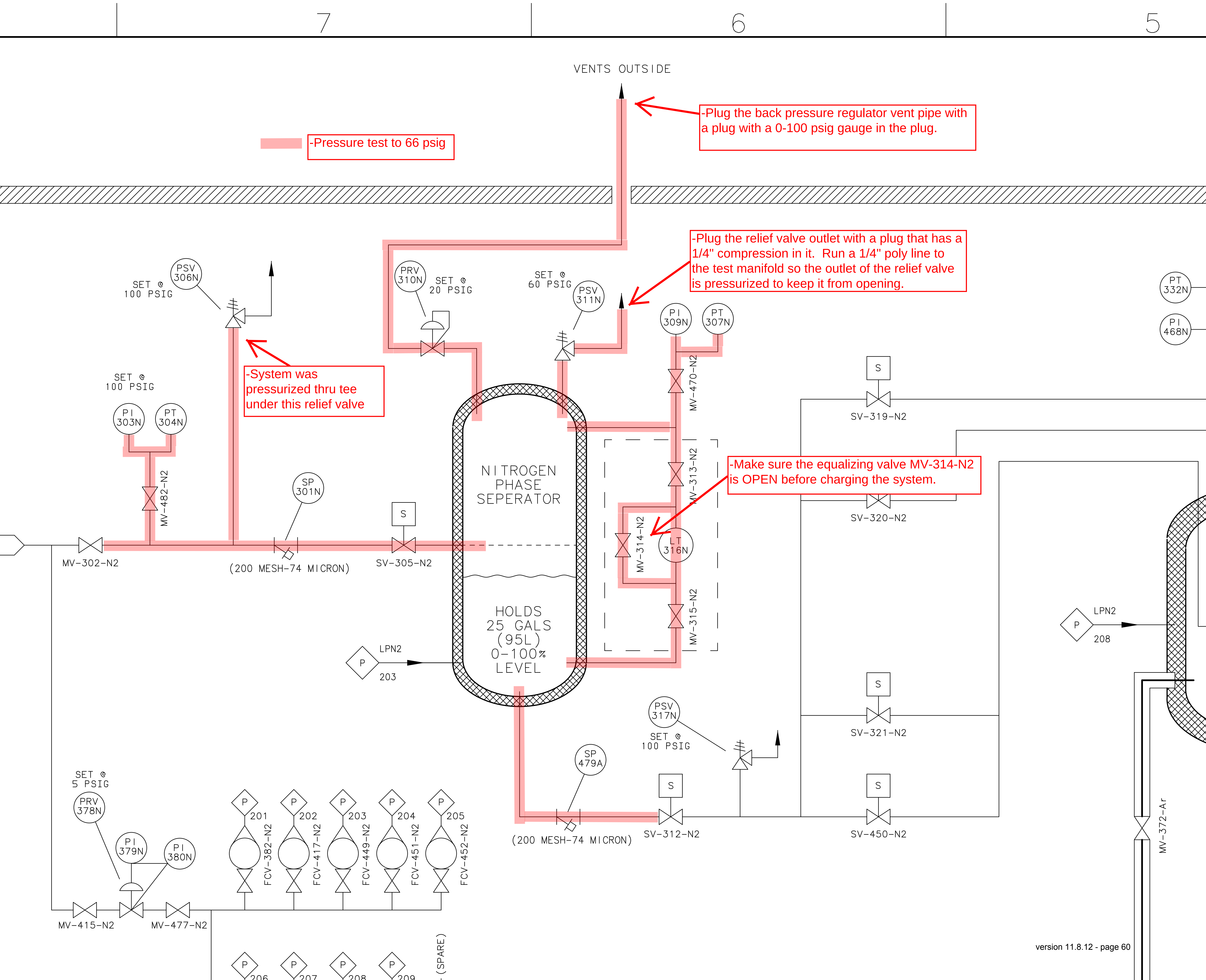
Qualified Person and Test Coordinator Terry Tope
Dept/Date PPD/MD/

Division/Section Safety Officer Ros Bushell
Dept/Date PPD/ESH 7-21-11

Results
Held 66 psig for 10 minutes w/out drop. 13329N

Witness (Safety Officer or Designee) **Dept/Date** PPD/ESH 7-21-11

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



7
6
5
VENTS OUTSIDE
-Plug the back pressure regulator vent pipe with a plug with a 0-100 psig gauge in the plug.
-Pressure test to 66 psig
-Plug the relief valve outlet with a plug that has a 1/4" compression in it. Run a 1/4" poly line to the test manifold so the outlet of the relief valve is pressurized to keep it from opening.
PSV 306N
SET @ 100 PSIG
PRV 310N
SET @ 20 PSIG
SET @ 60 PSIG
PSV 311N
PI 309N
PT 307N
PT 332N
PI 468N
-System was pressurized thru tee under this relief valve
SET @ 100 PSIG
PI 303N
PT 304N
MV-482-N2
MV-470-N2
S
SV-319-N2
NITROGEN PHASE SEPERATOR
MV-313-N2
-Make sure the equalizing valve MV-314-N2 is OPEN before charging the system.
SV-320-N2
SP 301N
S
MV-314-N2
LT 316N
MV-302-N2
(200 MESH-74 MICRON)
SV-305-N2
HOLDS 25 GALS (95L) 0-100% LEVEL
MV-315-N2
P
LPN2
208
P
LPN2
203
PSV 317N
SET @ 100 PSIG
S
SV-321-N2
SP 479A
S
S
SET @ 5 PSIG
PRV 378N
P 201
P 202
P 203
P 204
P 205
FCV-382-N2
FCV-417-N2
FCV-449-N2
FCV-451-N2
FCV-452-N2
(200 MESH-74 MICRON)
SV-312-N2
SV-450-N2
MV-372-Ar
PI 379N
PI 380N
MV-415-N2
MV-477-N2
(SPARE)
P 206
P 207
P 208
P 209

Fermilab

Date: 10/3/12

EXHIBIT B
Pressure Testing Permit*

Type of Test: [ ]Hydrostatic [X] Pneumatic

Test Pressure 110 psig **Maximum Allowable Working Pressure** 100 psig
1.1 x 100 psig = 110 psig

Items to be Tested
LAPD liquid nitrogen supply piping – see attached annotated flow schematic for highlighted test section. The piping itself is rated at 655 psig – all other components are rated for at least 100 psig. Phase separator to be tested separately at a lower pressure.
FCV-305-N2 and FCV-312-N will slowly leak thru to the phase separator. Phase separator pressure will be monitored.

Location of Test PC4 **Date and Time** 10/5/12 9:30 AM

Hazards Involved
Stored energy of compressed gas.

Safety Precautions Taken
Test personnel will wear eye protection.
Supply pressure test manifold relieved at 120 psig.

