

Helium Operators Familiarization Program

Unit 325 – Helium Loading Bays

Dec 2012 | Vincent HELOIN



Course Agenda

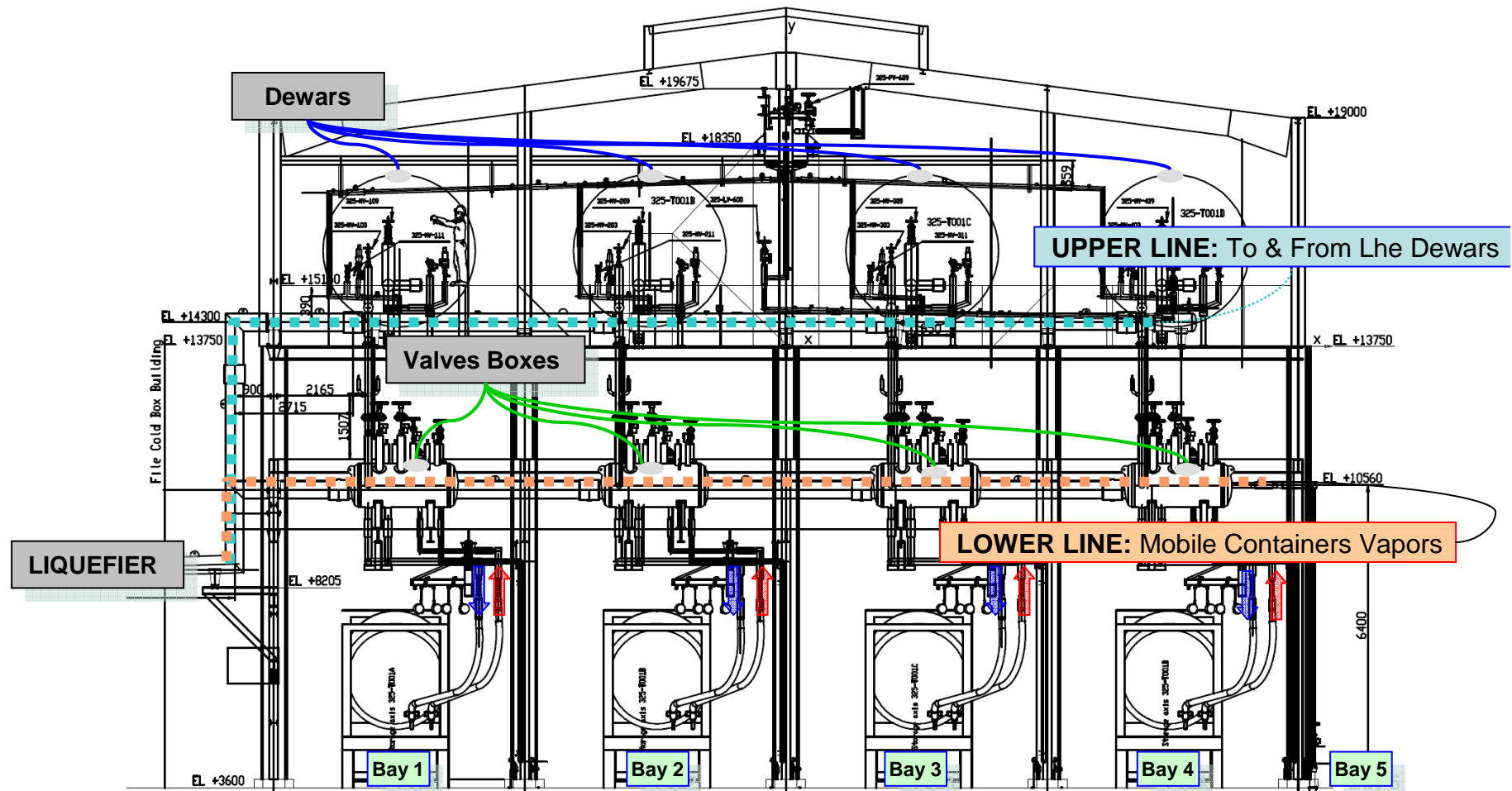
- Unit 325 Building : He and LN₂ Distribution

- Unit 325 PID & Simplified PFD

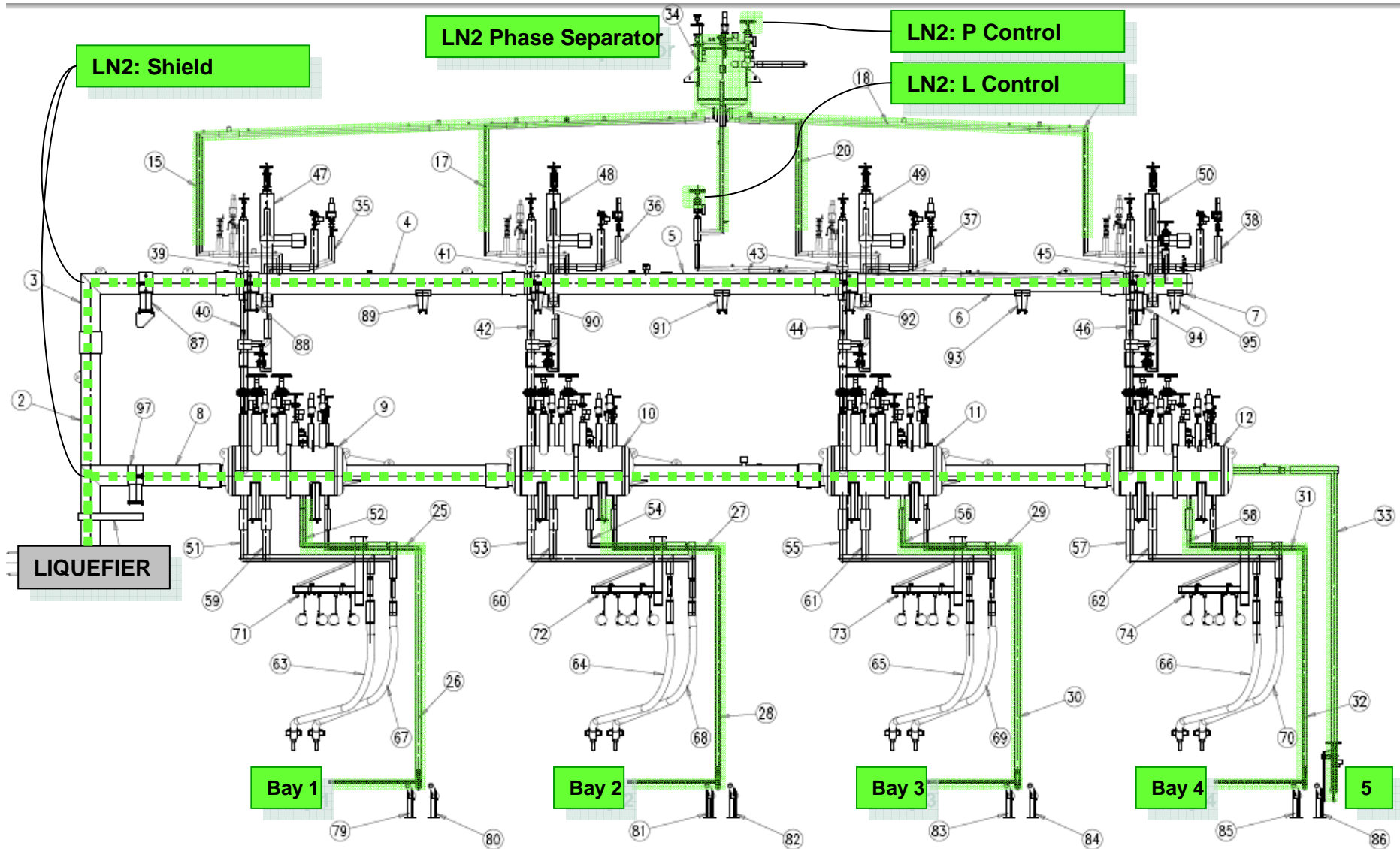
- Loading Sequences & Main Steps

Unit 325 Building : Helium Distribution

- The 4 Loading Bays of unit 325 allows the conditioning, cooling down and filling of helium mobile containers.

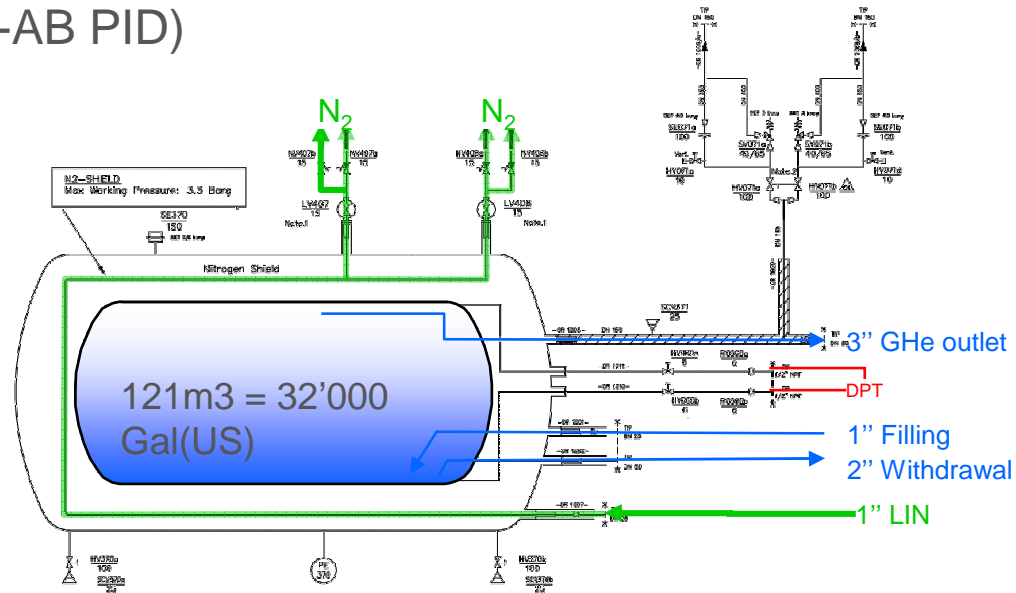


Unit 325 Building : Nitrogen Distribution



Unit 325 : Storages

Storage (CRYO-AB PID)

