PIP-II Compressed Gas Systems Design

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PIP-II LINAC Complex Mechanical Fluid Systems PDR

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A Partnership of:

US/DOE
India/DAE
Italy/INFN
UK/UKRI-STFC
France/CEA, CNRS/IN2P3
Poland/WUST

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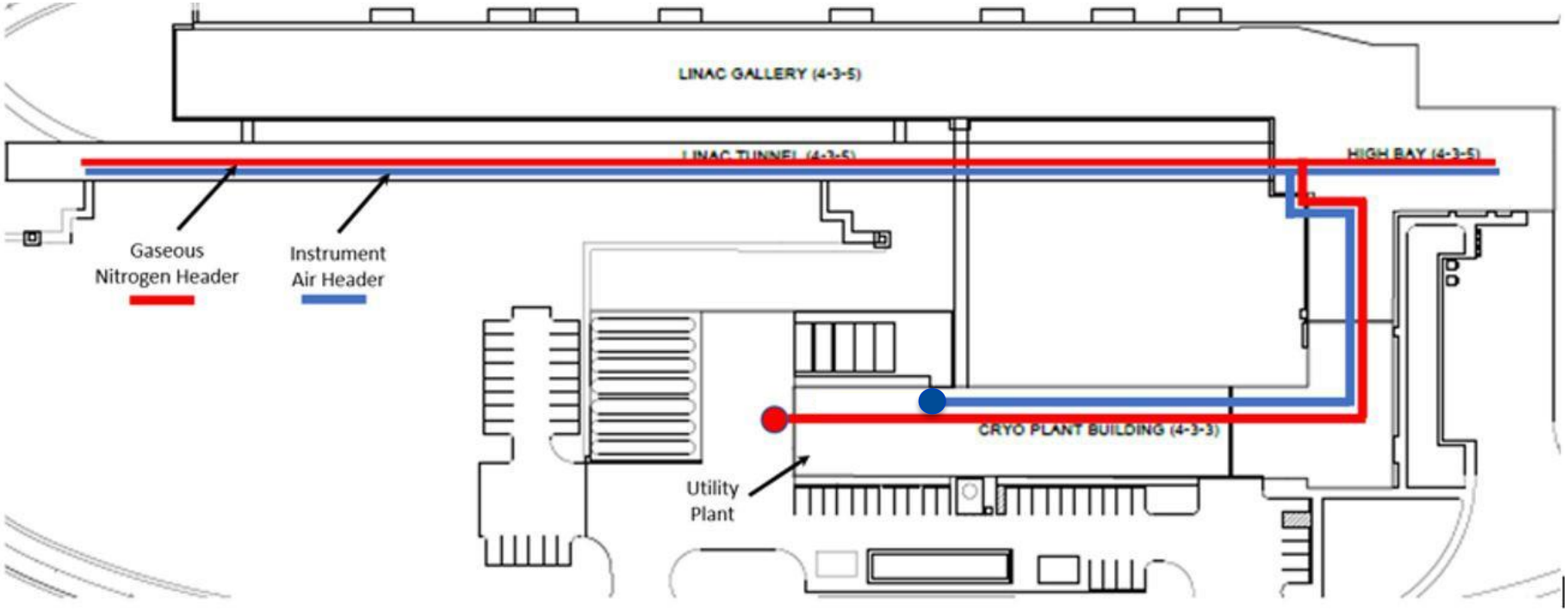
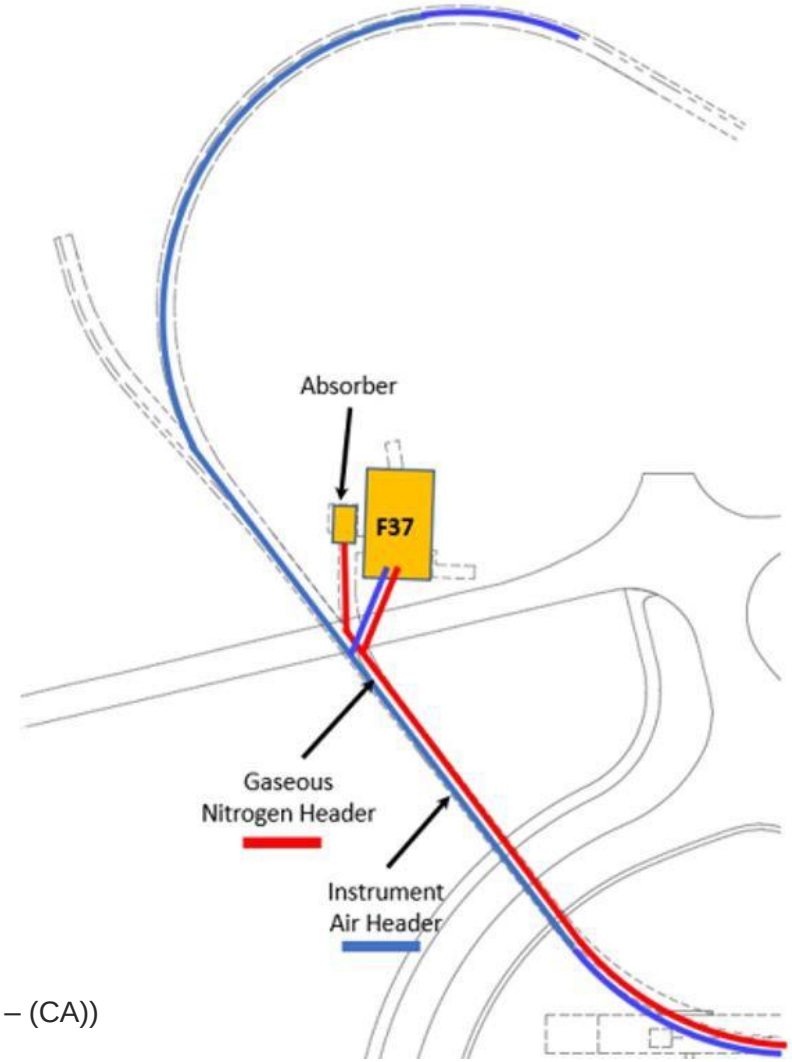
Compressed Gas Scope Layout – Cryo Plant/LINAC Complex Sections