Special Conditions or Requirements

Qualified Person and Test Coordinator Terry Tope
Dept/Date PPD/MD/

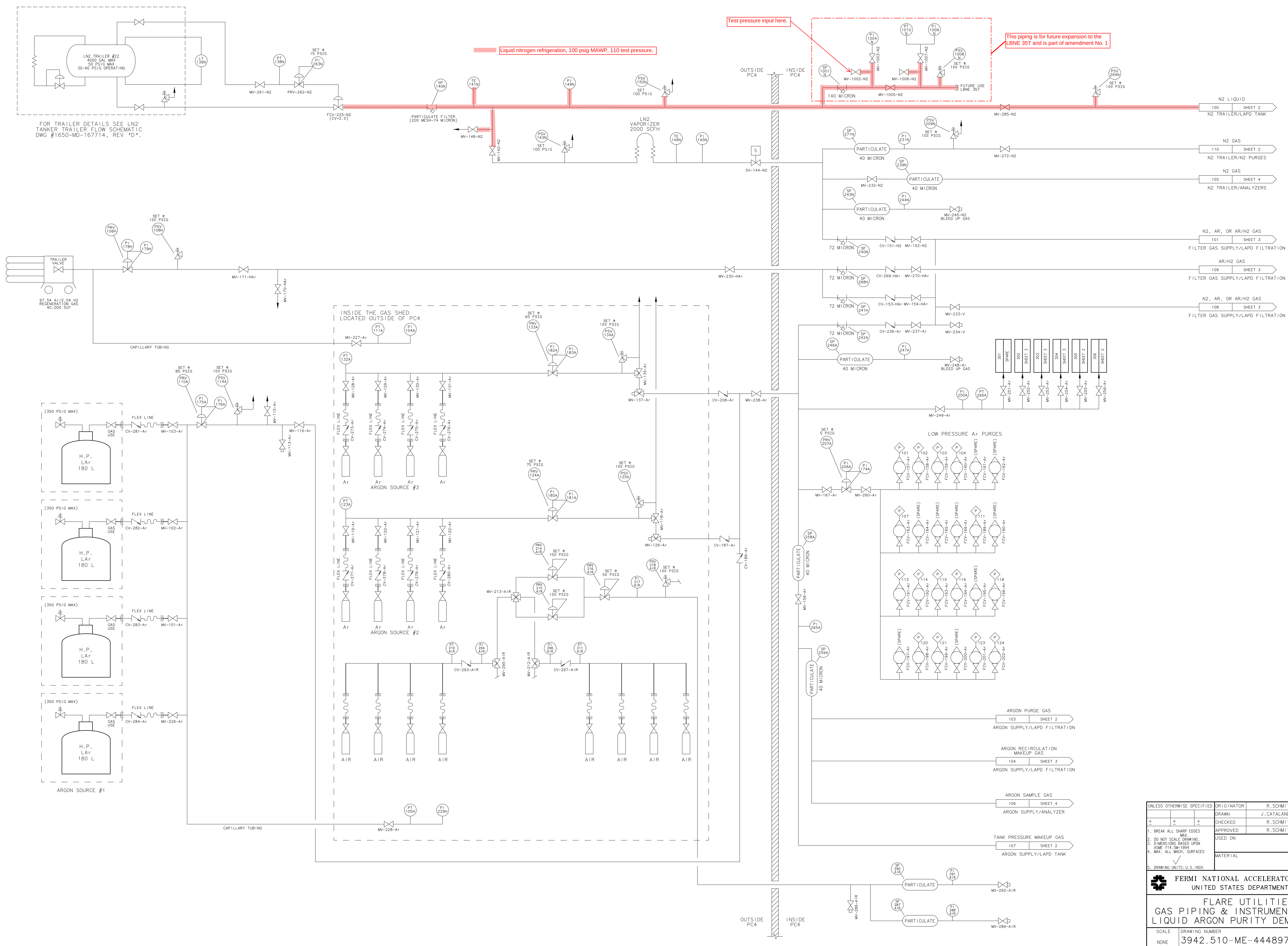
Division/Section Safety Officer Rob Bushek
Dept/Date PPD/ES&H

Results
System held 110 psig. Techs snooped all new/or opened joints @ 100 psig and found no leaks. - Terry Tope [illegible]

Witness [signature] /5007W ES&H **Dept/Date** 10-5-12
(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.

REV	DESCRIPTION	DRAWN / APPROVED	DATE
A	ADDED TAG NUMBERS TO VALVE TYPES	V. MAJDANSKI / R. SCHMITT	25FEB08 / 26FEB08
B	MOVE CONDENSOR OUTSIDE TANK	J.CATALANELLO / R.SCHMITT	07-DEC-2008 / 10-DEC-2008
C	MISC. REVISIONS MADE.	J.CATALANELLO / R.SCHMITT	23-DEC-2008 / 06-JAN-2009
D	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	17-NOV-2009 / 14-DEC-2009
E	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	17-NOV-2009 / 15-JAN-2010
F	MISC. REVISIONS MADE.	J.CATALANELLO / M.ADAMOWSKI	26-FEB-2010 / 26-FEB-2010
G	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	10-JAN-2011 / 12-JAN-2012
H	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	10-JAN-2011 / 03-FEB-2011
J	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	23-FEB-2011 / 28-FEB-2011
K	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	04-MAR-2011 / 22-JUN-2011
L	MISC. REVISIONS MADE.	J.CATALANELLO / T.TOPE	11-JUL-2011 / 01-MAR-2012
M	MISC. REVISIONS MADE.	J.CATALANELLO	22-MAY-2012



UNLESS OTHERWISE SPECIFIED

± ± ±

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

ORIGINATOR	R.SCHMITT	26-JUN-2007
DRAWN	J.CATALANELLO	07-DEC-2007
CHECKED	R.SCHMITT	12-DEC-2007
APPROVED	R.SCHMITT	12-DEC-2007