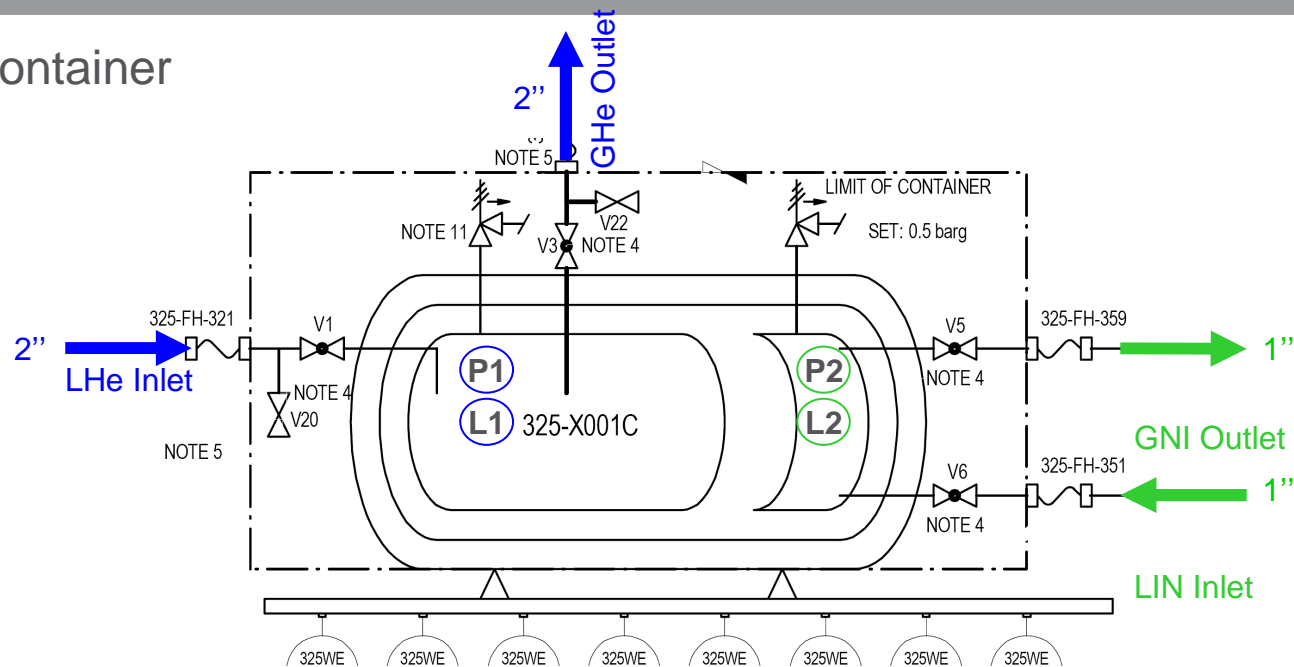


Some Figures

Capacity	33 800 Gal	128 m ³
Net Cold Capacity	32 000 Gal	121 m ³
Gross Weight (LHe + LN₂)	50 146 Lbs	58 500 kg
Weight Empty	97 000 Lbs	44 000 kg
LHe Weight	32 000 Lbs	14 500 kg
Dimensions	72' x Ø11'6"	22m x Ø3,5m

Unit 325 : Mobile Dewars

Typical Container



Capacity	11 000 Gal	41,64 m3
Net Cold Capacity	10 900 Gal	41,26 m3
LN2 Capacity	327 Gal	1,24 m3
Gross Weight (LHe + LN2)	50 146 Gal	22 746 kg
Weight Empty	36 600 Lbs	16 601 kg
<i>LHe Weight</i>	<i>11 020 Lbs</i>	<i>5 000kg</i>
<i>LN2 Weight</i>	<i>2 200 Lbs</i>	<i>1000 kg</i>
Dimensions	40' x 8' x 8'6"	12m x 2,4m x 2,6m

Course Agenda

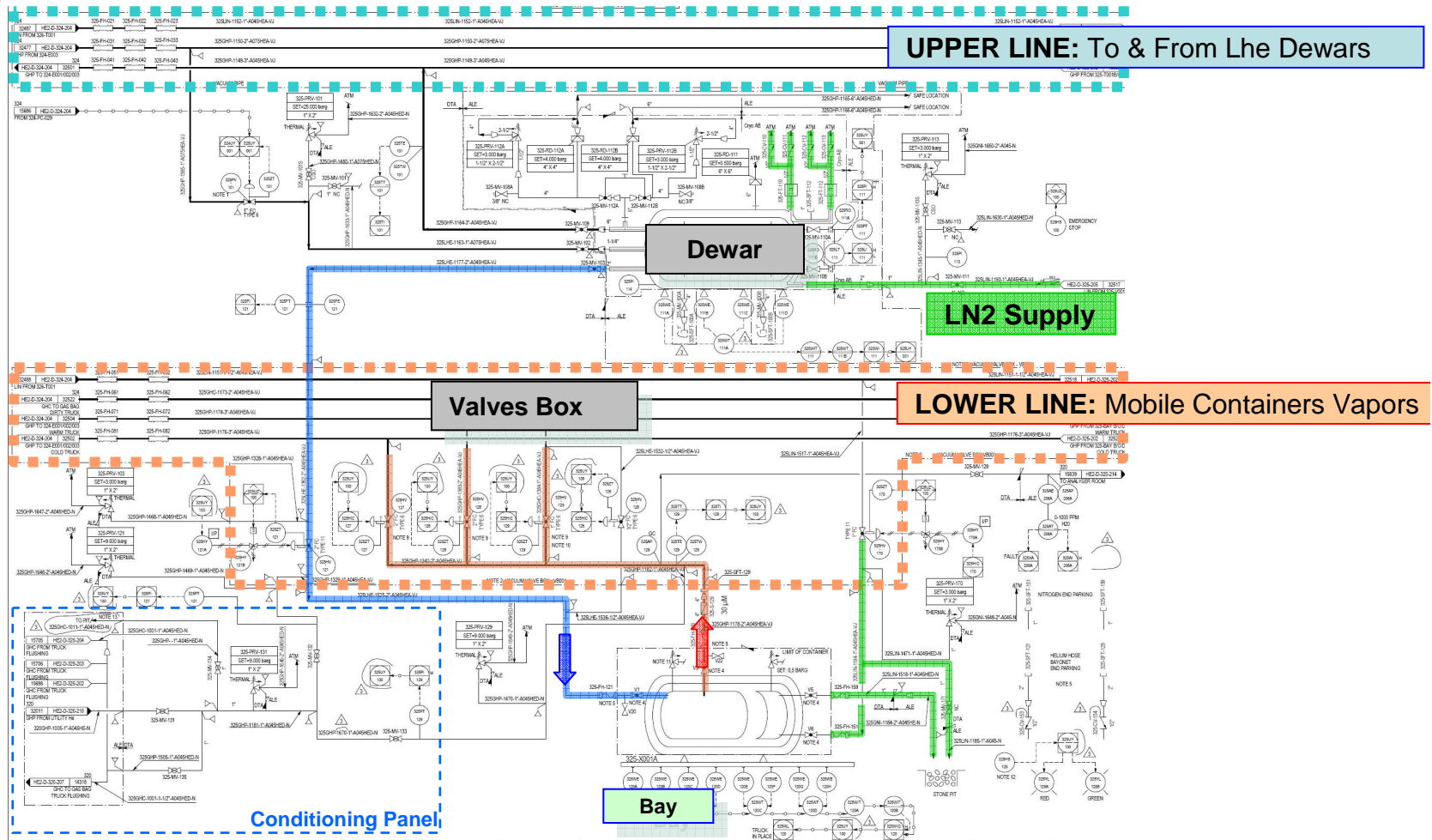
- Unit 325 Building : He and LN₂ Distribution

- **Unit 325 PID & Simplified PFD**

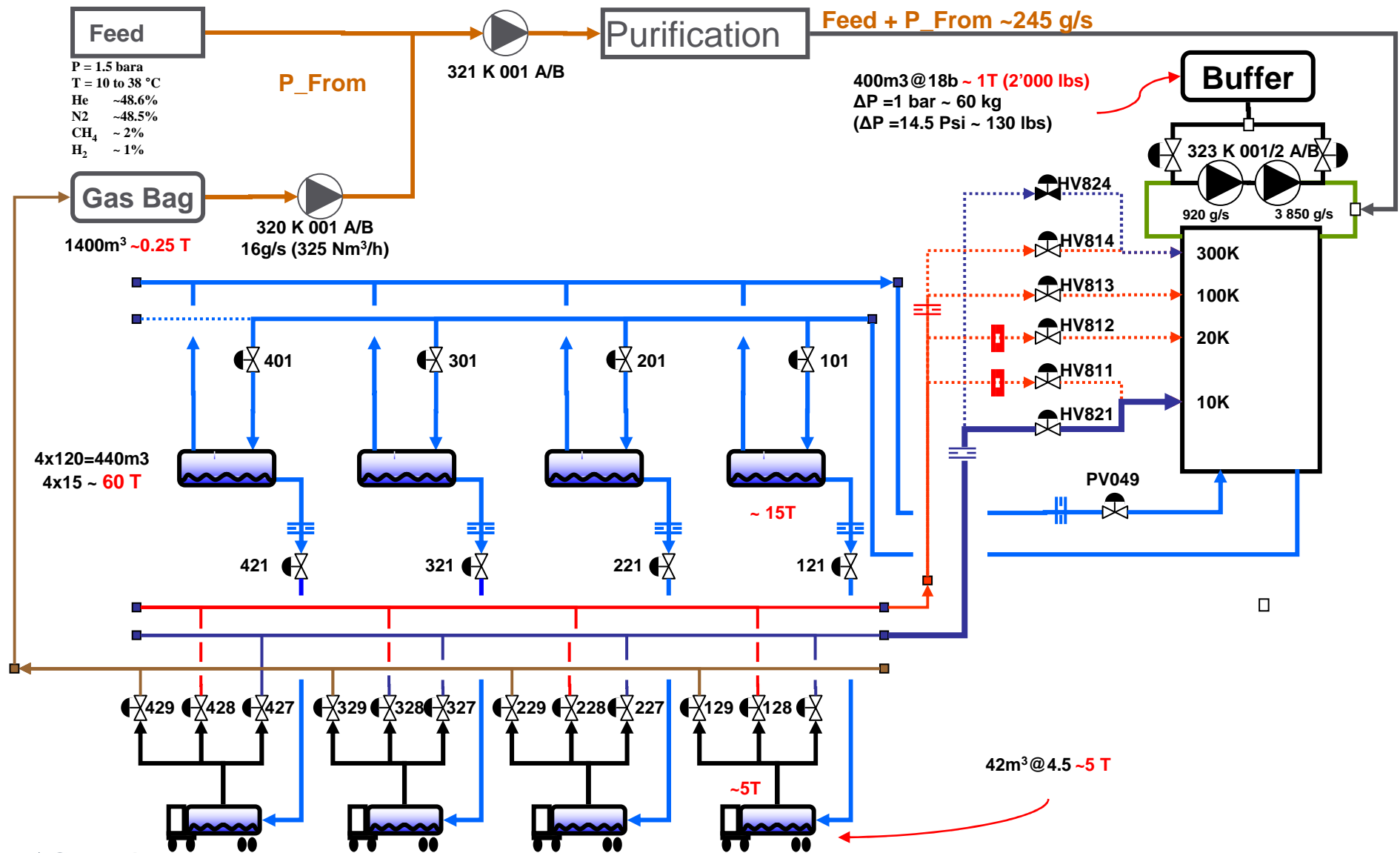
- Loading Sequences & Main Steps

Unit 325 : PID

- The 4 Loading Bays of unit 325 allows the conditioning, cooling down and filling of helium mobile containers.