Compressed Air/Instrument Air (CA))

Nitrogen Gas (N2)

Compressed Gas Scope Layout (Continued) – BTL Section



Compressed Air/Instrument Air – (CA))

Nitrogen Gas (N2)

Compressed Air Highlights

- 2 - 200 HP Rotary screw air compressors
- Redundant operation Air compressor arrangement
- Redundant operation desiccant air dryers and particulate filters
- 1500 Gallon reservoir tank
- Water/oil separator
- Electric operated automatic condensate drains

Technical Requirements for Compressed Instrument Air System

- Building Infrastructure shall design the compressed air system infrastructure according to the following specifications:
- Discharge Pressure = 100 PSIG
- Total Discharge Flow = 1060 SCFM (903.8 SCFM required)
- Dewpoint = - 40°C/F
- Particulate Filtration = .1 micron
- Instrument air flow requirement summary for individual components can be found in the Instrument Air Usage Document – Teamcenter Document #ED0012529

Compressed Instrument Air End User Flow Usage

Component	Quantity [#]	Unit Consumption [scfm]	Total Consumption [scfm]
RFQ Couplers	4	4	16
HWR Couplers	8	1.67	13.4
SSR1 Couplers	16	3.5	56.0
SSR2 Couplers	35	6.17	216.0
LB650 Couplers	36	6.17	222.1
HB650 Couplers	36	7.03	253.2
Cryomodule JT Control Valves	25	0.141	3.5
Cryomodule CD Control Valves	25	0.066	1.7
Beam and Vacuum Valves	All	0**	0**
CDS			
Tunnel Control Valves	All	-	28.3
Distribution Box Control Valves	All	-	1.4
Cryoplant			
Coldbox Control Valves	All	-	64.9
Warm Compressor System Control Valves	All	-	14.8
Warm Header Control Valves	2	0.2	0.4
Cryoplant ORS and GMP Control Valves	All	-	11.8
Recovery Compressor Control Valves	All	-	0.2
Liquid Helium Dewar Control Valve	1	0.1	0.1
		Total =	**903.8**

** Note that beam and vacuum gate valves throughout the complex use instrument air for opening and closing where consumption is only during actuation, therefore the usage is essentially zero during normal operation.