USED ON

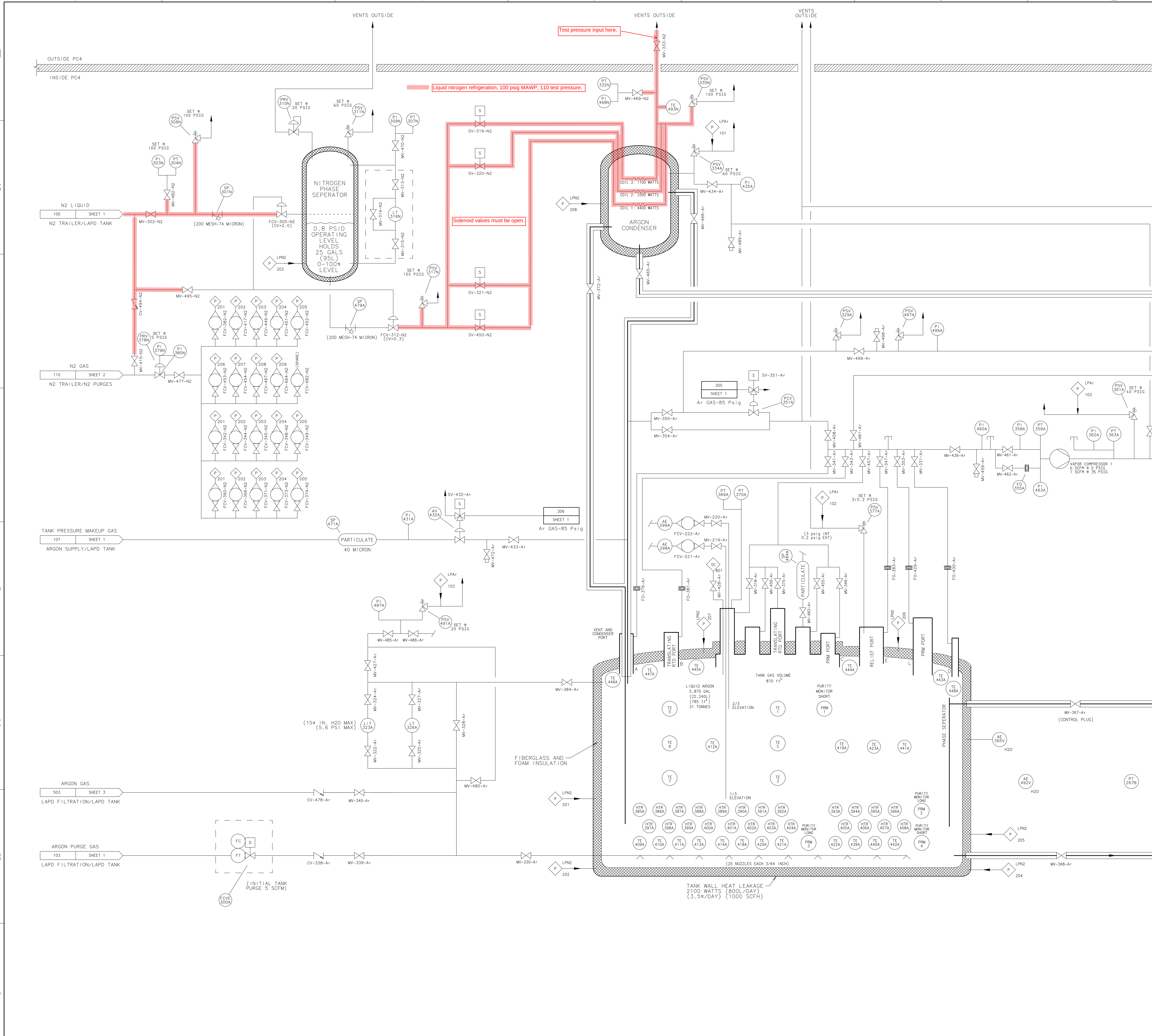
MATERIAL

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

FLARE UTILITIES
GAS PIPING & INSTRUMENT DIAGRAM
LIQUID ARGON PURITY DEMONSTRAT'N

SCALE	DRAWING NUMBER	SHEET	REV
NONE	3942.510-ME-444897	1 OF 4	M

CREATED WITH : Ideas12NXSeries GROUP: PPD/MECHANICAL DEPARTMENT



UNLESS OTHERWISE SPECIFIED	ORIGINATOR	R.SCHMITT	26-JUN-2007
	DRAWN	J.CATALANELLO	07-DEC-2007
	CHECKED	R.SCHMITT	12-DEC-2007
	APPROVED	R.SCHMITT	12-DEC-2007

1. BREAK ALL SHARP EDGES
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

FLARE UTILITIES
GAS PIPING & INSTRUMENT DIAGRAM
LIQUID ARGON PURITY DEMONSTRAT'N

SCALE NONE | DRAWING NUMBER 3942.510-ME-444897 | SHEET 2 OF 4 | REV M

CREATED WITH: Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

Created: 10:57:07 on 19-06-12 (D-M-Y) By: catalan State: 1-INITIAL

Fermilab

Date: 10/3/12

EXHIBIT B
Pressure Testing Permit*

Type of Test: [ ]Hydrostatic [X] Pneumatic

Test Pressure 66 psig **Maximum Allowable Working Pressure** 60 psig
1.1 x 60 psig = 66 psig

Items to be Tested
LAPD liquid nitrogen supply piping at phase separator – see attached annotated flow schematic for highlighted test section.
Because FCV-305-N2 and FCV-312-N2 leak thru, the piping associated with it will also be at the test pressure.

Location of Test PC4 **Date and Time** 10/5/12 10:00Am

Hazards Involved
Stored energy of compressed gas.

Safety Precautions Taken
Test personnel will wear eye protection.
Supply pressure test manifold has a relief valve set just above 66 psig.

Special Conditions or Requirements

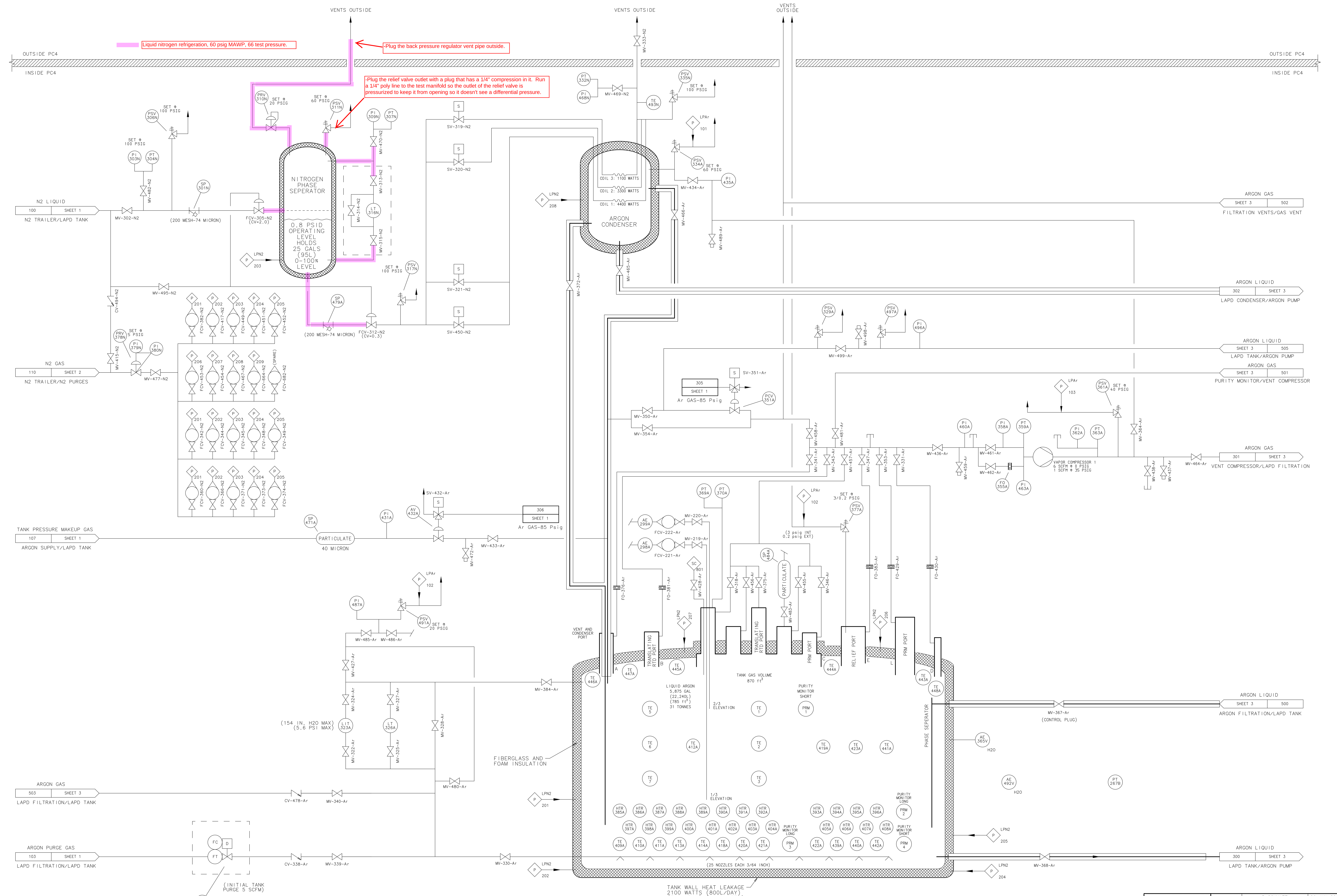
Qualified Person and Test Coordinator Terry Tope
Dept/Date PPD/MD/

Division/Section Safety Officer RoB Bushek
Dept/Date PPD/ES&H

Results
Phase separator held 66 psig. At 60 psig no leaks were detected over a 10 minute period. Terry Tope 13329N [signature]

Witness [signature] 15007N ES&H **Dept/Date** 10-5-12
(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.



