

Helium Operators Familiarization Program Unit 324/325 – Overview and Start-Up

Dec 2012 | Vincent HELOIN

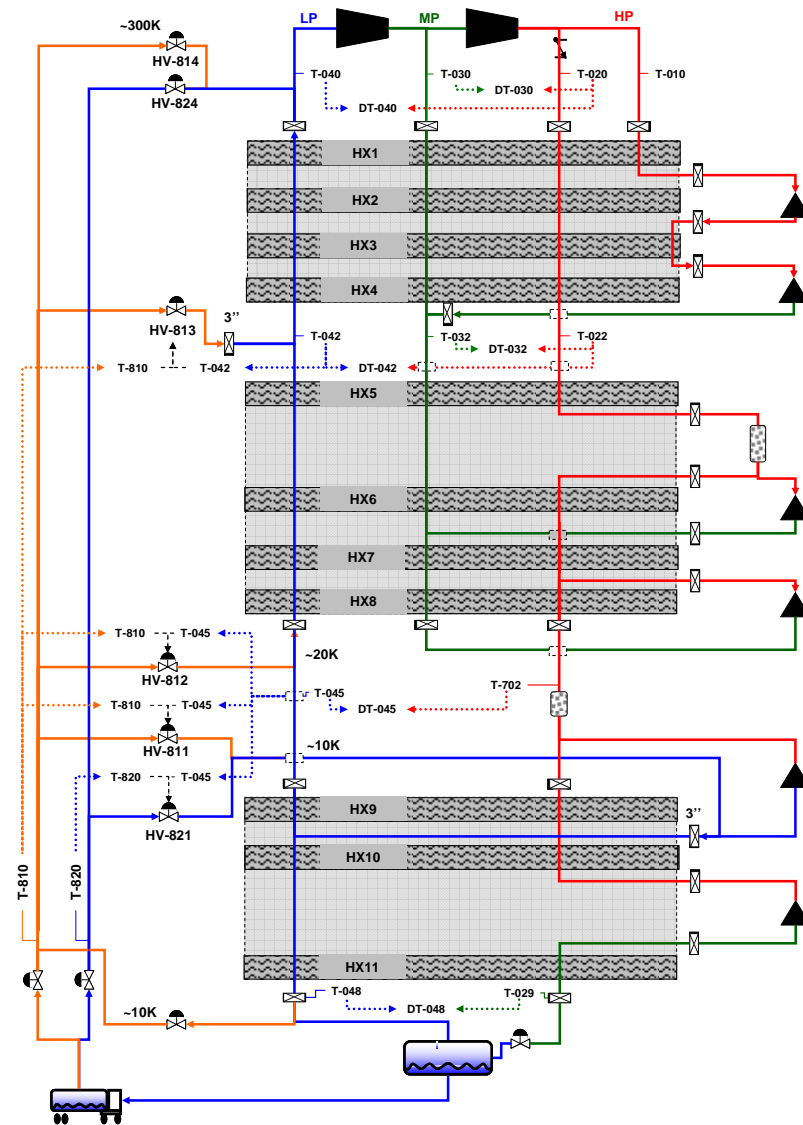


Course Agenda

- **Simplified PFD**
- Plant Overview
- Unit 324/325 Conditioning
- DCS Overview
- Plant Start-Up

Liquefier: Simplified PFD

- **3 pressures**
 - ▣ LP : 1,05b
 - ▣ MP: 5b
 - ▣ HP: 21, 5b
- 300K ⇔ 100K
 - ▣ 2 Turbines in series
- Dual **65K** adsorbers (**N₂**, **O₂**)
- 65K ⇔ 20K
 - ▣ 2 Turbines in //
- Dual **20K** adsorbers (**Ne**, **H₂**)
- 20K ⇔ 9K
 - ▣ 1 Turbine HP to LP
- 1 “JT” Turbine **T6**, controlling the **liquefaction flow**
- 2 vapor return lines
 - ▣ 1 cold
 - ▣ 1 warm



