



# Helium Operators Familiarization Program

Start Up and Shutdown (Units 320, 321, 322, 323 and 326)  
**Competency Assurance and Training**

Doha, January 2013 | SCHULLER Audrey | Air Liquide

# Course Agenda

1. Normal startup
2. Shutdown sequence
3. Emergency Shutdown

# Course Agenda

## 1. Normal startup

### 1. General sequence

### 2. Utilities

### 3. ASU

### 4. Inlet Compressor

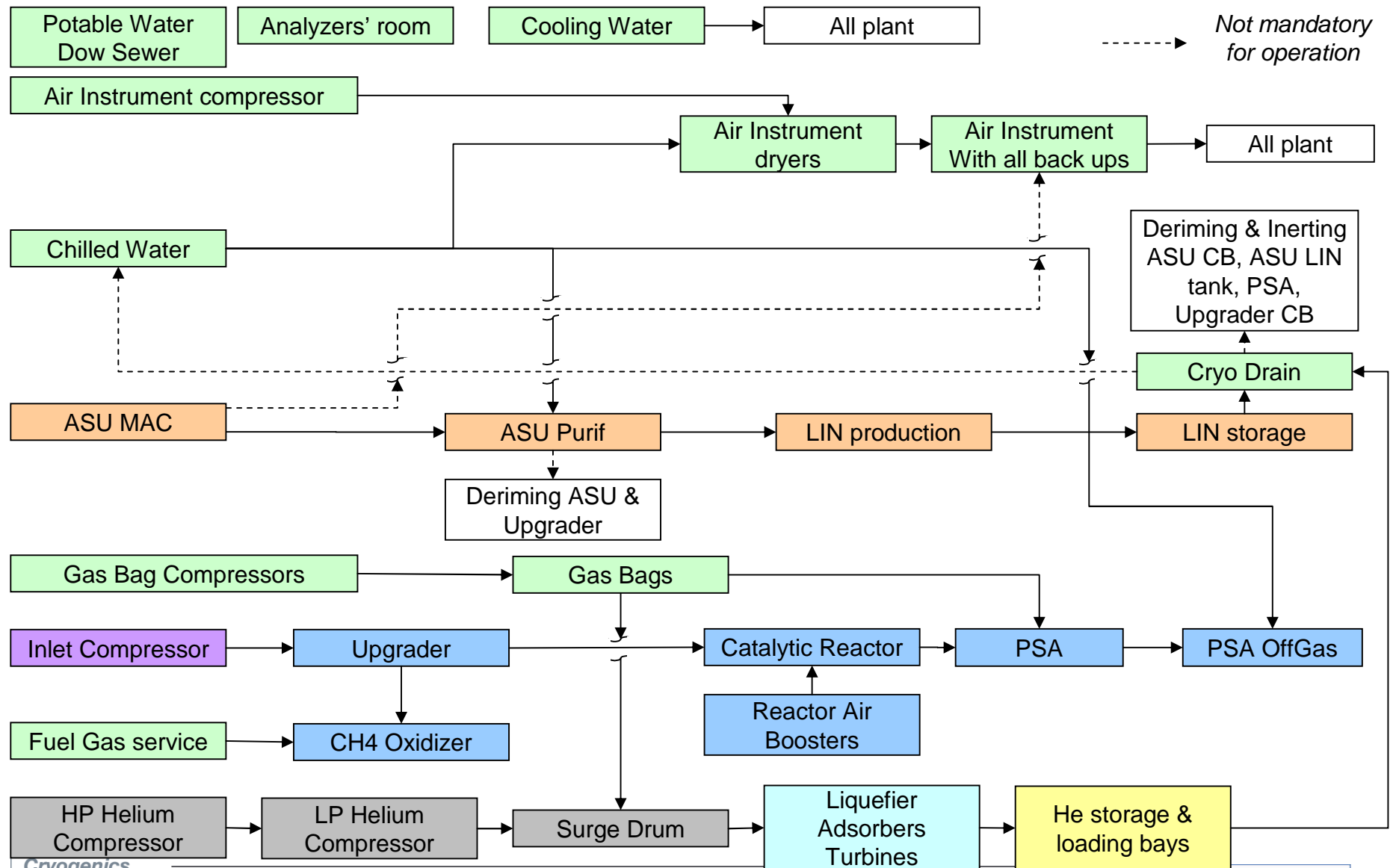
### 5. Unit 322

### 6. Helium Compressors

## 2. Shutdown sequence

## 3. Emergency Shutdown

# Normal start up – Sequence



# Course Agenda

## 1. Normal startup

### 1. General sequence

### 2. Utilities

### 3. ASU

### 4. Inlet Compressor

### 5. Unit 322

### 6. Helium Compressors

## 2. Shutdown sequence

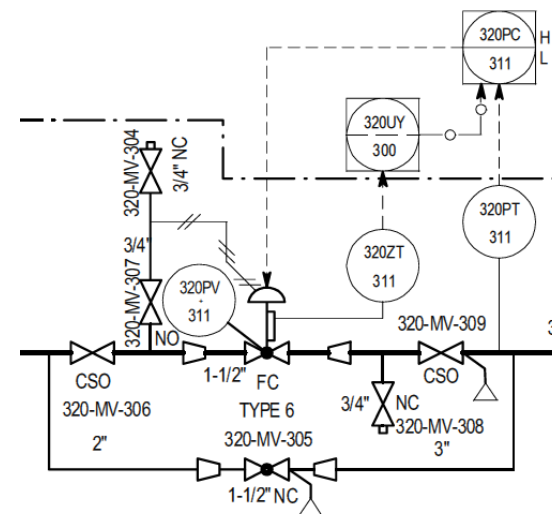
## 3. Emergency Shutdown

# Electricity

- Check the availability.

## Instrument Air (IA) service

- There are 3 sources of Instrument Air:
  - IA Compressor 320 K002 – connected to IA header through 320 MV 628
  - ASU Purification – connected to IA header through 320 XV 300 A
  - IA from RasGas – connected to IA header through 320 PV 311
- The priority order of the 3 sources is selected with 320 HS 310 in the DCS
- At start up:
  - Ensure IA from RasGas is properly tied in
  - As long as ASU is not operating, select position 2 for 320 HS 320 (only one back up: IA from customer)
  - Start up IA compressor
  - 320 PV 311 will automatically close as pressure Increases at 320 PT 311



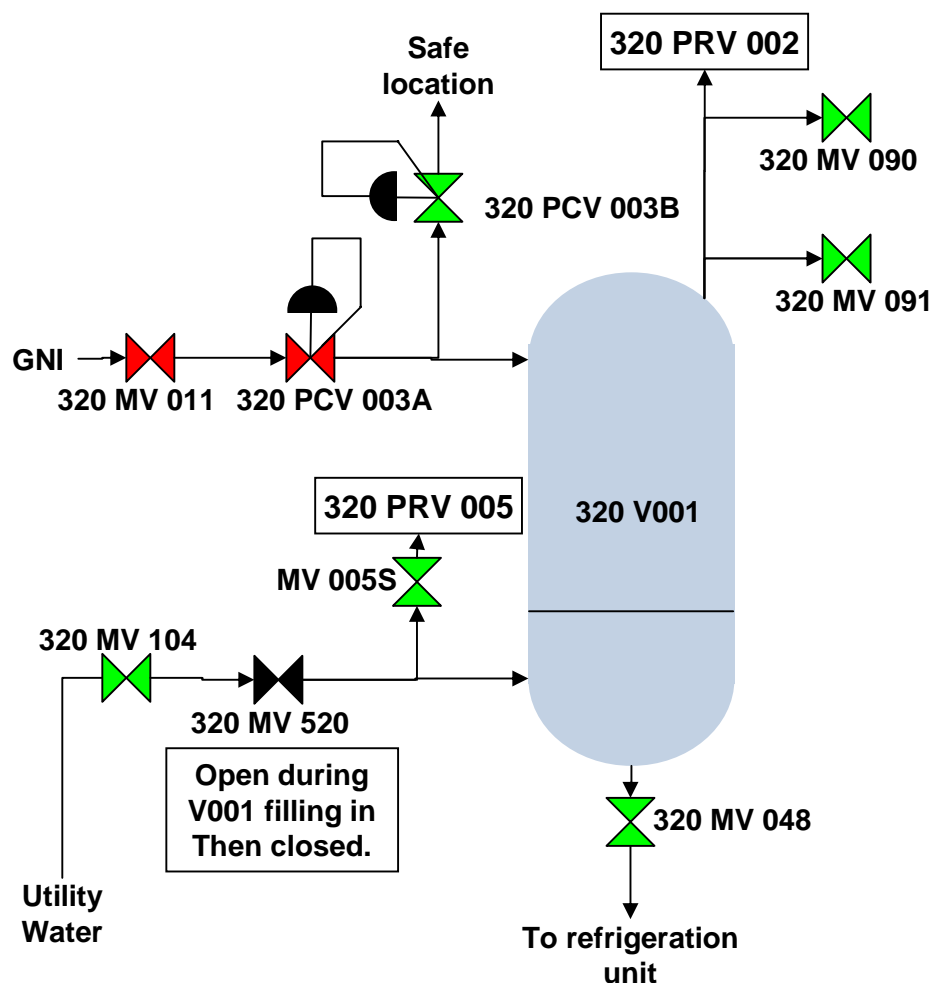
# Normal start up – Utilities – Chilled Water

## Chilled Water

- Check that Utility Water supply valve (320 MV 104) is open
- 2 cases:
  - ▣ **GNI is not available yet** (no N<sub>2</sub> scavenging in 320 V001):
  - ▣ **GNI is available**

# Normal start up – Utilities – Chilled Water

## Start up – As long as GNI not available



Open 320 MV 090 and 320 MV 091  
and close GNI inlet valve

→ While filling in the drum, overpressure will  
be released through these valves.

Maintain this position as long as GNI is not  
available.

When GNI available:

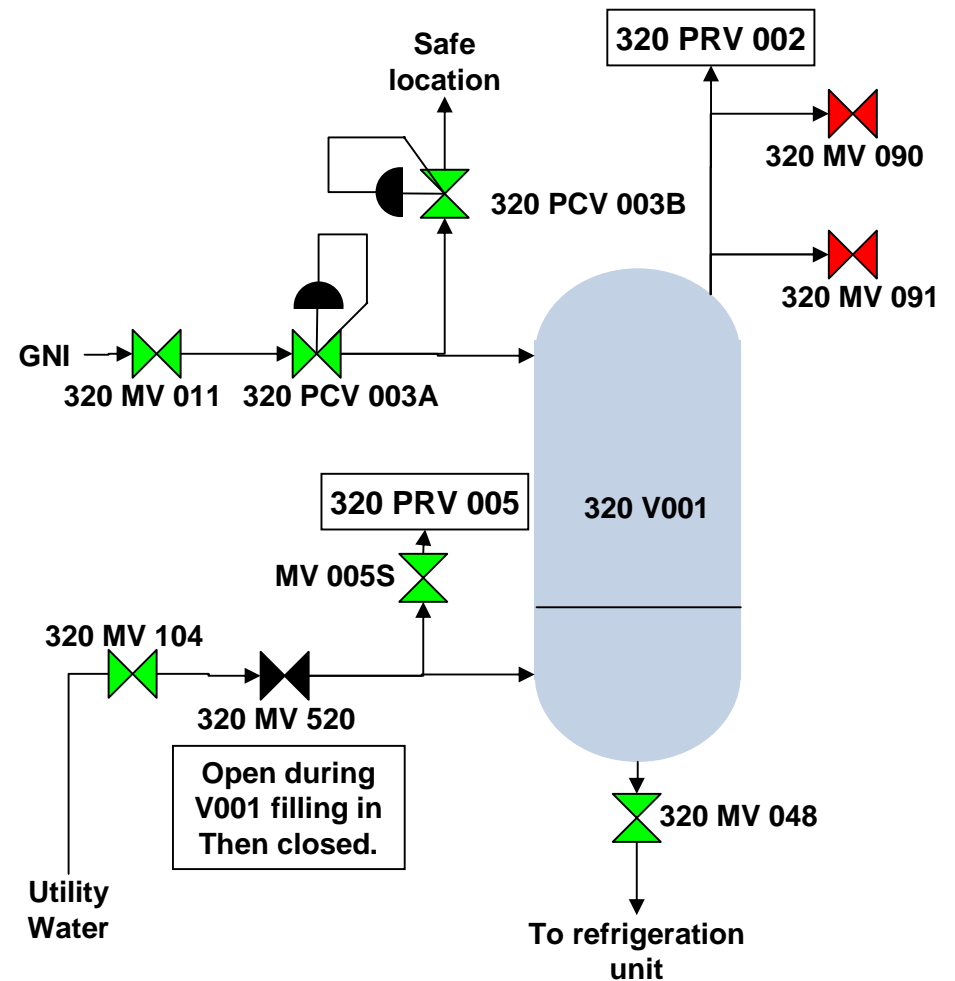
- Ensure 320 PCV 003A is set at 1.1 bara and  
320 PCV 003B is set at 1.2 bara.
- Open 320 MV 011 and set 320 MV 090 and  
320 MV 091 back to their closed position.



# Normal start up – Utilities – Chilled Water

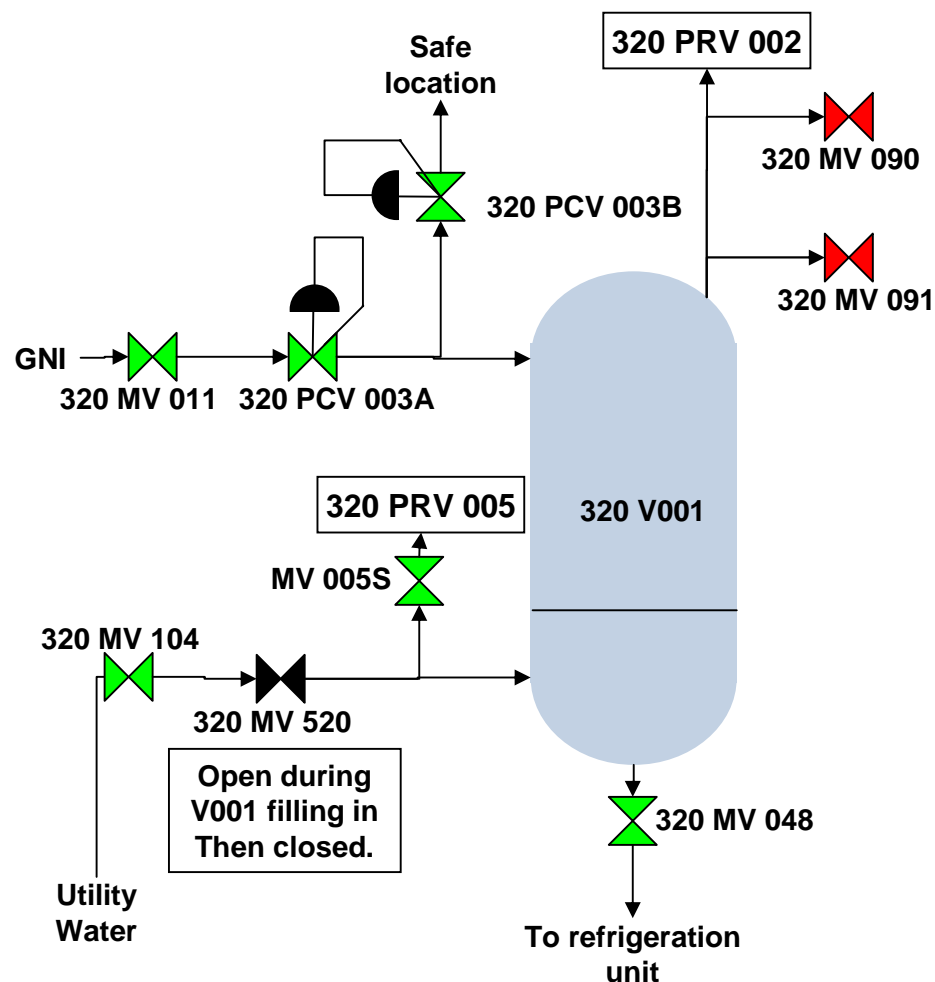
## Start up – GNI available

If GNI is available, ensure 320 PCV 003A is set at 1.1 bara and 320 PCV 003B is set at 1.2 bara.



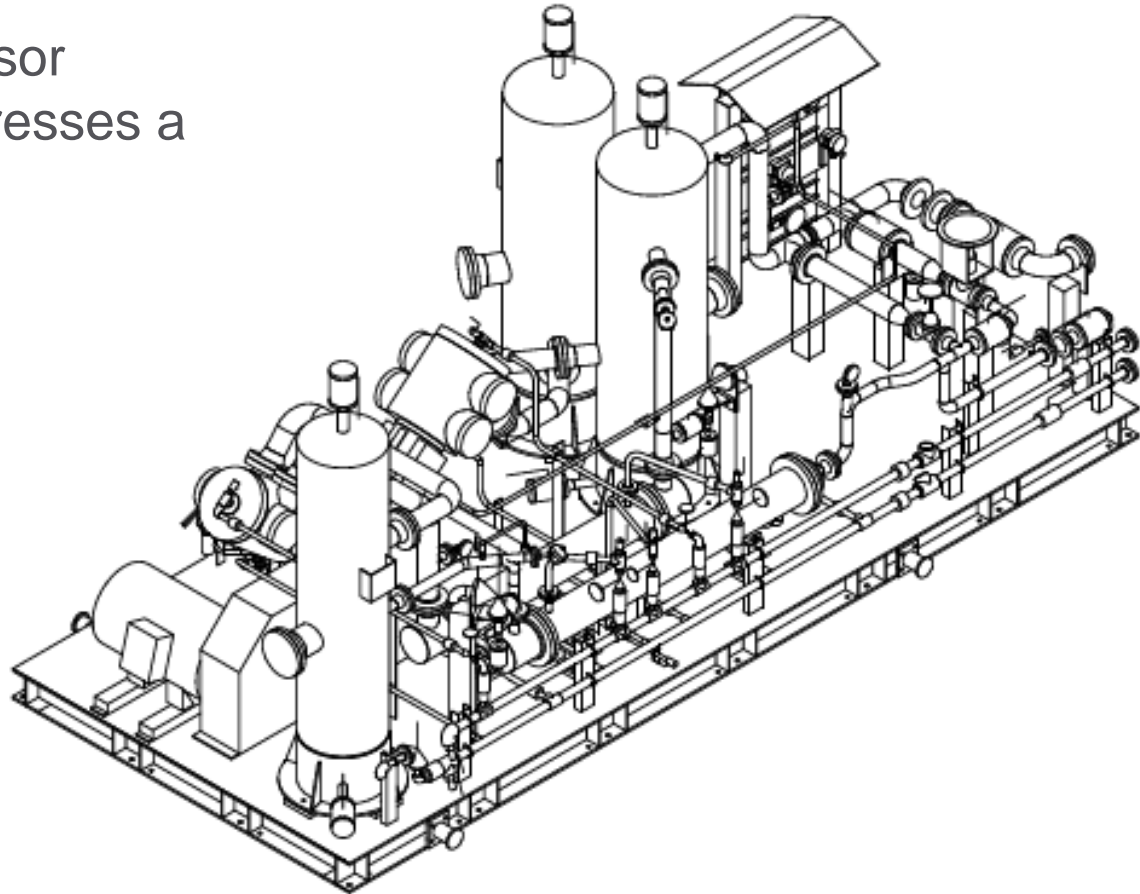
## Normal start up – Utilities – Chilled Water

- Make sure all manual valves of the Utility Water and Chilled Water Circuits are in their correct position, as shown in P&ID.
- Temporarily open 320 MV 520 to fill in Chilled Water circuits with Utility water. Purge the air in all Chilled Water pipes
- Fill in Chilled Water Expansion Vessel 320 V001 up to its nominal level (320 LI 001 = 25%). Then close 320 MV 520.