UNLESS OTHERWISE SPECIFIED			ORIGINATOR	R.SCHMITT	26-JUN-2007
			DRAWN	J.CATALANELLO	07-DEC-2007
±	±	±	CHECKED	R.SCHMITT	12-DEC-2007
			APPROVED	R.SCHMITT	12-DEC-2007

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

FLARE UTILITIES
GAS PIPING & INSTRUMENT DIAGRAM
LIQUID ARGON PURITY DEMONSTRAT'N

SCALE	DRAWING NUMBER	SHEET	REV
NONE	3942.510-ME-444897	2 OF 4	M

CREATED WITH : Ideas12NXSeries GROUP: PPD/MECHANICAL DEPARTMENT

Created: 10:57:07 on 19-06-12 (D-M-Y) By: catalan State: 1-INITIAL

Appendix 5
Brazing and Welding Details

LAPD:
LN2 Supply Brazing Specification

v4.29.10

Terry Tope

(Based on Mathew Cooper's "Booster 95°F LCW System: Brazing Specification")

1. GENERAL

1.1 Scope

The following specification describes the requirements for brazing (filler metal melting point > 840°F) piping in the LAPD LN2 system. In addition to reinforcement of the key requirements of the governing code listed below, this document specifies supplementary requirements and recommendations relevant to this system to ensure quality brazing.

1.2 Governing Code

All brazing shall be performed in accordance with ANSI/ASME B31.3 Process Piping Code. The LAPD LN2 system shall be considered "Normal Fluid Service" when interpreting Code requirements.

1.3 Inspection Requirements

As set forth in the ANSI/ASME B31.3, in-process examination of brazed joints must be performed.

2. BRAZING MATERIALS

2.1 Filler Metal

The filler metal used is Sil-Fos 15 (high temperature copper-silver-phosphorus alloy brazing filler) for all copper to copper joints. Stainless to copper joints shall use XUPER 1020 XFC silver brazing alloy.

2.2 Flux

There is no flux necessary when using Sil-Fos 15 as the filler metal. The XUPER 1020 XFC silver brazing alloy is coated with the corresponding flux.

3. PREPARATION

3.1 Cleaning

The surfaces to be brazed shall be clean and free from grease, oil, paint, scale and dirt of any kind.

3.2 Fit

The clearance between surfaces to be joined by brazing shall be no larger than necessary to allow complete capillary distribution of the filler metal. Additionally, the material should be completely free of burrs.

4. BRAZING REQUIREMENTS

4.1 Heat Protection

- Sensitive equipment (e.g. cable) must be protected from the heat by the use of heat blankets and shielding where possible.
- Shielding should be used to prevent scorch marks on wall, cabinets, etc.
- Joint shall be brought to brazing temperature in as short a time as possible without localized underheating or overheating

4.2 Gas Purge

To limit oxidation during brazing the piping should be purged with argon.

4.3 Final Finish

All external surfaces in the braze area shall be left in a condition suitable for subsequent inspections (visual, bubble, and hydrostatic pressure tests). The residual soot and/or scale should be removed by wire brush or scouring pad.

5. INSPECTION AND TESTING

5.1 Inspection

As stated in ASME B31.3, not less than 5% of all brazed joints shall be examined by in-process examination, the joints to be examined being selected to ensure that the work of each brazer making the production joints is included. In-process examination comprises examination of the following:

- Joint preparation and cleanliness
- Preheating
- Fit-up, joint clearance, and internal alignment prior to joining
- Variables specified by the joining procedure, including filler material, position, flux, brazing temperature, proper wetting, and capillary action
- Appearance of the finished joint

In-Process Braze Inspection Form

Project: LAPD LN2 Supply

Braze Number: ______________________________

Braze Location: ______________________________

		Acceptable	Not Acceptable
1.	Joint preparation and cleanliness	☐	☐
2.	Preheating	☐	☐
3.	Fit-up, joint clearance, and internal alignment	☐	☐
4.	Filler material	☐	☐
5.	Position	☐	☐
6.	Flux	☐	☐
7.	Brazing temperature	☐	☐
8.	Proper wetting	☐	☐
9.	Capillary action	☐	☐
10.	Appearance of the finished joint	☐	☐

Brazer: ______________________ / ______________________ Date: ____________
(Print) *(Sign)*

Inspector: ______________________ / ______________________ Date: ____________
(Print) *(Sign)*

PPD Mechanical
In-Process Weld Inspection Form

(as per In-Process Weld Inspection Guidelines, AD Cryogenics, Nov 3, 2006)

Date_____________Project: ______________________________________
Pipe Section: ______________________ Weld Number:______________
Weld location: ____
Welder:____________________Inspector: ___________________________

Before Welding:

Type of weld: (butt)________ (other)___________
(1) Pipe #1 Size, Schedule and material: ________________________
(2) Pipe #2 Size, Schedule and material: ________________________

(1) Joint Preparation and Cleanliness

Joint Preparation and Cleanliness acceptable? ___________________

(2) Welding Machine

(a) Remote foot pedal? ___________
(b) DC straight machine? __________

(3) Joint Fit-up, and Internal Alignment.

(a) Internal alignment acceptable? ____________________
(b) Joint Clearance acceptable? _____________________
(c) End Preparation acceptable? _____________________

(4) Filler Rod

(a) AWS A5.9 stainless steel filler rod? ________________
(b) Filler rod: Class _______________ Diameter_____________

(5) Purge Gas.

(a) type of purge gas : __________________
(b) time length of purge: _________________ purge flow rate:________ SCFH___
(b) (if done) O2 reading: ___________O2 Monitor manf/model : ________

(6) Inspection After Root Pass

(a) No visible cracks. _____________
(b) No suck holes, which are small holes in middle of weld. ___________
(c) No porosity or obvious imperfections. ______________
(d) Filler material fused along edges of weld . __________

(8) Repeat inspection after every pass: ______________

(9) Final Inspection: ____________________

In-Process Weld Inspection Guidelines
PPD Mechanical Department
(As per AD Cryogenics Department
Nov. 3, 2006)

This procedure is only valid for: GTAW welding of 304SS, 304LSS, 316SS pipe, tube or pipe components such as valves by Fermilab certified welders.

Fermilab welders are certified to weld in any position so there is no need to verify the position when welding. An In-process weld inspection must reflect the WPS for an individual welder.

(1) Joint Preparation and Cleanliness.

Internal and external surfaces to be welded are to be clean and free from rust, oil, grease, dirt, paint, etc. Cleanliness is very important. Even dried residue from a coffee spill is unacceptable and can cause problems. Use scotch bright or Aluminum oxide to clean the joint. Do not use a carbon steel wire brush because it could leave carbon steel particles on the joint.

(2) Welding Machine

(a) Remote foot pedal required

(b) DC straight machine required

(3) Joint Fit-up, and Internal Alignment

(a) Internal Alignment:

Butt Weld: The inside surfaces of the two pieces being welded together must be aligned to within 1/32" of each other. If the two pieces are the same outside diameter and wall thickness, then this alignment can be confirmed by using a straight edge on the outside surface.

(b) Joint Clearance

Butt weld: the gap between the two pieces should be should be less than 1/16".

Socket weld: 1/16" clearance inside the socket.