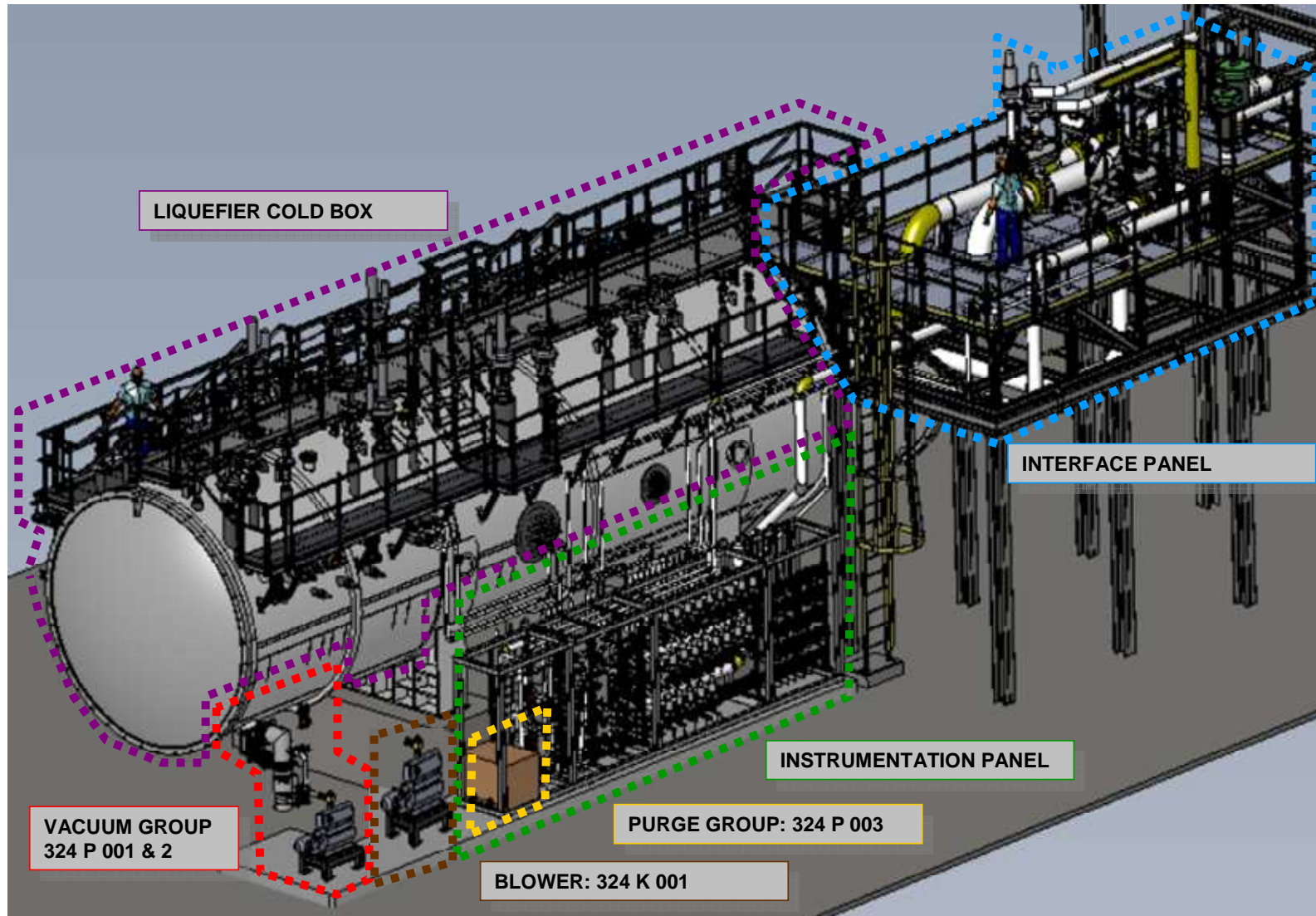
Course Agenda

- Simplified PFD

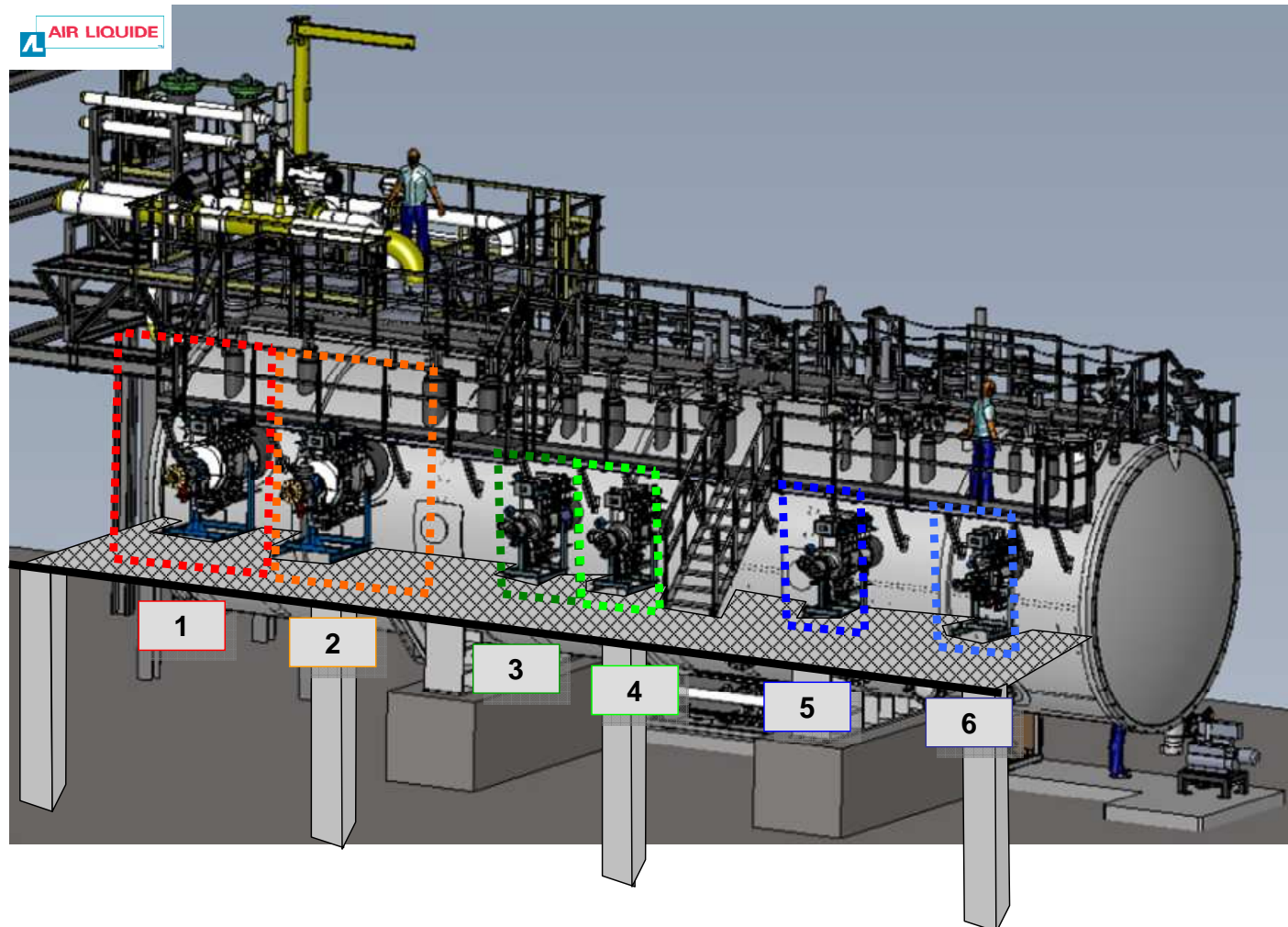
- **Plant Overview**

- Unit 324/325 Conditioning
- DCS Overview
- Plant Start-Up

Plant Overview



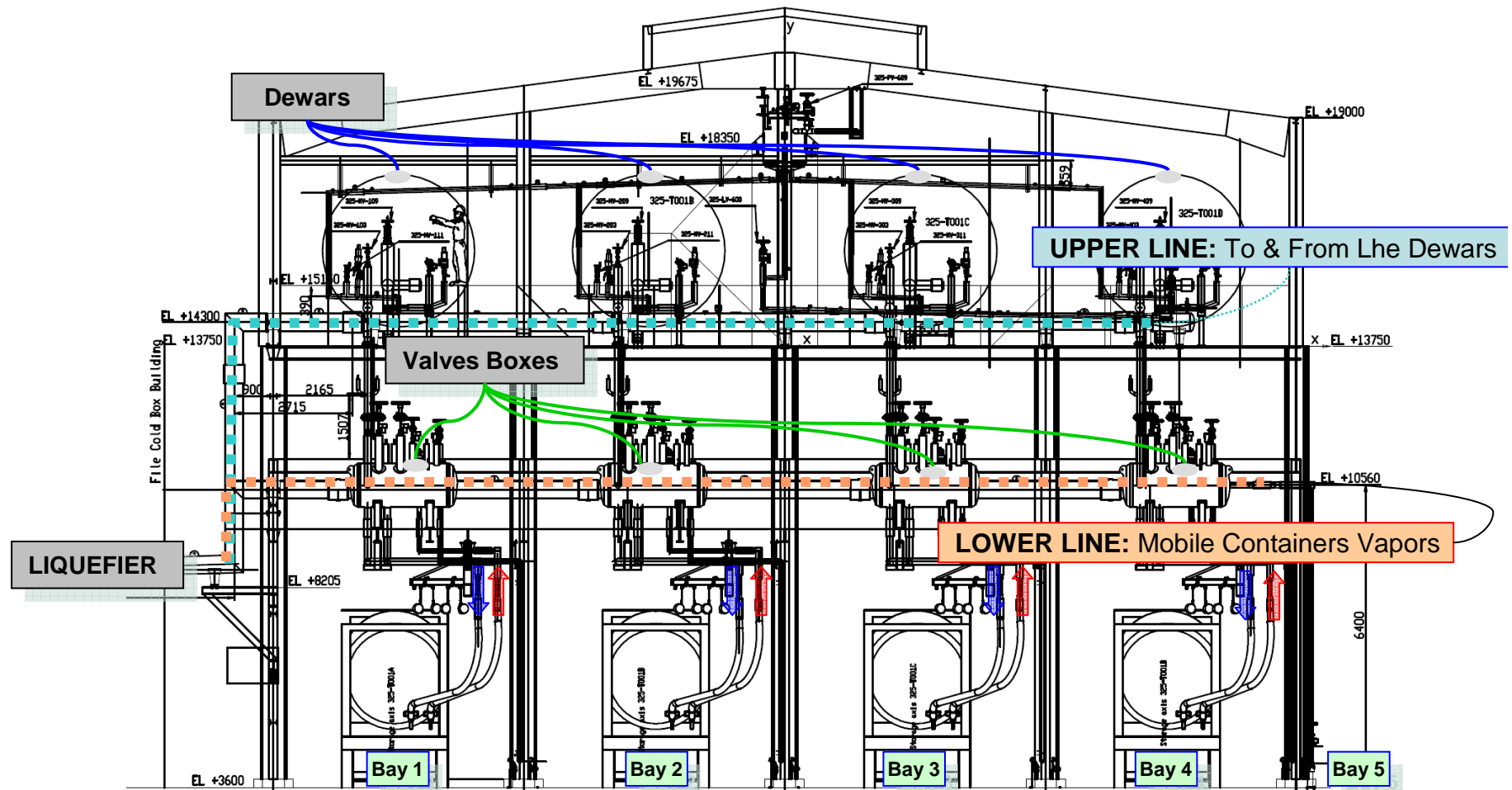
Plant Overview



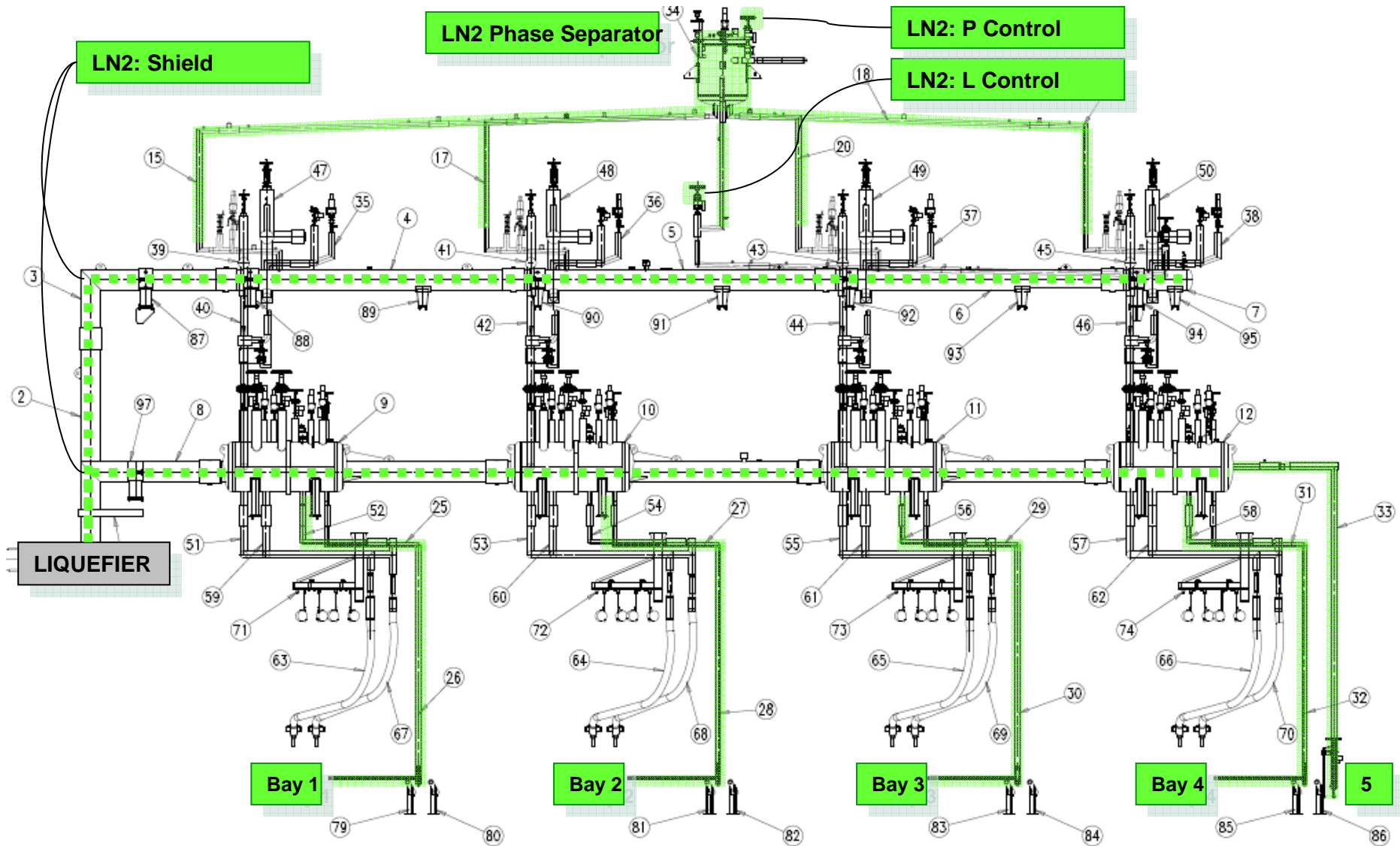
Turbines 1 to 5 are equipped with Tube and Shell Heat Exchangers. The Heat Exchangers are installed under the plat form. Turbine 6 is equipped with a Heat Exchanger directly mounted on the break side

Plant Overview

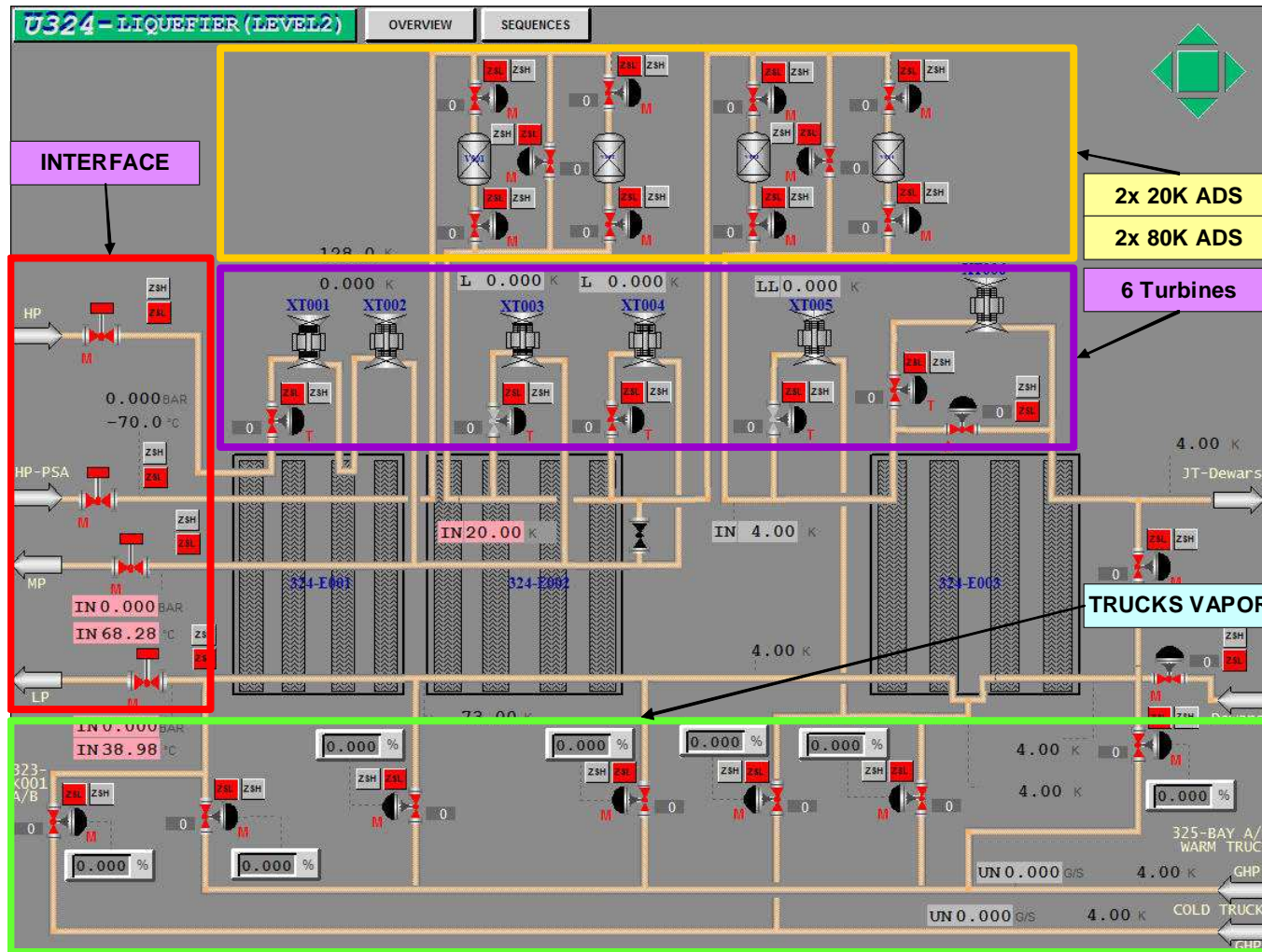
- The 4 Loading Bays of unit 325 allows the conditioning, cooling down and filling of helium mobile containers.



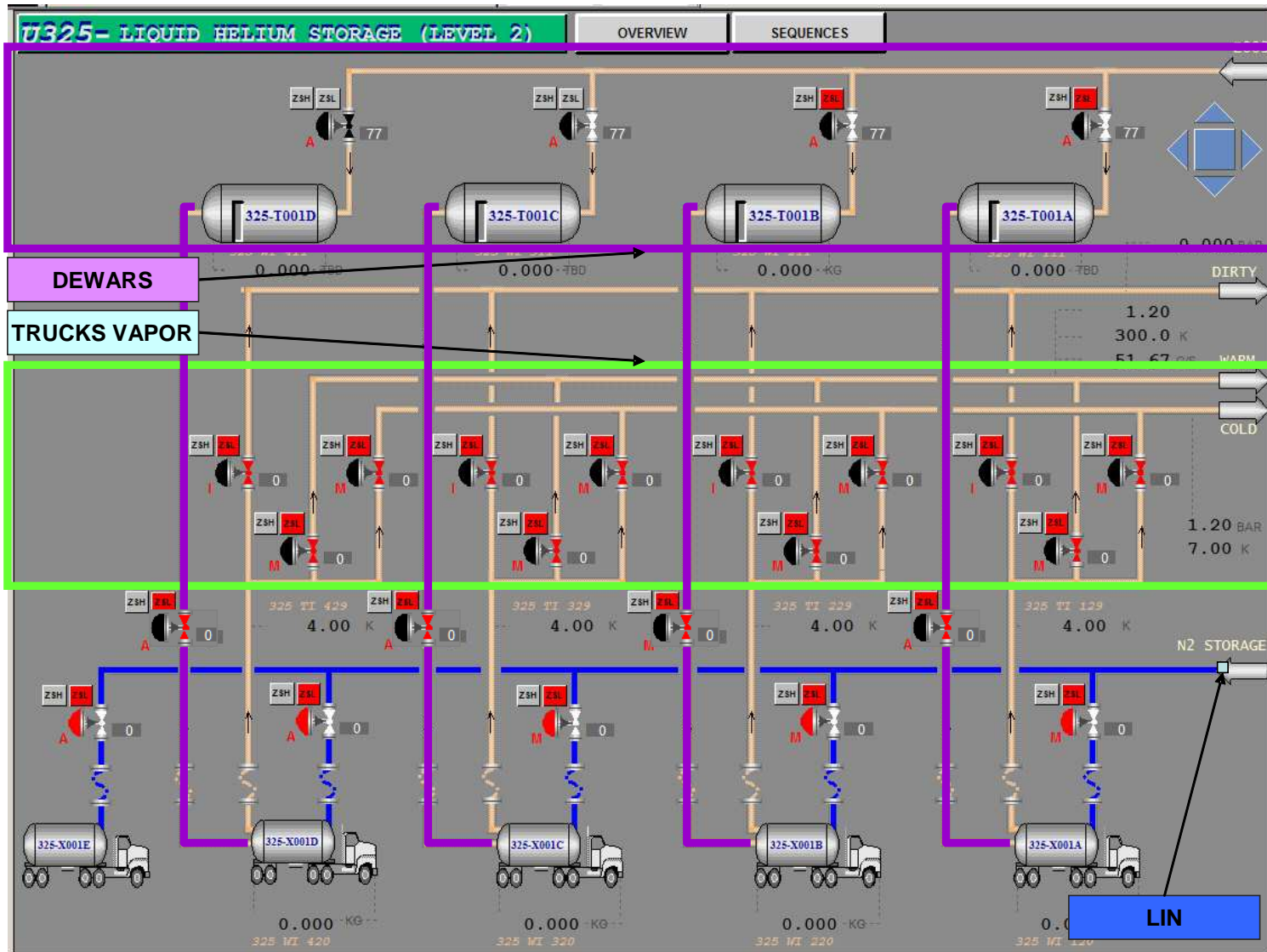
Unit 325 Building : Nitrogen Distribution



Plant Overview – DCS view of Unit 324



Plant Overview – DCS view of Unit 325



Course Agenda

- Simplified PFD
- Plant Overview
- **Unit 324/325 Conditioning**
- DCS Overview

Liquefier Conditioning = Pumping / filling

- The Conditioning aims at **removing all gaseous impurities** (including moisture, nitrogen and air) present in the helium circuits.
- It consists in 3 cycles of Pumping/Filling:
 - ▣ **Venting** shall be performed before Pumping: Circuits Pressure shall be ~1 atm to protect the Purging Group.
 - ▣ **Pumping** shall be performed using purging groups: Circuits Pressure shall be brought to 10mbara or less.
 - ▣ **Filling** shall be performed with pure He: Circuits Pressure shall be brought to ~1 atm.
- **WARNING:** Do not open the Vent Valve if the circuit pressure is below 1 atm.
- Each Cycle from (1000 to 10 to 1000 mbara) divides the Impurities concentration by 100. 3 cycles cut contaminants down to **ppm level**.
- **Pumping Duration:** The first pumping shall be long (> 30 minutes @ < 10 mbara) to evaporate traces of water. Other pumping shall be shorter to limit the amount of air ingress.