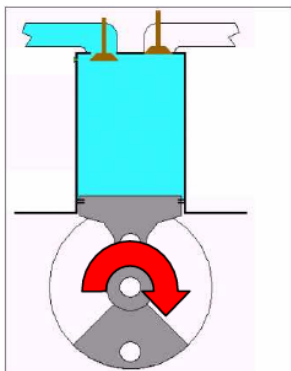


## Normal start up – Utilities – Gas Bag Compressor

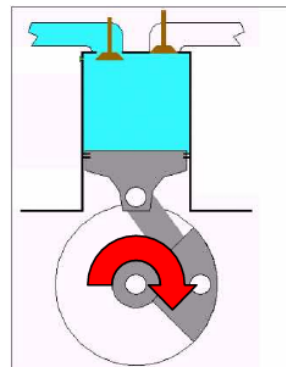
- Reciprocating compressor (piston): a piston compresses a gas inside a cylinder



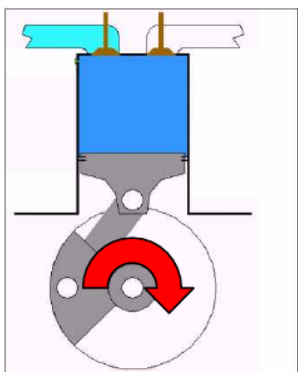
# Normal start up – Utilities – Gas Bag Compressor



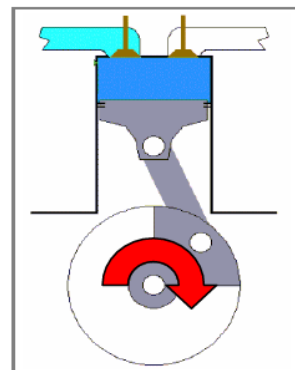
- Piston at bottom dead centre (BDC),
- Cylinder is full of gas at suction pressure
- Suction valve is open
- Discharge valve is closed.



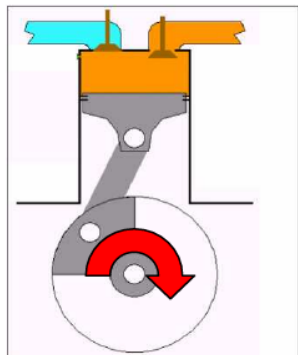
- Piston moving towards bottom dead centre (BDC)
- The cylinder pressure is decreasing to suction pressure. Both valves are closed.



- Piston moving towards top dead centre (TDC)
- Pressure inside the cylinder increases
- Both valves are closed.



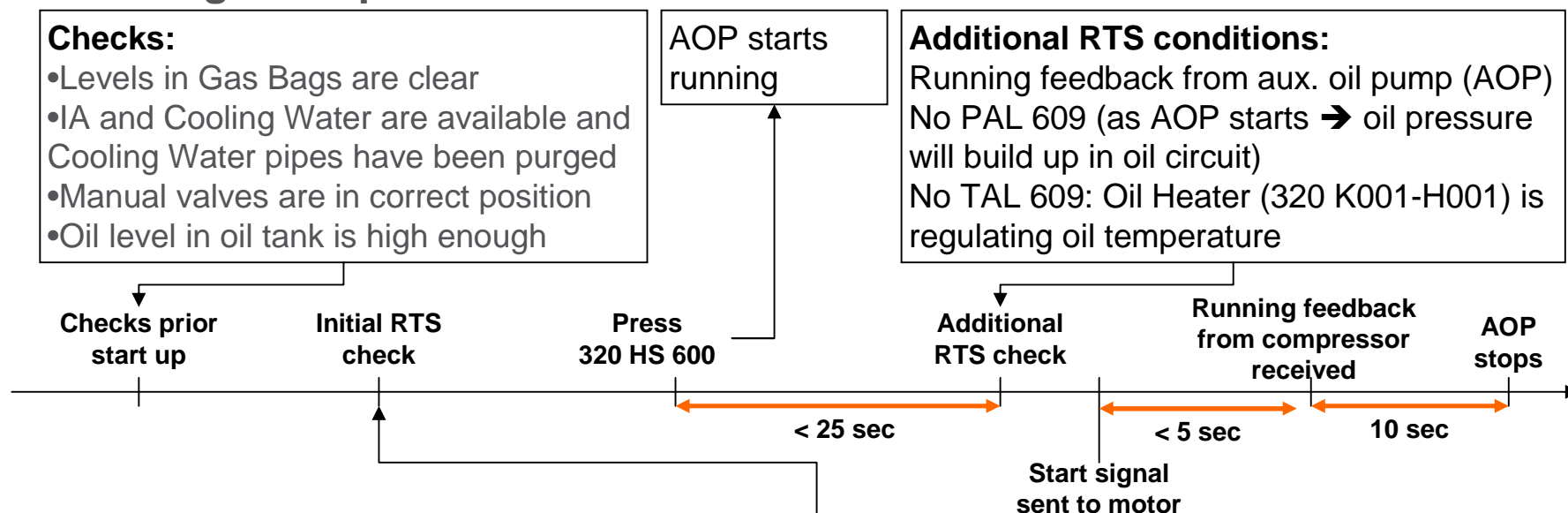
- Piston reaches the dead centre (BDC)
- The pressure has reached suction pressure.
- The suction valve is open.
- The discharge valve is closed.



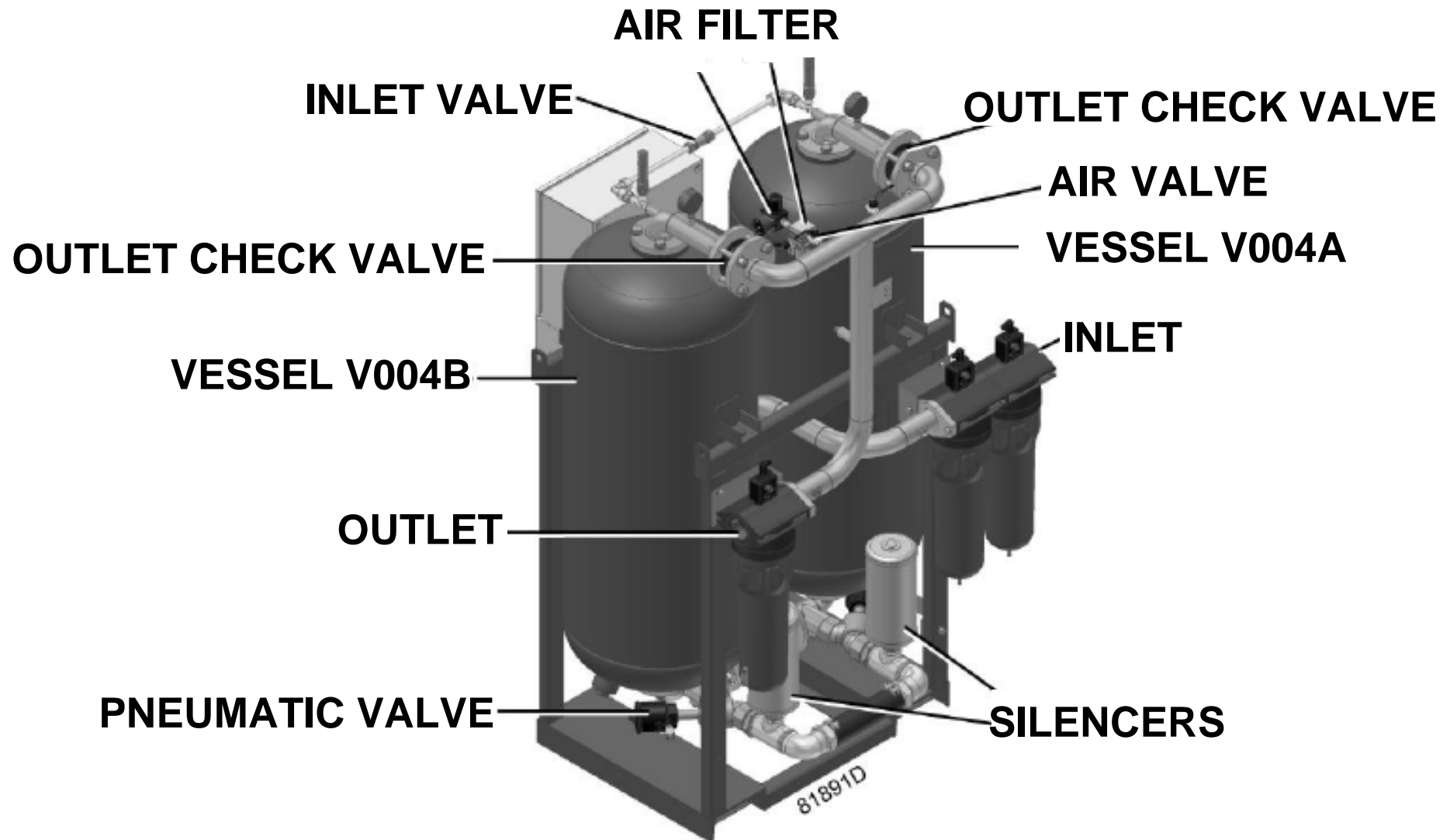
- Piston reaches the top dead centre (TDC)
- The cylinder pressure has reached discharge pressure.
- The suction valve is closed, while the discharge valve is open.

# Normal start up – Utilities – Gas Bag Compressor

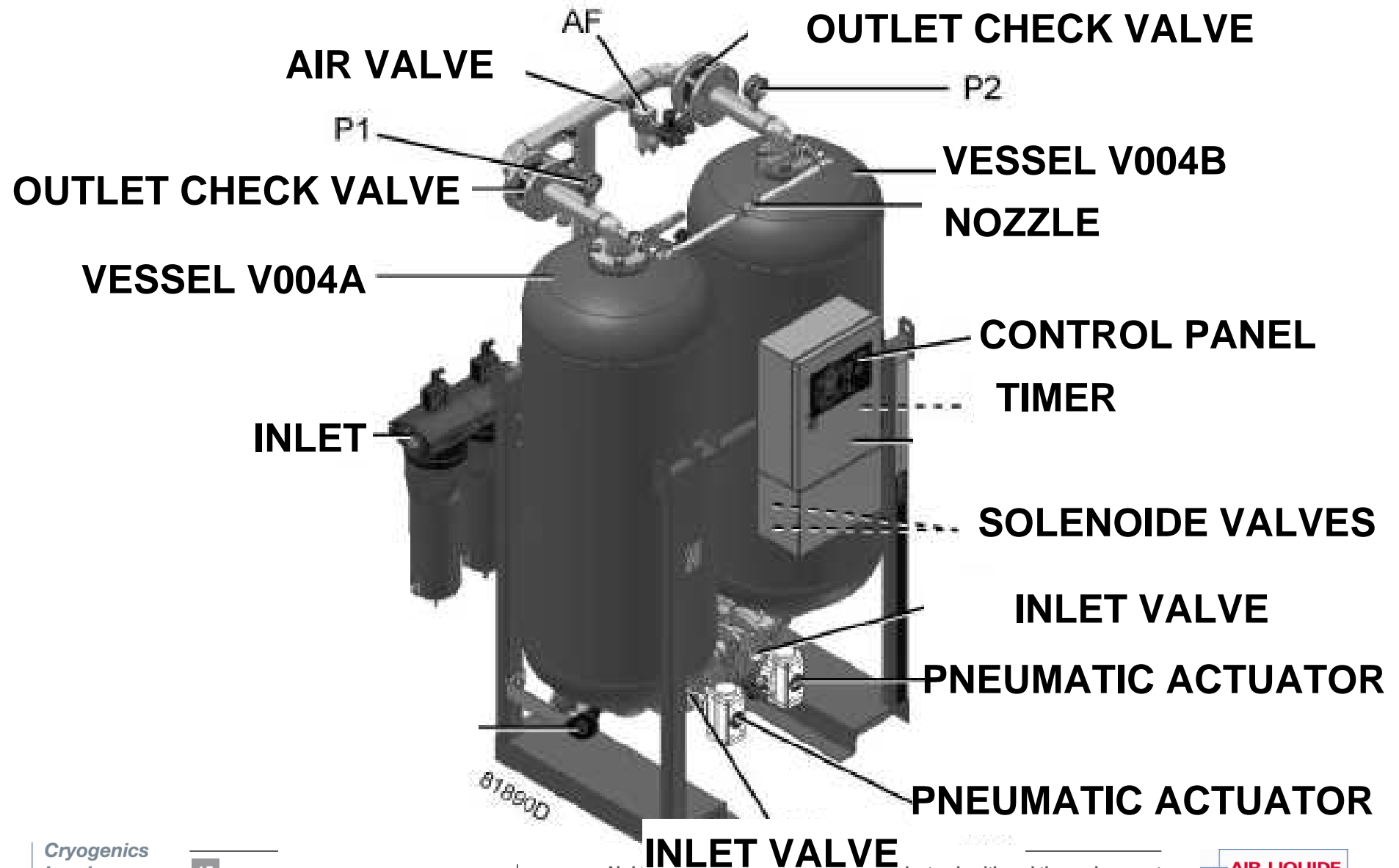
## Gas Bags Compressor



## Normal start up – Utilities - Instrument Air dryers



## Normal start up – Utilities - Instrument Air production



# Normal start up – Utilities - Instrument Air production

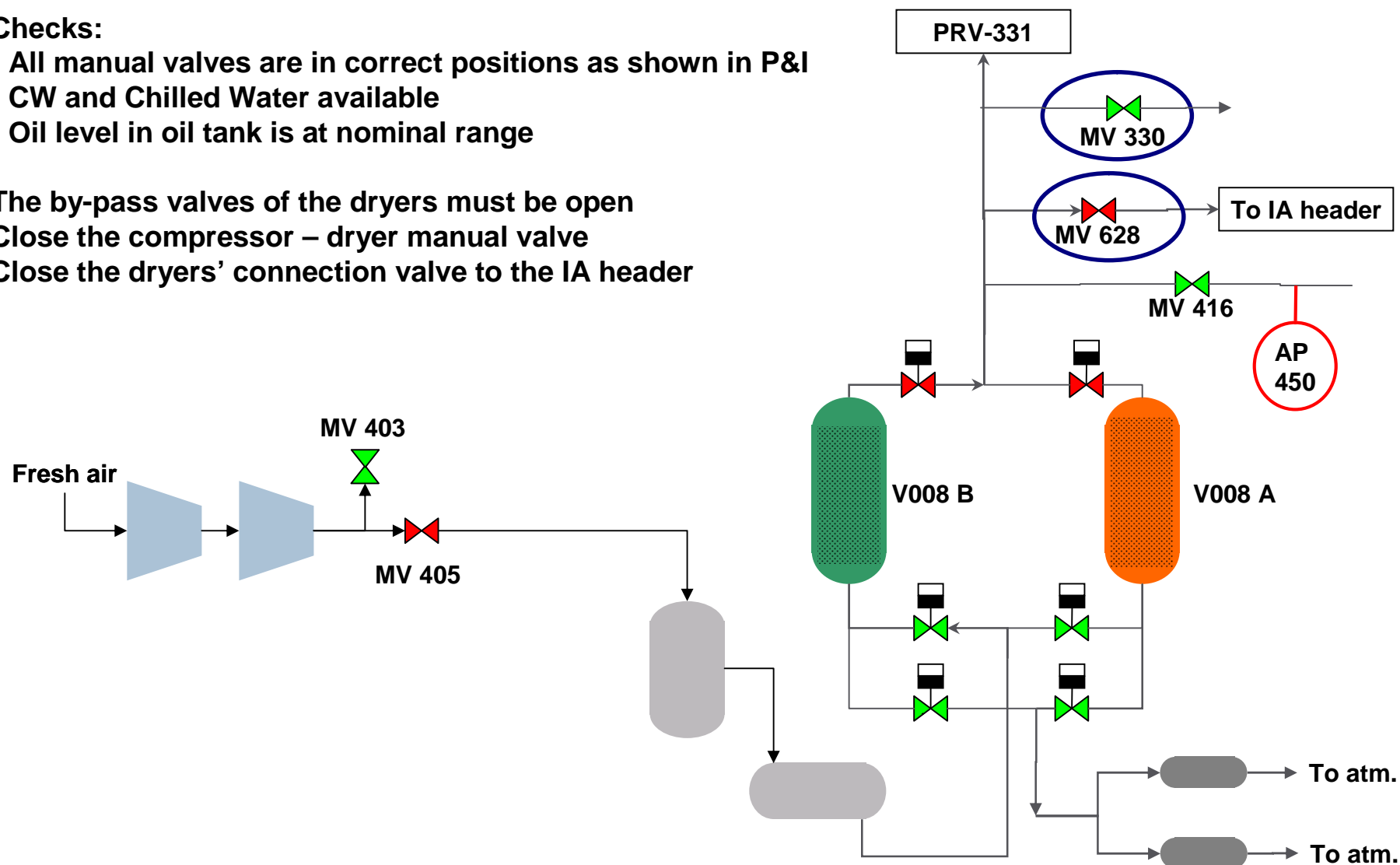
## Checks:

- All manual valves are in correct positions as shown in P&I
- CW and Chilled Water available
- Oil level in oil tank is at nominal range