(c) End Preparation

For butt welds where the wall thickness is over 3/32", prepare pipe ends as per Fig 328.4.2 (attached). If the wall thickness's of the two pipes or tubes differ, prepare their ends as per (attached) Fig 328.4.3.

(4) Filler material

(a) Certification

Filler rod must be AWS designation A5.9 (for stainless).

(b) Record diameter and class (308SS or 304LSS ... etc) of filler rod

(c) Required Filler Rod Class

If connecting	304SS to 304SS	use 308 filler rod
If connecting	304SS to 304LSS	use 308L filler rod
If connecting	304LSS to 304LSS	use 308L filler rod
If connecting	316SS or 304 SS to 316SS	use 316 filler rod

For any other combination consult with the Fermilab weld shop.

(5) Purge Gas

(a) Purity

Purge gas must be 99.995% pure welding grade Argon. Boiloff gas from a liquid argon dewar is acceptable.

(b) Purge Flow

Purge gas must flow through the pipe past weld joint to remove oxygen. As a general rule the preweld purge should give 5-6 volume changes. The attached AWS Fig. 2 chart can be used to determine the required flow rate and length of time of the purge.

(c) Oxygen concentration

Oxygen concentration must be less than 1%. If available, use an oxygen monitor to measure the O2 concentration of the exhausting purge gas.

(7) Inspection after Root Pass

(a) No visible cracks

(b) No suck holes, which are small holes in middle of weld.

(c) No porosity or obvious imperfections

(d) Filler material fused along edges of weld to parent material. Ideally the weld should be concave.

(8) Repeat inspection #7 above after every pass

(9) Final Pass

Final pass should have a convex shape. Maximum buildup should be less than 1/16" above surface of pipe or tube.

Fermilab

Accelerator Division
Cryogenic Department
630.840.6858 (office)
630.840.4989 (fax)

Memorandum

To: Arkadiy Klebaner, Jay Theilacker, Alex Martinez, Bill Soyars, Brian DeGraff, Jerry Makara, Michael Geynisman

From: Michael White

Subject: Charpy Impact Testing for LN2 Piping

Date: April 13, 2010

Summary of Revision 1

The initial Charpy Impact Testing for LN2 Piping memorandum that was sent on December 29, 2009 contains a known error. The memorandum suggested that welding 316 or 316L with 308L filler metal was acceptable. However, welding 316 or 316L with 308L filler metal is a violation of the AD/Cryo weld procedure, which has now been attached as Appendix 3 to this memo for easy reference. The Charpy impact testing that was performed qualified the AD/Cryo weld procedure for 308L filler rod, but the procedure must be followed to remain within the qualification. All instances where 316 or 316L stainless steel was previously mentioned have been removed, since those materials require the use of 316 filler rod according to the AD/Cryo weld procedure.

It should also be noted that type 308L filler rod also qualifies as type 308, so it is acceptable to weld type 304 to type 304 stainless steel using 308L filler rod even though it is not explicitly specified in the AD/Cryo weld procedure. This memorandum will be updated again once Charpy impact testing data becomes available for welds made with type 316 filler rod using the AD/Cryo weld procedure.

Introduction

The Fermilab Environmental Health & Safety Manual (FESHM) Chapter 5032 stipulates that cryogenic piping must meet the requirements of ASME B31.3. At colder temperatures materials often become brittle and lose their toughness. ASME B31.3 has impact testing requirements that force the designer to ensure that the selected materials do not undergo a brittle transition while being cooled down to the design temperature. Fermilab has had extensive and successful experience with using austenitic stainless steels for cryogenic piping. This paper was written to demonstrate that all impact testing requirements are satisfied for the vast majority of LN2 piping components at Fermilab through one set of impact tests that were recently performed.

Mandatory Impact Testing

The ASME B31.3 code specifies impact testing instructions in Section 323 and in Table 323.2.2. The two types of stainless steel most commonly used at Fermilab for cryogenic piping are type 304 and type 304L, which are listed in Table A-1 as having a minimum design metal temperature (MDMT) of -425°F (19 K). Table 323.2.2 has two columns of requirements, with column A for materials above their MDMT and column B for materials below their MDMT. The temperature of LN2 at atmospheric pressure is 77 K and well above the MDMT, so the requirements of column B (which are pertinent to LHe piping) will be neglected here.

Column A of Table 323.2.2 is subdivided into two additional columns, with column (a) for the base metal and column (b) for the weld metal requirements. The four types of steel commonly used for cryogenic piping at Fermilab are all austenitic steel, so the appropriate requirements can be found in row 4. Cell A-4(a) specifies that if either (1) carbon content by analysis is > 0.1% or (2) material is not in solution heat treated condition then impact testing is required. Cell A-4(b) specifies that if the MDMT is less than -20°F then the weld metal deposits must be impact tested.

Cell A-4 has two notes, Note (3) and Note (6), which provide exemptions from impact testing. Note (3) only applies above -155°F and therefore is not applicable to LN2 piping. Note (6) exempts material from impact testing if the maximum obtainable Charpy specimen has a width along the notch of less than 2.5 mm (0.098 in). The wall thickness requirements difficult to maintain even if thin-walled tubing or piping is used, since the 2.5 mm wall thickness is often exceeded in the flanges, coupling, and adapters.

One source for stainless steel material composition requirements is ASTM A269-08 “Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing”, which can be found using links to published standards provided by the Fermilab library. There are various other ASTM standards for stainless steel pipe (such as A312, A358, etc.) but the material composition requirements should be uniform for all ASTM standards. ASTM A269-08 Table 1 specifies that the maximum carbon content is 0.08% for 304 stainless steel and 0.035% for 304L stainless steels.

Section 6 of ASTM A269-08 specifies that the both types of stainless steel must be furnished in solution annealed condition. ASME B31.3 Table A-1 lists all each of the both types of stainless steel as having the same P-No, Group-No, MDMT, and allowable stress regardless of whether it is tube or pipe form. The heat treatment of the tubes and pipes must be similar since the ASME B31.3 listed properties are the same. Therefore, the conditions of cell A-4(a) have been satisfied and impact testing is not required on the base metal when using 304 or 304L stainless steel for LN2 piping.

Cell A-4(b) mandates impact testing on weld metal at LN2 temperatures for 304 or 304L stainless steel if the wall thickness is greater than 2.5 mm. Note (2) applies to all cells in column (b) and states “Impact tests that meet the requirements of Table 323.3.2, which are performed as part of the weld procedure qualification, will satisfy all requirements of para. 323.2.2 and need not be repeated for production welds.” This means that once the AD/Cryo welding procedure is qualified, no more impact testing is required as long as the weld procedure continues to be followed.

Weld Procedure Qualification

The requirements for impact testing are listed in Table 323.3.1. Since impact tests are only required on the welds, the test is governed by the requirements in column A, cells A-4 to A-7. Cell A-4 states that one impact test is required for each welding procedure, type of filler metal, and flux used. AD/cryo only has one weld procedure, does not use flux for welding, and uses AWS-E308L filler metal so only one test is required. The number of test pieces is dictated by Cell A-5 and Note (3). Note (3) states that the test piece must be large enough to obtain three specimens from the weld metal. Cell A-5(a) states that one test validates a range of thicknesses from T/2 to T+ 0.25". A test on 1" Sch 10 pipe (T=0.109") then would cover the range of 0.055" to 0.359". Almost all fittings and pipe used for LN2 piping at Fermilab fall in this thickness range or below. Cell A-5 states that tests do not need to be repeated as long as the material has the same P-number and Group-number. ASME Boiler Pressure Vessel Code (BPVC) IX QW-422 lists 304 and 304L stainless steels as P-No. 8 and Group-No. 2. Both types of stainless steel typically used by AD/Cryo for LN2 piping will be covered by one set of impact tests.