Liquefier Conditioning = Pumping / filling

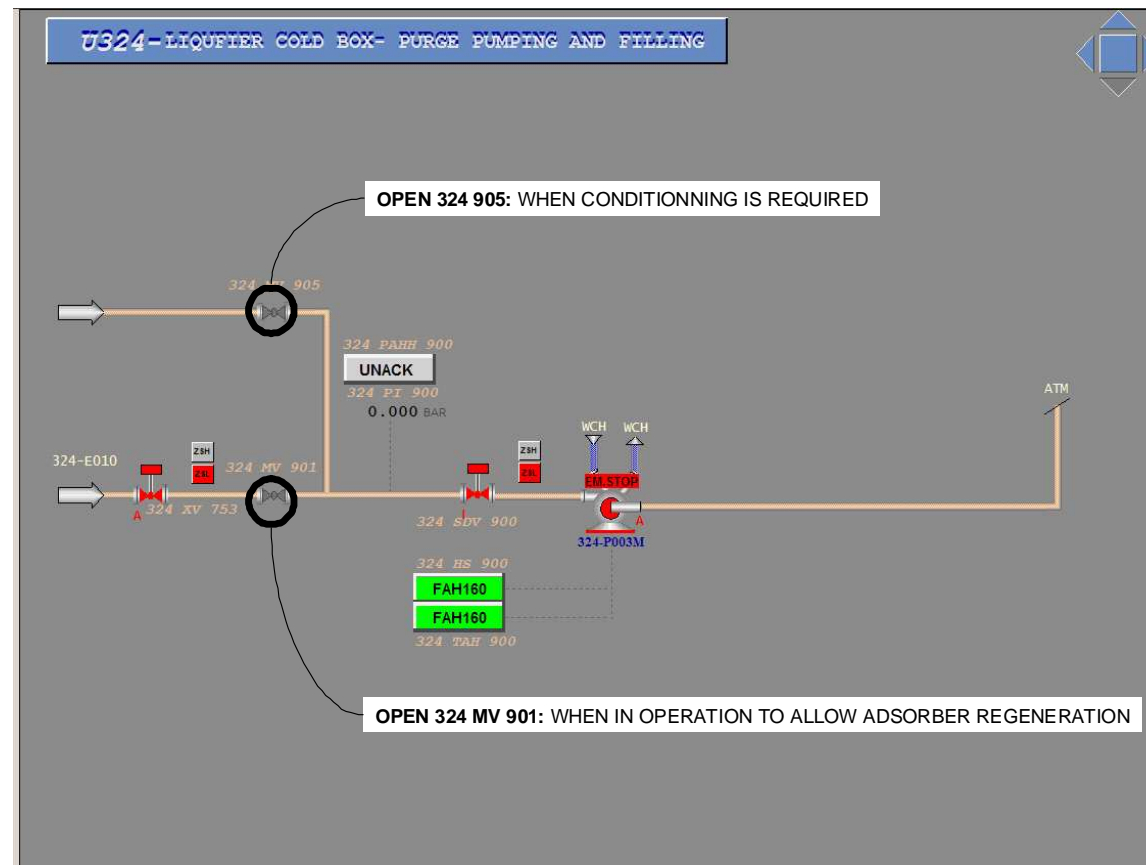
Leak Search: After The first Pumping, the Purge Group shall be stopped and isolated. The pressure in the circuits shall be monitored over 5 minutes. A pressure increase indicates that a leak is present and leak search shall be carried out.

He Gas: for Conditioning shall be clean, i.e. Dew Point < -60°C and Total Impurity Concentration < 50 ppmv.

WARNING: Moisture and Impurities contained in the first charge of Helium can result in Heat Exchanger and Turbine Filters Plugging. Eventually, Turbines Failures can result

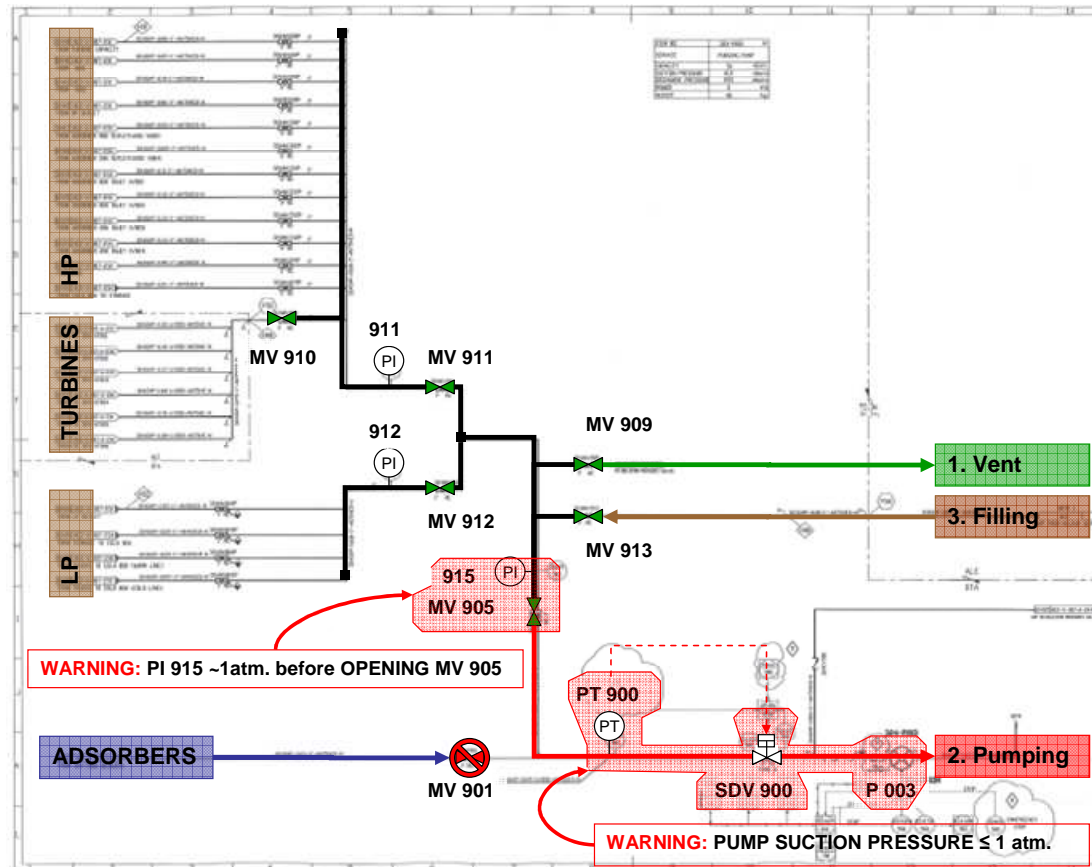
Liquefier Conditioning – Vacuum Pump

- IN OPERATION 324 MV 901 shall be **Open** (Adsorber Regeneration), 324 MV 905 shall be Closed.
 - CONDITIONNING 324 MV 901 shall be **Closed** by operator and use 324 MV 905 for Purging.
- !! WARNING: DO NOT OPEN 324 MV 905 IF 324 PI 915 > 1atm.**



Liquefier Conditioning

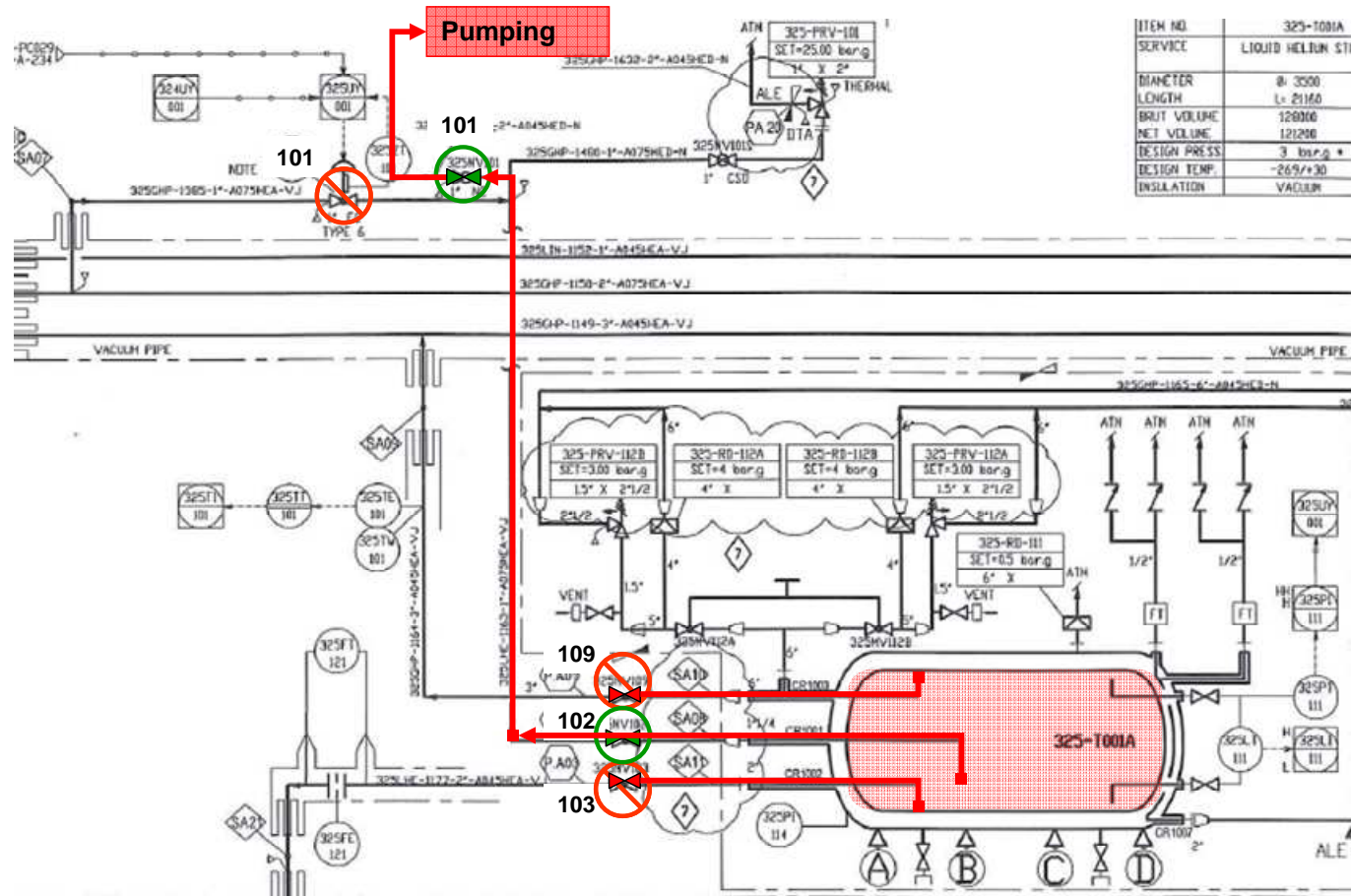
Note: Repeat 3 Times to obtain Satisfactory Gas Purity: Target is Dew Point < -60°C and Impurity < 50 ppmv.



Distribution Conditioning

Unit 325 Circuits shall be conditioned along with UNIT 324, using the Liquefier Valve Panel.

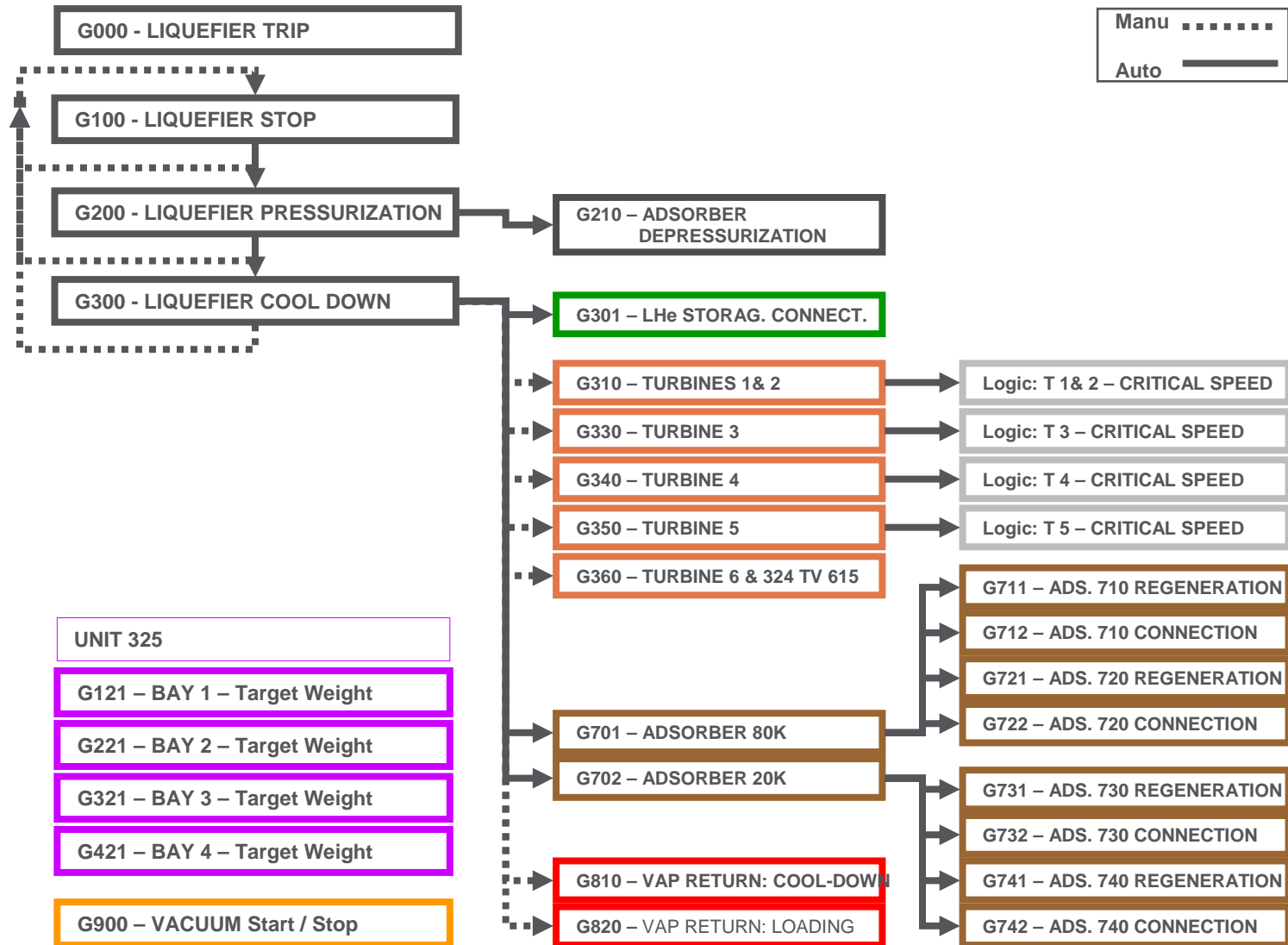
NOTA : The LHe Dewars have a volume of 120m³ each, and will require thorough pumping. While Conditioning can be performed using the Liquefier Valve Panel, additional pumping group can be used for conditioning. The Pumping Group can be connected to the valves: 325 MV 101, 201, 301 and 401