Compressed Air System P&ID

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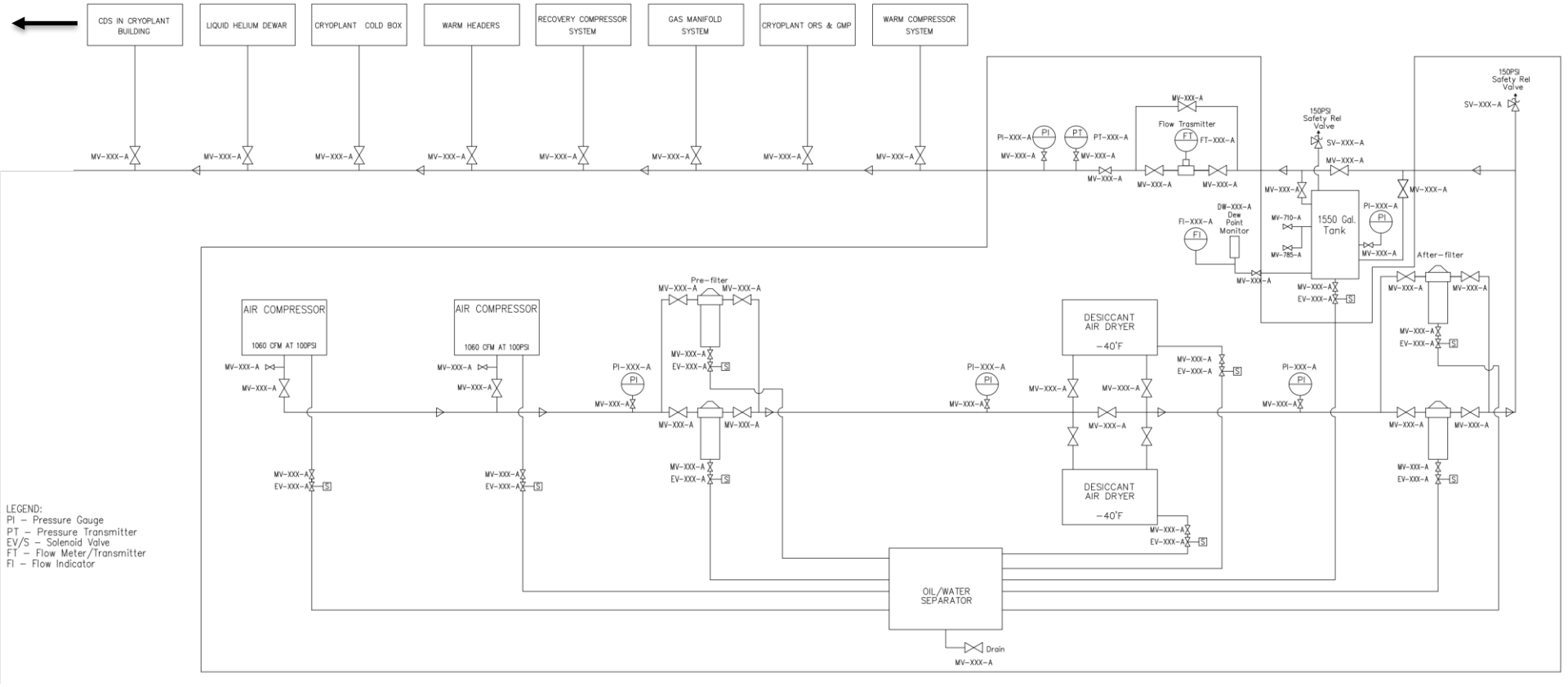

Compressed Air System P&ID (Continued)

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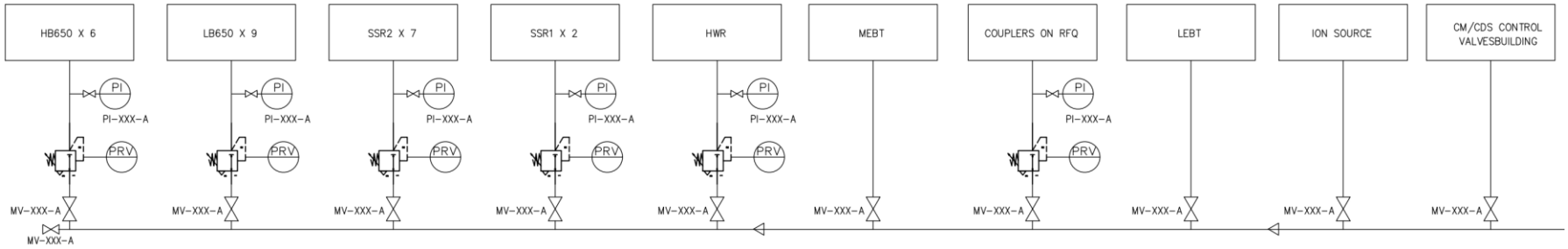