The by-pass valves of the dryers must be open

Close the compressor – dryer manual valve

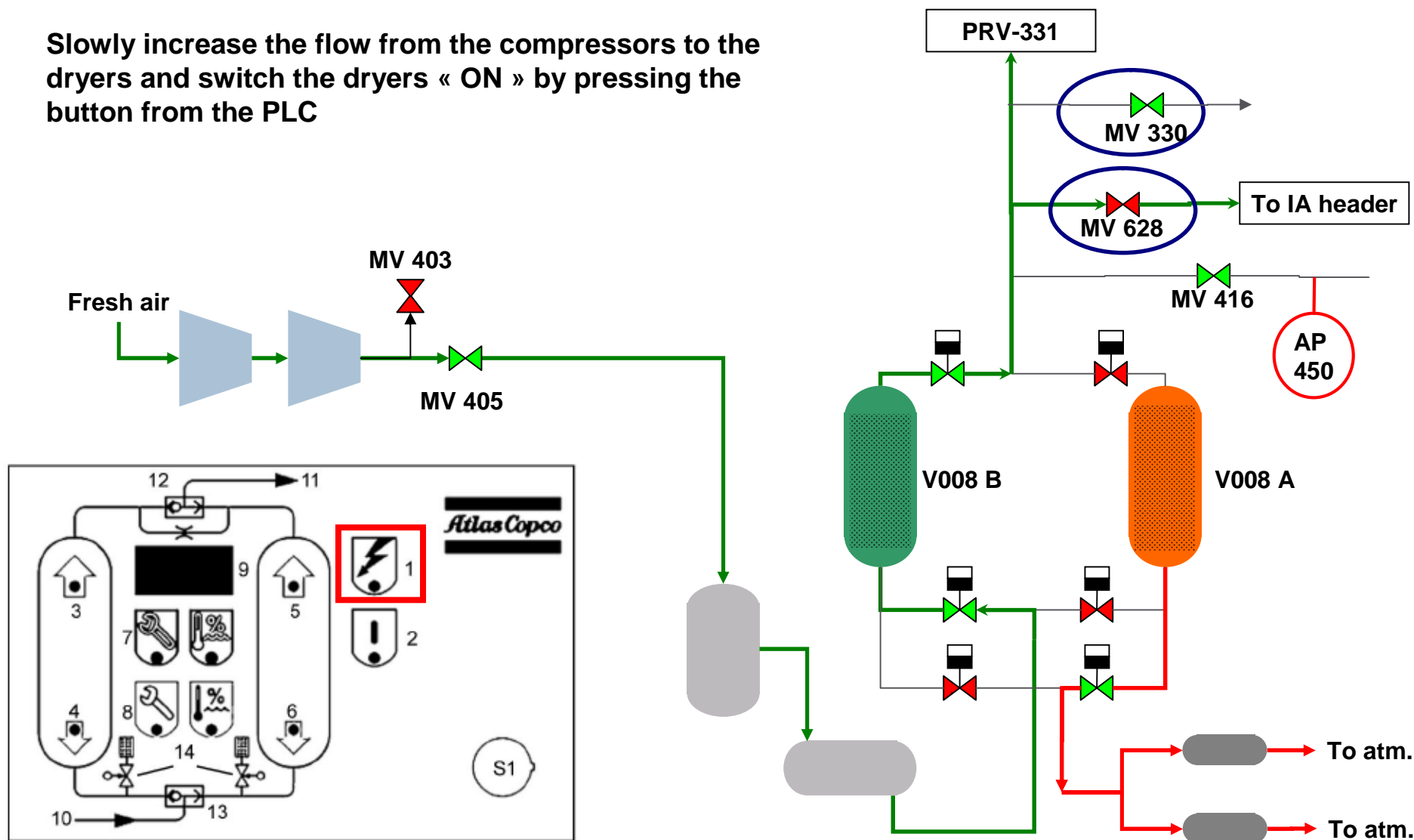
Close the dryers' connection valve to the IA header





# Normal start up – Utilities - Instrument Air production

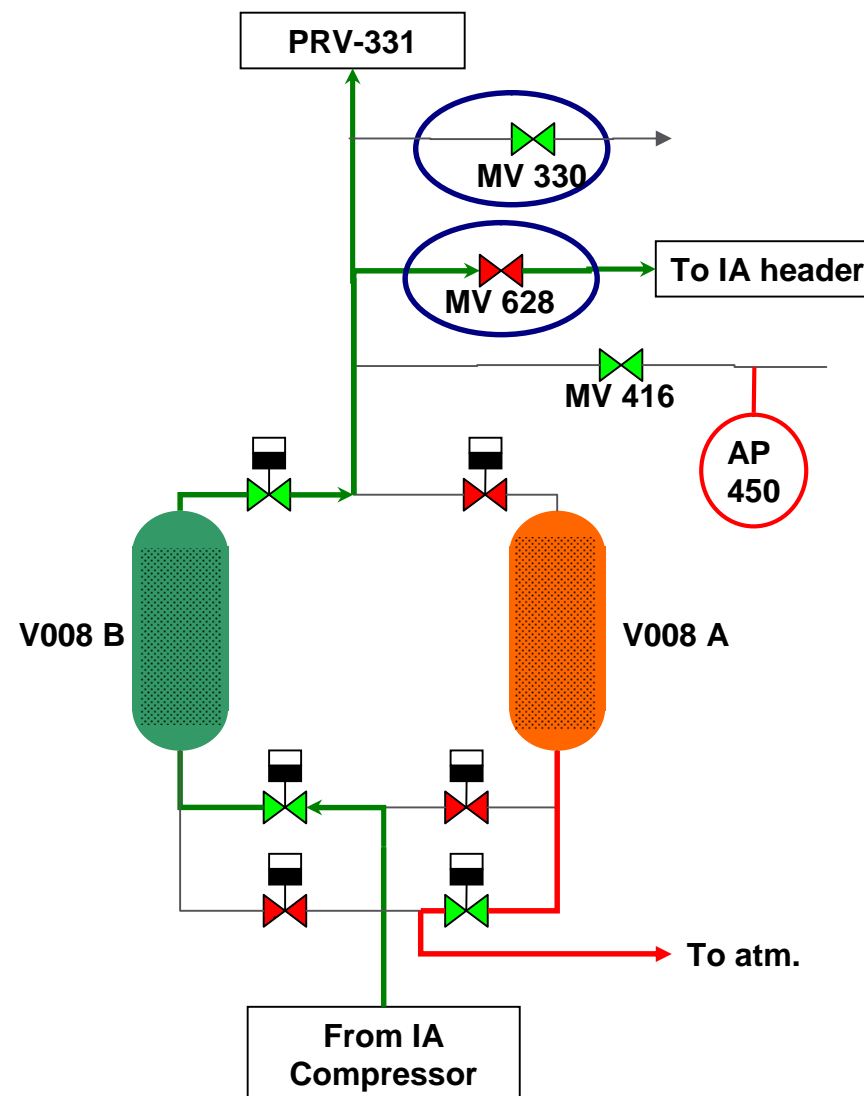
Slowly increase the flow from the compressors to the dryers and switch the dryers « ON » by pressing the button from the PLC



# Normal start up – Utilities - Instrument Air production

## Instrument Air Production

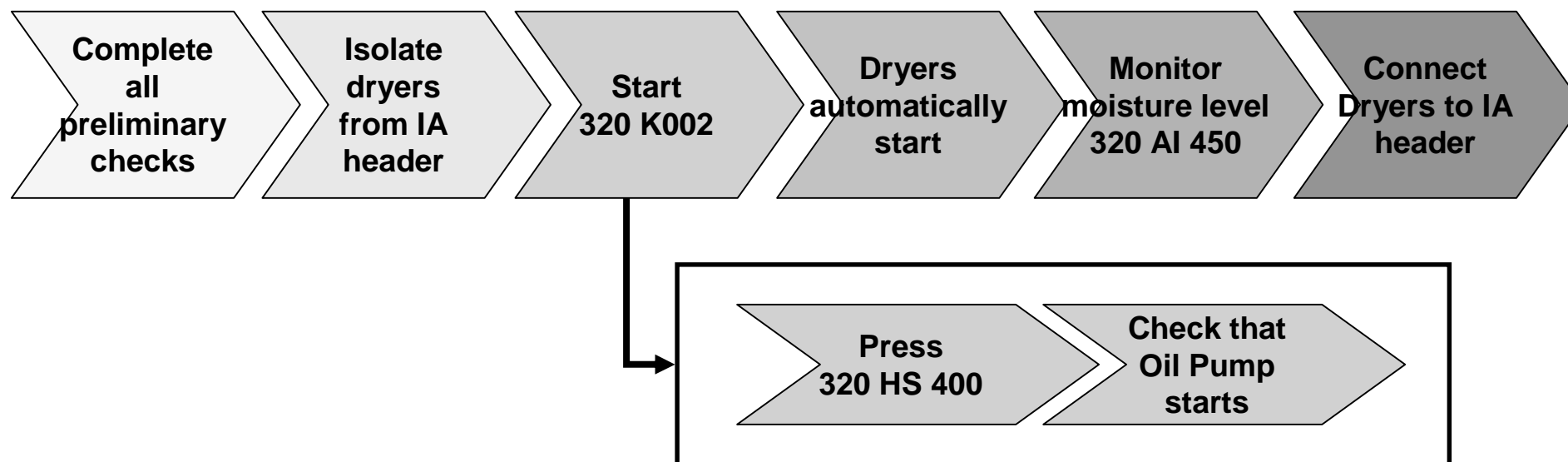
- As long as dryers have not been started, isolate Instrument Air Dryers and Compressor: open 320 MV 330 and close 320 MV 628 to isolate the compressor.
- When AI 450 is correct (i.e. air is dry), 320 MV 628 can be opened and 320-MV-330 closed



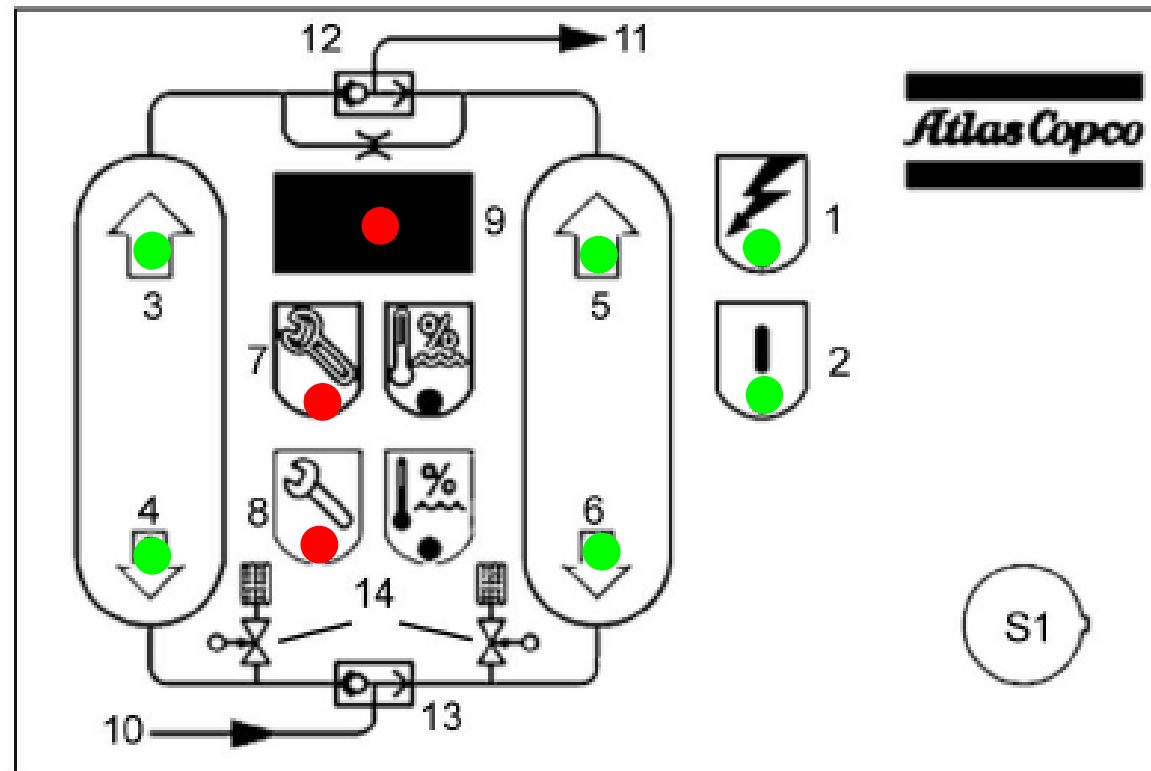
# Normal start up – Utilities - Instrument Air production

## Instrument Air Production

- Start compressor from DCS (320 HS 400):
  - ▣ Oil Pump starts, motor starts and pressure builds up at compressor outlet
  - ▣ Dryers automatically start
  - ▣ Before connecting Instrument Air dryers to the IA network, monitor the moisture level by checking 320 AI 450.



# Normal start up – Utilities - Instrument Air production



S1	On/Off switch
1	LED <Power On>
2	LED <In Operation>
3	LED <Left tower drying>
4	LED <Left tower regenerating>
5	LED <Right tower drying>
6	LED <Right tower regenerating>
7	LED <Service warning>

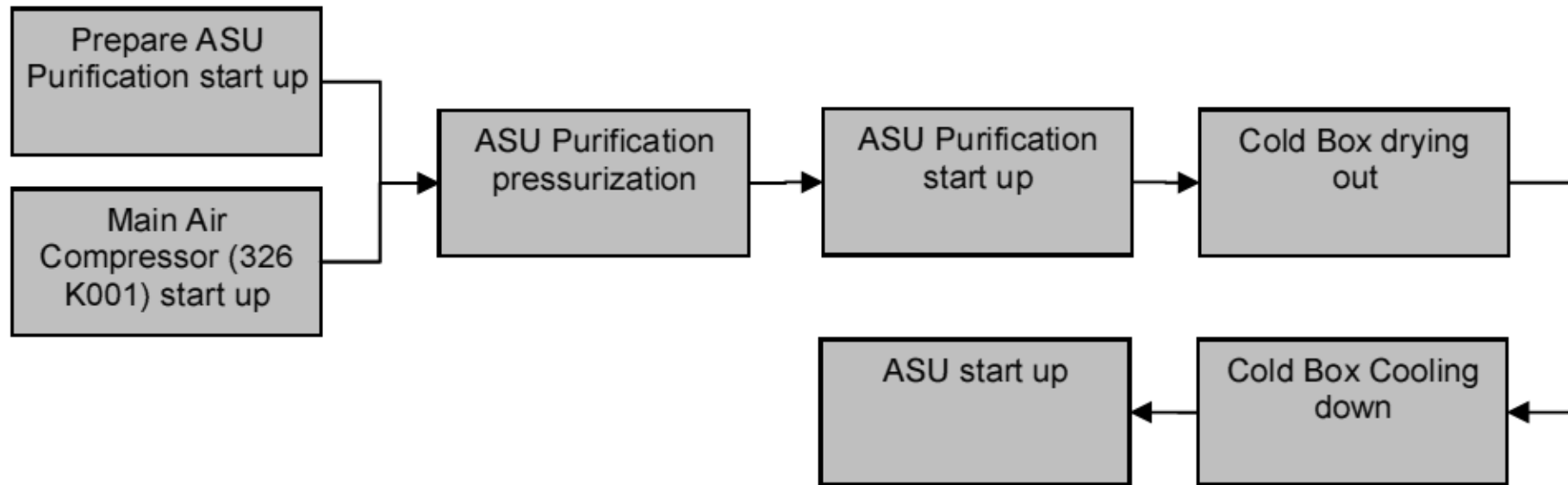
8	LED <Service alarm>
9	Timer countdown
10	Air inlet
11	Air outlet
12	Outlet non return valves
13	Inlet valves
14	Blow off valves

# Course Agenda

1. Normal startup
  1. General sequence
  2. Utilities
  3. ASU
  4. Inlet Compressor
  5. Unit 322
  6. Helium Compressors
2. Shutdown sequence
3. Emergency Shutdown

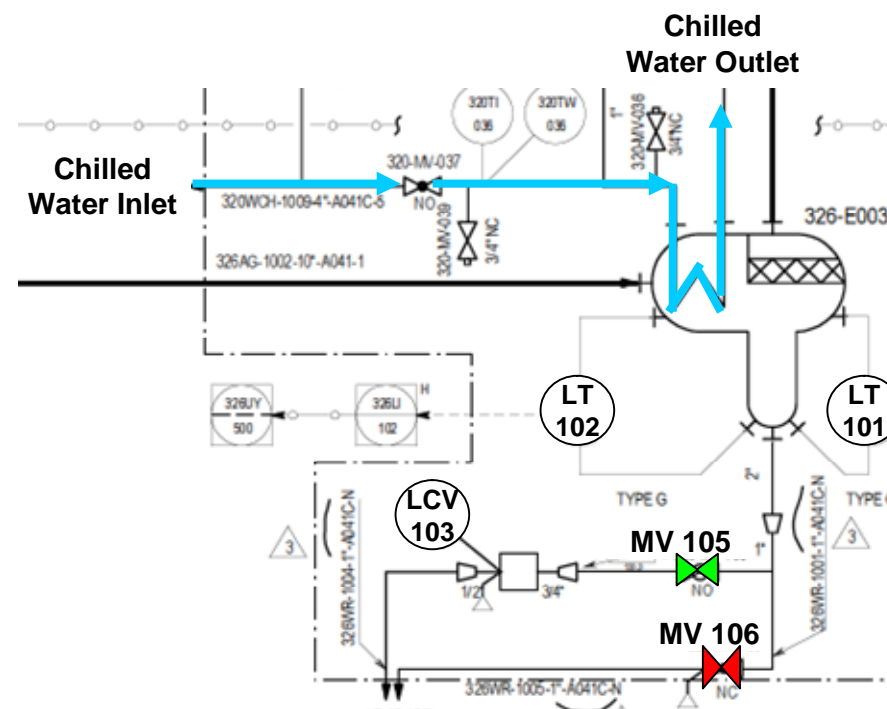
# Normal Start Up – ASU – Sequence

- Overview of the start up sequence:



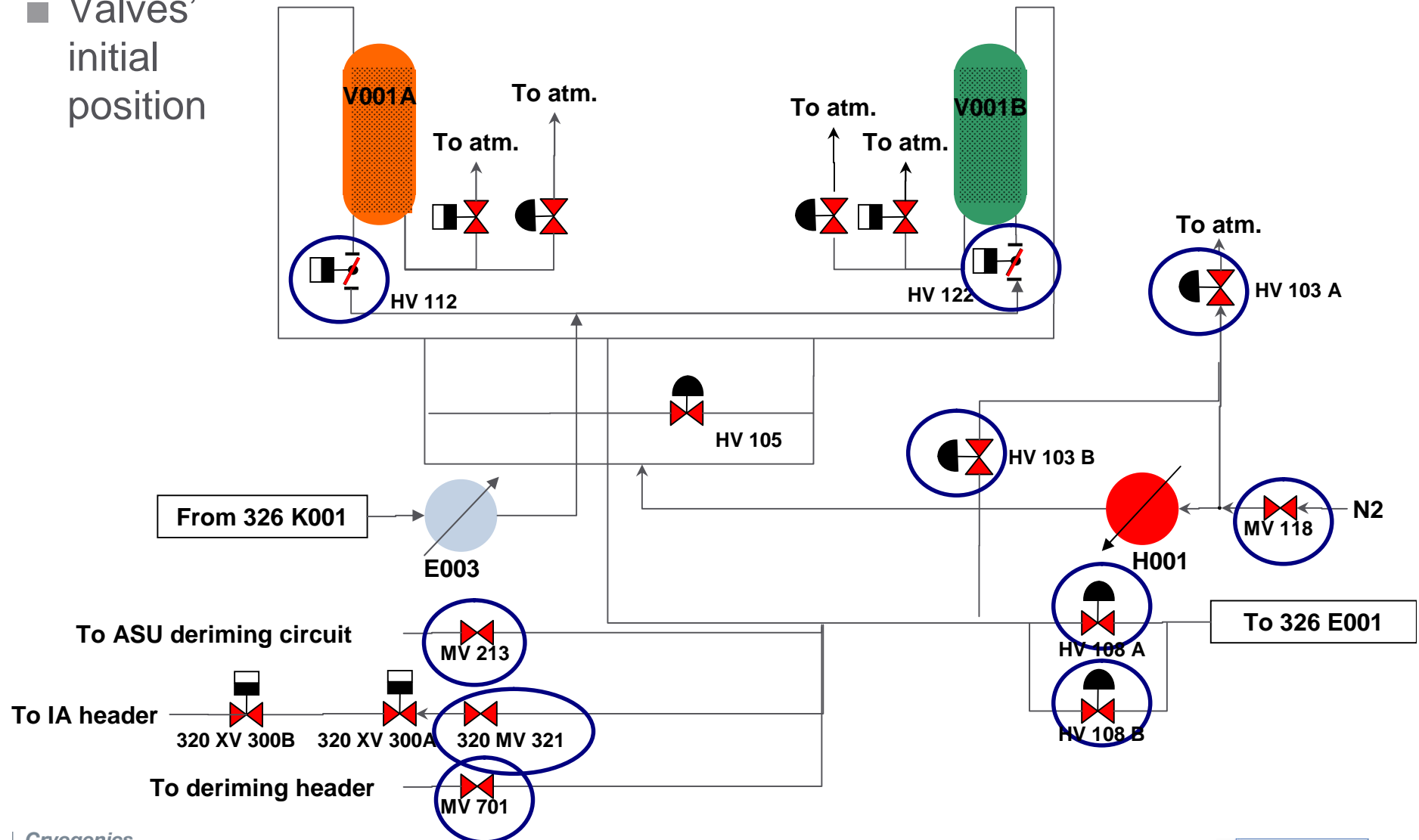
# Normal Start Up – ASU – Purification unit – Preparation

- **ASU Compressor must not be running before the purification unit is ready for start up**
- **Preliminary checks:**
  - IA, Cooling Water, Chilled Water are available
  - Electrical breaker for 326 H001 is ready
  - 326 LCV 103 is lined up
  - If start up follows a shutdown due to CO2 breakthrough, an exceptional regeneration must have been carried out.



# Normal Start Up – ASU – Purification unit – Preparation

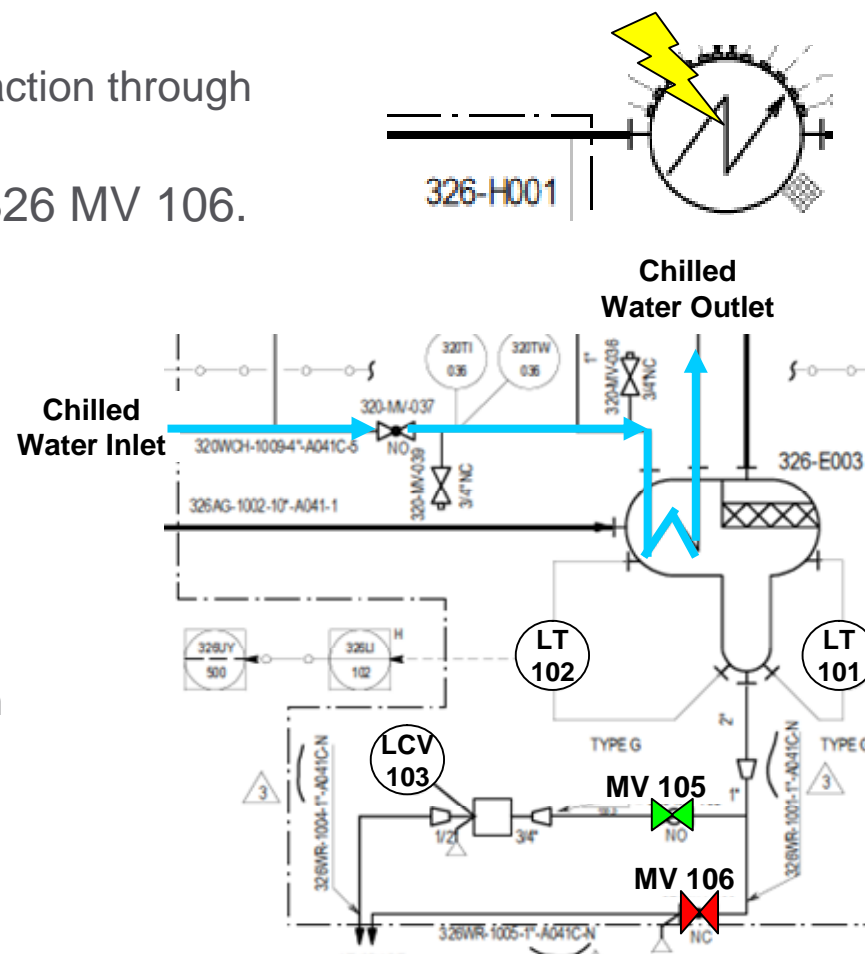
- Valves' initial position



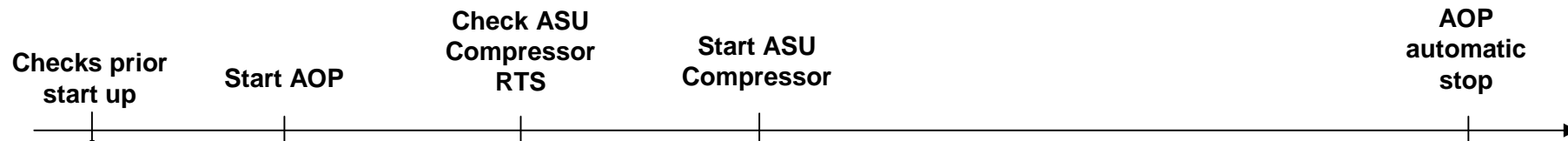


# Normal Start Up – ASU – Purification unit – Preparation

- Start ASU Heater 326 H001
  - ▣ 326 H001 is automatically controlled, no action through the DCS is needed
- Start ASU Chiller 326 E003: crack open 326 MV 106. Then, close MV 106
- All the system must be depressurized (air lines, bottles and regeneration lines)
- Initialize the sequence from the DCS,
  - ▣ Set the sequence in manual and press 326-HS-189 to initialize
  - ▣ Both bottles move to step 0
  - ▣ Air inlet valves 326-HV-112 and 122 open
- Pressurization: start up ASU Compressor



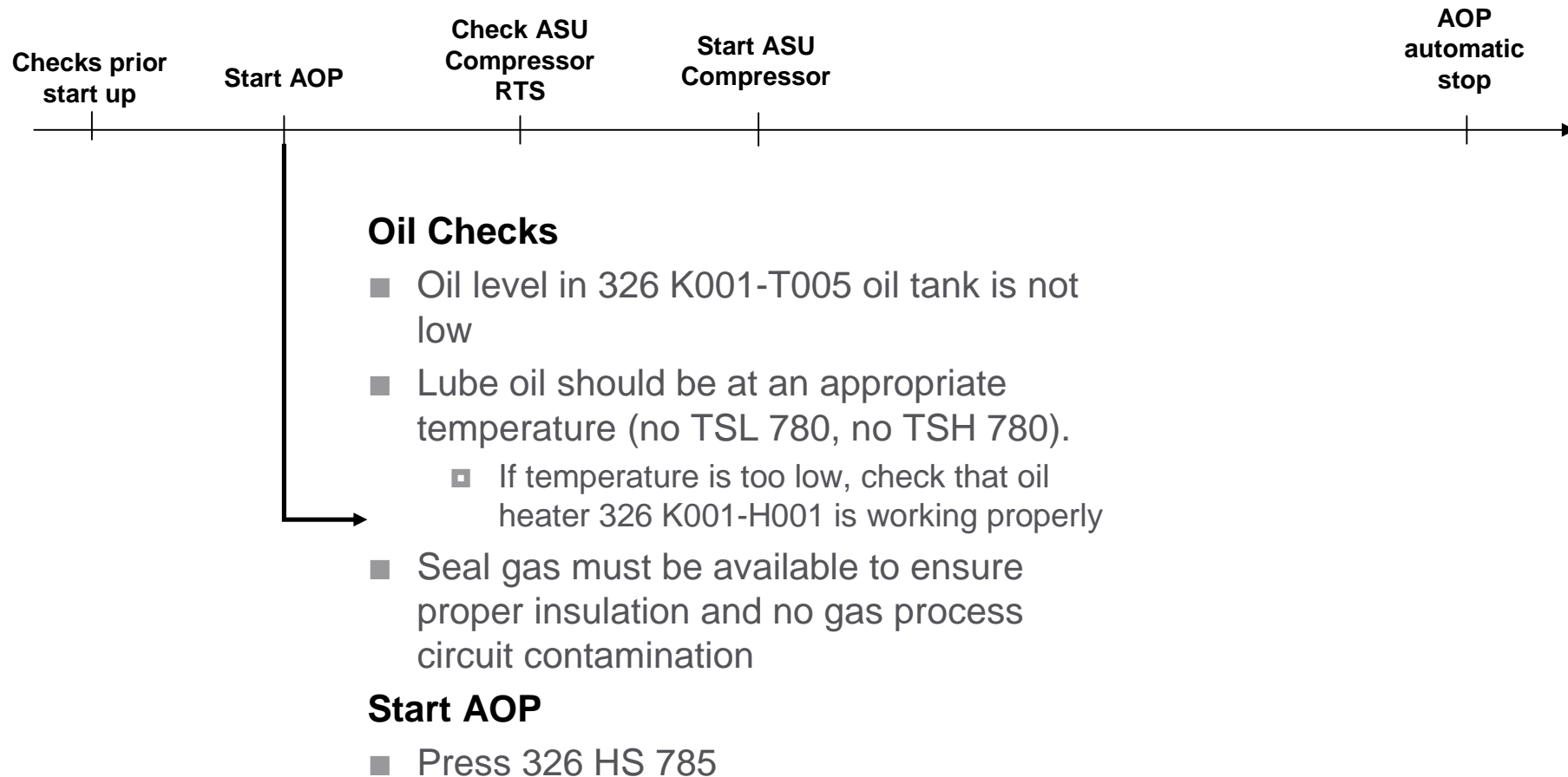
# Normal Start Up – ASU – ASU Compressor



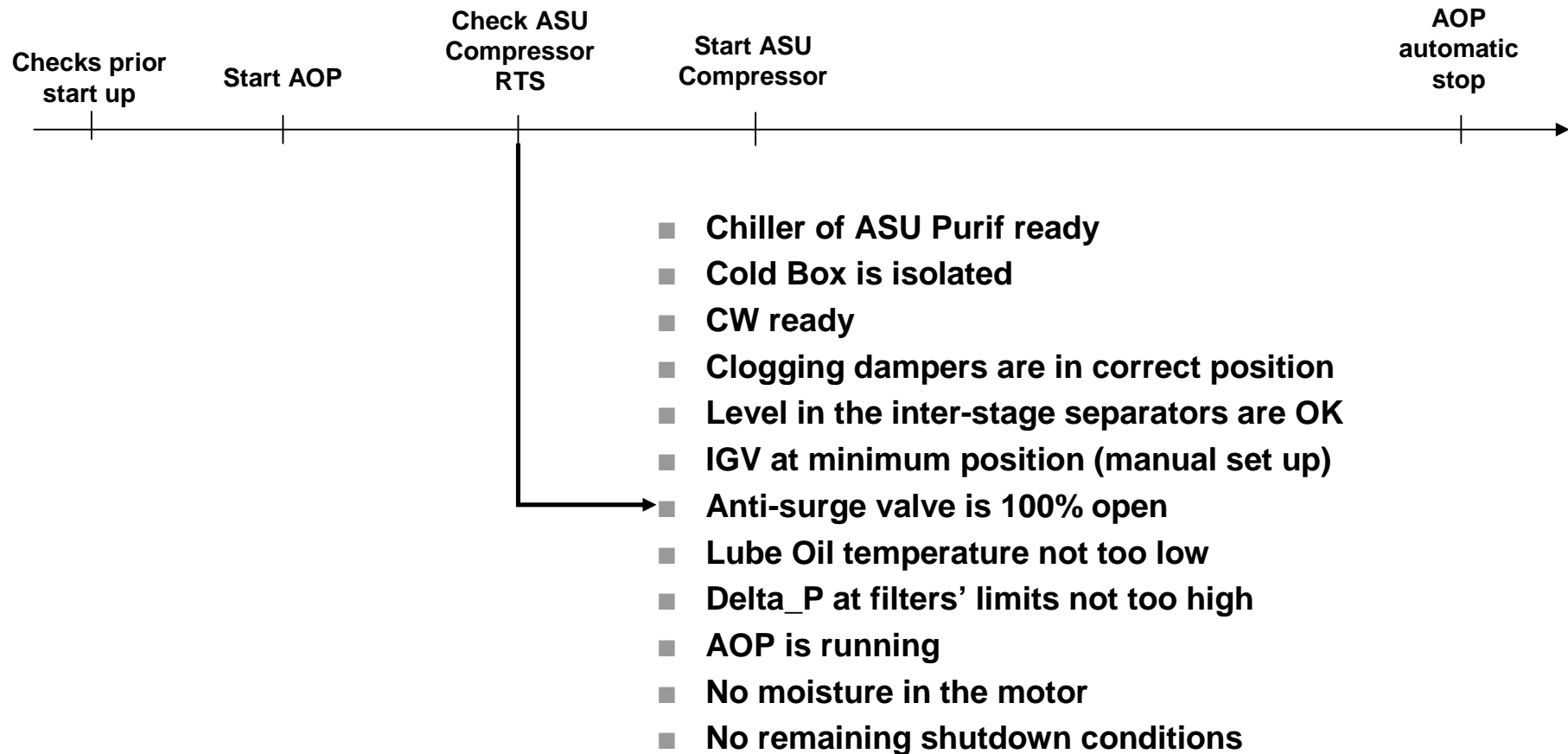
## General Checks

- IA and Cooling Water are available and the air in the Cooling Water pipes has been purged for the circuits of:
  - Inter-stage coolers (K001-E001/E002)
  - Final cooler (K001 E003)
  - Motor cooler (KM001 E001)
- Manual valves are in their default position, as shown in P&ID
- Cold Box is isolated

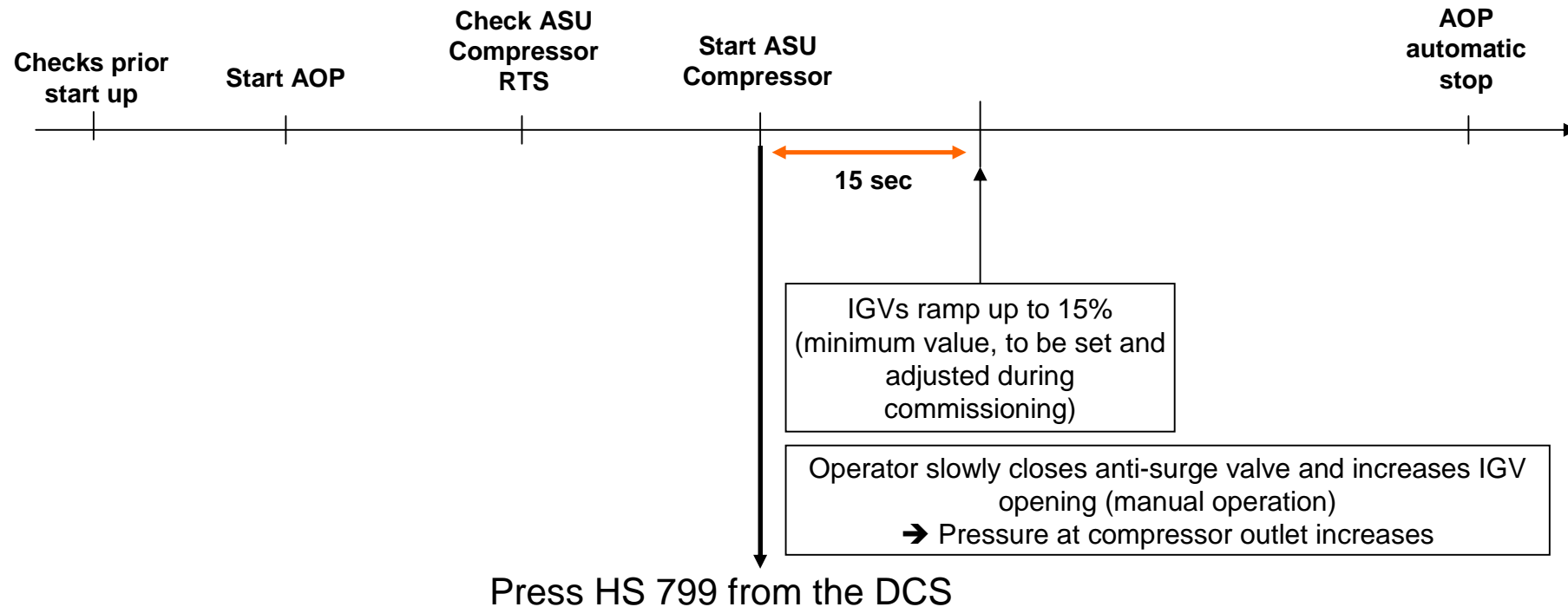
# Normal Start Up – ASU – ASU Compressor