Course Agenda

- Simplified PFD
- Plant Overview
- Unit 324/325 Conditioning
- **DCS Overview**
- Plant Start-Up

DCS Sequences



- UNIT 325**
- G121 - BAY 1 - Target Weight
 - G221 - BAY 2 - Target Weight
 - G321 - BAY 3 - Target Weight
 - G421 - BAY 4 - Target Weight
 - G900 - VACUUM Start / Stop

DCS Sequences

GENERAL	G	NAME	START BY		REMARK
			DCS	OPERATOR	
SEQUENCE	G100	STOP		X	
SEQUENCE	G200	PRESSU		X	
SEQUENCE	G210	PRESSU: Adsorbres	X	X	
SEQUENCE	G300	COOL-DOWN		X	
SEQUENCE	G301	COOL-DOWN: Dewars	X	F	
TURBINES					
SEQUENCE	G310	Turbines 1&2		X	
SEQUENCE	G330	Turbine 3		X	
SEQUENCE	G340	Turbine 4		X	
SEQUENCE	G350	Turbine 5		X	
SEQUENCE	G360	Turbine 6		X	
ADSORBERS					
SEQUENCE	G701	Adsorbres 80K	X	F	
SEQUENCE	G702	Adsorbres 20K	X	F	
SEQUENCE	G711	Regen Adsorber 710	X	X	Operator Start Available if 701 & 702 in Step 0
SEQUENCE	G721	Regen Adsorber 720	X	X	Operator Start Available if 701 & 702 in Step 0
SEQUENCE	G731	Regen Adsorber 730	X	X	Operator Start Available if 701 & 702 in Step 0
SEQUENCE	G741	Regen Adsorber 740	X	X	Operator Start Available if 701 & 702 in Step 0
SEQUENCE	G712	Connect Adsorber 710	X	X	Operator Start Available if 701 & 702 in Step 0
SEQUENCE	G722	Connect Adsorber 720	X	X	Operator Start Available if 701 & 702 in Step 0
SEQUENCE	G732	Connect Adsorber 730	X	X	Operator Start Available if 701 & 702 in Step 0
SEQUENCE	G742	Connect Adsorber 740	X	X	Operator Start Available if 701 & 702 in Step 0
ADSORBERS					
SEQUENCE	G810	Vapors: Cool-Down		X	
SEQUENCE	G820	Vapors: Loading		X	
SEQUENCE	G121	Loading: Bay 1	X	X	
SEQUENCE	G221	Loading: Bay 2	X	X	
SEQUENCE	G321	Loading: Bay 3	X	X	
SEQUENCE	G421	Loading: Bay 4	X	X	
ADSORBERS					
SEQUENCE	G900	VACUUM		X	
ADSORBERS					
SEQUENCE	G000	TRIP	X		

Note: “F” stands for **Force Start**, only accessible by **ENGINEER**, proceed with care.

Note: Operator Start Order will only be maintained if Initial Transition Conditions are OK.

DCS Sequences

UNIT	UY	#	→	UNIT	G	#	
324	UY	001	→				Covers Liquefier General Sequences
			→	324	G	000	Liquefier Trip
			→	324	G	100	Liquefier Stop
			→	324	G	200	Liquefier Pressurization
			→	324	G	300	Liquefier Cool-Down
			→	324	G	G301	LHe Storages Connection
			→	324	G	G900	Vacuum Group
324	UY	002	→	324	G	800	Vapors Return Lines: General
			→	324	G	810	Vapors Return Line: For Cool-Down
			→	324	G	820	Vapors Return Line: For Loading
324	UY	100 200	→	324	G	310	Turbines 1&2 Start & Stop
			→	324	G	311	Turbines 1&2 Critical Speed
324	UY	300	→	324	G	330	Turbine 3 Start & Stop
			→	324	G	331	Turbine 3 Critical Speed
324	UY	400	→	324	G	340	Turbine 4 Start & Stop
			→	324	G	341	Turbine 4 Critical Speed
324	UY	500	→	324	G	350	Turbine 5 Start & Stop
			→	324	G	351	Turbine 5 Critical Speed
324	UY	600	→	324	G	360	Turbine 6 Start & Stop & Trip with By-Pass
324	UY	700	→				Covers Adsorbers Sequences
			→	324	G	210	Adsorbers Pressurization (Relate to 324 G 200)
			→	324	G	701	80K Adsorbers General Sequence: 710 & 720
			→	324	G	711	ADS. 710: Regeneration
			→	324	G	712	ADS. 710: Connection
			→	324	G	721	ADS. 720: Regeneration
			→	324	G	722	ADS. 720: Connection
			→	324	G	702	20K Adsorbers General Sequence: 730 & 740
			→	324	G	731	ADS. 730: Regeneration
			→	324	G	732	ADS. 730: Connection
			→	324	G	741	ADS. 740: Regeneration
			→	324	G	742	ADS. 740: Connection
325	UY	121 221 321 421	→	325	G	121	Target Weight Bay 1
			→	325	G	221	Target Weight Bay 2
			→	325	G	321	Target Weight Bay 3
			→	325	G	421	Target Weight Bay 4

DCS Sequences

U324 - LIQUEFIER: Sequences

LIQUEFIER TURBINES

- G310 - TURBINES 1&2
- G330 - TURBINE 3
- G340 - TURBINE 4
- G350 - TURBINE 5
- G360 - TURBINE 6 & 324 TV 615

LIQUEFIER PRESSURIZATION

- G000 - LIQUEFIER TRIP
- G100 - LIQUEFIER STOP
- G200 - LIQUEFIER PRESSURIZATION
- G210 - ADS. DEPRESSURIZATION
- G300 - LIQUEFIER COOL DOWN
- G301 - LHe STORAG. CONNECT
- G810 - VAP RETURN: COOL-DOWN
- G820 - VAP RETURN: LOADING
- G900 - VACUUM Start / Stop

UNIT OVERVIEW

LIQUEFIER ADSORBERS 20K

- G702 - ADSORBER 20K
- G731 - ADS. 730 REGENERATION
- G732 - ADS. 730 CONNECTION
- G741 - ADS. 740 REGENERATION
- G742 - ADS. 740 CONNECTION

LIQUEFIER ADSORBERS 80K

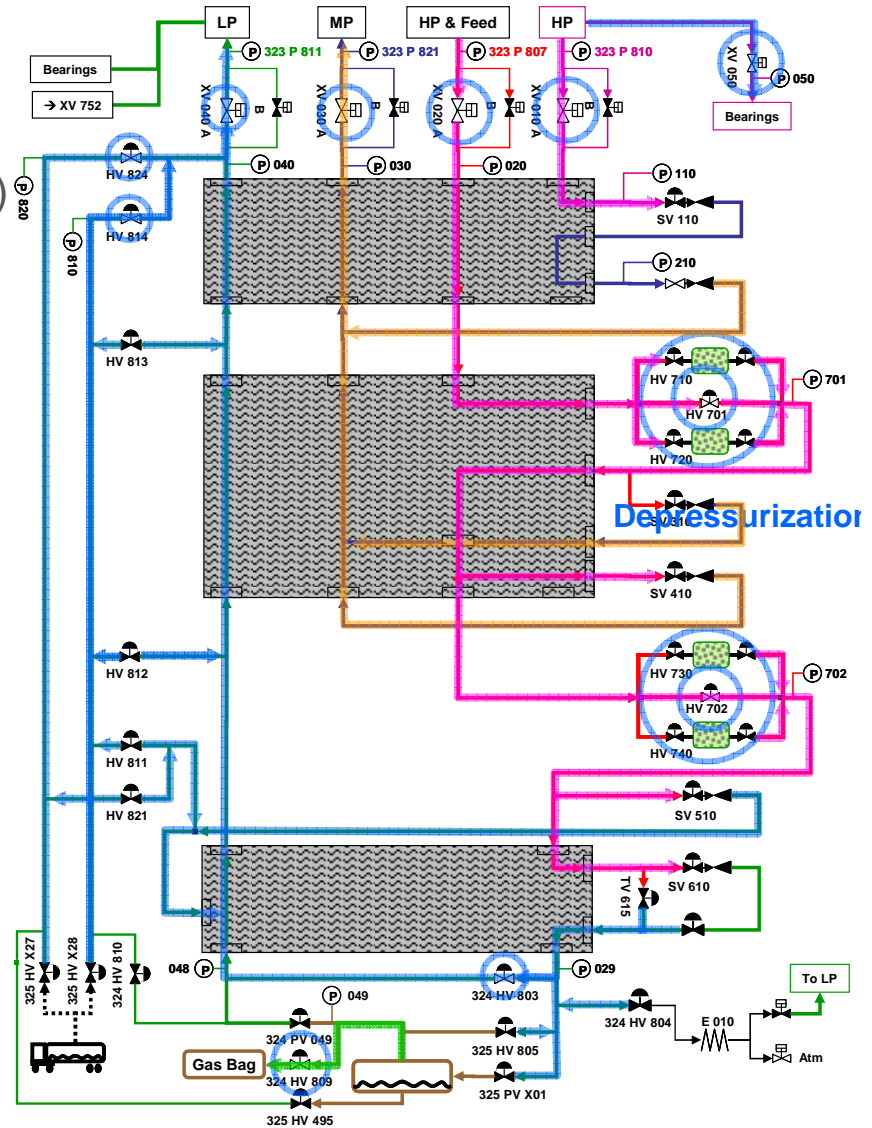
- G701 - ADSORBER 80K
- G711 - ADS. 710 REGENERATION
- G712 - ADS. 710 CONNECTION
- G721 - ADS. 720 REGENERATION
- G722 - ADS. 720 CONNECTION

UNIT 325

- G121 - BAY A - Target Weight
- G221 - BAY B - Target Weight
- G321 - BAY C - Target Weight
- G421 - BAY D - Target Weight

DCS Sequences – G200 Liquefier Pressurization

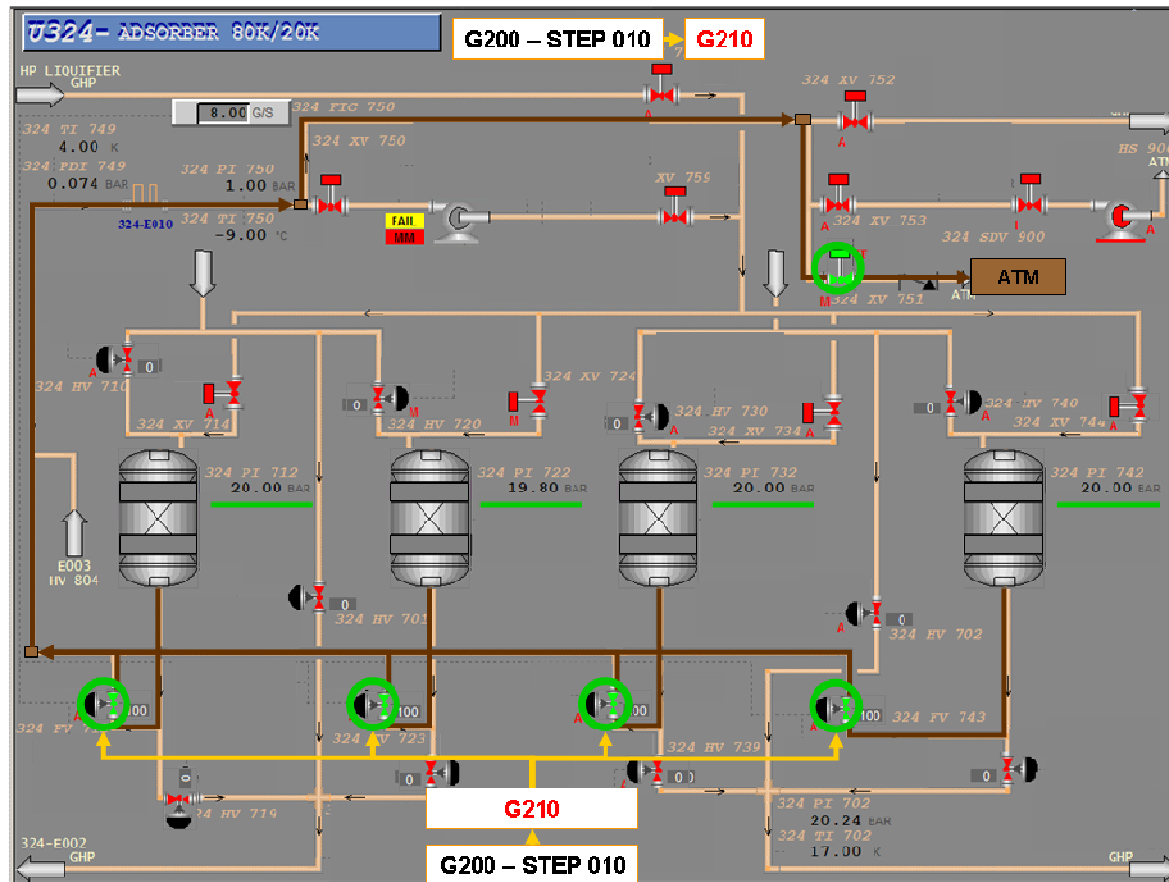
- **Initiate G200** – Liquefier Pressurization
(only possible after completion of (G100))
 - 010-Starts adsorber Depressurization (->G210)
 - 100-Pressurization of Turbines Bearing
 - 200-LP Pressurization
 - 300-MP Pressurization
 - 400-T1&T2 Pressurization
 - 500-T3,T4,T5,T6 Pressurization
 - Nota : bypass valves are open before butterfly isolation valves
 - Nota : XV020A is open after HV701 & 702 are open
 - 700-Depressurize LHe Storages to Gas Bag
 - START 324 PC 809 WITH SET-POINT = 1.15 Bara