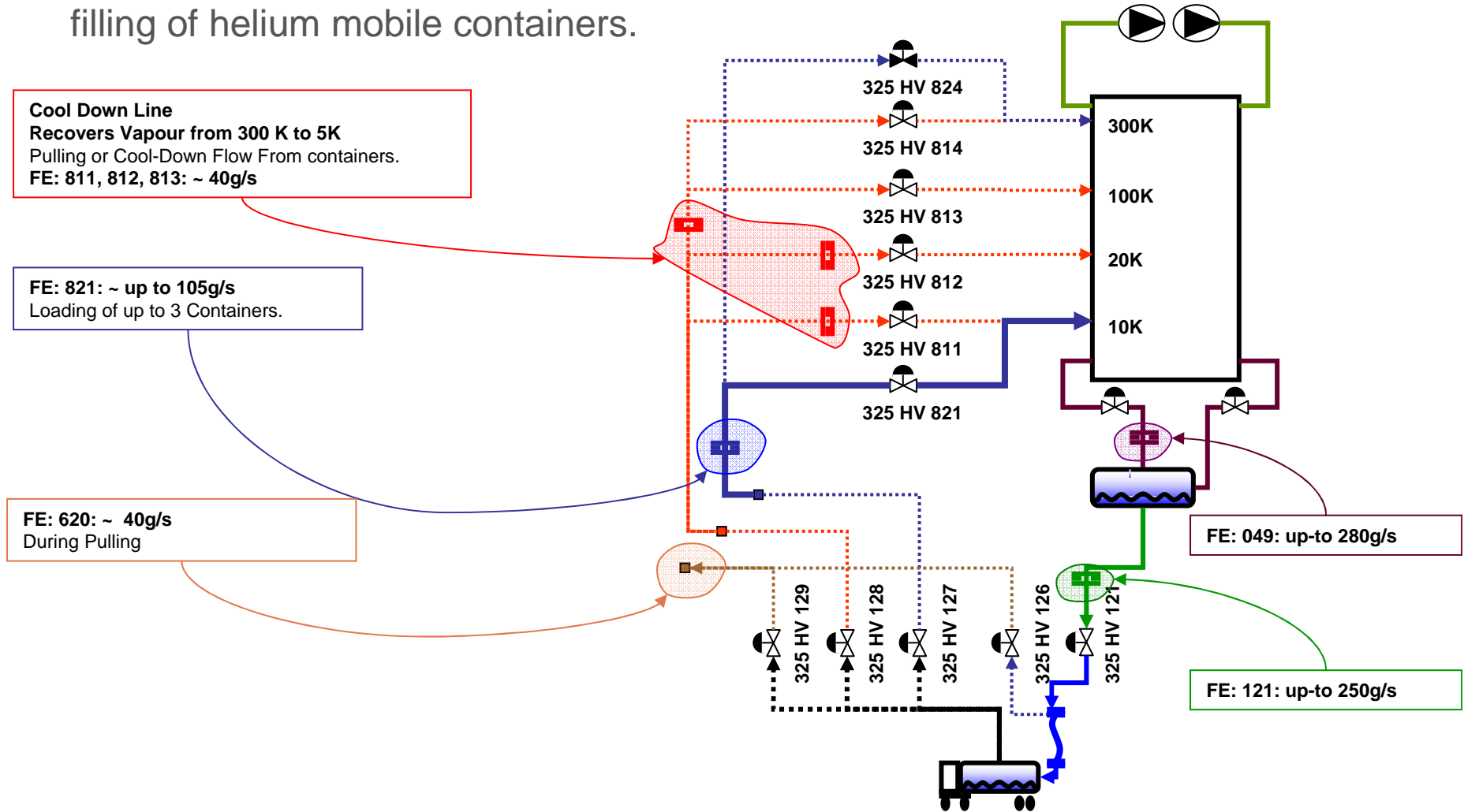


Unit 325 : Simplified PFD

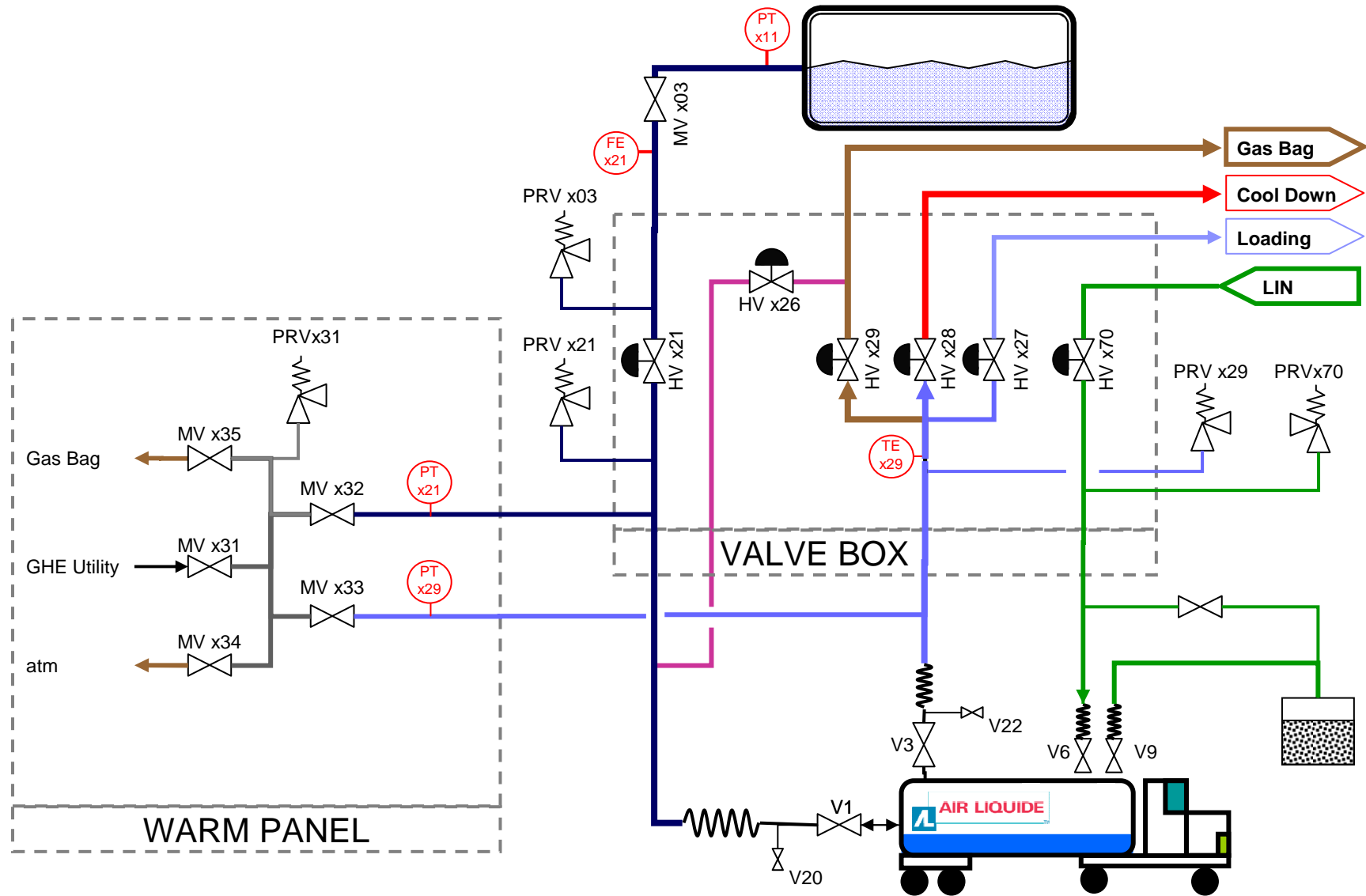


Unit 325 : Simplified PFD

- The 4 Loading Bays of unit 325 allows the conditioning, cooling down and filling of helium mobile containers.

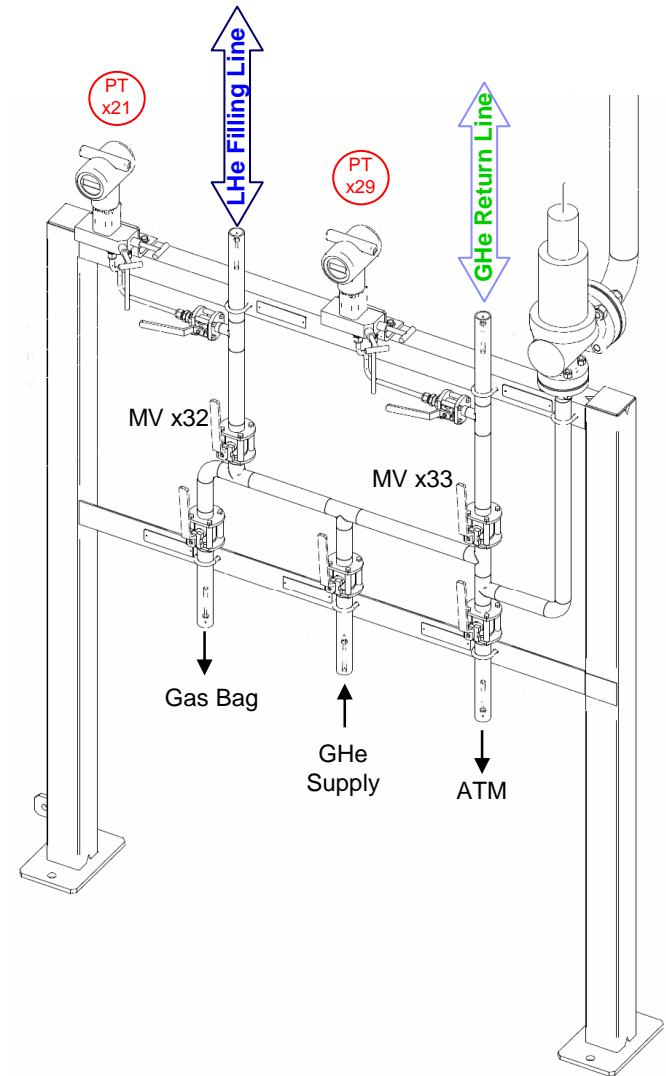
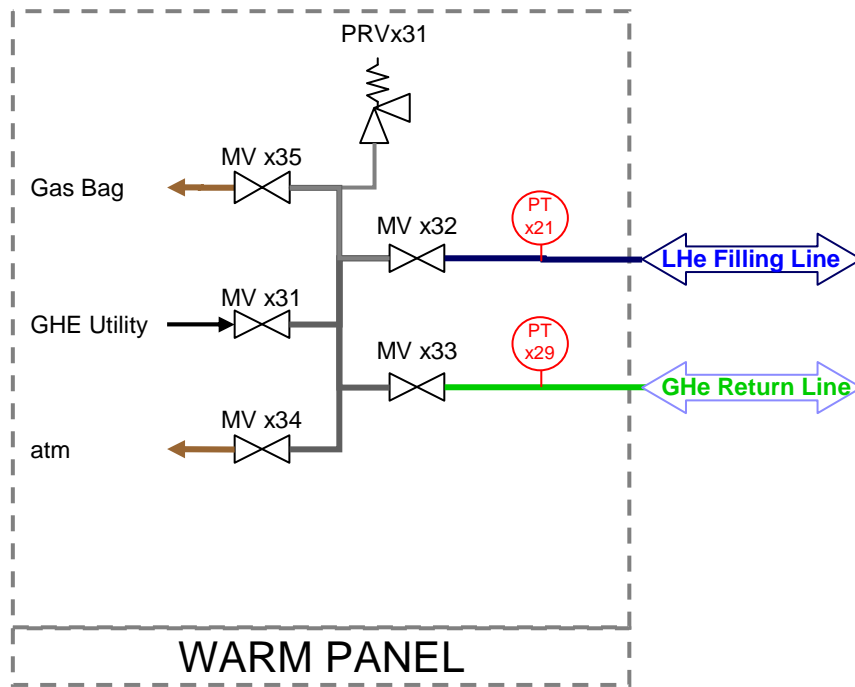