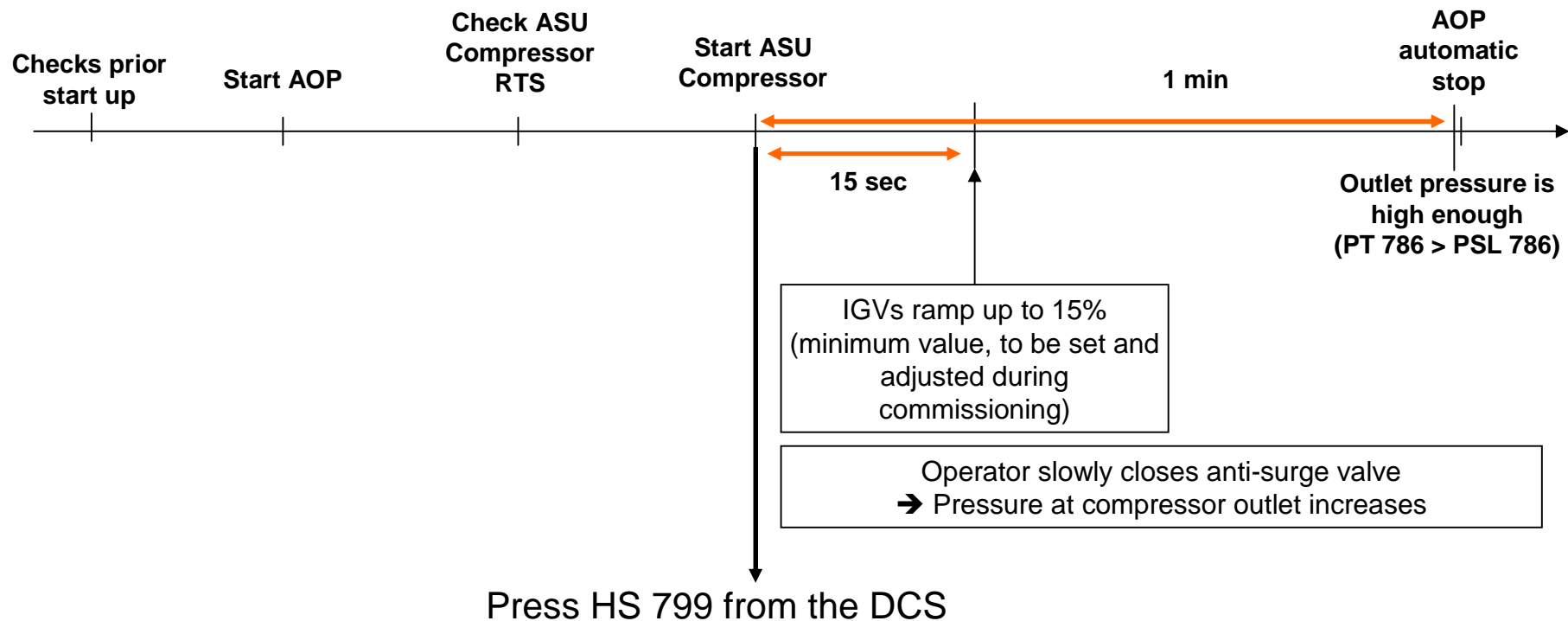
# Normal Start Up – ASU – ASU Compressor



# Normal Start Up – ASU – ASU Compressor



# Normal Start Up – ASU – ASU Compressor



- In operation, IGV opening is controlled by the pressure at purification outlet (CB inlet).
- IGV opening is limited at 1.5%/sec
- If the 326 PT 786 does not exceed PSL 786 within 1 minute, the AOP needs to be stopped manually

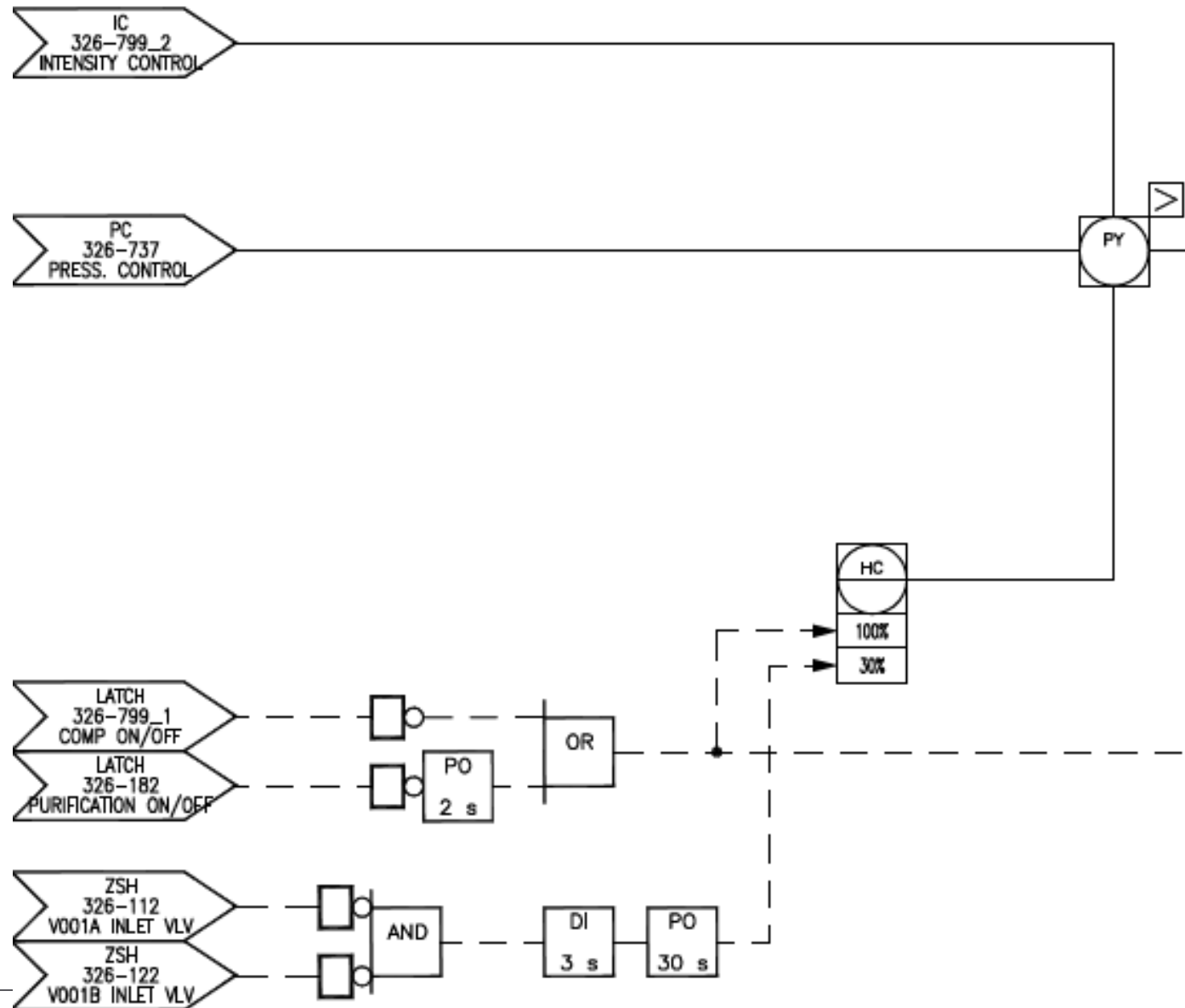
# Normal Start Up – ASU – ASU Compressor – Anti-surge valve

Intensity value is controlled by automatic control: 326 IC 799, acting on the opening of the anti-surge valve

In normal operation, the opening of the anti-surge valve is controlled by the pressure at third stage outlet

When compressor is OFF  
→ Anti-surge valve forced at 100%  
At ASU Purif shutdown/trip, the anti-surge valve is forced at 100%

When none of the inlet valves to purification is open during 3 sec, the anti-surge valve is forced to 30% during 30 sec



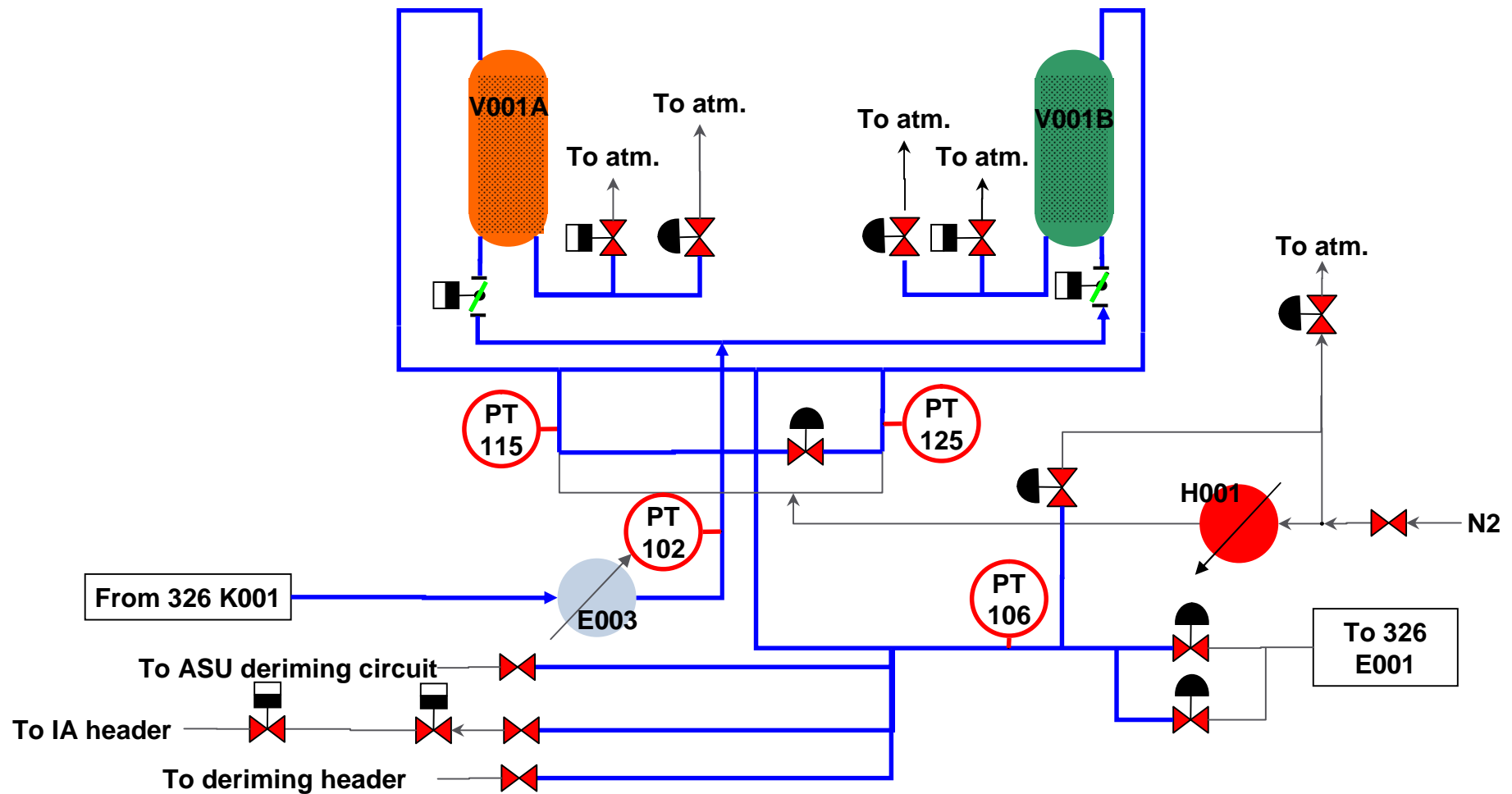
## Normal Start Up – ASU – Purification unit

- Once ASU Compressor is running in steady conditions, the pressure increases in purification unit
- Monitor pressure build up through 326-PT-115, 326-PT 125, 326 PT-102 and 326-PT-106.



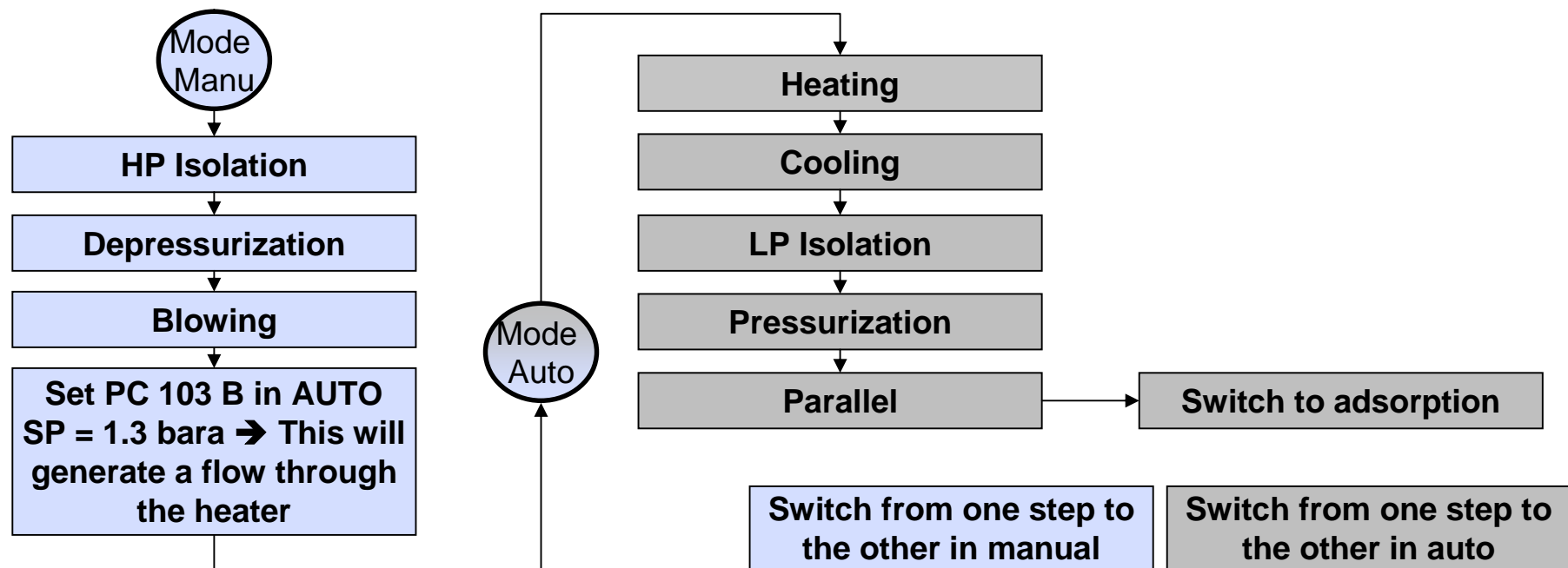
# Normal Start Up – ASU – Purification unit – Pressurization

## ■ Pressurization



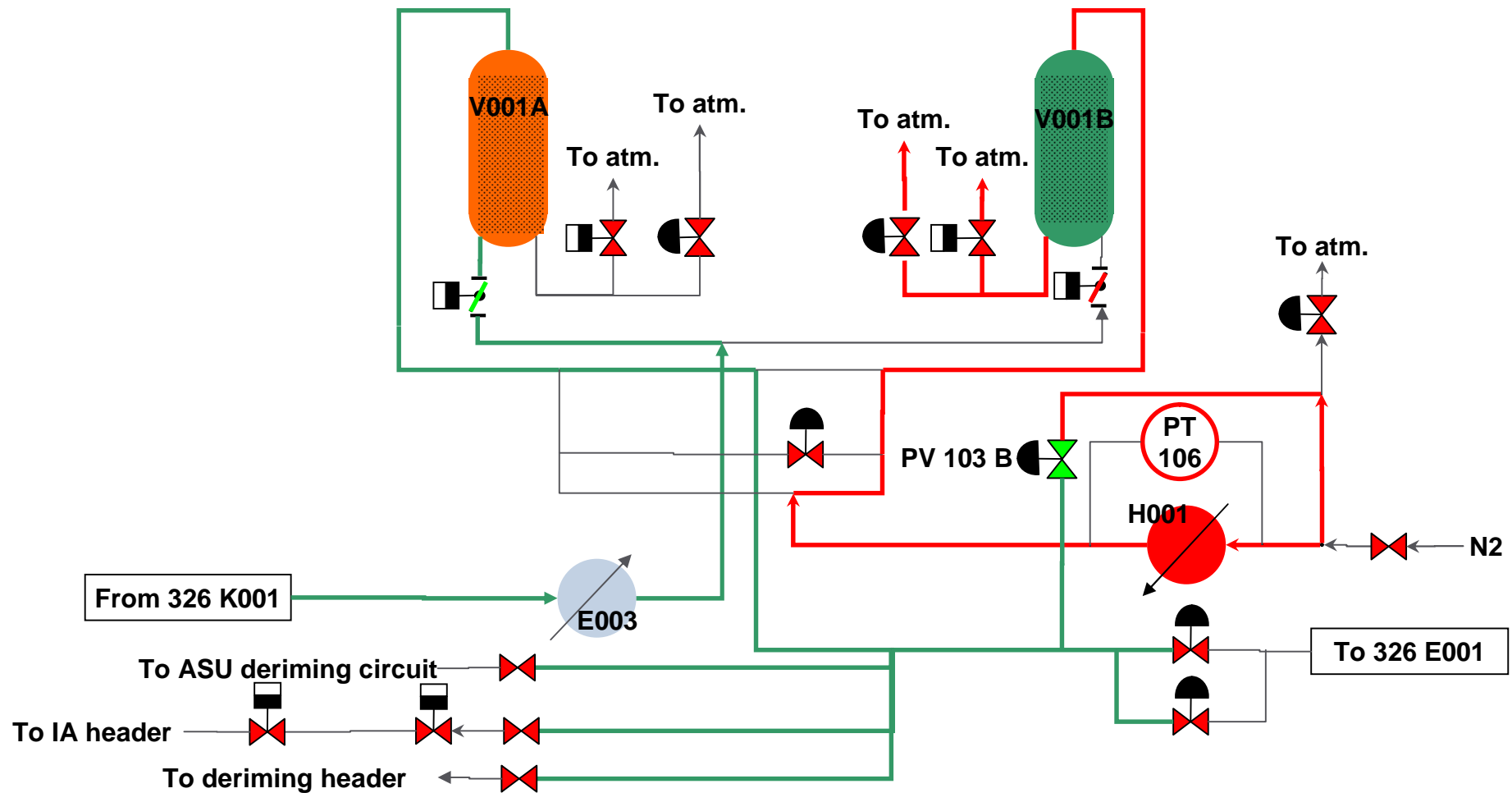
# Normal Start Up – ASU – Purification unit