LEGEND:
PI – Pressure Gauge
PT – Pressure Transmitter
EV/S – Solenoid Valve
FT – Flow Meter/Transmitter
FI – Flow Indicator

Nitrogen Gas Highlights

- Source of Nitrogen Gas is Nitrogen Dewar provided by Cryo Group

Technical Requirements for Nitrogen Gas System

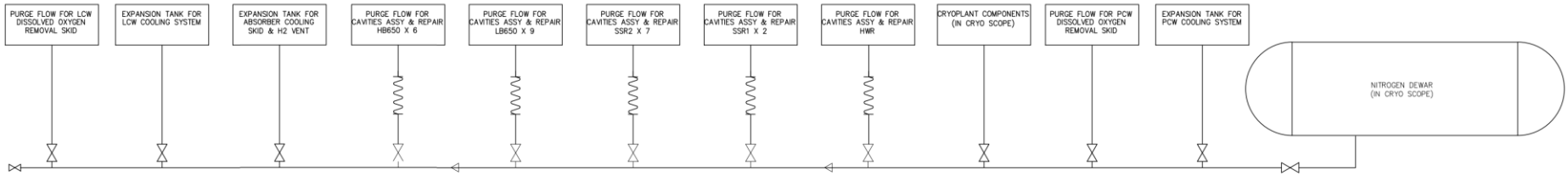
- Building Infrastructure shall design piping infrastructure for utility nitrogen gas according to the following specifications:
- Discharge Pressure = 100 PSIG
- Total Discharge Flow = 35.5 SCFM (20 g/s)
- Nitrogen gas flow requirement summary for individual components can be found in the Nitrogen Usage Document – Teamcenter Document #ED0012529

Nitrogen Gas End User Flow Usage

System	Frequency	Pressure	Flow Rate	
		[psig]	[-]	[g/s]
LCW – oxygen removal	continuous	50	10 cfm	5.43
LCW – vessel blanket flow	continuous	50	2 cfh	0.02
Clean nitrogen for portable cleanroom and vacuum use	infrequent	100	2000 cf/day (10 cfm instantaneous)	0.75
Cryoplant purifier charcoal bed regeneration	infrequent	50		10**
			Total =	16.2

** Based on NML regeneration procedure with 1 kW heater 225° F outlet temperature

Nitrogen Gas Block Diagram



NOTES:

1. NITROGEN PRESSURE 100PSIG
2. —wvw— FLEXIBLE HOSE
3. FLEXIBLE HOSES ARE USED FOR PURGE, VACUUM AND PORTABLE CLEAN ROOM

Preliminary Analysis Of Designed Compressed Gas Piping Loads

PIP-II COMPRESSED AIR MATERIAL TYPE AND SIZES

PRESSURE DESIGN OF COMPONENTS (FROM ASME B31.3 – 304)

Minimum Pipe Thickness is given by,

$$t_m = t + c \qquad (2)$$

Here,

$$t = \frac{PD}{2(SEW + PY)} \qquad (3b)$$

Nomenclature used in equations:

c = sum of the mechanical allowances thread depth plus corrosion and erosion allowances.

D = outside diameter of pipe

d = inside diameter of pipe

E = quality factor from Table A-1A or Table A-1B

P = internal design gage pressure

S = stress value for material from Table A-1 or Table A-1M

T = pipe wall thickness

t = pressure design thickness in accordance with para. 304.1.2

t_m = minimum required thickness, including mechanical, corrosion, and erosion allowances

W = weld joint strength reduction factor in accordance with para. 302.3.5(e)

Y = coefficient from Table 304.1.1, valid for t < D/6

Preliminary Analysis Of Compressed Gas Piping (continued)

Tube:

Material Specification: Cu Type "K"

Design Pressure (P): 100 psig

Design Temperature: 68 ºF (Ambient)

Pipe Thickness Calculation Parameters:

Coefficient Y = 0.4

Stress Value for Material, S = 6,000 psi

Quality Factor, E = 1

Weld Joint Strength Reduction Factor, W = 1

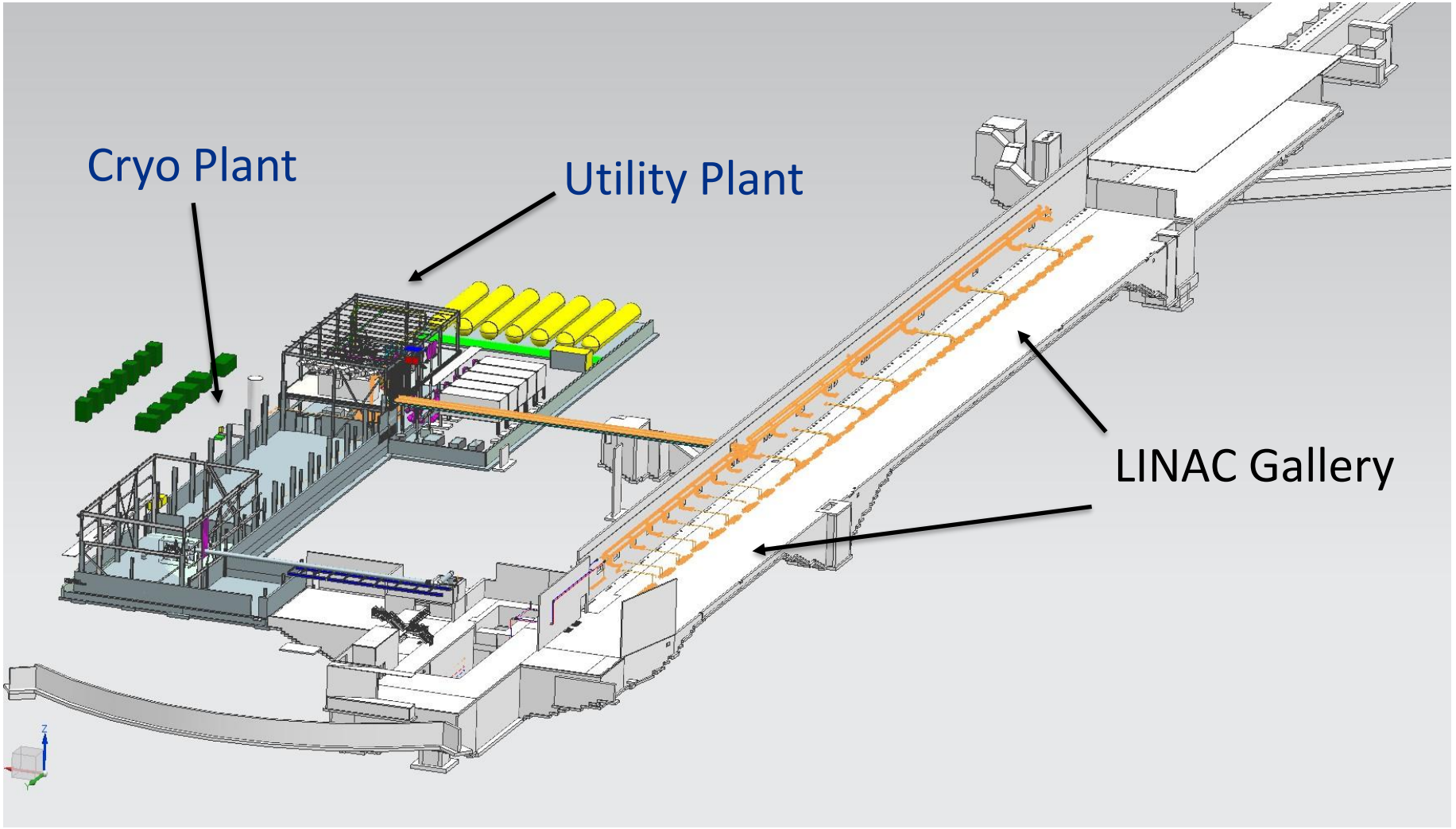
Primary piping wall thickness (T) exceeds minimum wall thickness (t_m) requirements