Unit 325 – Simplified PFD Loading Bay



Unit 325 : Conditioning Panel Simplified PFD

■ Conditioning Panel

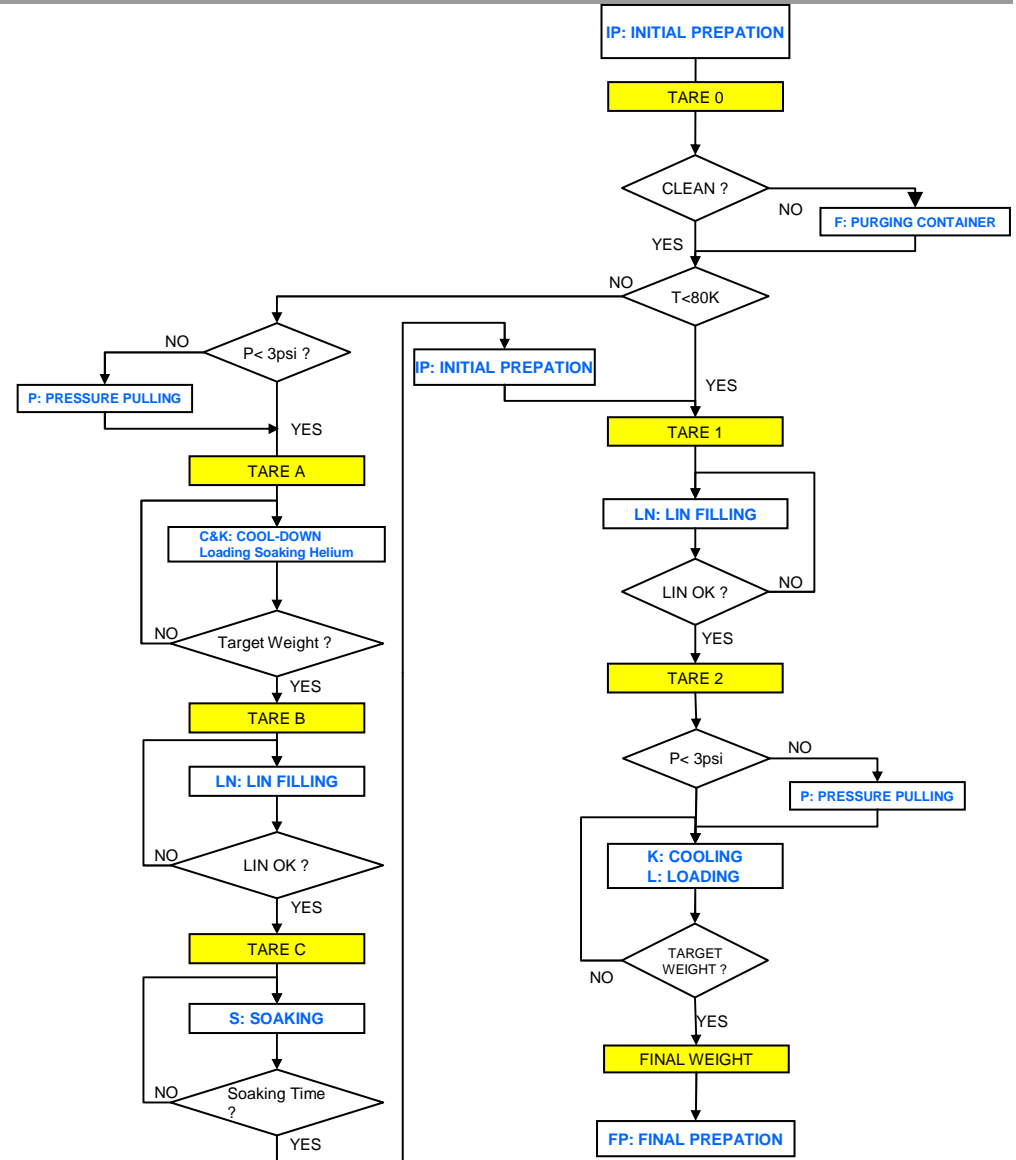


Course Agenda

- Unit 325 Building : He and LN₂ Distribution
- Unit 325 PID & Simplified PFD
- Loading Sequences & Main Steps

Loading Sequences - Chart

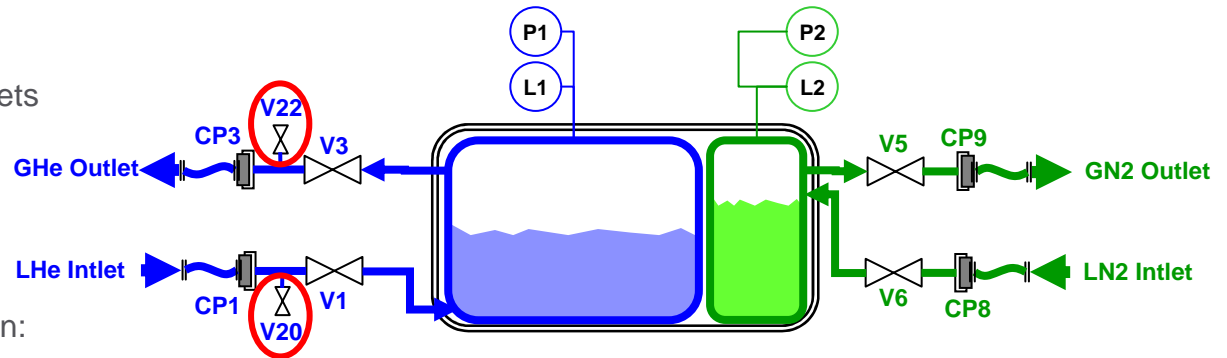
- IP : Initial Preparation
- F : Flush (Purge)
- P : Pressure Pulling
- C & K: Cool Down
- S : Soaking
- L : Loading
- LN : LIN Filling
- FP : Final Preparation



Loading Sequences – IP : Initial Preparation

■ IP : Flush CP1 & CP2

- Remove the caps on the bayonets
CP-1 and CP-3
- Purge the LHe inlet connection:
Open & Close V1
- Purge the GHe outlet connection:
Open & Close V3

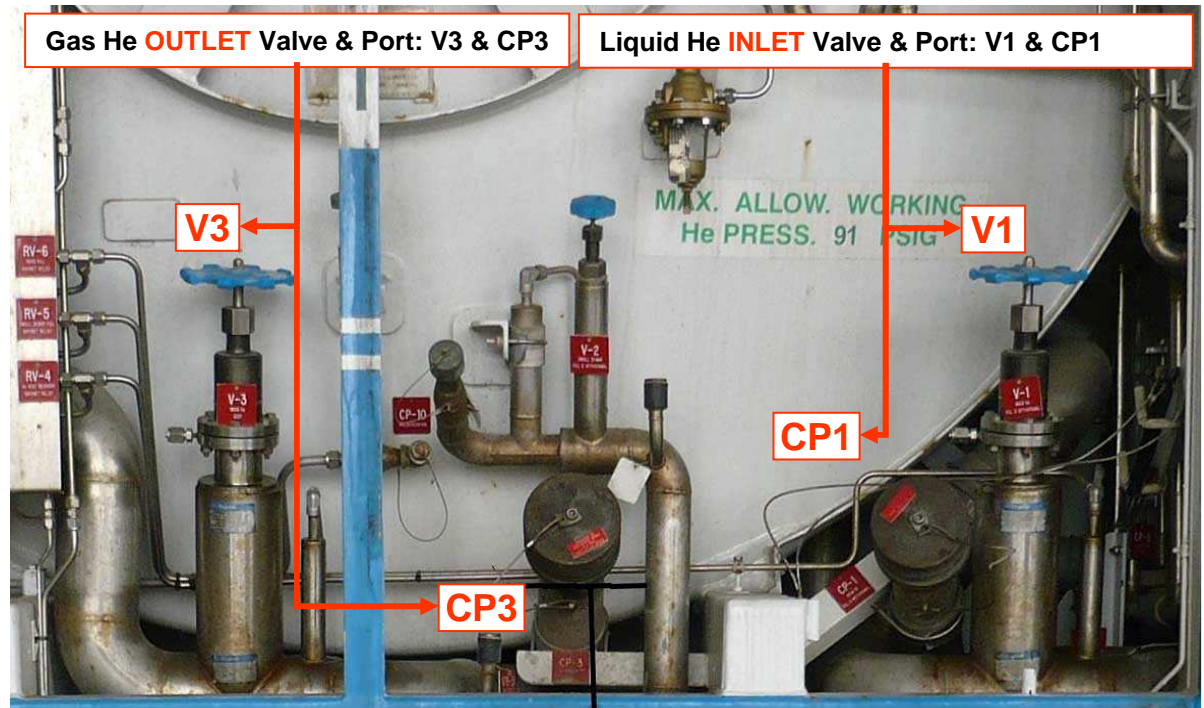


! CAUTION :