DCS Sequences – G200 Liquefier Pressurization

Step 010 - Adsorbers Depressurization (Call G210)

During pressurization, adsorbers are isolated and depressurized in order to avoid pressure rise related to thermal expansion

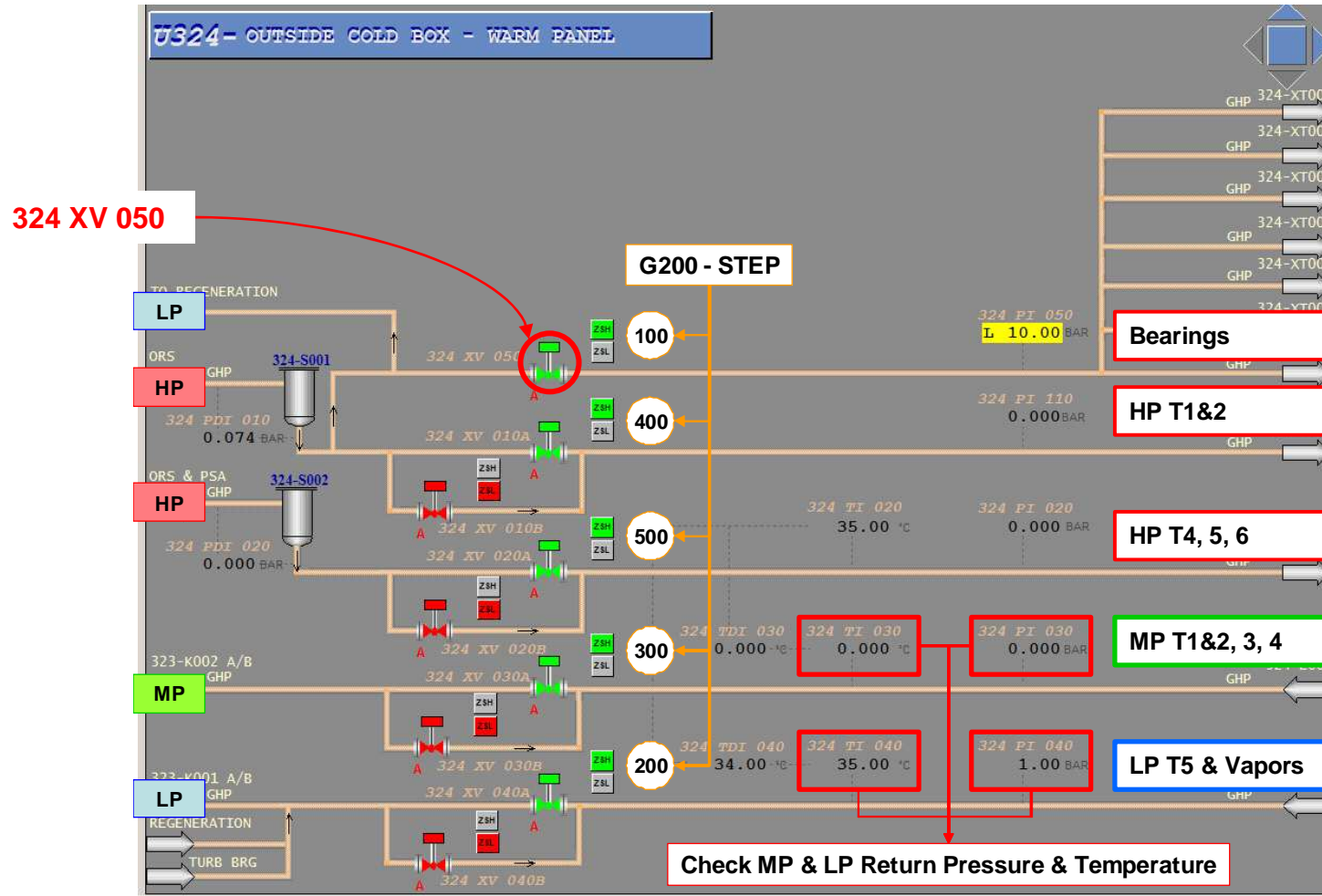


Note: G210 will only be started if all valves related to Adsorbers are closed (i.e. Adsorbers in/out & Pressurisation Valves, Blower in/out valves, Purge Valve etc...)

DCS Sequences – G200 Liquefier Pressurization

Steps 100 to 500

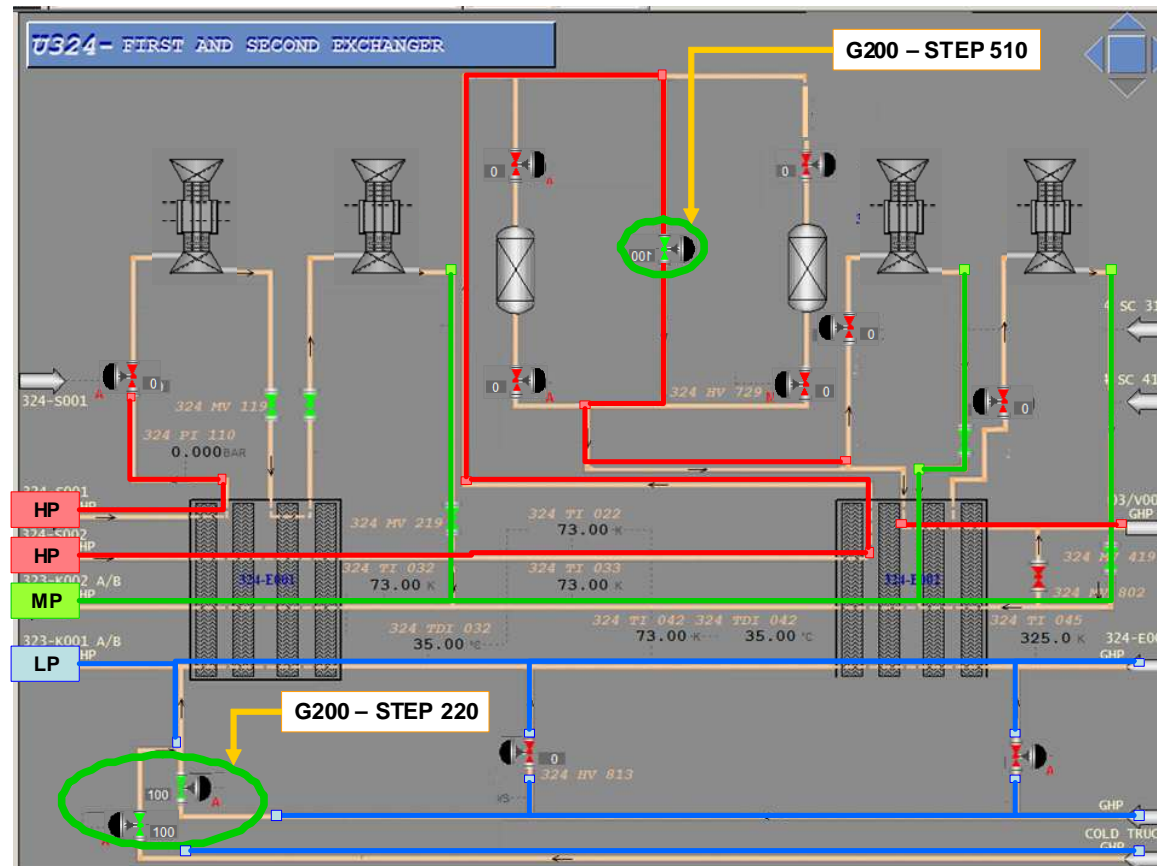
Liquefier Circuits (Unit 324): Turbines Bearings, LP, MP, HP T1&2 and HP T3,4,5,6 are successively connected to the compressor station (Unit 323).



DCS Sequences – G200 Liquefier Pressurization

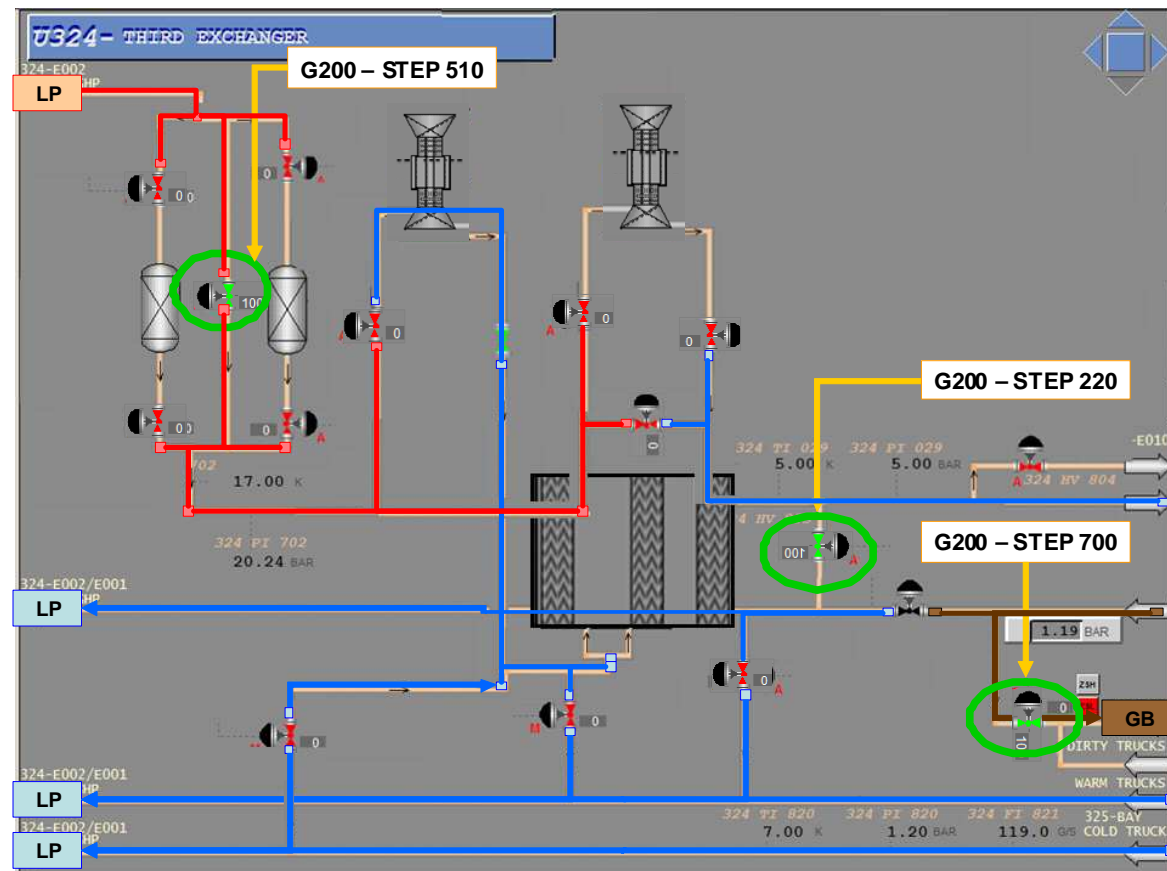
324 HV 814 & 824
324 HV 701

Open. The Vapors Return Line are connected to the LP for depressurization.
The 80K Adsorbers by-Pass is open to allow full connection of the HP Line.



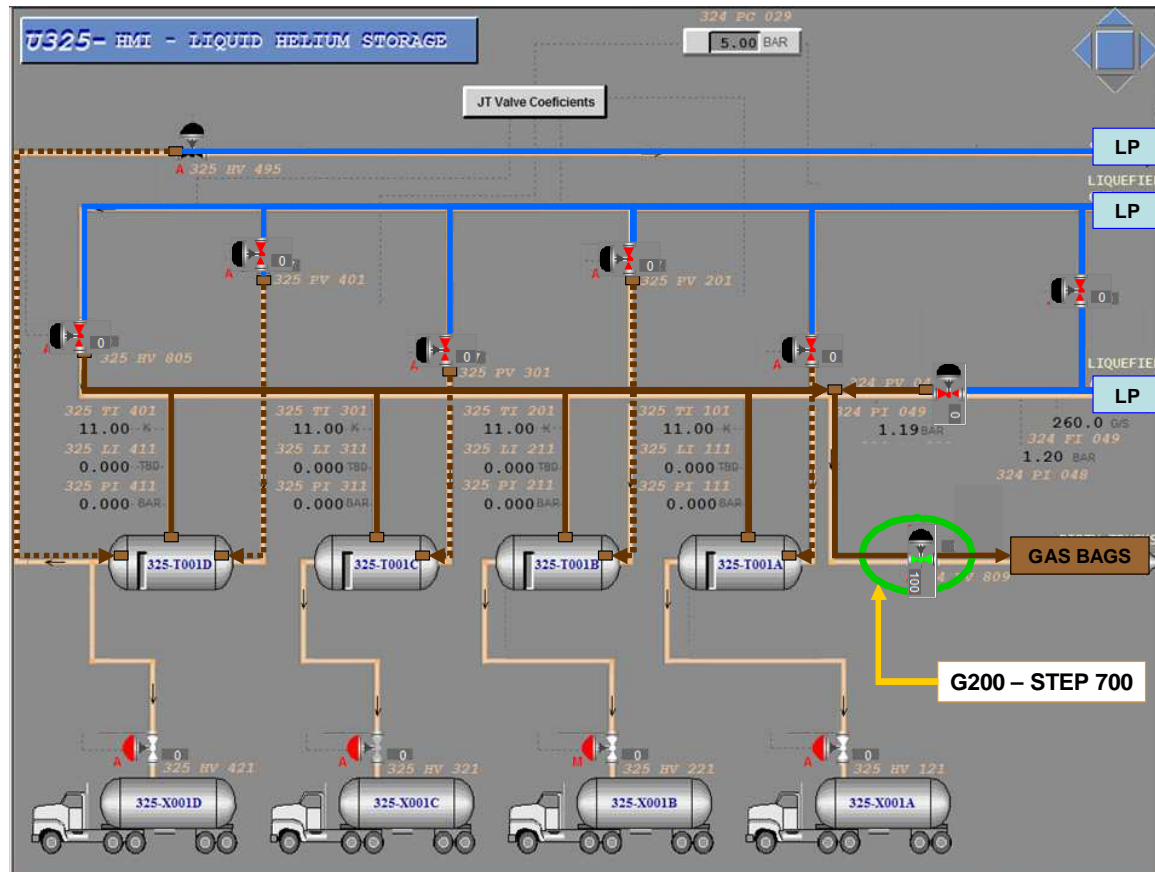
DCS Sequences – G200 Liquefier Pressurization

324 HV 702: The 20K Adsorbers by-Pass is open to allow full connection of the HP Line.
324 HV 803: The Cold By-Pass is open to depressurize the line up-stream the JT Valve
 Note: T6 is OFF and 324 TV 615 is closed: No flow through 324 HV 803.