Cell A-6 gives directions for the orientation and location of the specimens, which will be covered further in the next section. Cell A-7 states that the fabricator (FNAL) is responsible for the ensuring the tests are completed.

Charpy Impact Test Results

FNAL does not have a Charpy impact test facility, so the work was contracted out to Westmoreland Mechanical Testing & Research, Inc (WMT&R) in Youngstown, PA. WMT&R is accredited by the American Association for Laboratory Accreditation (A2LA) to meet ASTM E23 standards for impact testing.

Two 3" long 1" Schedule 10 304 stainless steel pipes were butt welded and sent to WMT&R for impact testing. Impact test specimens were cut and machined by WMT&R. Verbal and written instructions were provided to WMT&R regarding the location and orientation of the specimens. The written instructions included with the welded pipe were the following:

Please follow the instructions from ASME B31.3 Table 323.3.1 on the location and orientation of Charpy Impact test specimens on pipe welds:

Across the weld, with notch in the weld metal; notch axis shall be normal to material surface, with one face of specimen <= 1.5 mm (1/16 in.) from the material surface

Please include the lateral expansion in the test results for all three specimens. ASME B31.3 defines the lateral expansion as:

The increase in width of the broken impact specimen over that of the unbroken specimen measured on the compression side, parallel to the line constituting the bottom of the V-notch

Should you have any questions please contact Mike White at 630-840-6858 or mjwhite@fnal.gov

The AD/Cryo In-Process Weld Inspection form used on the sample sent to WMT&R is included in Appendix 1. The WMT&R test results are included in Appendix 2. ASME B31.3 Table 323.3.5 requires steels with a P-No. of 8 to have at least 0.015" of lateral expansion and has no requirements for dissipated energy. The test results showed that the three specimens had lateral expansion in the range of 0.021"-0.029" at -320°F (77K). All requirements of the Charpy impact test were satisfied.

Conclusion

All Charpy impact testing requirements have been satisfied for using 304 and 304L piping components with 308L filler metal and a wall thickness of less than 0.359". The extensive and successful experience Fermilab has had with the materials listed above has been reinforced with successful Charpy impact testing. No further testing should be required for most LN2 piping assemblies fabricated by AD/Cryo as long as thickness requirements are met.

COPY

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Welder Qualification Test Record

Welder's Name Leonard Harbacek Ident No. 122261 Date 03/19/99

Welding Process GTAW Type Manual

Test in Accordance With WPS # ES-155003 Root Open

Material Specification SA 53-B To Material Specification SA 53-B

P-No 1 To P-No 1 Thickness .280" Diam 6"

Filler Metal Specification SFA A5.18 Classification ER-70S-2 F-No 6

Thickness Deposited .280

Backing Argon Gas Shielding Argon

Position 6-G Progression Upward

Electrical Characteristics: Current DC Polarity Straight

Thickness Qualified .560" Max Diameter Qualified 2-7/8" O.D. and over

GUIDED BEND TEST RESULTS

Specimen No	Type	Figure	Results
1	Face	QW-462.3a	Acceptable
2	Face	QW-462.3a	Acceptable
3	Root	QW-462.3a	Acceptable
4	Root	QW-462.3a	Acceptable

Test Conducted By IFR Engineering Test No. 008-09-01 Date 3/19/99

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

By: [signature]

Date: 4/22/99

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Welder Qualification Test Record

Welder's Name Leonard Harbacek Ident No. 122261 Date 03/19/99

Welding Process SMAW Type Manual

Test in Accordance With WPS # ES-155000 Root Open

Material Specification SA 53-B To Material Specification SA 53-B

P-No 1 To P-No 1 Thickness .280" Diam 6"

Filler Metal Specification SFA A5.1 Classification E6010/E7018 F-No F3/F4

Thickness Deposited .280

Backing None Gas Shielding N/A

Position 6-G Progression Upward

Electrical Characteristics: Current DC Polarity Reverse

Thickness Qualified .560" Max Diameter Qualified 2-7/8" O.D. and over

GUIDED BEND TEST RESULTS

Specimen No	Type	Figure	Results
1	Face	QW-462.3a	Acceptable
2	Face	QW-462.3a	Acceptable
3	Root	QW-462.3a	Acceptable
4	Root	QW-462.3a	Acceptable

Test Conducted By IFR Engineering Test No. 008-09-01 Date 3/19/99

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

By: [signature] 4/22/99

Date: 4/22/99

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Welder Qualification Test Record

Welder's Name Leonard Harbacek Ident No. 122261 Date 03/19/99

Welding Process SMAW Type Manual

Test in Accordance With WPS # ES-155000 Root Open

Material Specification SA 53-B To Material Specification SA 53-B

P-No 1 To P-No 1 Thickness .280" Diam 6"

Filler Metal Specification SFA A5.1 Classification E6010/E7018 F-No F3/F4

Thickness Deposited .280

Backing None Gas Shielding N/A

Position 6-G Progression Upward

Electrical Characteristics: Current DC Polarity Reverse

Thickness Qualified .560" Max Diameter Qualified 2-7/8" O.D. and over

GUIDED BEND TEST RESULTS

Specimen No	Type	Figure	Results
1	Face	QW-462.3a	Acceptable
2	Face	QW-462.3a	Acceptable
3	Root	QW-462.3a	Acceptable
4	Root	QW-462.3a	Acceptable

Test Conducted By IFR Engineering Test No. 008-09-01 Date 3/19/99

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

By: [signature] 4/22/99

Date: 4/22/99

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Fermi National Accelerator Laboratory

Technical Division-Machine Shop

Welder Performance Qualification Record

Welder's Name	*Ryan Mahoney*			**FNAL #**	*15470N*	**ASME #**	*W-2*
Welding Process:	**1st**	*GTAW*	Type	*Manual*	**2nd**	Type	
Performed in accordance with:	*Fermi WPS SS-3,R4*						

Joint:	~~**Fillet:**~~		~~Production Weld~~	*Test Coupon*		
Groove:	~~Double Welded:~~	~~Yes~~	No			
	Single Welded:	~~Metal Fused~~	~~Metal Non-Fused~~	~~Non-Metal~~	*Open Root*	~~Consumable Insert~~
		~~With Solid Backing~~	*Without Solid Backing*			

Base Metal:	Specification:	*SA 312, Gr 304*	TO	*SA 312, Gr 304*	ASME P #8	TO ASME P # 8

~~Plate~~	Pipe		Pipe	~~Tube~~
Actual Thickness:	Nominal Diameter: *4*		Actual Diameter: *4/5"*	Overall Diameter:
Qualified Range:	Wt/Schedule: *Sch. 80*	Qualified Thickness Range: *0-0.674*		Wall:
	Actual Thickness: *0.337*	Qualified Diameter Range: *2.875" minimum*		Qualified Thickness Range:
				Qualified Diameter Range:

Filler:	1st Process		2nd Process	
	Specification: *SFA 5.9*	Class: *ER 308/308L*	Specification:	Class:
	Diameter(s): *1/16"Ø, 3/32"Ø*		Diameter(s):	
	F #: *6*		F #:	
	Deposit Thickness: *0.0337*	Range Qualification: *0-0.674"*	Deposit Thickness:	Range Qualification:

Welding Position: *6G*	If Vertical: *Upward* ~~Down~~				
Gas (Type & Composition:	Shielding: *Argon 99.9%*		Root Side Backing	*Argon 99.9%*	
Electrical Characteristics	Type Current	~~AC~~	~~DCEP~~	*DCEN*	
	Transfer GMAW	~~Spray~~	~~Globular~~	~~Pulse~~	~~Short Circuit~~

For Information Only		**Machine Welding**		
Filler Metal Trade Name:		Control:	☐ Visual	☐ Remote Visual
SAW Flux Trade Name:		Arc Voltage Control:	☐ Auto	☐ Other:
Shielding Gas Trade Name:		Joint Tracking:	☐ Yes	☐ No

Visual Inspection					
Appearance:	*Satisfactory*	Undercut:		Piping Porosity:	

Guided Bend Test					
Type and Figure	Results	Type and Figure	Results	Type and Figure	Results
Test Conducted by:			Lab Test #:		Date:

Radiographic Test			
Results: Satisfactory	Per ASME IX-2007 and AWS D1.1-06		
Radiographer: *Alloyweld Inspection Co., Inc.*	Examiner: *Jennifer Anaya-Level II*	*Register #5615*	Date: *6/18/2010*

Fillet Weld Test Results			
Fracture Test:(Location, Nature, and size of Crack or Tear in Specimen)			
Length of Weld:	Length of Defect:	Percent of Defect	
Macro Test: Fusion			
Appearance: Fillet Size inch X inch		☐ Convex	☐ Concave
Test Conducted by:	Lab Test #:		

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of **ASME IX-2007 & AWS D1.1-06** ***Fermi National Accelerator Laboratory***

By:	Date:

Fermilab

Fermi National Accelerator Laboratory

Technical Division-Machine Shop

Welder Performance Qualification Record

Welder's Name	*Ryan Mahoney*			**FNAL #**	*15470N*	**ASME #**	*W-2*
Welding Process:	**1st**	*GTAW*	Type	*Manual*	**2nd**	Type	
Performed in accordance with:	*Fermi WPS SS-3,R4*						

Joint:	~~Fillet:~~	~~Production Weld~~	*Test Coupon*		
Groove:	~~Double Welded:~~	~~Yes~~	No		
	Single Welded:	~~Metal Fused~~	~~Metal Non-Fused~~	~~Non-Metal~~	*Open Root* / ~~Consumable Insert~~
		~~With Solid Backing~~	*Without Solid Backing*		

Base Metal:	Specification:	*SA 312, Gr 304*	TO	*SA 312, Gr 304*	ASME P #8	TO ASME P # 8
~~Plate~~	**Pipe**					~~Tube~~
Actual Thickness:	Nominal Diameter: 4		Actual Diameter: *4/5"*			Overall Diameter:
Qualified Range:	Wt/Schedule: *Sch. 80*		Qualified Thickness Range: *0-0.674*			Wall:
	Actual Thickness: *0.337*		Qualified Diameter Range: *2.875" minimum*			Qualified Thickness Range:
						Qualified Diameter Range:

Filler:	**1st Process**		**2nd Process**	
	Specification: *SFA 5.9*	Class: *ER 308/308L*	Specification:	Class:
	Diameter(s): *1/16"Ø, 3/32"Ø*		Diameter(s):	
	F #: *6*		F #:	
	Deposit Thickness: *0.0337*	Range Qualification: *0-0.674"*	Deposit Thickness:	Range Qualification:

Welding Position: *6G*	If Vertical: *Upward* ~~Down~~				
Gas (Type & Composition:	Shielding: *Argon 99.9%*		Root Side Backing	*Argon 99.9%*	
Electrical Characteristics	Type Current	~~AC~~	~~DCEP~~	*DCEN*	
	Transfer GMAW	~~Spray~~	~~Globular~~	~~Pulse~~	~~Short Circuit~~

For Information Only		**Machine Welding**		
Filler Metal Trade Name:		Control:	☐ Visual	☐ Remote Visual
SAW Flux Trade Name:		Arc Voltage Control:	☐ Auto	☐ Other:
Shielding Gas Trade Name:		Joint Tracking:	☐ Yes	☐ No

Visual Inspection					
Appearance:	*Satisfactory*	Undercut:		Piping Porosity:	

Guided Bend Test					
Type and Figure	Results	Type and Figure	Results	Type and Figure	Results
Test Conducted by:			Lab Test #:		Date:

Radiographic Test			
Results: Satisfactory	Per ASME IX-2007 and AWS D1.1-06		
Radiographer: *Alloyweld Inspection Co., Inc.*	Examiner: *Jennifer Anaya-Level II*	*Register # 5615*	Date: *6/18/2010*

Fillet Weld Test Results			
Fracture Test:(Location, Nature, and size of Crack or Tear in Specimen)			
Length of Weld:	Length of Defect:	Percent of Defect	
Macro Test: Fusion			
Appearance: Fillet Size inch X	inch	☐ Convex	☐ Concave
Test Conducted by:	Lab Test #:		

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of ASME IX-2007 *Fermi National Accelerator Laboratory*	
By:	Date: 6/18/2010

Fermilab

Fermi National Accelerator Laboratory

Technical Division-Machine Shop

Welder Performance Qualification Record

Welder's Name	*Ryan Mahoney*			**FNAL #**	*15470N*	**ASME #**	*W-2*
Welding Process:	**1st**	*GTAW*	Type *Manual*	**2nd**		Type	
Performed in accordance with:	*Fermi WPS SS-3,R4*						

Joint:	~~Fillet:~~	~~Production Weld~~	*Test Coupon*		
Groove:	~~Double Welded:~~	~~Yes~~	No		
	Single Welded:	~~Metal Fused~~	~~Metal Non-Fused~~	~~Non-Metal~~	*Open Root* ~~Consumable Insert~~
		~~With Solid Backing~~	*Without Solid Backing*		

Base Metal: Specification:	*SA 312, Gr 304* TO *SA 312, Gr 304*		ASME P #8 TO ASME P # 8	
~~Plate~~	**Pipe**		~~Tube~~	
Actual Thickness:	Nominal Diameter: *4*	Actual Diameter: *4/5"*	Overall Diameter:	
Qualified Range:	Wt/Schedule: *Sch. 80*	Qualified Thickness Range: *0-0.674*	Wall:	
	Actual Thickness: *0.337*	Qualified Diameter Range: *2.875" minimum*	Qualified Thickness Range:	
			Qualified Diameter Range:	

Filler:	**1st Process**		**2nd Process**	
	Specification: *SFA 5.9*	Class: *ER 308/308L*	Specification:	Class:
	Diameter(s): *1/16"Ø, 3/32"Ø*		Diameter(s):	
	F #: *6*		F #:	
	Deposit Thickness: *0.0337*	Range Qualification: *0-0.674"*	Deposit Thickness:	Range Qualification:

Welding Position: *6G*	If Vertical: *Upward* ~~Down~~				
Gas (Type & Composition:	Shielding: *Argon 99.9%*	Root Side Backing	*Argon 99.9%*		
Electrical Characteristics	Type Current	~~AC~~	~~DCEP~~	*DCEN*	
	Transfer GMAW	~~Spray~~	~~Globular~~	~~Pulse~~	~~Short Circuit~~

For Information Only		**Machine Welding**		
Filler Metal Trade Name:		Control:	☐ Visual	☐ Remote Visual
SAW Flux Trade Name:		Arc Voltage Control:	☐ Auto	☐ Other:
Shielding Gas Trade Name:		Joint Tracking:	☐ Yes	☐ No