Do not stand in front of CP1 & CP3

(Cold gas venting)

Set a safety area at the rear of container



Loading Sequences – IP : Initial Preparation

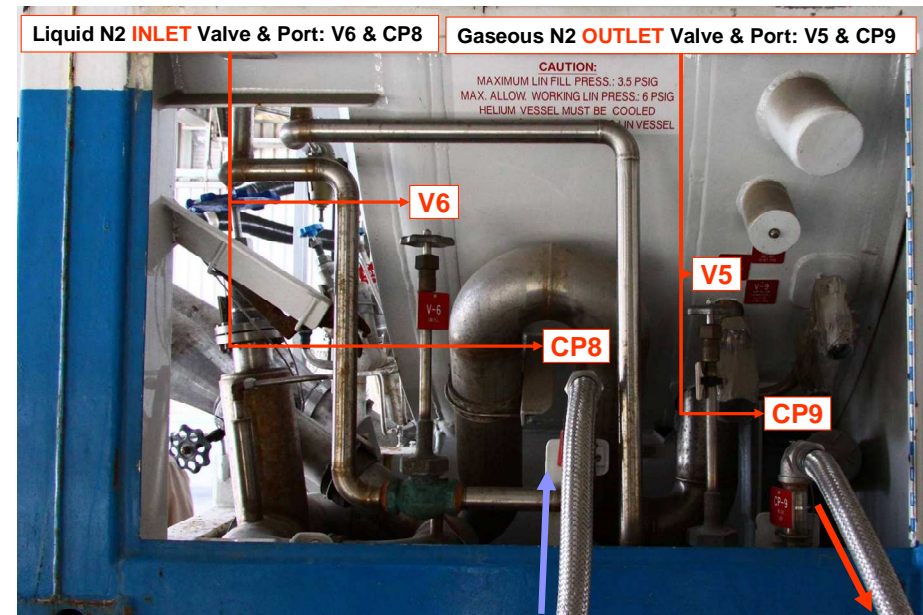
■ IP : Connect He hoses

- Hose 325FHx21 is connected to CP1 – Liquid Helium loading hose
- Hose 325FHx29 is connected to CP3 – Gaseous Helium return hose



■ IP : Connect N₂ hoses

- Hose 325FHx51 is connected to CP8 – Liquid nitrogen loading hose
- Hose 325FHx59 is connected to CP9 – Gaseous nitrogen return hose

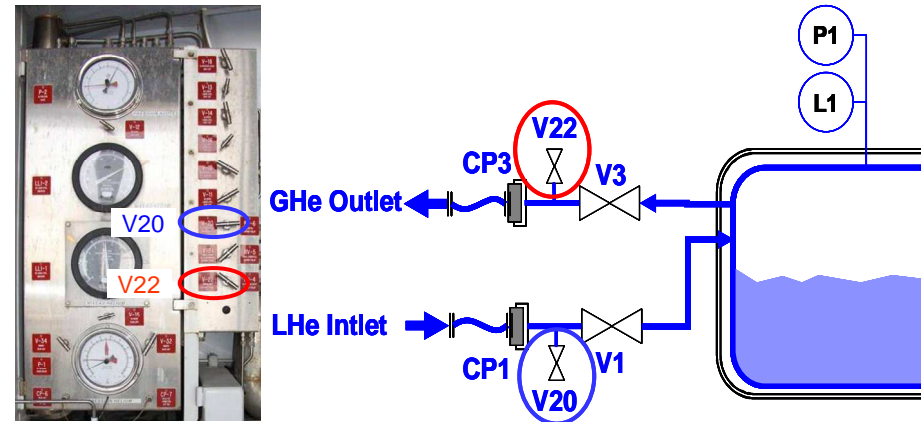


Loading Sequences – IP : Initial Preparation

■ IP : Purge He Hoses

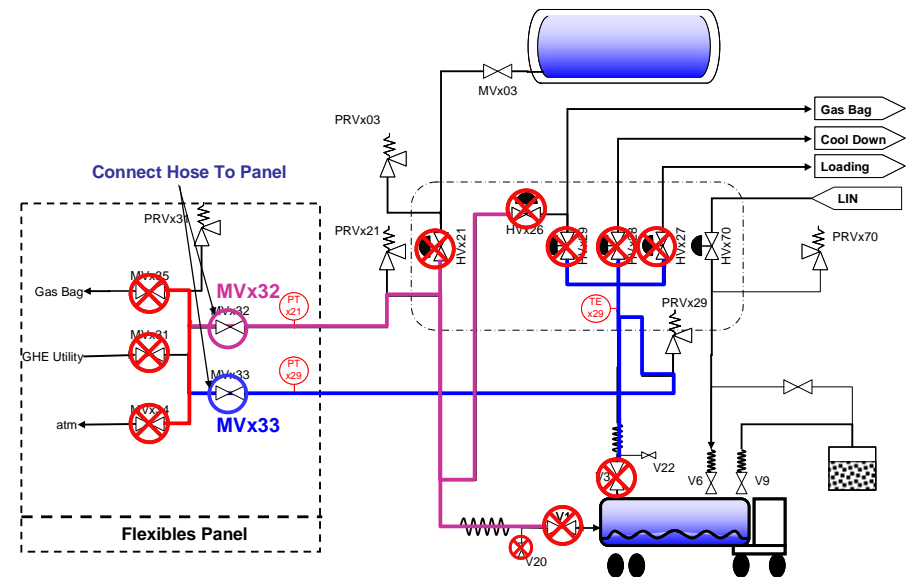
!! CAUTION : V1 & V3 are closed.

- Depressurize the Feed and Return Helium hoses: Use V20 and V22
- Close V20 & V22



■ IP : Connect Hose to Panel

- Open 325 MV x32: LHe Filling Line
- Open 325 MV x33: GHe Return Line



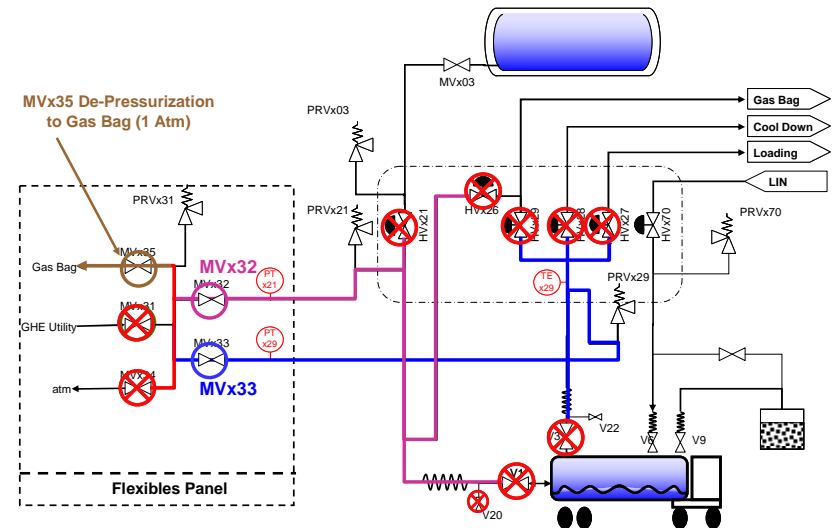
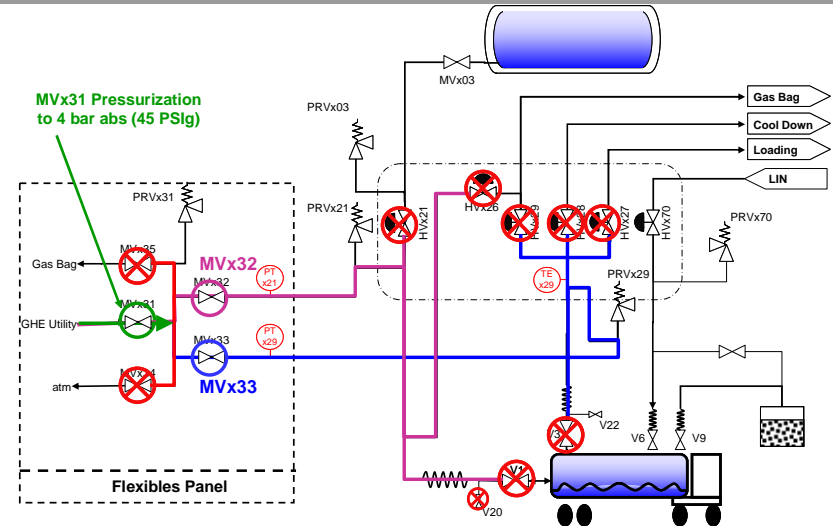
Loading Sequences – IP : Initial Preparation

!/ CAUTION : V1 & V3 are closed.

- IP : Pressurize Lines
 - ▣ **Pressurize Hose:** Open by 325 MV x31
→ 325 PT x29 & 325 PT x21= 4 bar abs (~45 PSig)
 - ▣ **Stop Pressurization:** Close 325 MV x31

- IP : Depressurize Lines
 - ▣ **Vent Hose:** Open by 325 MV x35
→ 325 PT x29 AND 325 PT x21= 1 bar abs (~15 PSig)
 - ▣ **Stop Venting:** Close 325 MV x35

- Repeat 10 times
 - ▣ **Close Vent & Pressurization Valves:**
325 MV x31 & 325 MV x35
 - ▣ **Close Connection to Panel:**
325 MV x32 & 325 MV x33