DCS Sequences – G200 Liquefier Pressurization

-324 PV 809: will open to depressurize the Dewars to the gas bags.



DCS Sequences – G300 Liquefier Cool Down

- ⚠️ Cool-Down rate shall be about 1K/min**
- ⚠️ DT<50K across two adjacent channels**

■ Initiate G300 – Liquefier Cool Down

(only possible after completion of G200)

- Force Flow Circulation (open ~50% TV615)
- Partial by-pass of HX3 (open ~50% HV803 and HV810)
- CLOSE 324 HV 814

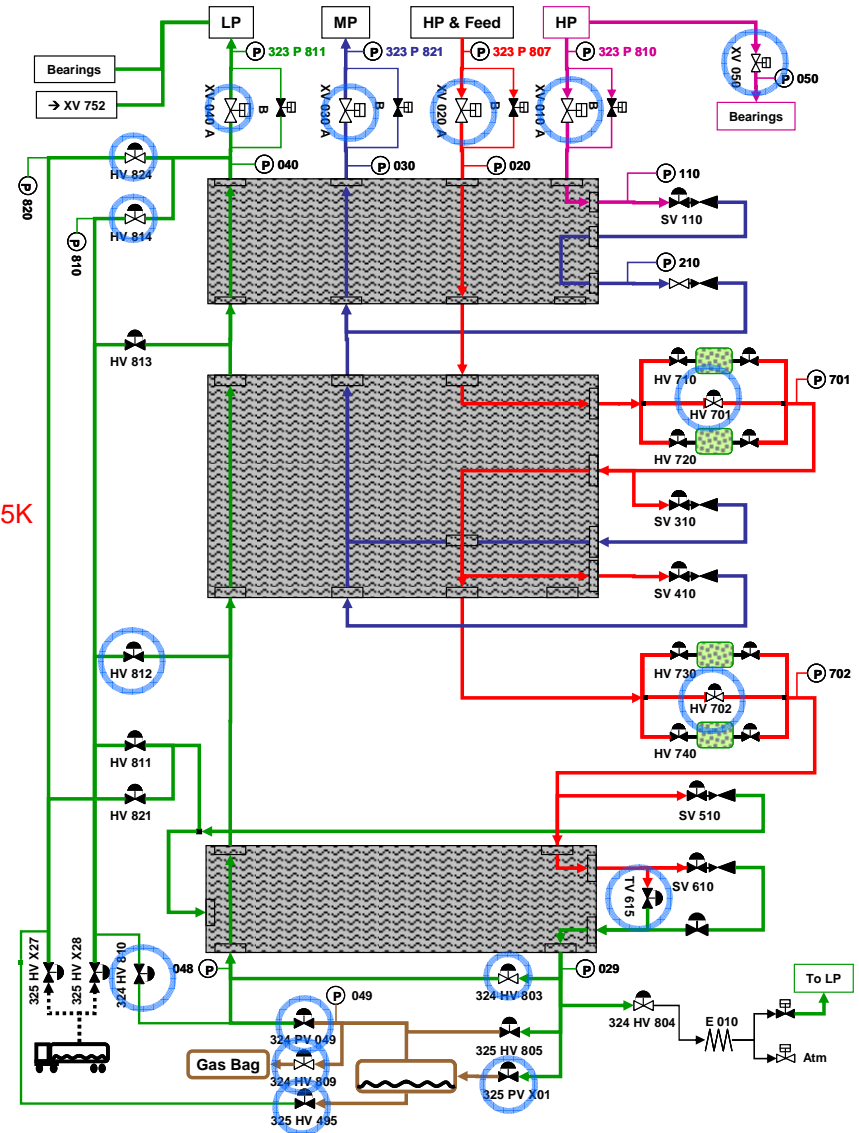
WARNING: While Helium expands, its temperature increases, which can cause the Temperature 324 TT 029 and 324 TT 048 to rise. As per ALPEMA 65°C is the Maximum allowable temperature. This temperature is out of the sensors range. [4-325K i.e Max = 52°C].

▪ START G301 : Connection of LHe storages

- > Flow goes through 324 HV 803
- > LHe Storages are depressurized to the gas bag (324 PV 809 open)
- > LHe Storages will connect (324 PV 049 & PV x01) when P & T are OK

NOTA : Slow LHe storages connection is required to:

- Avoid large amount of cold gas from LHe Storages to the liquefier
- Avoid fast vaporization of LHe while connecting warm lines to LHe storages



DCS Sequences – G300 Cool Down

G300 STEP 100: He CIRCULATION

324 TV 615:

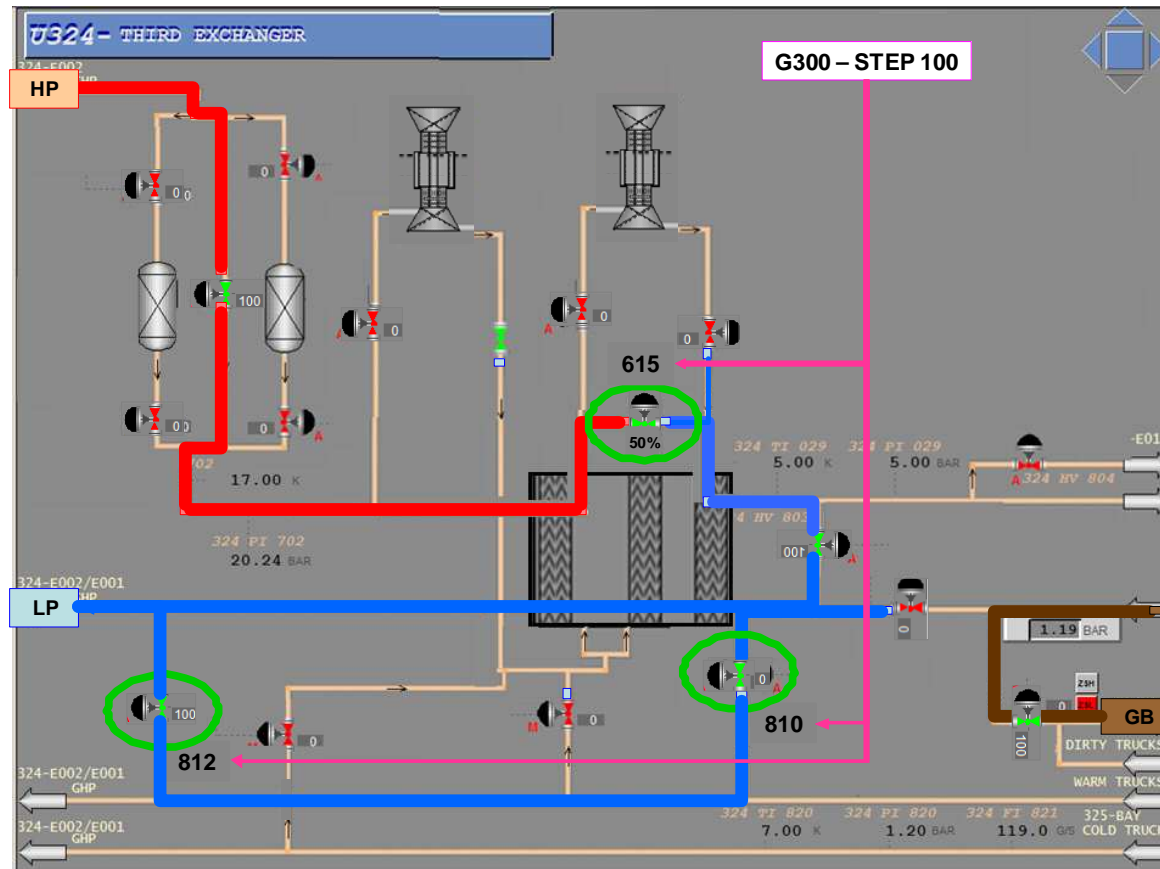
Turbine 6 By-Pass is Open to allow flow circulation from HP to LP.

324 HV 810 & 812:

The Cold By-Pass is open to depressurize the line up-stream the JT Valve

324 HV 814:

Closed. (View HX 1&2)



Note: 324 HV 810 and 812 allow HX3 By-Pass, to Un-Balance HX3 and to cool-down the cold-end.

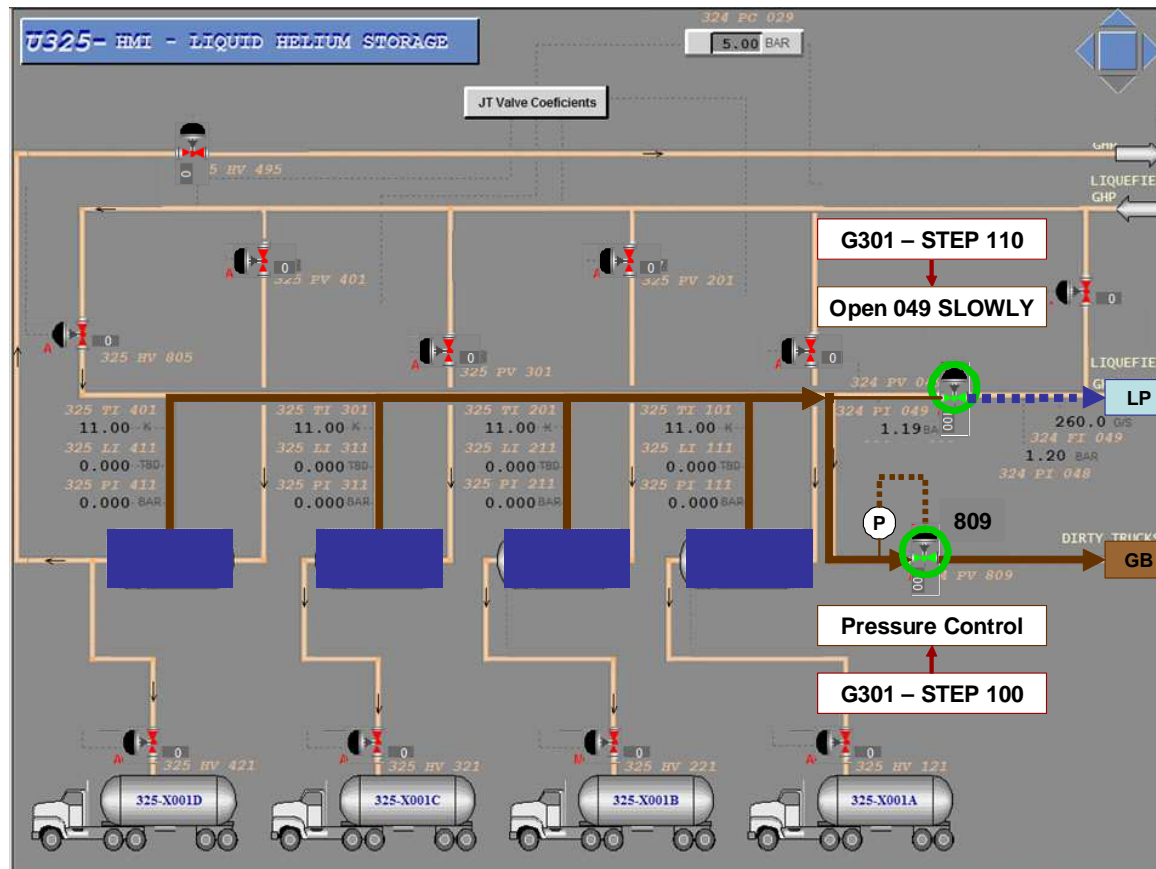
DCS Sequences – G300 Cool Down

G300-Step 110 will START G301

324 PV 809: Depressurizes LHe Storages to Gas Bags.

324 PV 049: Is open very slowly to connect the LHe Storages to the Liquefier

Once the LHe Storages are depressurized, 324 PV 809 is Closed.