Nominal Size	Outer Diameter, D	Thickness, T	Inner Diameter, d	Mechanical Allowance, c	Pressure Design Thickness, t	Is t < D/6?	t_m	Is T > t_m?
in	in	in	in	in	in		in	
4	4.125	0.134	3.857	0.02	0.03415	Yes	0.05415	Yes
3	3.125	0.109	2.907	0.02	0.02587	Yes	0.04587	Yes
2	2.125	0.083	1.959	0.02	0.01759	Yes	0.03759	Yes
1	1.125	0.065	0.995	0.02	0.00931	Yes	0.02931	Yes
3/4	0.875	0.065	0.745	0.02	0.00724	Yes	0.02724	Yes
1/2	0.625	0.049	0.527	0.02	0.00517	Yes	0.02517	Yes
3/8	0.500	0.049	0.402	0.02	0.00414	Yes	0.02414	Yes
1/4	0.375	0.035	0.305	0.02	0.00310	Yes	0.02310	Yes

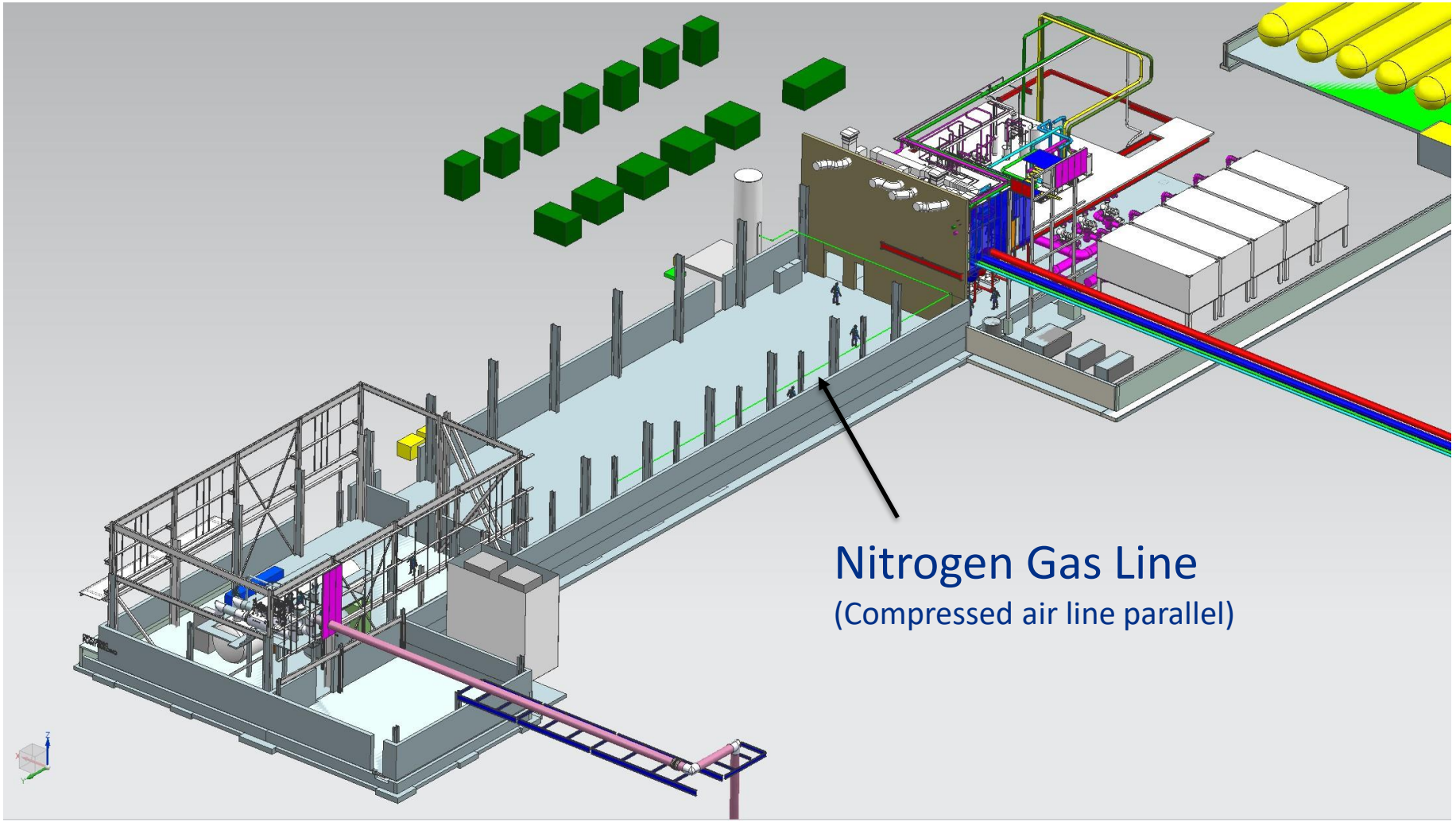
Installation Plan

- Compressed air equipment will be located in Utility Plant and will be procured and installed by Conventional Facilities
- Both Nitrogen and Compressed air piping in the Utility Plant will be installed within this Building Infrastructure scope.
- Both Nitrogen and Compressed air piping through the Cryoplant and throughout the LINAC complex, including the LINAC enclosure will be installed by Conventional Facilities.