Loading Sequences – IP : Initial Preparation

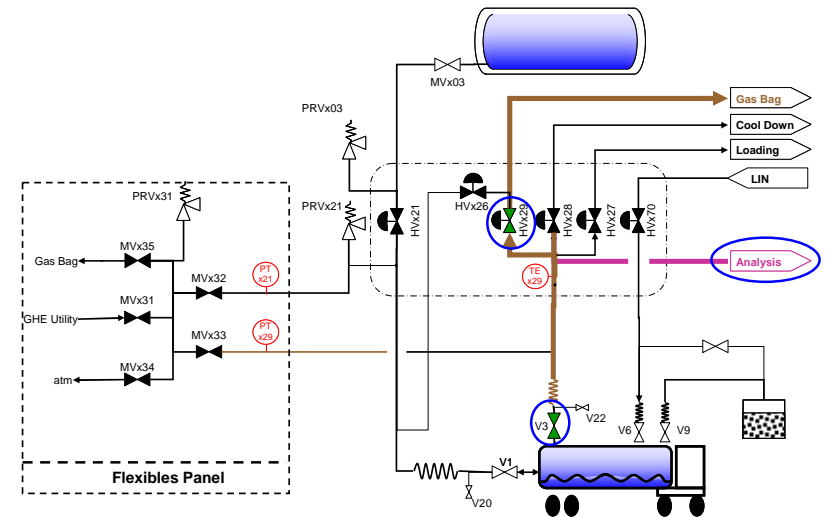
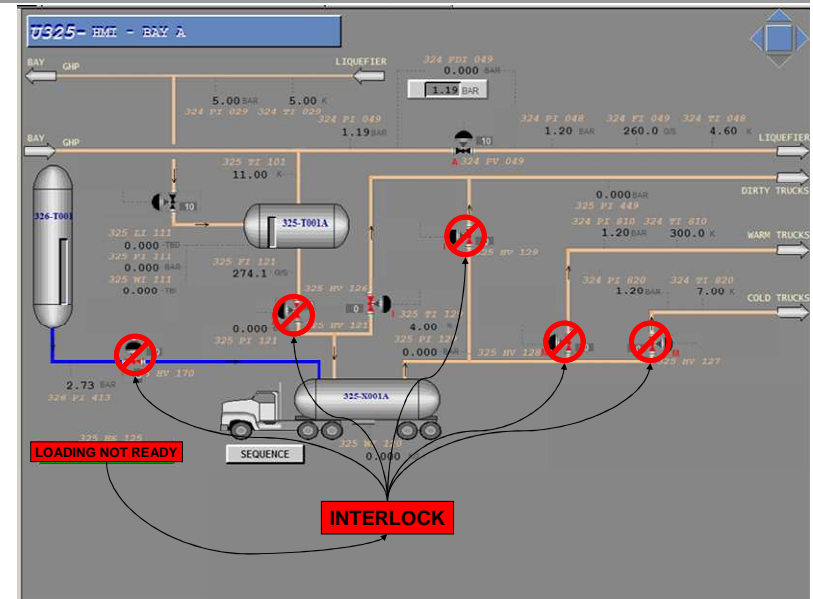
■ IP : Loading Position

- ▣ Switch 325 HS X25 to LOAD POSITION:
Bay Automatic Valves can now be open.
(325 HV X21, X26, X27, X28, X29, X70)
- ▣ Proceed with TARE 0 (if not from Soaking)

■ IP : Contaminants Analysis

(if not coming from soaking)

- ▣ Connect Vapor Return Line: Open slowly V3
→ Check & Write down the pressure on 325 PT x29
- ▣ Open Slowly valve to Gas Bag (325 HV x29)
→ Check & Write down the temperature 325 TT x29
- ▣ Line up high range analyzer and moisture analyzer
→ If contaminants < 200 ppm, line-up low range analyzer
→ Check & Write down Analysis Measurements
- ▣ Close Bay Vapor Valve to Gas Bag (325 HV x29)
- ▣ Disconnect Container Vapor Return Line: Close: V3



Loading Sequences – F : Flushing

In case of a **warm and dirty** mobile container(>200ppm), flushing is required.

■ F : Connect Truck To Bay Panel

- Open Container Valves: **V1 & V3**
(V20 & V22 are Closed)
- Open Panel Valves: 325 MV X32 & 325 MV X33

■ F : Depressurize Truck

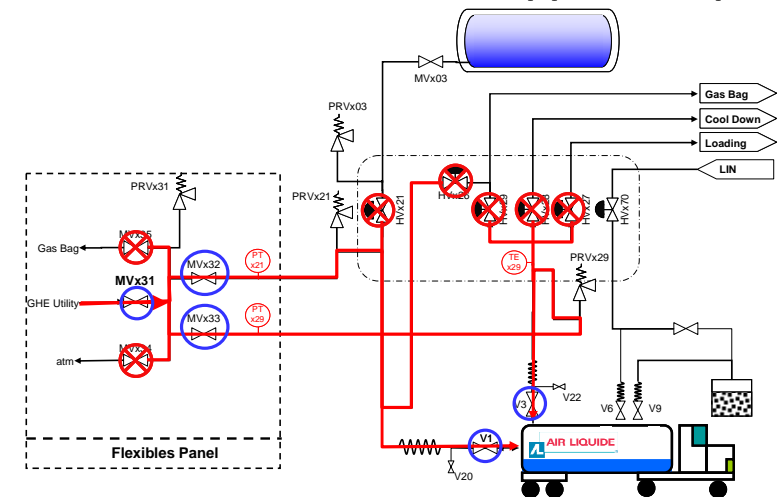
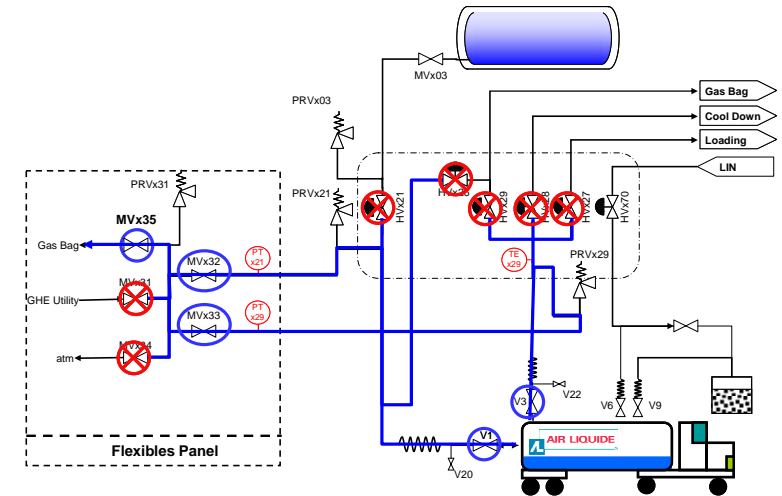
- Open 325 MV x35
→ 325 PT x29 AND 325 PT x21 < 1.2 bar abs (18 PSIG)
- Close 325 MV x35

■ F : Pressurize Truck

- Open 325 MV x31
→ 325 PT x29 AND 325 PT x21 = 4 bar abs (45 PSIG)
- Close 325 MV x31

■ F : Repeat 10 Times

- Close Container Valves: **V1 & V3**
- Close Panel Valves: 325 MV X32 & 325 MV X33
- Close Panel Valves: 325 MV X31 & 325 MV X35
- **Return to Analysis**



Note: Pulling with a vacuum group would also allow removing efficiently impurities. Such method could be proposed during the performance and/or later on during operation.

Loading Sequences – F : Flushing

Remark : Flushing by pressurization / depressurization, allows **in theory** to divide the pollution content as following :
Nevertheless, in practice more pressurization could be necessary to obtain a good purity !
That is why we have considered up to 10 cycles.

Flushing

Mobile Dewar Capacity	11 000 Gal	41,64 m ³
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Temperature	40,0°C
Low Pressure	1,15 bar
High Pressure	4,00 bar
Pressure Ratio	3,5

Rho	Mass
0,18 kg/m ³	7,36 kg
0,58 kg/m ³	24,03 kg

Initial State (ppm)	200,000 ppm	10 000,000 ppm
Initial State (%)	0,020%	1%

GAS NEEDED	
0,00 kg	0,00 Nm ³
16,67 kg	2,93 Nm ³
33,34 kg	5,87 Nm ³
50,01 kg	8,80 Nm ³
66,69 kg	11,74 Nm ³
83,36 kg	14,67 Nm ³
100,03 kg	17,60 Nm ³
116,70 kg	20,54 Nm ³
133,37 kg	23,47 Nm ³
150,04 kg	26,41 Nm ³
166,71 kg	29,34 Nm ³

Cycle 1	57,500 ppm	2 875,000 ppm
Cycle 2	16,531 ppm	826,563 ppm
Cycle 3	4,753 ppm	237,637 ppm
Cycle 4	1,366 ppm	68,321 ppm
Cycle 5	0,393 ppm	19,642 ppm
Cycle 6	0,113 ppm	5,647 ppm
Cycle 7	0,032 ppm	1,624 ppm
Cycle 8	0,009 ppm	0,467 ppm
Cycle 9	0,003 ppm	0,134 ppm
Cycle 10	0,001 ppm	0,039 ppm

Pulling with a vacuum group would also allow removing efficiently impurities. Such method could be proposed during the performance and/or later on during operation.

Loading Sequences – LN : LIN Filling

In case of clean and **cold container**, the liquid nitrogen filling is performed **at the beginning** of the procedure, whereas in case of a **warm** mobile container, it should be performed **after** cool down of inner vessel.

■ LN : LN2 Hose Cool-Down

- ▣ Open 325 HV x70 to ~ 30 %
- ▣ Open 325 MV x71

■ LN : LN2 FILLING

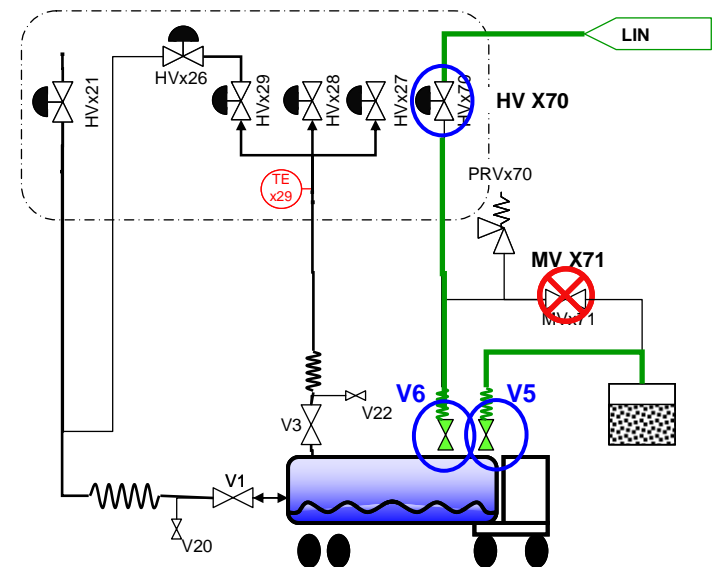
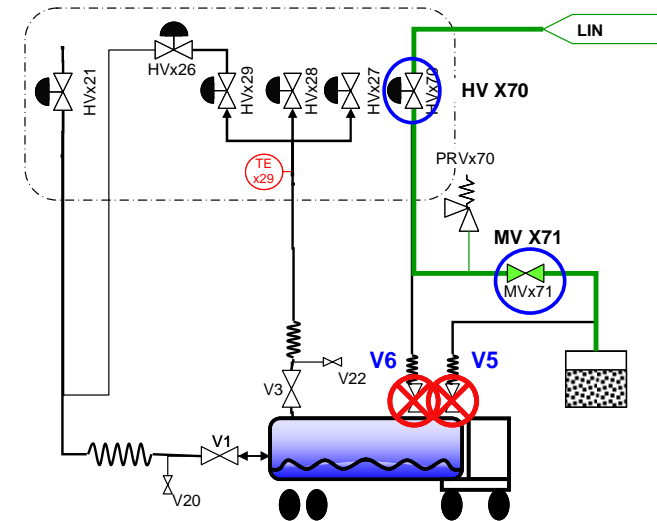
→ When the line in the stone pit is frozen the filling of the nitrogen shield can start. Capacity **~330 Gal (1240 L)**

- ▣ Reduce opening of 325 HVx70 to ~ 10 %
- ▣ Open GN2 Vapor Line (V5 : shield outlet)
 - When V5 fully open:
- ▣ •Close 325 MV x71
- ▣ •Open Slowly LN2 Filling Line (V6 : shield inlet)

⚠ WARNING: Keep LN2 Pressure below 3 PSig.