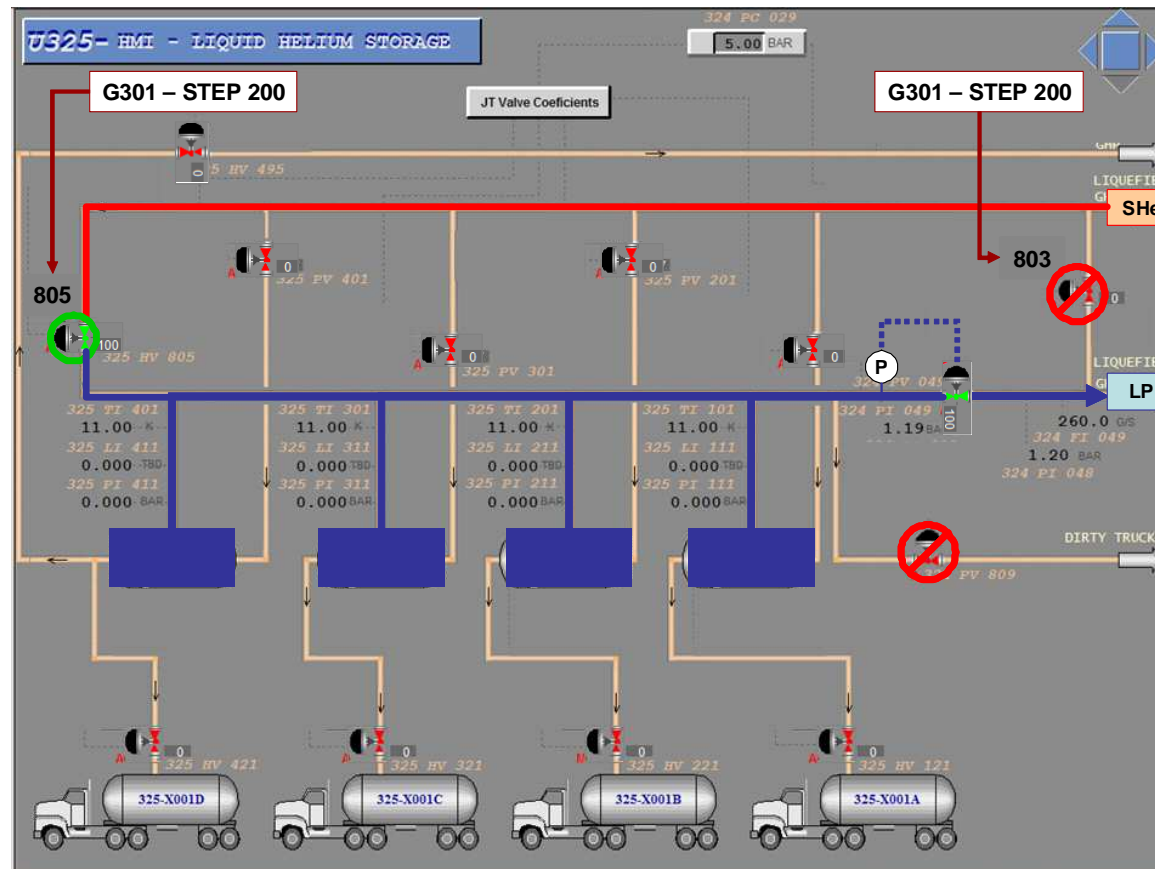


DCS Sequences – G300 Cool Down

G301 STEP 200, 210: Cool Down Of Lines Up-Stream the JT Valves (for smooth connection)

324 HV 805: is Open to allow circulation of cold helium up-stream the JT Valves.

324 HV 803: is Closed to force more flow through 324 HV 805.



Note: 324 HV 810 and 812 allow HX3 By-Pass, to Un-Balance HX3 and to cool-down the cold-end.

DCS Sequences – G300 Cool Down

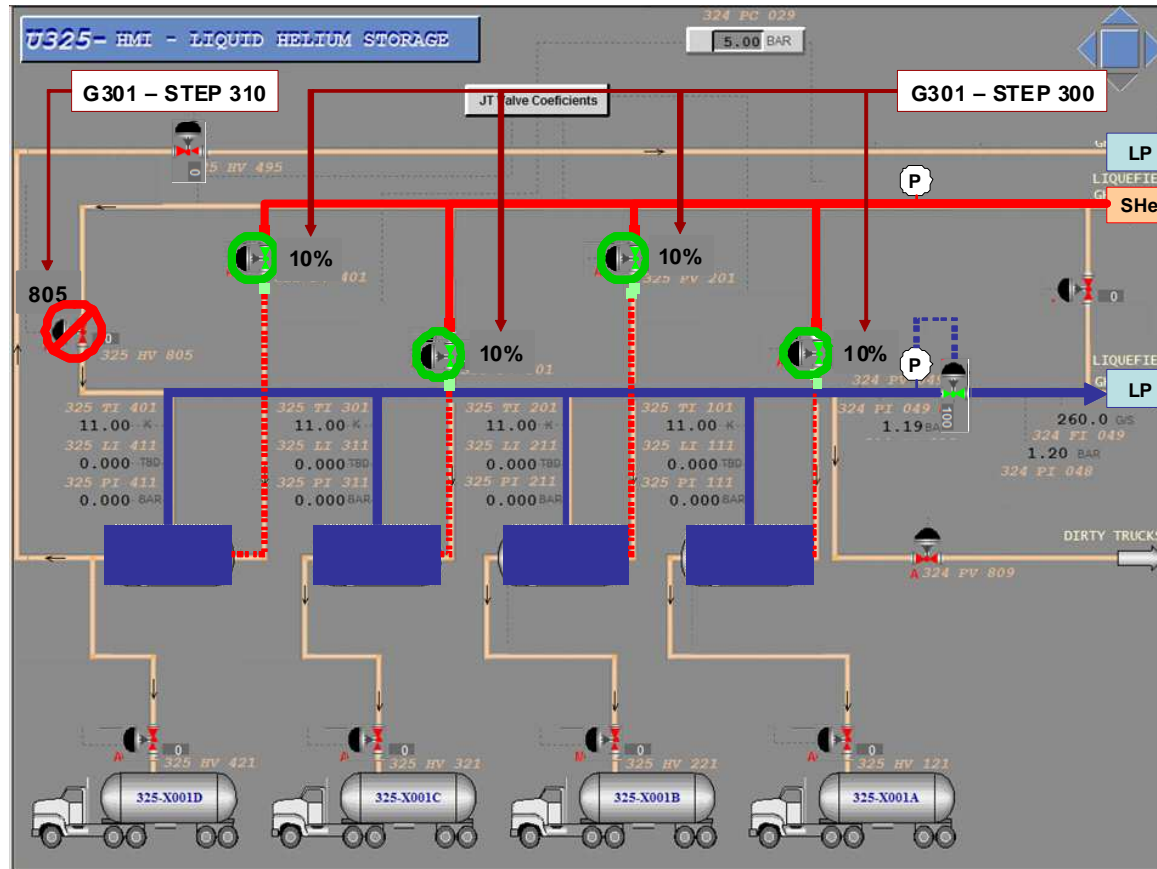
G301 STEP 300, 310: JT Valves are Slowly Open and 324 HV 805 is Closed

324 PV 101, 201, 301 & 401

Slowly Open for smooth connection.

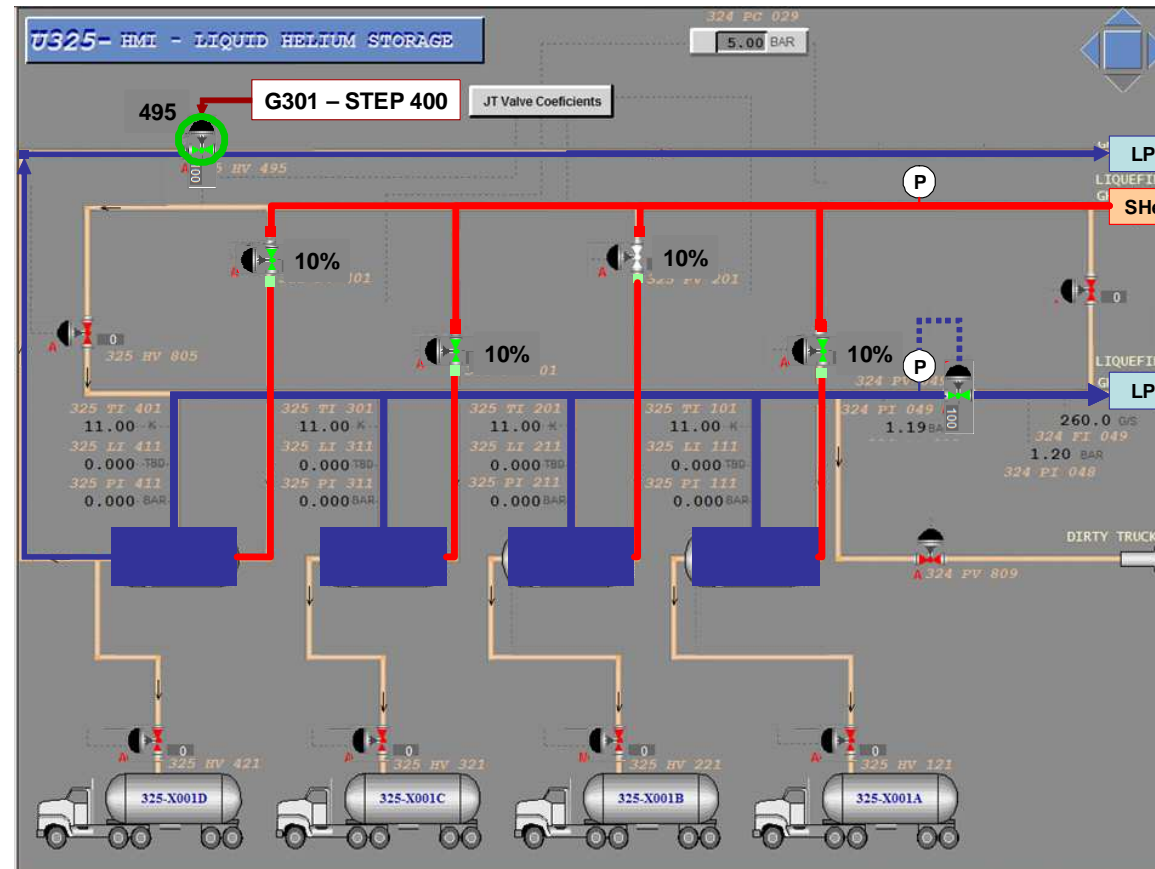
324 HV 805

Closed to force all flow through 324 PV 101, 201, 301 & 401.



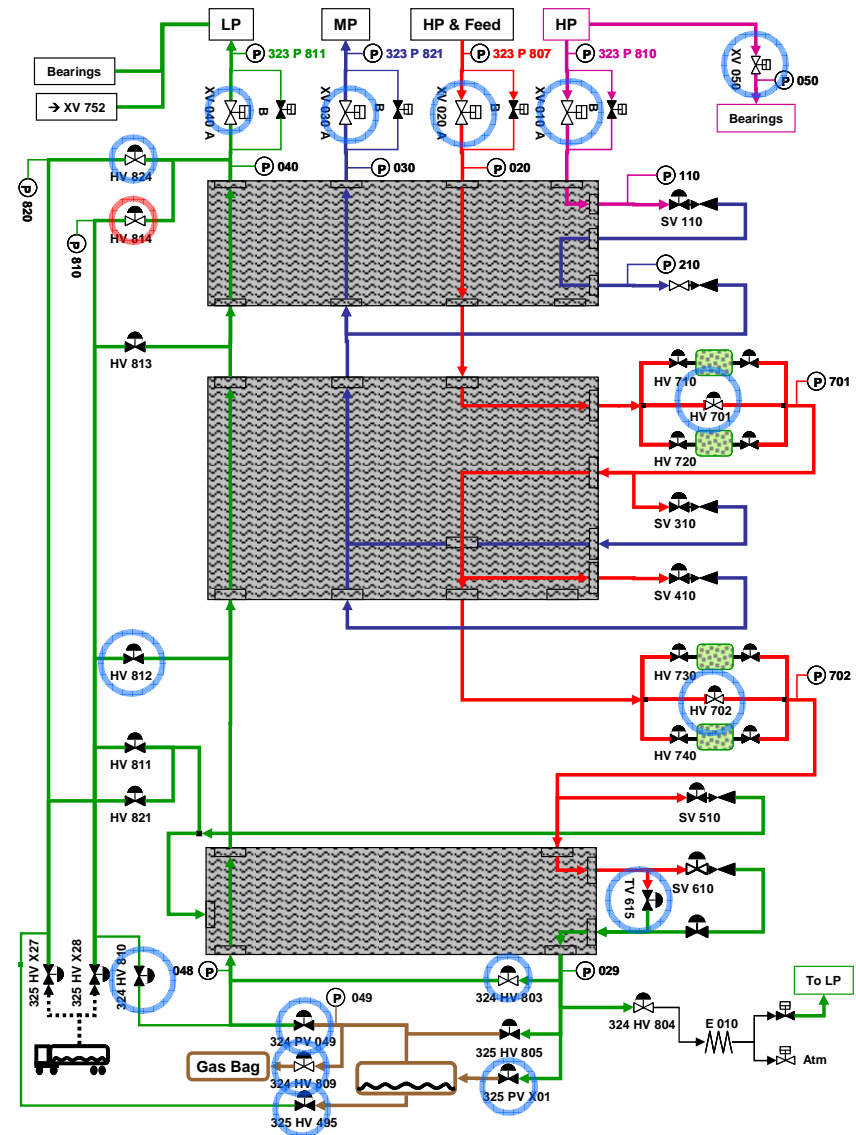
DCS Sequences – G300 Cool Down

G301 STEP 400: Final Step, will open 324 HV 495 to keep the vapor return line cold.
 324 HV 495 Open to maintain the cold vapor return line under cold conditions.