Visual Inspection					
Appearance:	*Satisfactory*	Undercut:		Piping Porosity:	

Guided Bend Test					
Type and Figure	Results	Type and Figure	Results	Type and Figure	Results
Test Conducted by:			Lab Test #:		Date:

Radiographic Test			
Results: Satisfactory	Per ASME IX-2007 and AWS D1.1-06		
Radiographer: *Alloyweld Inspection Co., Inc.*	Examiner: *Jennifer Anaya-Level II*	*Register # 5615*	Date: *6/18/2010*

Fillet Weld Test Results				
Fracture Test:(Location, Nature, and size of Crack or Tear in Specimen)				
Length of Weld:	Length of Defect:		Percent of Defect	
Macro Test: Fusion				
Appearance: Fillet Size inch X	inch	☐ Convex	☐ Concave	
Test Conducted by:	Lab Test #:			

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of **ASME IX-2007** ***Fermi National Accelerator Laboratory***

By: *[signature]*	Date: *6/18/2010*

Fermilab

Fermi National Accelerator Laboratory

Technical Division-Machine Shop

Welder Performance Qualification Record

Welder's Name	*Ryan Mahoney*			FNAL #	*15470N*	ASME #	*W-2*
Welding Process:	1st	*GTAW*	Type	*Manual*	2nd	Type	
Performed in accordance with:	*Fermi WPS-SS-8-001*						

Joint:	~~Fillet:~~	~~Production Weld~~	*Test Coupon*		
Groove:	~~Double Welded:~~	~~Yes~~	*No*		
	Single Welded:	~~Metal Fused~~	~~Metal Non Fused~~	~~Non Metal~~	*Open Root* / Consumable Insert
		~~With Solid Backing~~	*Without Solid Backing*		

Base Metal: Specification:	*SA 213, Type 304/304L* TO *SA 213, Type 304/304L*		*ASME P #8, Gp 1* TO *ASME P # 8, Gp 1*
Plate	Pipe		Tube
Actual Thickness:	Nominal Diameter:	Actual Diameter	Overall Diameter: *0.250"*
Qualified Range:	Wt/Schedule:	Qualified Thickness Range	Wall: *0.035"*
	Actual Thickness	Qualified Diameter Range: .	Qualified Thickness Range: *0.070" Maximum*
			Qualified Diameter Range: *0.250" Minimum*

Filler:	1st Process		2nd Process	
	Specification: *5.9*	Class: *308/308L*	Specification:	Class:
	Diameter(s): *.035, .045, 1/16*		Diameter(s):	
	F #: *6*		F #:	
	Deposit Thickness: *0.035*	Range Qualification: *0.070 Maximum*	Deposit Thickness:	Range Qualification:

Welding Position: *6G*	If Vertical: *Uphill* ~~Down~~				
Gas (Type & Composition:	Shielding: *Argon 99.9%*		Root Side Backing - *Argon 99.9%*		
Electrical Characteristics	Type Current	~~AC~~	~~DCEP~~	*DCEN*	
	~~Transfer GMAW~~	~~Spray~~	~~Globular~~	~~Pulse~~	~~Short Circuit~~

Visual Inspection

Appearance:	*Satisfactory*	Undercut:	*None*	Piping Porosity:	*None*

Guided Bend Test

Type and Figure	Results	Type and Figure	Results	Type and Figure	Results
Test Conducted by:			Lab Test #:		Date:

Radiographic Test

Results: *Satisfactory*		Per ASME IX-2007	
Radiographer: *Alloyweld Inspection Co., Inc.*	Examiner: *Jennifer Anaya-Level II*	Register # *5615*	Date: *6/18/2010*

Fillet Weld Test Results

Fracture Test: (Location, Nature, and size of Crack or Tear in Specimen)		
Length of Weld:	Length of Defect:	Percent of Defect
Macro Test: Fusion		
Appearance: Fillet Size inch X inch	☐ Convex	☐ Concave
Test Conducted by:	Lab Test #:	

Test Verified by: *Roger Hiller, 00362N*	Verification Report *#5112010-2RH*	Signature

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of ASME IX-2007 & AWS D1.1-06 *Fermi National Accelerator Laboratory*

By: Roger Hiller 00362N [signature] Authorized Representative

Date: *6/18/2010*

Fermilab

Fermi National Accelerator Laboratory

Technical Division-Machine Shop

Welder Performance Qualification Record

Welder's Name	Ryan Mahoney			FNAL #	15470N	ASME #	W-2
Welding Process:	1st	GTAW	Type	Manual	2nd		Type	
Performed in accordance with:	Fermi WPS-SS-9-002						

Joint:	~~Fillet:~~		~~Production Weld~~	Test Coupon	
Groove:	Double Welded:	~~Yes~~	No		
	Single Welded	~~Metal Fused~~	~~Metal Non-Fused~~	~~Non-Metal~~	Open Root	Consumable Insert
		~~With Solid Backing~~	Without Solid Backing		

Base Metal:	Specification:	SA 213, Type 304/304L	TO	SA 213, Type 304/304L	ASME P #8, Gp 1	TO	ASME P # 8, Gp 1
Plate	Pipe				Tube		
Actual Thickness:	Nominal Diameter:		Actual Diameter		Overall Diameter: 0.500"		
Qualified Range:	Wt/Schedule:		Qualified Thickness Range		Wall: 0.095"		
	Actual Thickness		Qualified Diameter Range		Qualified Thickness Range: 0.190" Maximum		
					Qualified Diameter Range: 0.500" Minimum		

Filler:	1st Process		2nd Process	
	Specification: 5.9	Class: 308/308L	Specification:	Class:
	Diameter(s): .045, 1/16, 3/32		Diameter(s):	
	F #: 6		F #:	
	Deposit Thickness: 0.095	Range Qualification: 0.190 Maximum	Deposit Thickness:	Range Qualification:

Welding Position: 6G	If Vertical: Uphill ~~Down~~				
Gas (Type & Composition:	Shielding: Argon 99.9%		Root Side Backing - Argon 99.9%		
Electrical Characteristics	Type Current	~~AC~~	~~DCEP~~	DCEN	
	~~Transfer GMAW~~	~~Spray~~	~~Globular~~	~~Pulse~~	~~Short Circuit~~

Visual Inspection					
Appearance:	Satisfactory	Undercut:	None	Piping Porosity:	None

Guided Bend Test					
Type and Figure	Results	Type and Figure	Results	Type and Figure	Results
Test Conducted by:			Lab Test #:		Date:

Radiographic Test			
Results: Satisfactory	Per ASME IX-2007 and AWS D1.1-06		
Radiographer: Alloyweld Inspection Co., Inc.	Examiner: Jennifer Anaya-Level II	Register # 5615	Date: 6/18/2010

Fillet Weld Test Results		
Fracture Test: (Location, Nature, and size of Crack or Tear in Specimen)		
Length of Weld:	Length of Defect:	Percent of Defect
Macro Test: Fusion		
Appearance: Fillet Size inch X inch	☐ Convex	☐ Concave
Test Conducted by:	Lab Test #:	

Test Verified by: Roger Hiller 00362N	Verification Report #5272010-2	Signature

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of ASME IX-2007 & AWS D1.1-06 *Fermi National Accelerator Laboratory*

By: Roger Hiller 00362N [signature]
Authorized Representative

Date: 6/18/2010