→ When liquid goes out from V9 (visible in stone pit) then filling is completed.

- ▣ Close 325 HV x70, V6, V9
- ▣ Purge LN2 Filling Hose using 325 MV X71
- ▣ Remove N2 Hoses
- ▣ Close 325 MV X71



Loading Sequences – P : Pressure Pulling

■ P : Pressure Pulling

An incoming Mobile Dewar usually arrives with a pressure above 3 psig. Depressurization is thus necessary before connecting it to the liquefier.

- Open Container He Vapor Line (V3)
- Open Slowly Valve to Gas Bag (HV x29)
- Adjust 325 HV 129 to keep 325PT449 < ~1,1 bars abs
- Adjust 325 HV 129 to keep **320 FE 620 < ~ 40 g/s**

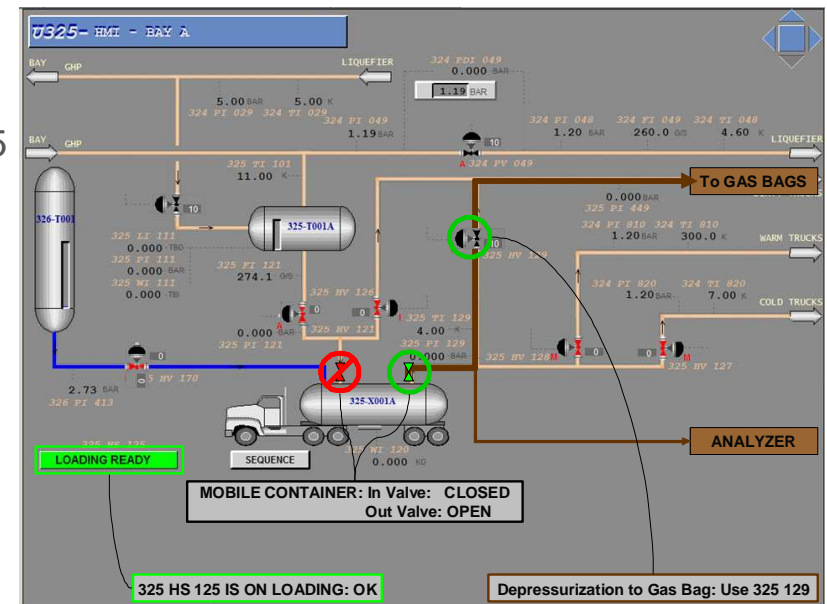
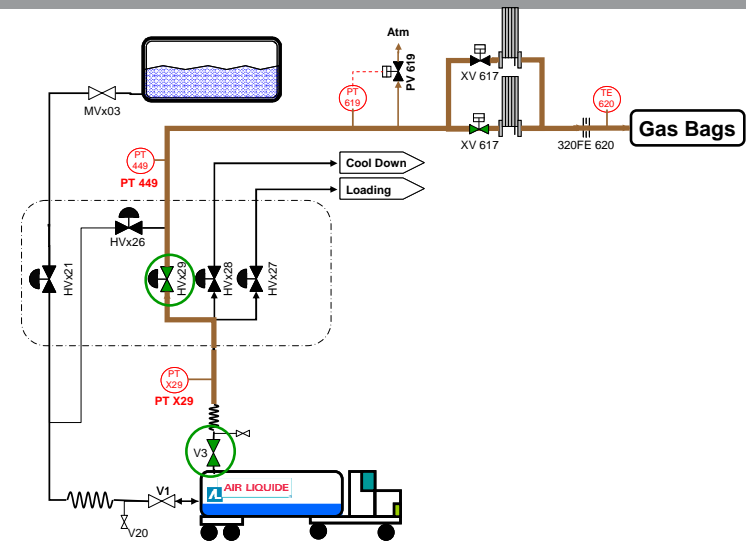
Nota: The Gas is sent to the Gas Bags. In case of full Gas Bags, the 320XV601 is open, GHe is vent to atmosphere.

Nota: If the pressure in the Line to the Gasbags increases, 325 PV 619 will automatically open.

→ Pressure Pulling completed when :

325 PT x29 ≤ 1,2 bar abs (15 PSIG)

- Close 325 HV x29

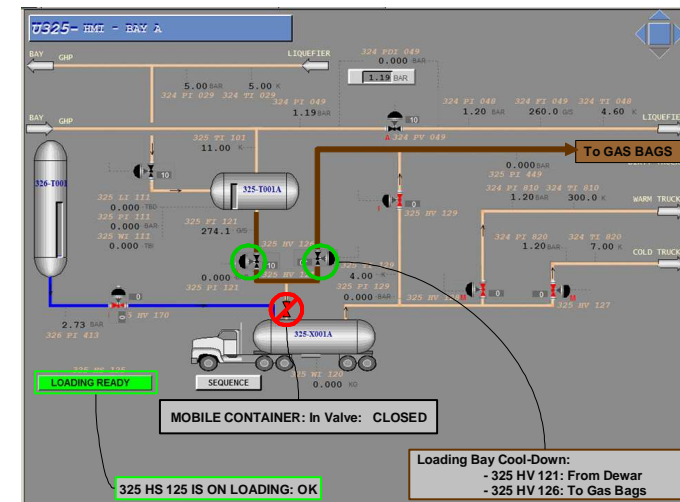
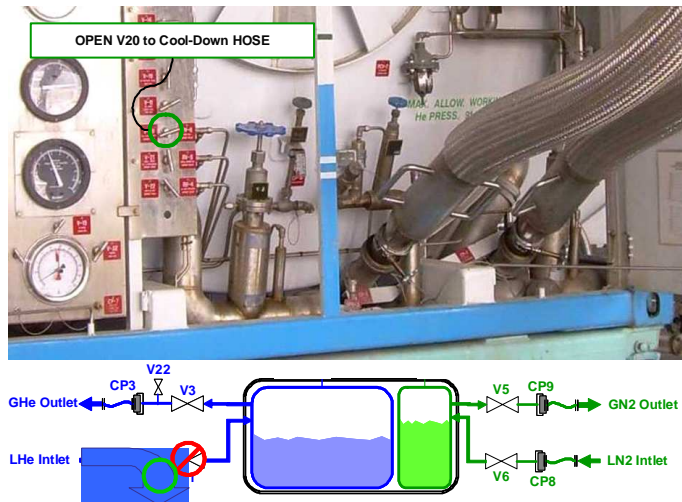
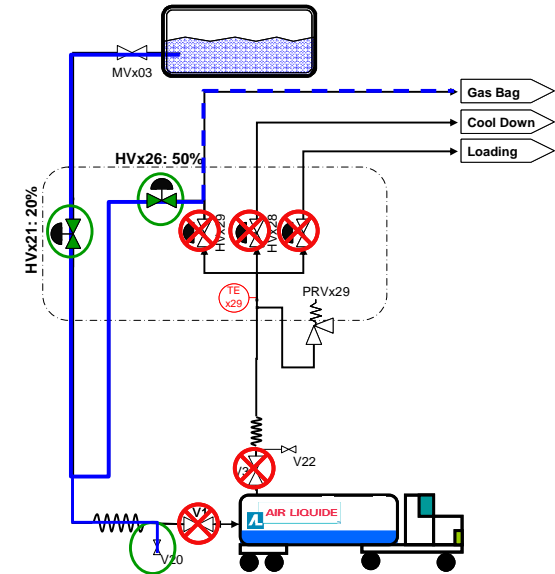


Loading Sequences – C: Cool Down

IF CONTAINER WARM: Temperature > 80K.

C : LHe Filling Hose Cooling

- Truck Inlet connection valve is closed (V1)
 - Open Truck Inlet purge Valve (V20)
 - Open LHe Loading Valve (HVx21) ~ 20%
 - Cool Down Valve (HVx26) ~ 50%
- Wait ~10 minutes Valve (HVx26)
- Close HVx21, HVx26 & V20



Loading Sequences – C: Cool Down

IF CONTAINER Warm: Temperature > 80K.

!!WARNING: According to Gardner Documentation.

-In case of initial cooling, the inner vessel has to be cool down before the nitrogen shield, at least while $T > 140$ K.

-During cool down the internal pressure in the reservoir and shield circuit has to be at least 70 mbar (1 PSig), if necessary a nitrogen gas cylinder connected to the nitrogen vent line can be used to increase the pressure of the shield.

C : INITIAL COOLING (300K-80K)

NOTA : Cooling down of two mobile containers at the same time should be avoided.

During Initial Cool Down, vapors are returned to liquefier by “Cool Down Line”.