- Select the bottle that will start the sequence by a regeneration
  - ▣ For a start up after a shutdown, the status of each bottle must have been recorded
  - ▣ As much as possible, the shutdown must occur after one bottle has completed the step “Cooling” (regeneration). This bottle will be lined up at the next start up.
- After pressurization, the selected bottle moves to the first regeneration step (HP isolation).
- Slowly move from step 1, 2 and 3 in manual, and switch in automatic mode:



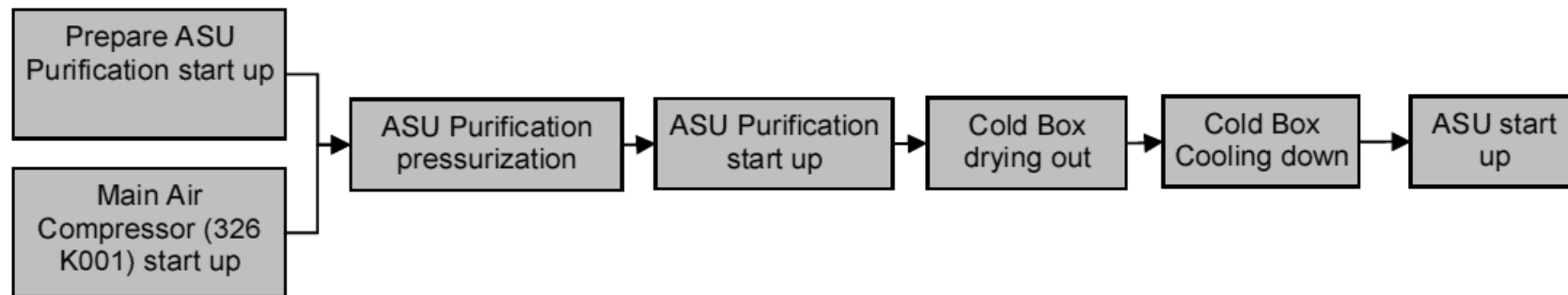
# Normal Start Up – ASU – Purification unit

## ■ Start up scheme:

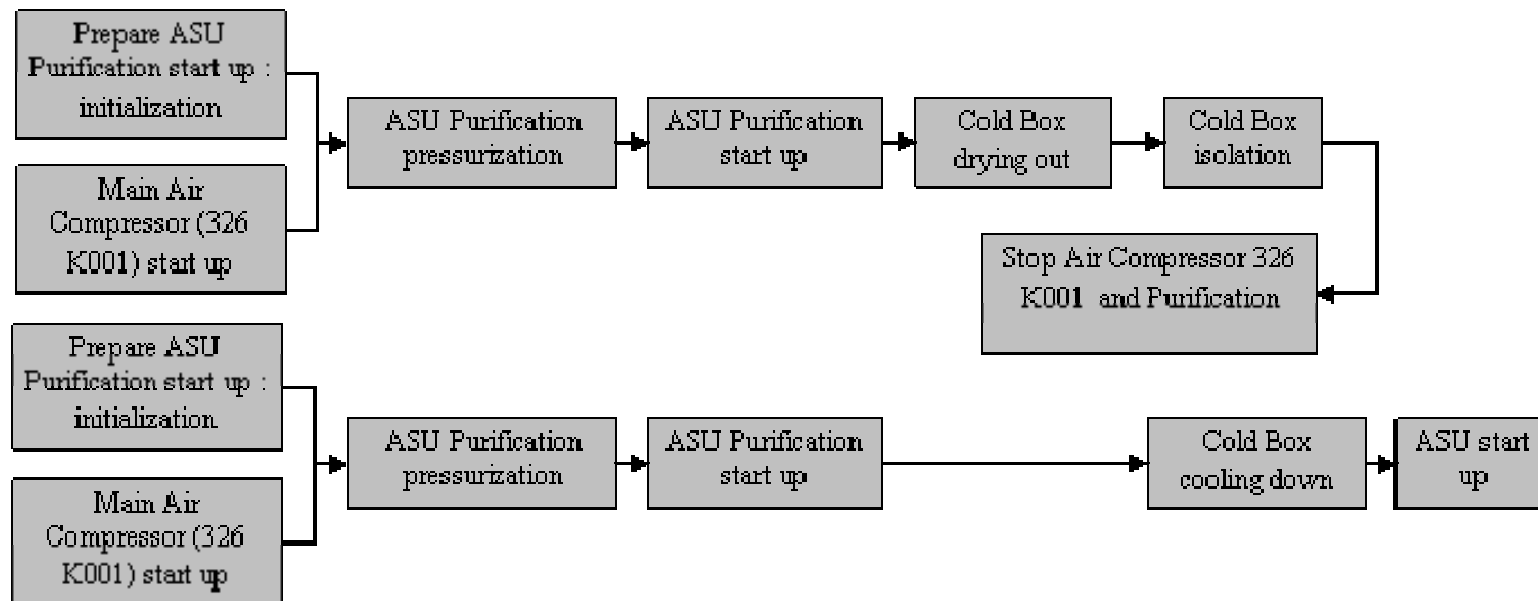


# Normal Start Up – ASU – ASU Cold Box

- First case: dry out is performed right before the Cold Box is started:

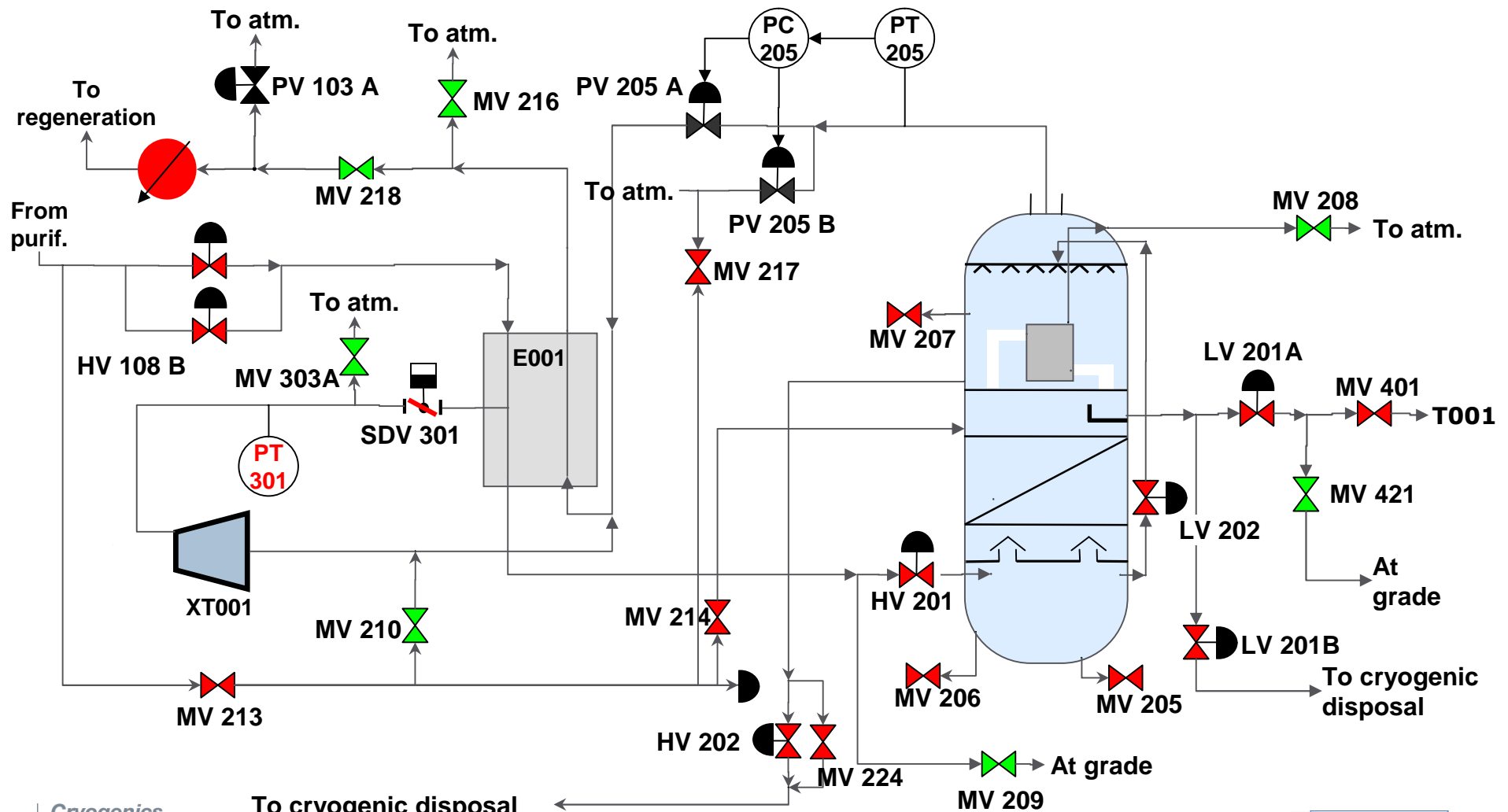


- Second case: dry out is performed in advance:



# Normal Start Up – ASU – ASU Cold Box – Dry out

## ■ Initial status of drying out:



# Normal Start Up – ASU – ASU Cold Box – Dry out

## ■ Step 1: Turbine deriming

- Set 326 XT 001 in “Deriming” mode, in order to keep SDV 301 closed.
- Create a flow circulation in the turbine: the dry air flow from purification will circulate in reverse direction in the turbine and be evacuated through 326 MV 303 A.
- The pressure is controlled by 326 PC 205 A and 326 PC 103 A:
  - 326 PV 205 A, 326 PV 205 B are regulating the pressure at the top of E002
  - 326 PV 103 A is regulating the pressure at Waste Nitrogen outlet.
- Dry out the turbine until dew point at 326 PT 301 is below -60°C.

## ■ Step 2: Deriming of E002

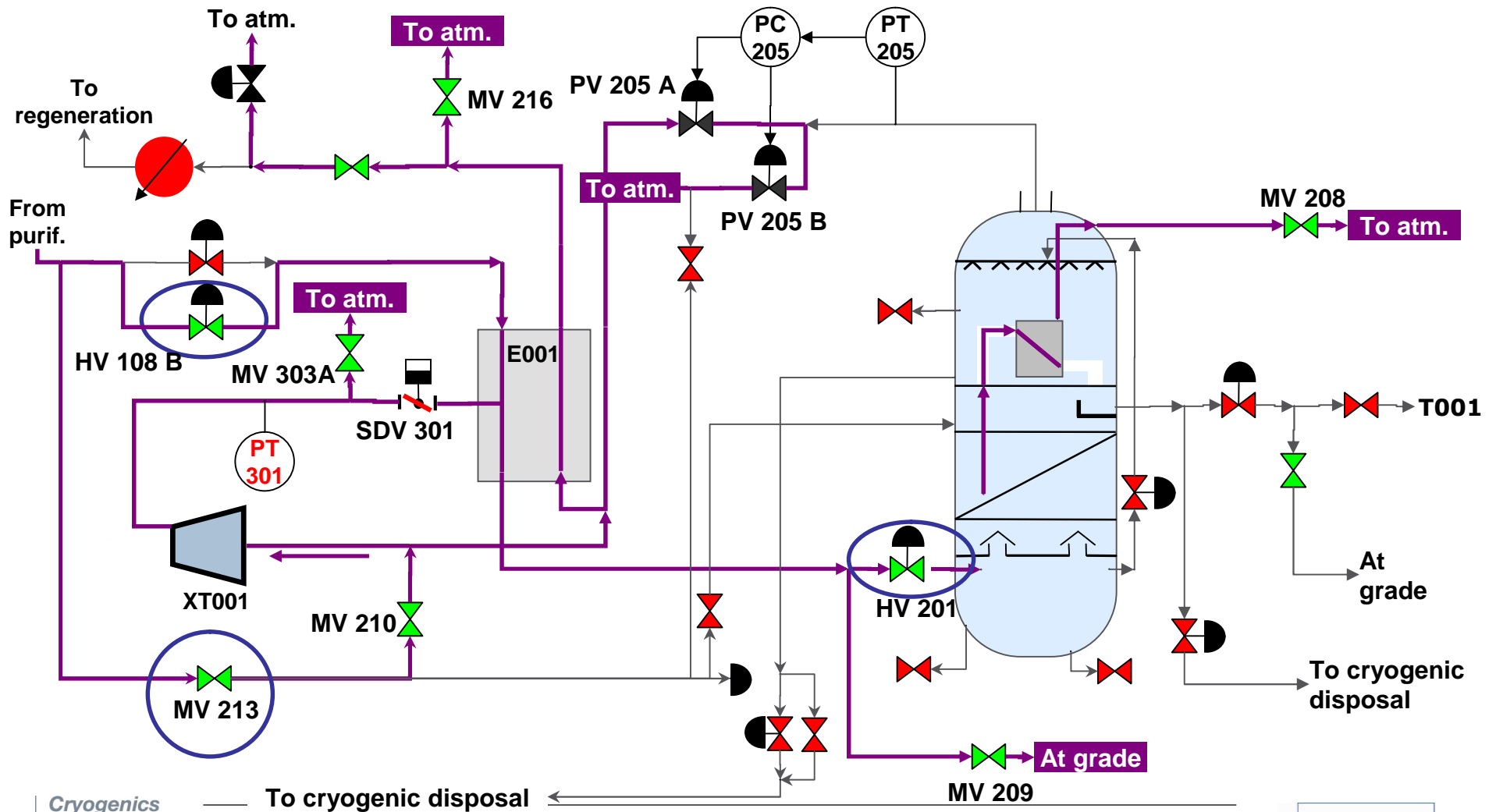
- Open all the column drains and the transmitters' drain
- Dry out vaporizer

## ■ Step 3: Deriming of C001

- Create a flow circulation by opening 326 LV 202
- Open all deriming valves to complete the drying out.

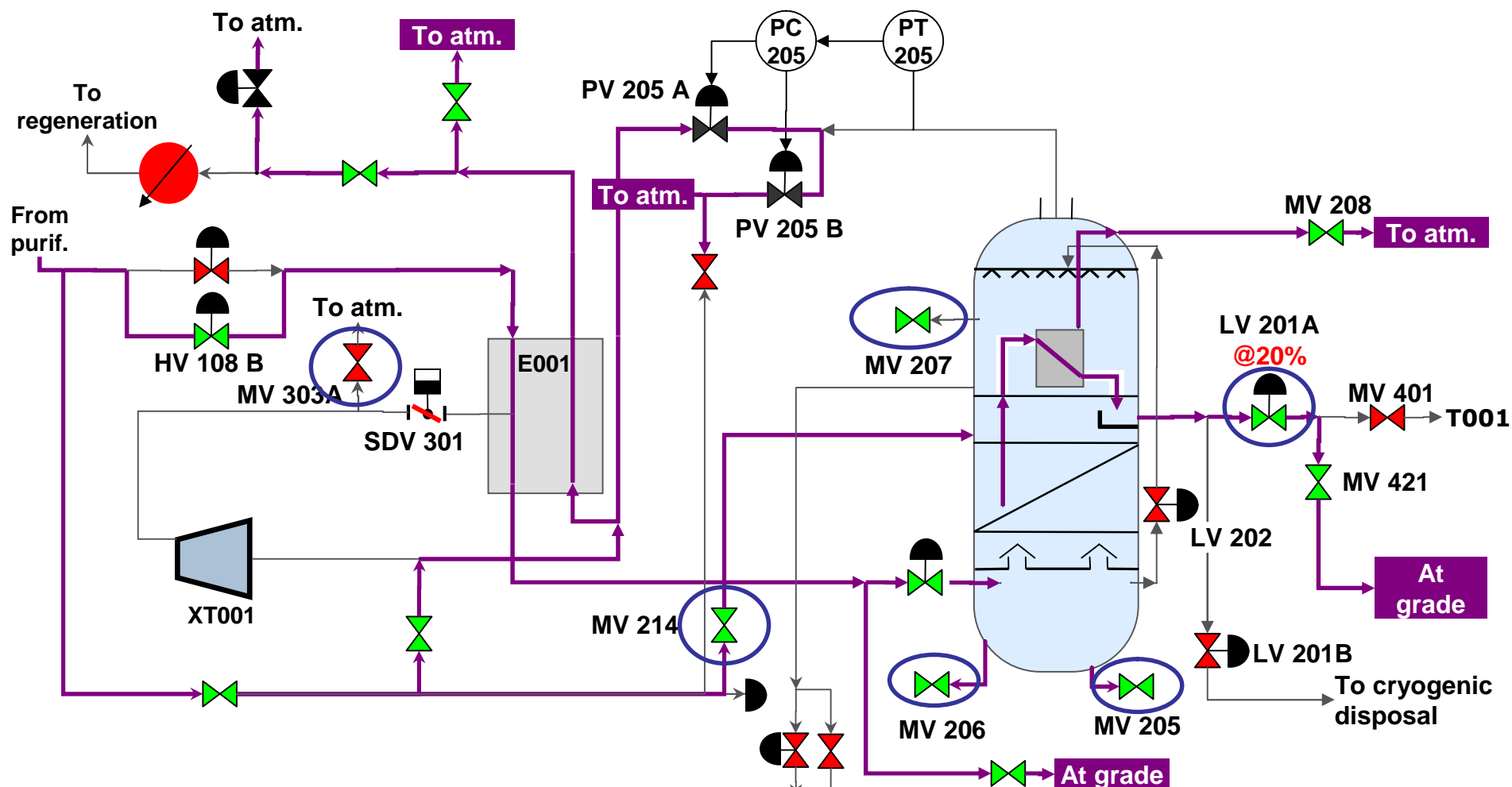
Normal Start Up – ASU – ASU Cold Box – Dry out