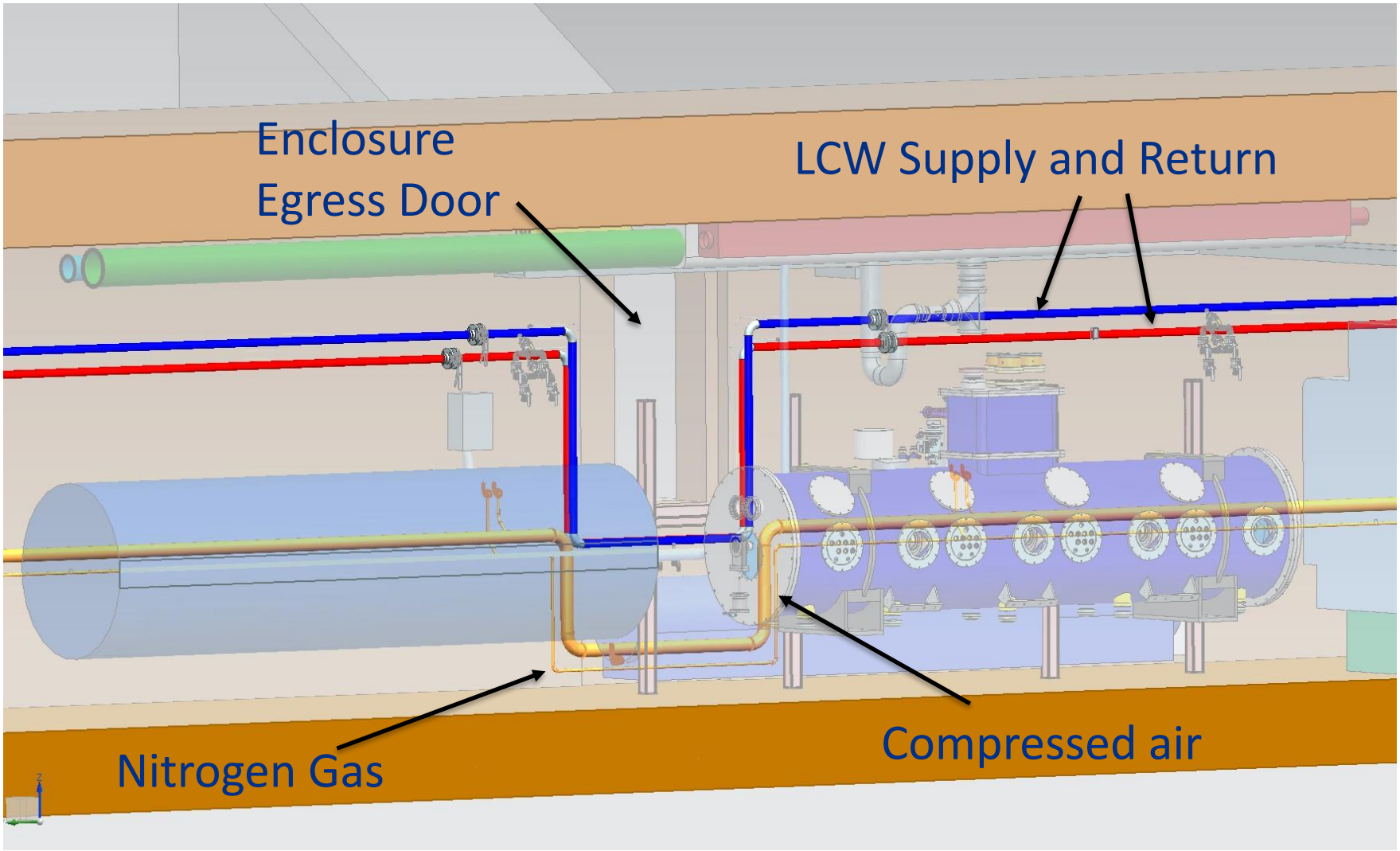
Screenshot – Scope Complex (Northwest Elevated View)