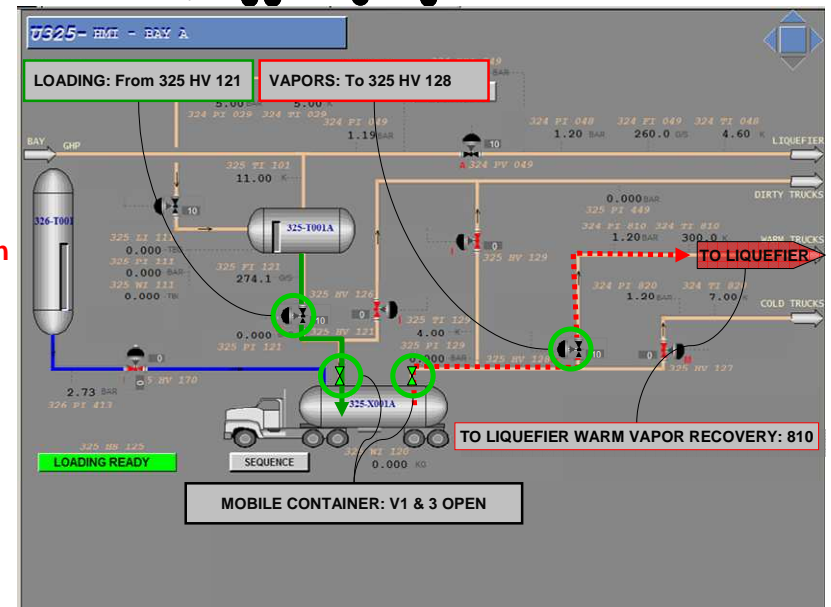
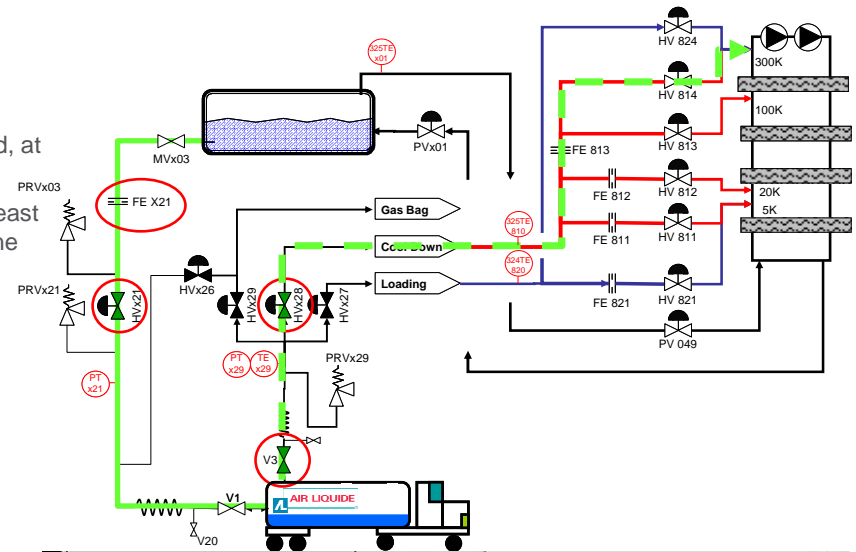
- Container is depressurized : $325\text{ PT }x29 \leq 1,2\text{ bar abs (15 PSig)}$
- Purge valves (V20) & (V22) are closed
- Main Inlet and Outlet valves are open (V1) & (V3)

!! Warning : Line-up vapors to liquefier only when identified as clean

- ▣ Open 325 HV x28 to send the gas to the cooling line

!! Warning : Temperature is higher than 80K, respect a cool down of around 1K/min

- ▣ Slowly open 325 HV x21 to cool down at 1K/min (325 TT X29)
- ▣ Adjust opening of 325HVx21 to get $325\text{FT}x21 \sim 40\text{ g/s}$



Loading Sequences – K: Cool Down

K : COOLING (80K-5K)

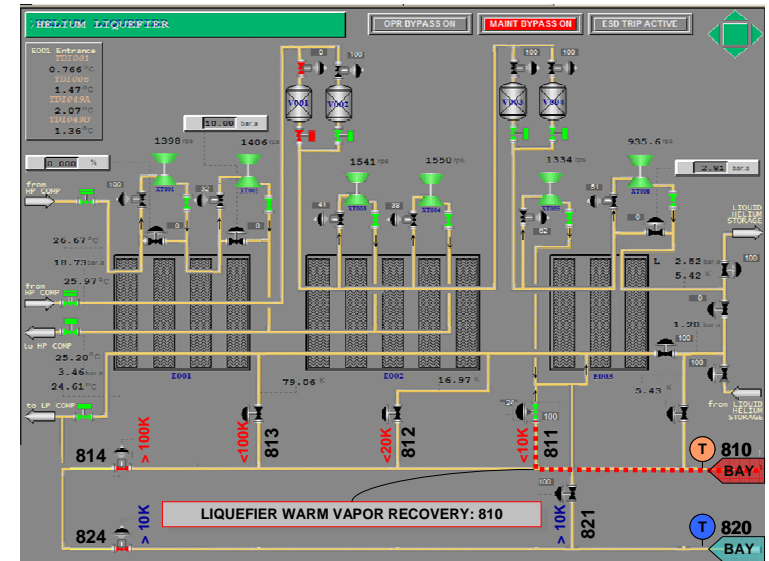
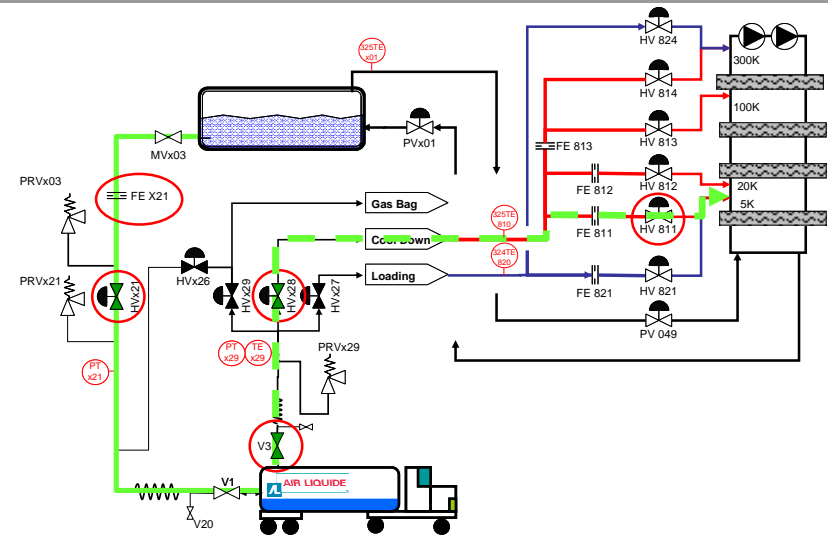
- Adjust Slowly Opening of 325HVx21 to get :
 - 325FTx21 ~ 130 g/s
 - 325FT810 ~ 40g/s

When 325 TT x29 ~80K Helium densification occurs and 324 FE 810 << 325 FE x21.

- Density Increase: From ~80K to 4.5K, GHe density goes from ~ 1 to 20 kg/m³
 - Container Volume: 11,000USGal x 0.0038USGal/m³ = 41m³
 - Mass Increase: 41m³ x (20kg/m³ – 1kg/m³) ~ 800kg
- > **Liquid Starts to accumulate once the mass increase is higher than 800kg**

Vapors returned to the Liquefier Warm Recovery Line: 810, are **directed to the required port.**

- FOR **WARM CONTAINER**
 - Stop Cool-Down once Mass increase = 1000kg (i.e. ~200kg LHe).
 - Send them to **SOAKING** .
- FOR **COLD CONTAINER**
 - Initial cool-down is completed when 325 TT X29 < 10K.
 - Continue with **LOADING Step**



Loading Sequences – L: Loading

L : Loading (5K)

Nota: It is likely to always have at least one Container in Loading.

Nota: Up to 3 Containers Loading simultaneously.

Loading will naturally follow cool-down. As soon as the Mobile Container Temperature is Low enough, Liquid starts to accumulate and Loading begins. The Flow is adjusted using 325 HV 121

As soon as the operator enters the TARGET WEIGHT on MASTER K Weight Scale, the TARGET WEIGHT Sequence is initiated:

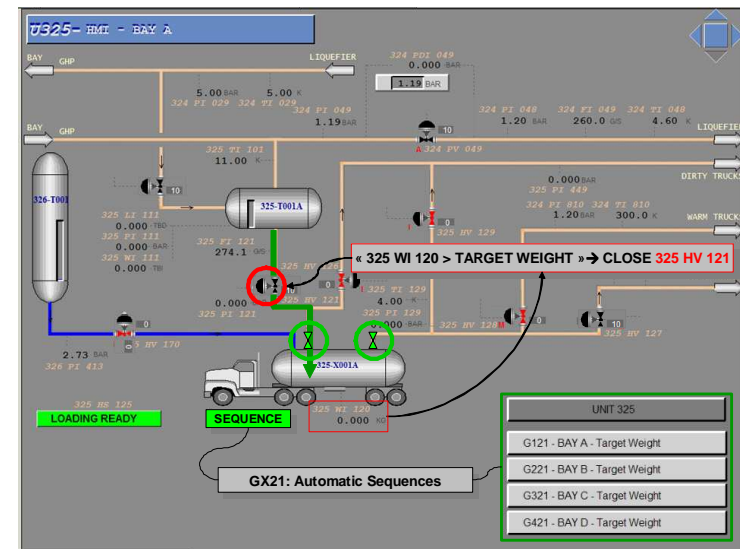
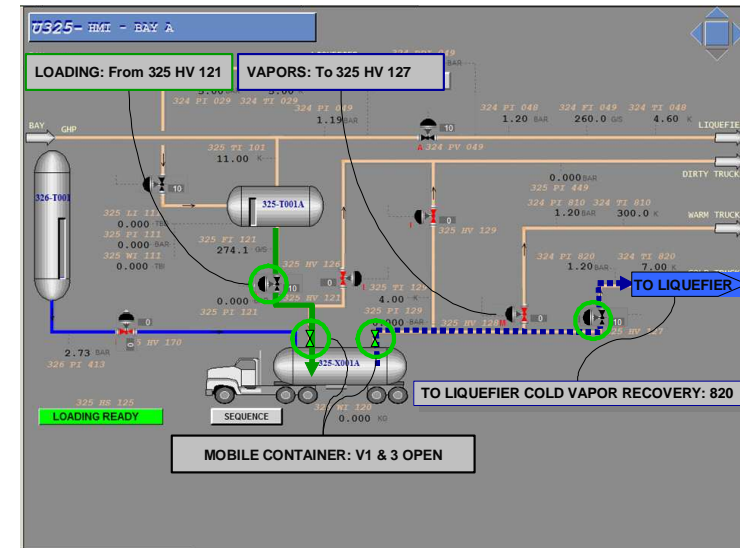
→ When $TT_{x29} < 10K$

- ▣ OPEN SLOWLY 325 HV x27 @ 100%
- ▣ CLOSE SLOWLY 325 HV x28 @ 0%
- ▣ ADJUST 325 HV x21 to get 325 FT x21 ~ 220 g/s

- ▣ ENTER Target Weight on Master K.

→When target weight is reached 325 HV x21 will close

- ▣ CLOSE: 325 HV x27
- ▣ CLOSE: V1 and V3 (Trucks valves)
- ▣ OPEN: V20 and V22 to purge hoses
- ▣ Disconnect Hose and Install Bayonet in Holders.



Loading Sequences – FP: Final Preparation

FP : Final Preparation

→ When 325 HV x21 is closed

- CLOSE: 325 HV x27
- CLOSE: V1 and V3 (Trucks valves)
- OPEN: V20 and V22 to purge hoses
- SWITCH HS X25 in LOADING READY: NO Position
- Disconnect Hose and Install Bayonet in Holders.