## ■ Step 1: Drying out of the turbine



# Normal Start Up – ASU – ASU Cold Box – Dry out

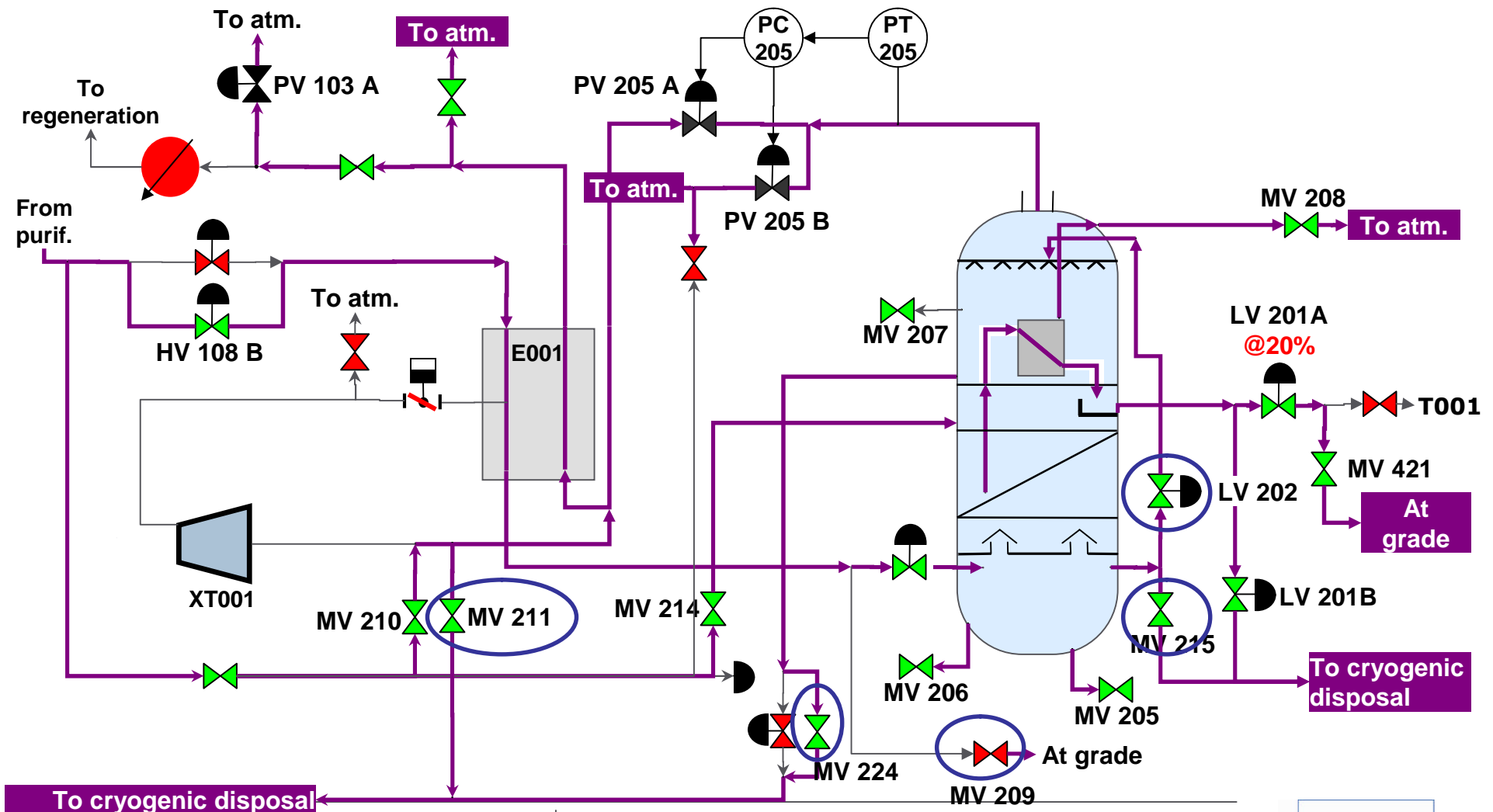
## ■ Step 2: Drying out of E002





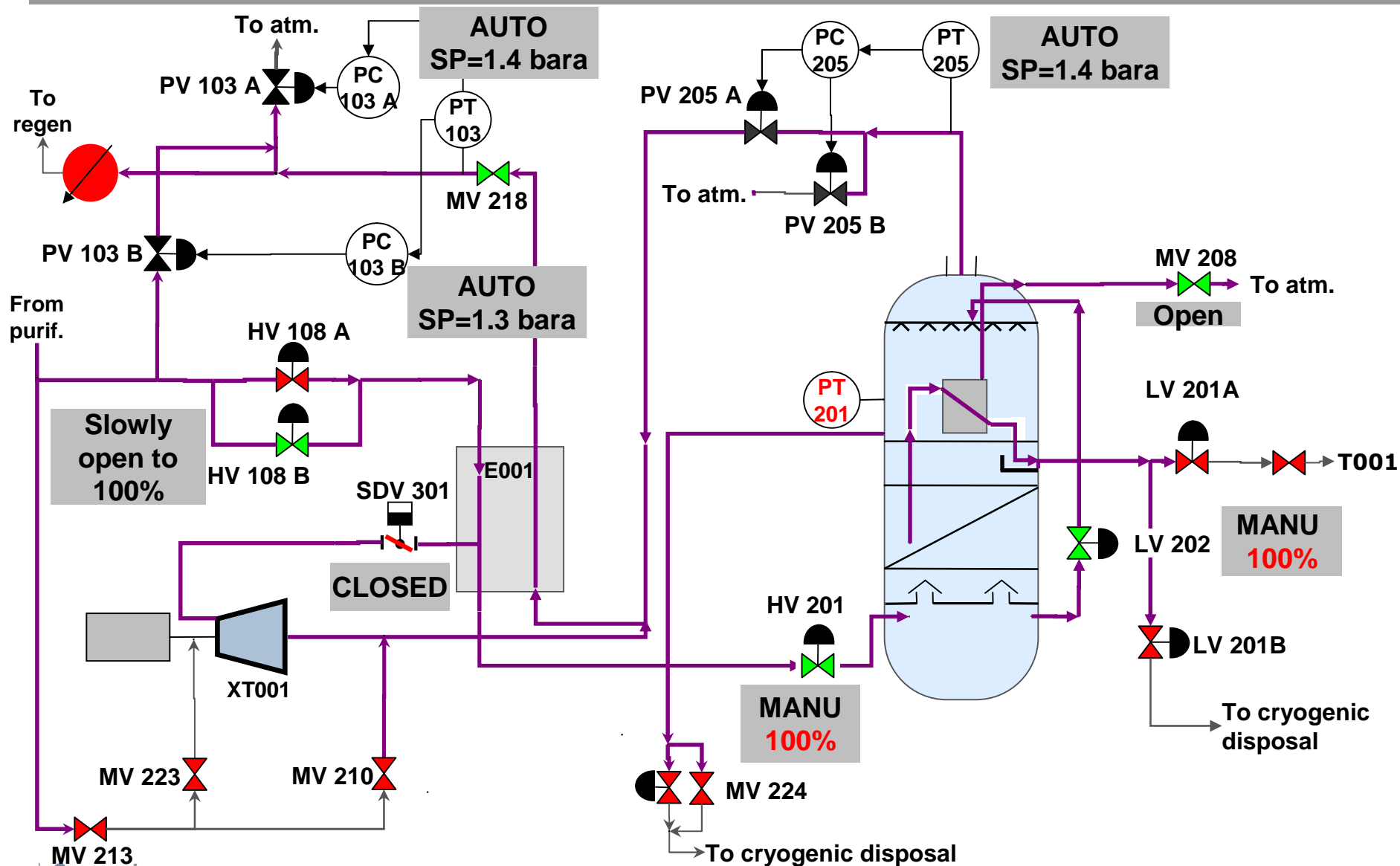
# Normal Start Up – ASU – ASU Cold Box – Dry out

## ■ Step 3: Drying out of C001 and completion



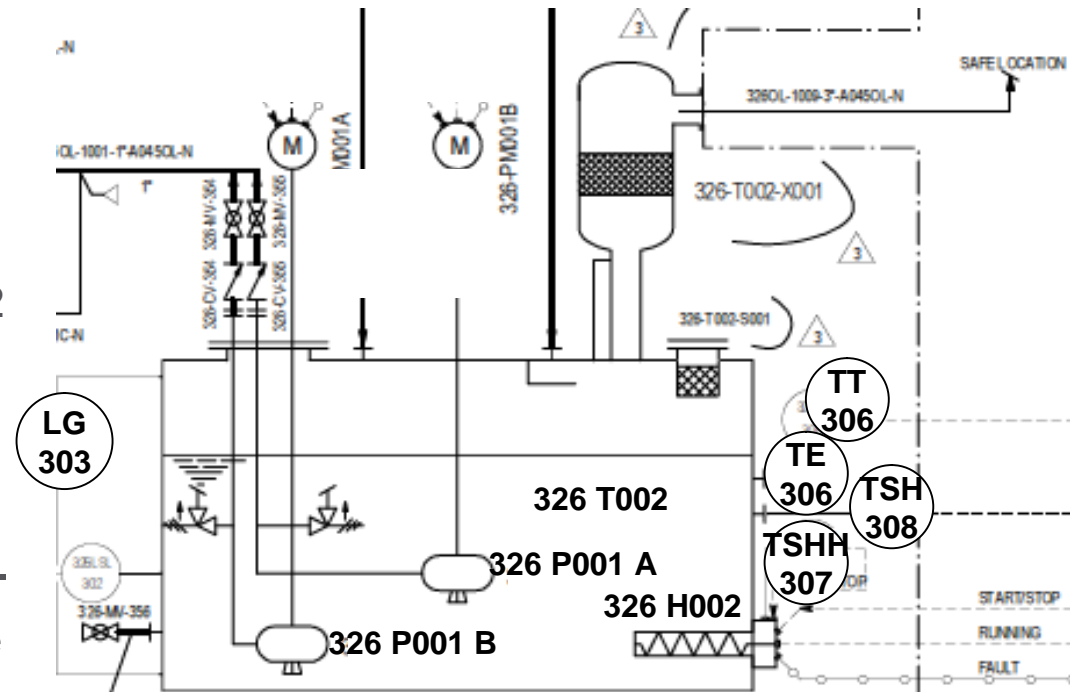
## Normal Start Up – ASU – ASU Cold Box – Pressurization

- Create dry air flow circulation in the ASU by opening:
  - ▣ 326 HV 108 B and 326 HV 201
  - ▣ Note that as long as ASU Cold Box is not “On”, 326 HV 108 A cannot be opened
  - ▣ 326 LV 202 to allow a flow circulation in C001
- Pressurize the whole circuit:
  - ▣ The pressure build up is monitored through 326 PT 201 and 326 PT 205
  - ▣ PT 201 = 6.6 bara
  - ▣ PT 205 = 1.4 bara (PC 205 and PC 103 A must be in auto).



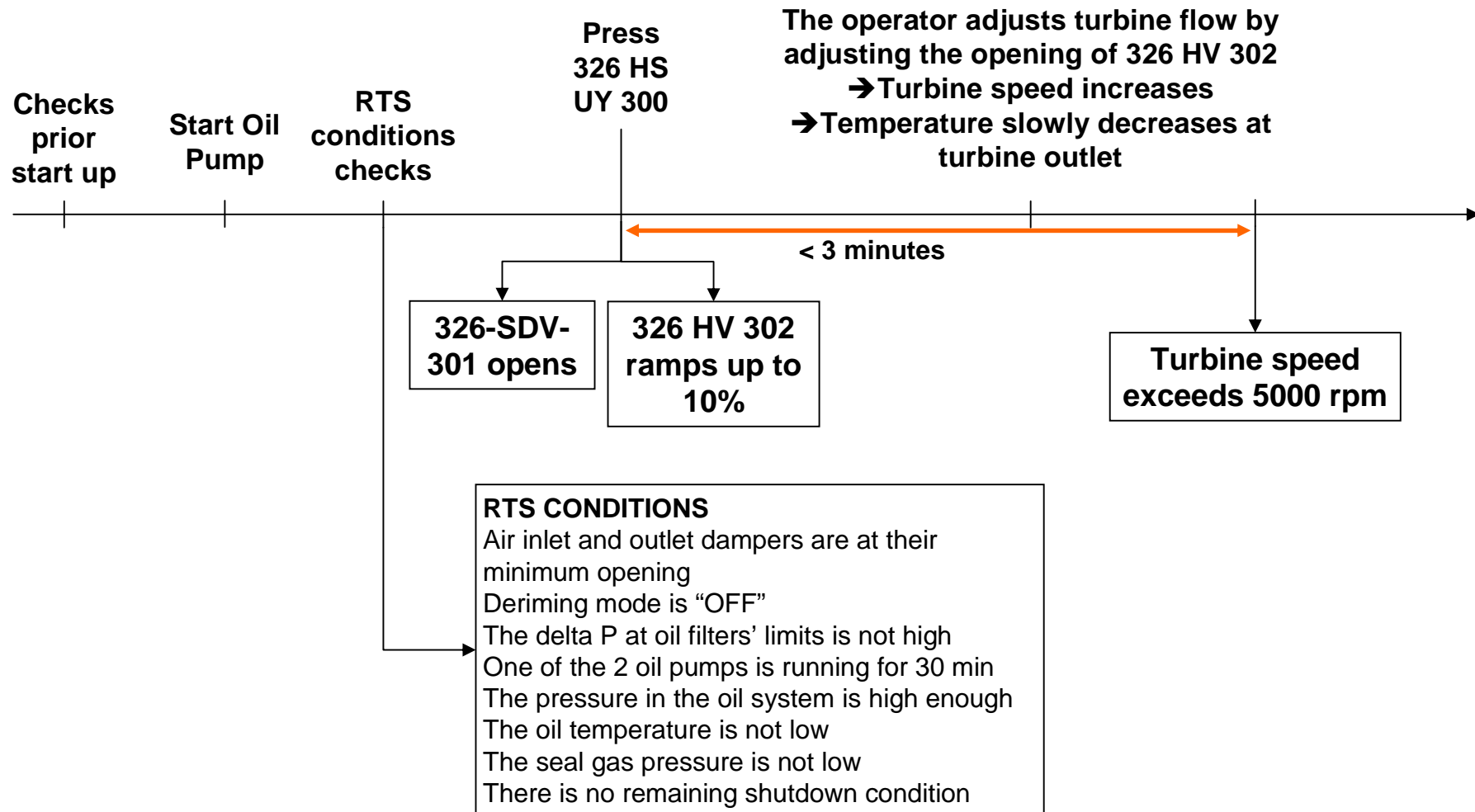
# Normal Start Up – ASU – ASU Cold Box – Expander

- Checks prior start up:
  - Oil circuit:
    - Check the oil level through 326 LG 303
    - Start the Oil Heater 326 H002
    - Select one of the Oil Pumps
  - Check seal gas is available and the oil temperature
- Start up the selected Oil Pump.
- Oil Pressure will build up in the oil circuit.



**SEAL GAS MUST BE AVAILABLE PRIOR TO STARTING THE OIL PUMPS**  
**In order to avoid contamination of the process gas circuit with oil**

# Normal Start Up – ASU – ASU Cold Box – Expander



**An appropriate temperature ramp down is 30°C per hour**

## Normal Start Up – ASU – ASU Cold Box – Cooling down

### ■ Safety note:

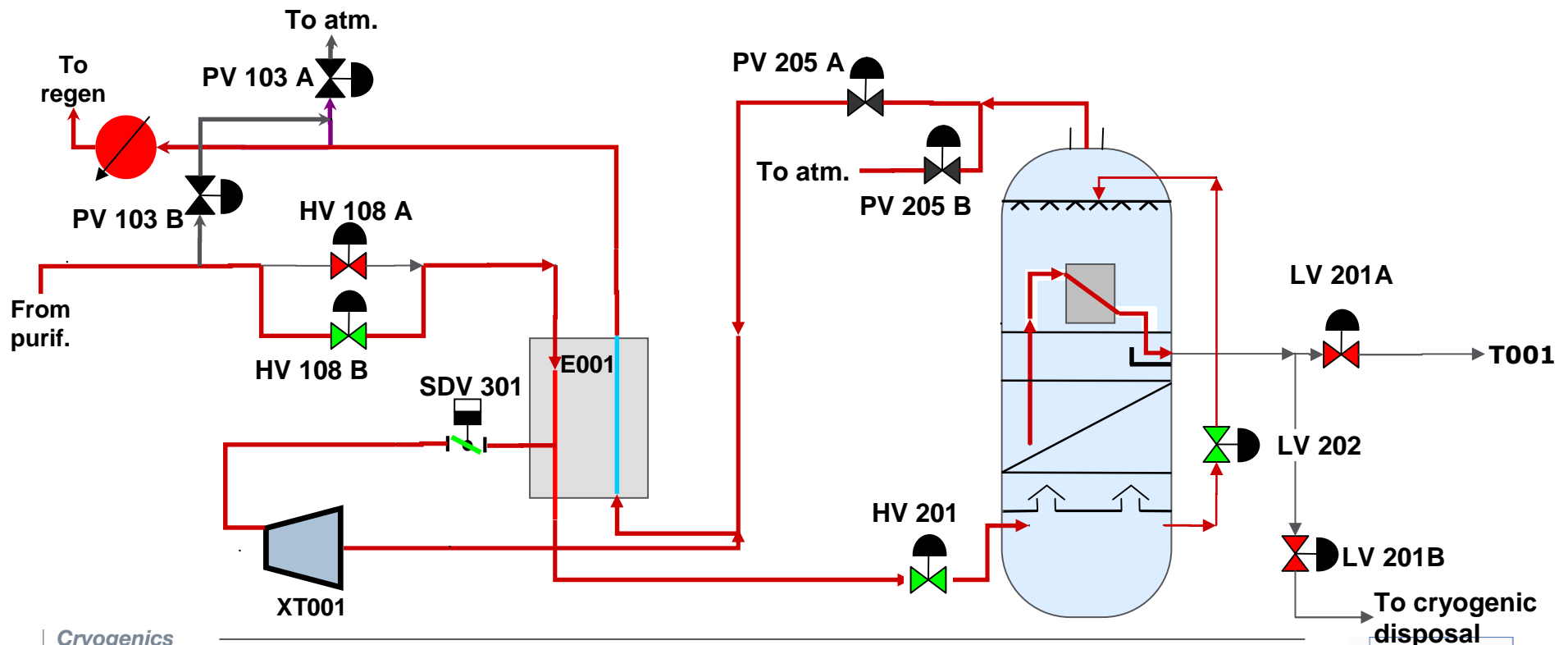
- Cooling down must be undergone at the same moment for
  - Main Heat Exchanger 326 E001
  - ASU Column 326 C001
  - ASU Vaporizer 326 E002
- Temperature drop must not be too fast: an appropriate ramp down is 0.5 °C per minute
  - If necessary, the cooling down speed can be adjusted by reducing/increasing turbine's speed
  - The main risk is to damage the equipments with materials' contraction due to the cooling down.