DCS Sequences – G300 Liquefier Cool Down

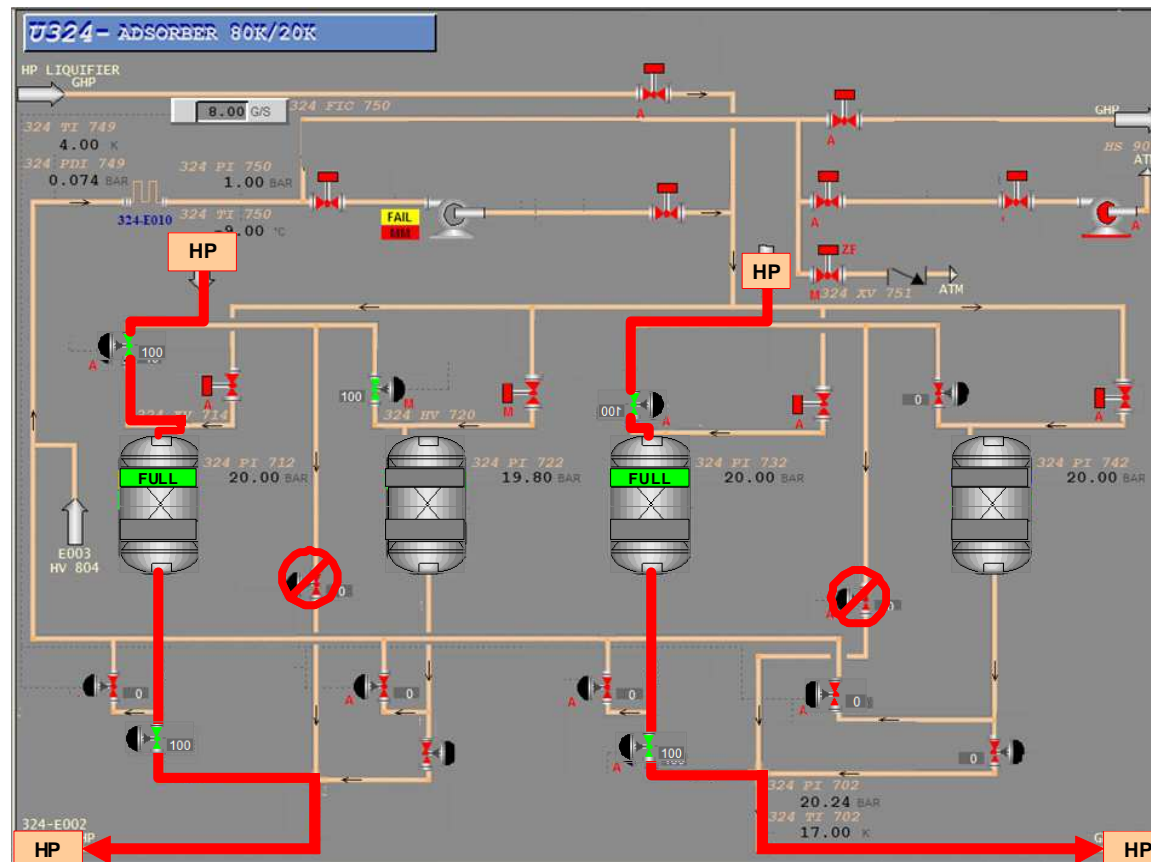
- Connection of Adsorber **80 K (G701)**
- Message : “T1 & T2 Ready for Start-up” -> Operator Action
- Message : “T2 Ready for Start-up” -> Operator Action
 - When Adsorbers 80K connected
- Connection of Adsorbers **20 K (G701)**
- Message : “T4 Ready for Start-up” -> Operator Action
 - When Adsorbers 20K connected
- Message : “T5 Ready for Start-up” -> Operator Action
 - If LHe connected (end of G301)
- Close 324 HV 810 & 324 HV 812
- Open 324 HV 814
 - When 324 HV 814 open at 100%
 - And 324 TT 029 <10 K (Up-stream JT valves)
- Start 324 PC 029
 - When 324 HV 814 open at 100%
- Start 324 TV 615 Computation based on
 - Surge Drum Pressure (323 PV 812)
 - Cycle Load Valve (323 PV 810 A)
 - Adsorbers Temperatures



DCS Sequences – G300 Cool Down

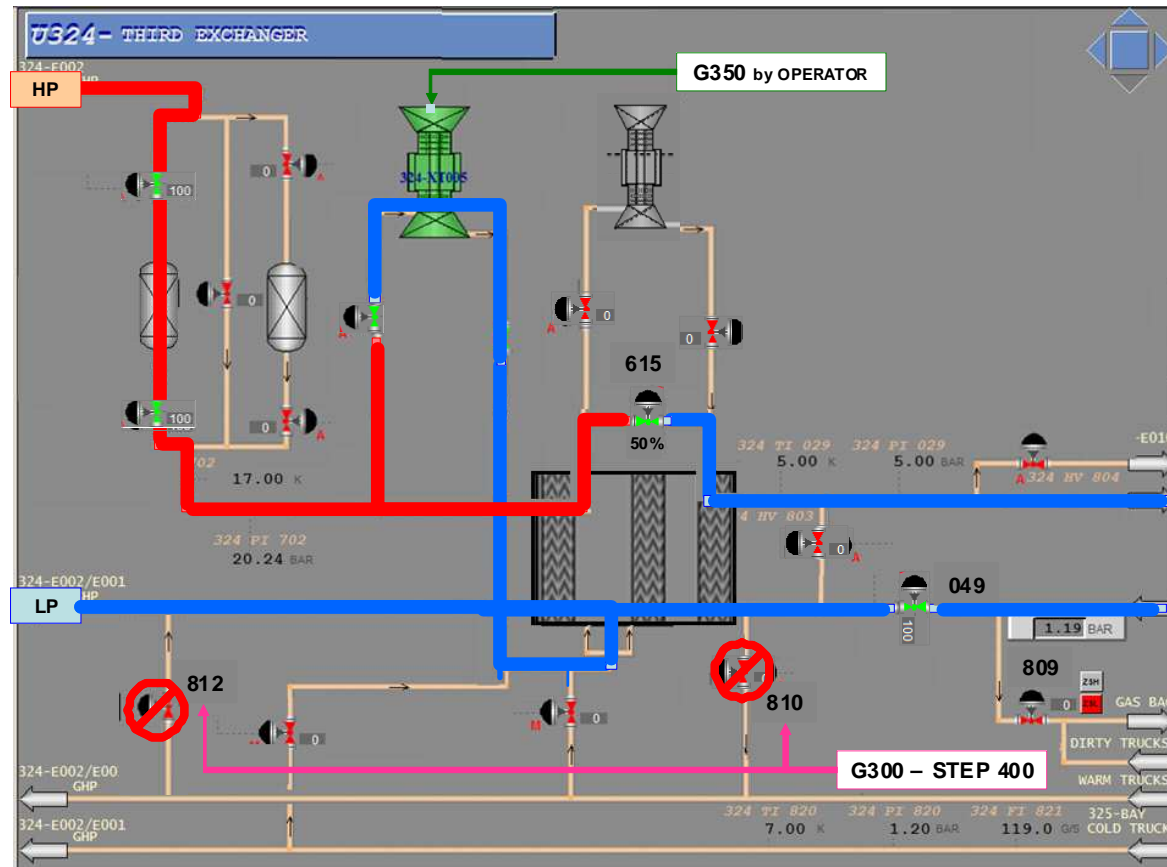
G300 STEP 200 to 230: ADSORBERS & TURBINES 1 to 5

- Adsorber 80K & 20K are connected automatically by G701 (80K) & G702 (20K)
- Turbines 1 to 5 can be started: **BY THE OPERATOR.**



DCS Sequences – G300 Cool Down

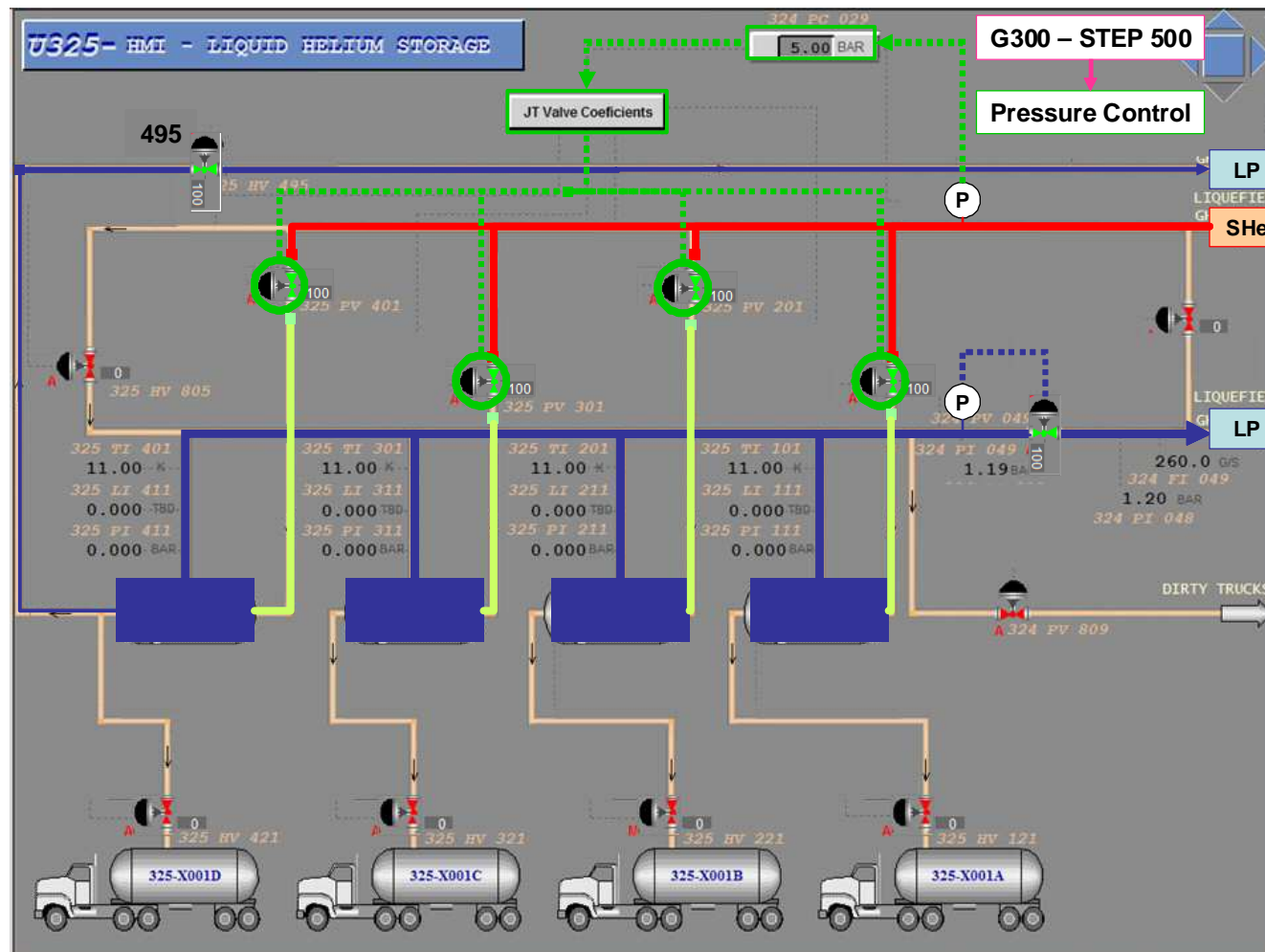
- G300 STEP 400: End of LHe Storages Connection, Close Cool-Down By Pass**
- Cold Storages are connected: **324 HV 803 CLOSED**, **324 PV 049 in AUTO**, **324 PV 809 CLOSED**.
 - **324 HV 810 and 812**: Cool-Down By-Pass are Closed.



DCS Sequences – G300 Cool Down

STEP 500: JT Valves Control is Started

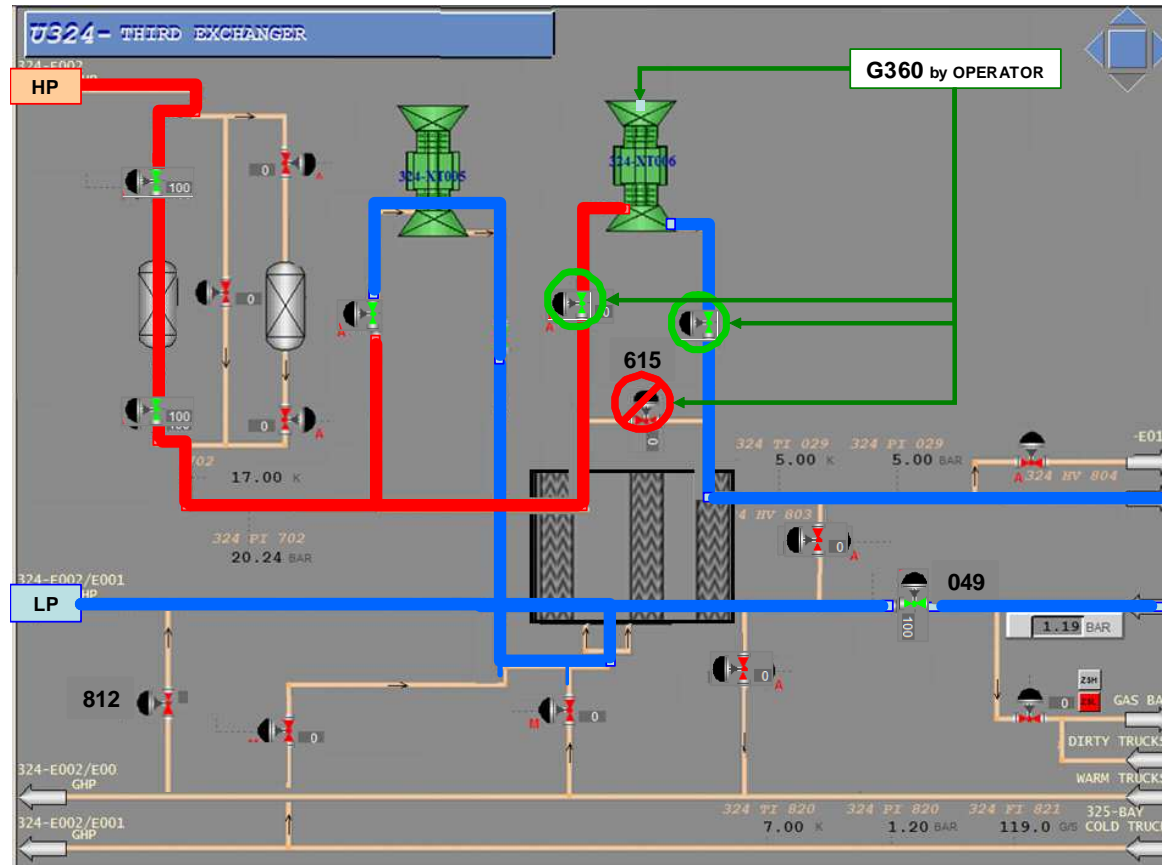
- 324 PC 029: Is Started.



DCS Sequences – G300 Cool Down

STEP 600: Final Step: T6 can be started

- Turbine 6 can be started **by the Operator**: G360.



NOTE: G300 – STEP 600: NOMINAL STEP!

Liquefier will remain in G300 – STEP 600 until a STOP is requested