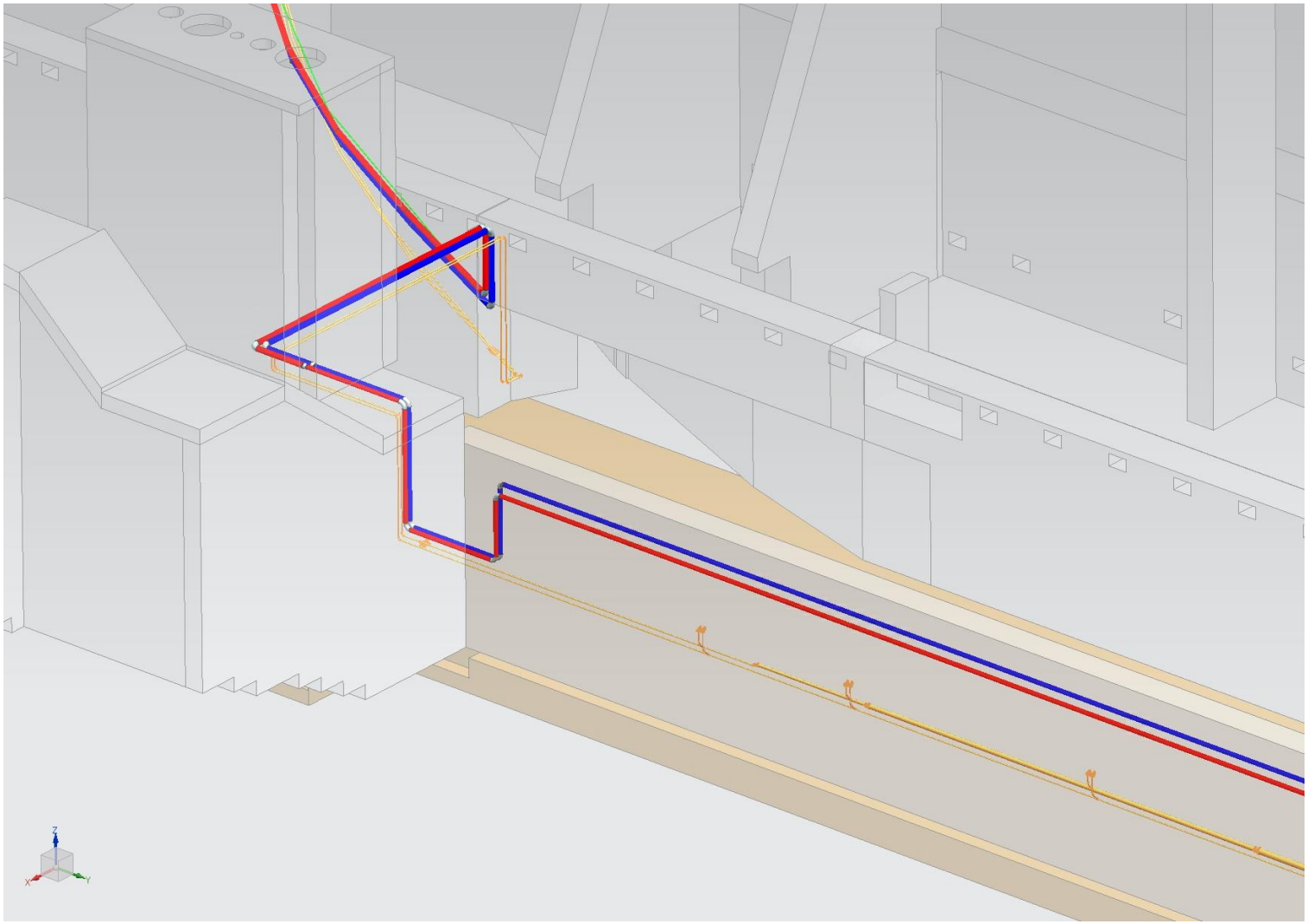
Screenshot – CRYO Plant and Utility Plant (Northwest Elevated View)



Screenshot – LINAC Enclosure – LCW/Compressed Gas Routing (West Elevated View)



Screenshot – LINAC Enclosure to BTL Transition – LCW/Compressed Gas Routing (NE Elevated View)



Screenshot – BTL Enclosure Transition to F37 Building – LCW/Compressed Gas Routing (SE Elevated View)