### ■ Cooling down will take ~24 hours from a hot start.

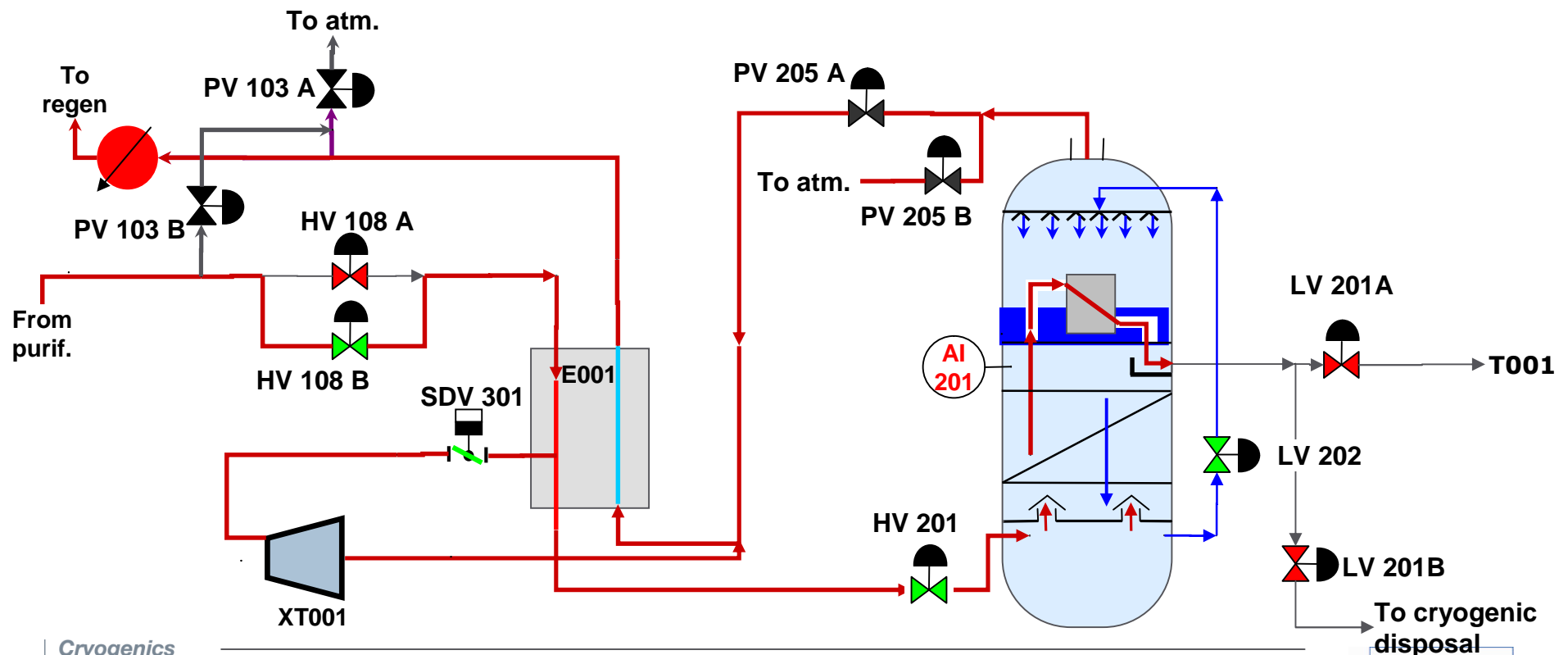
- During the whole cooling down, 326 PC 205 controls the pressure at 326 E002 outlet and 326 PC 103 A and B control the pressure in the regeneration flow.

# Normal Start Up – ASU – ASU Cold Box – Cooling down

- Dry air is cooled down in 326 XT001, and mixed at the cold end of 326 E001.
- The cold duty exchanged in 326 E001 increases and the flow going to C001 is cooled down → C001 progressively cools down.
- At first, as rich liquid is not formed yet, the flow through 326 LV 202 is very low.
- With temperature drop, the gas density in C001 increases, more flow can go through C001 and E002, and 326 PV 103 B slowly closes.



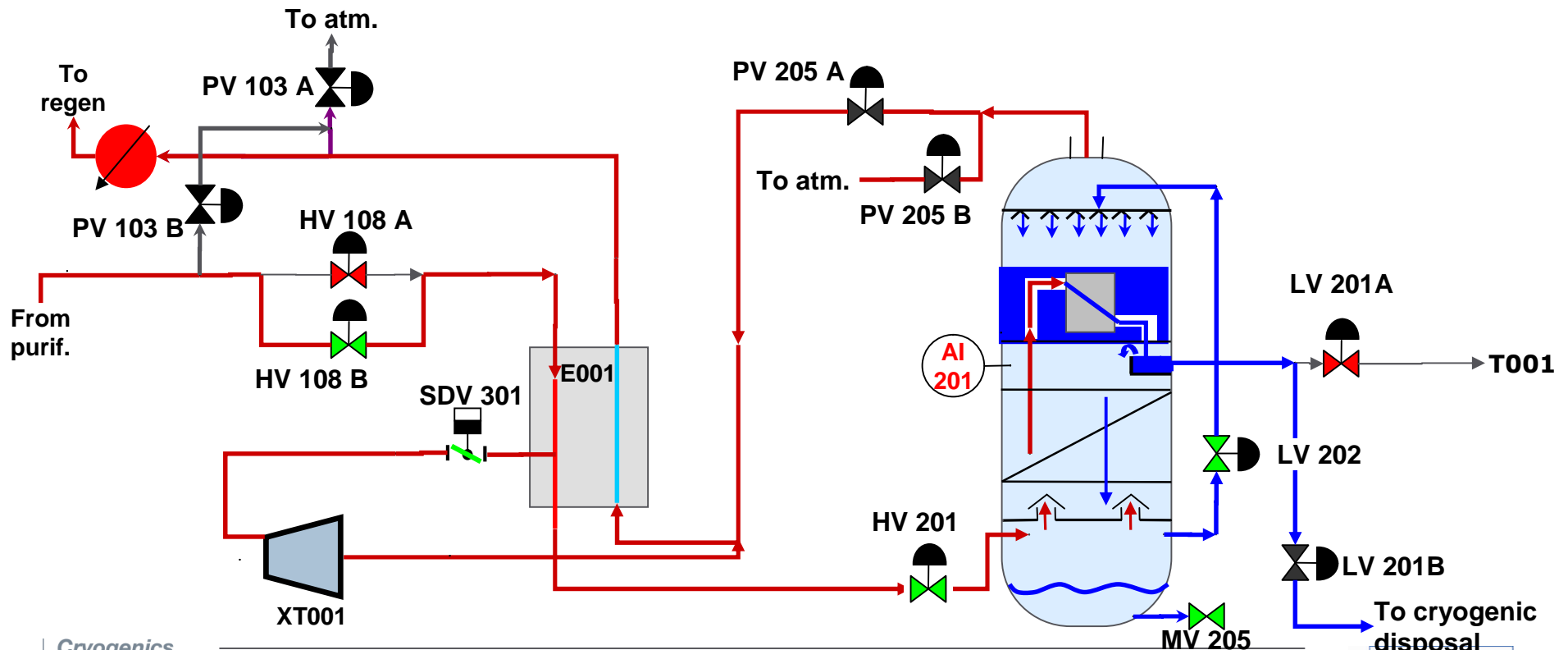
- When temperature is low enough, air liquefaction starts in C001.
- Eventually, liquid appears in the bottom of the column and a level builds up in E002 bath.
- Heat transfer starts in E002.
- 326 Al 201 allows monitoring the start of distillation, as O2 content decreases in the N<sub>2</sub> ascending gas.





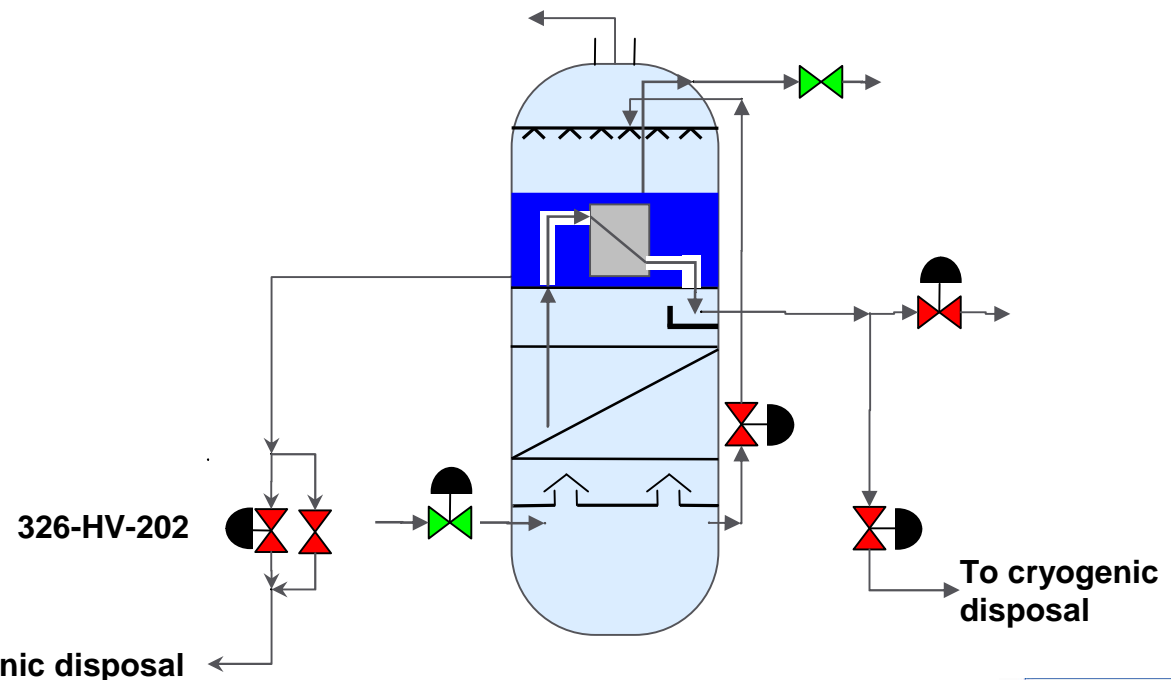
# Normal Start Up – ASU – ASU Cold Box – Cooling down

- When heat transfer is sufficient, pure N<sub>2</sub> starts condensing in E002 and LIN is produced.
- The system progressively stabilizes and LIN purity increases.
- When submergence level reaches 100%, manually operate 326 LV 202 to build up the level at C001 bottom.
- For the first start up, drain the column through 326 MV 205 to remove potential dirt.
- Then, set 326 LC 202 in auto, with set point at 50%. Set 326 LC 201 B in auto.



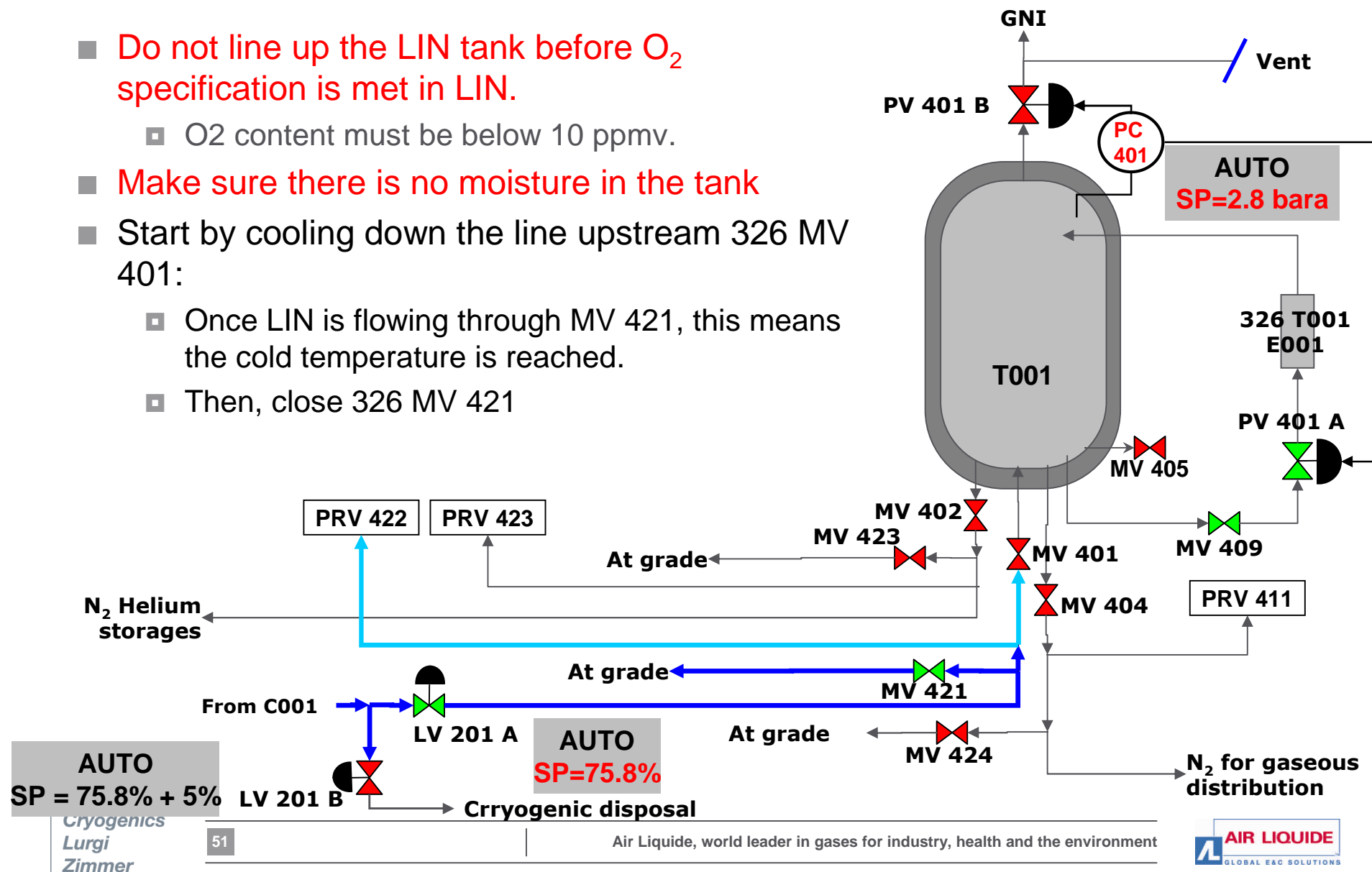
# Normal Start Up – ASU – ASU Cold Box

- Check the RTS conditions of the cold box
- Press 326 HS UY 200
- The deconcentration 326-HV-202 valve auto control will start
- It is now allowed to open 326 HV 108 A.



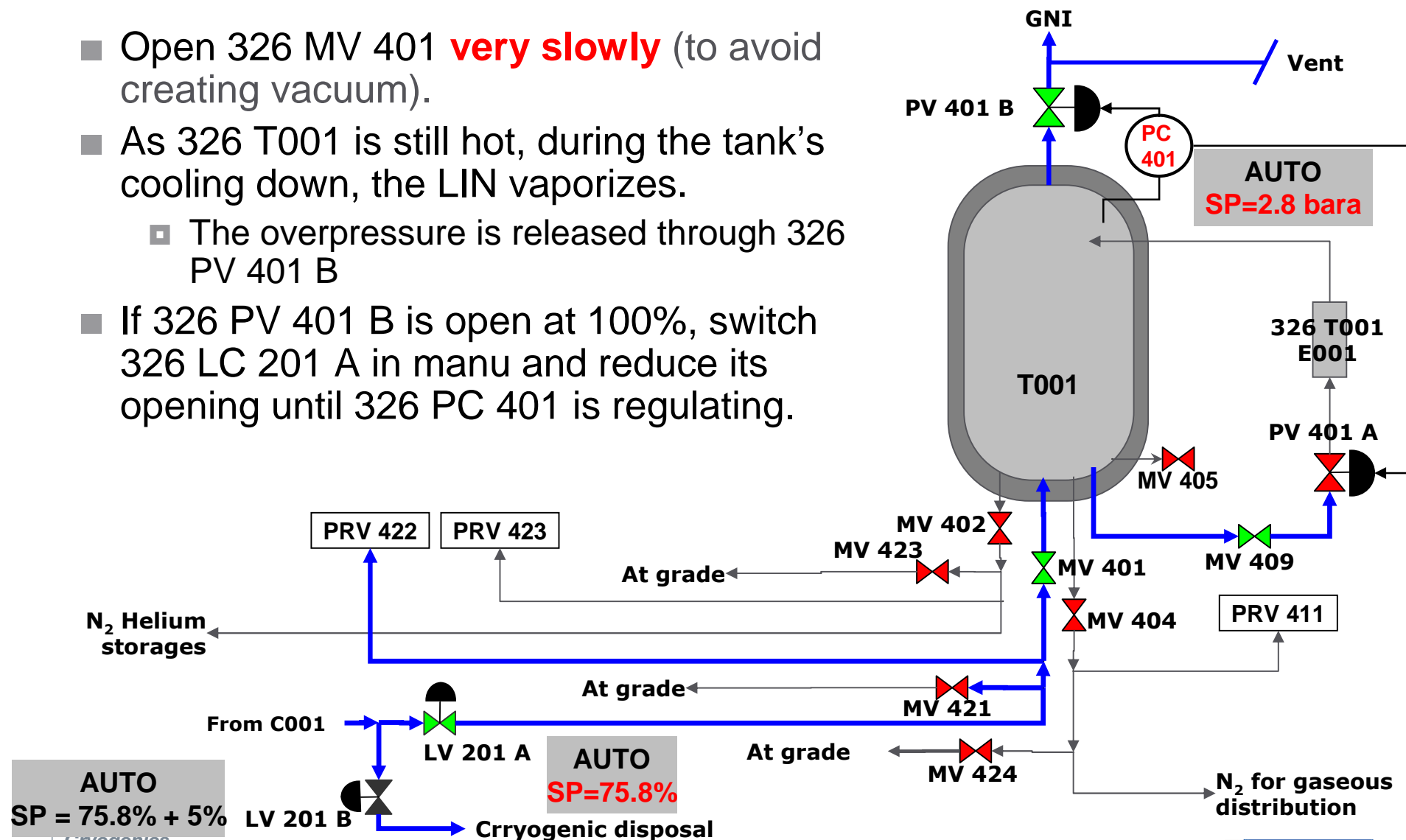
# Normal Start Up – ASU – LIN Tank

- Do not line up the LIN tank before O<sub>2</sub> specification is met in LIN.
  - ▣ O<sub>2</sub> content must be below 10 ppmv.
- Make sure there is no moisture in the tank
- Start by cooling down the line upstream 326 MV 401:
  - ▣ Once LIN is flowing through MV 421, this means the cold temperature is reached.
  - ▣ Then, close 326 MV 421



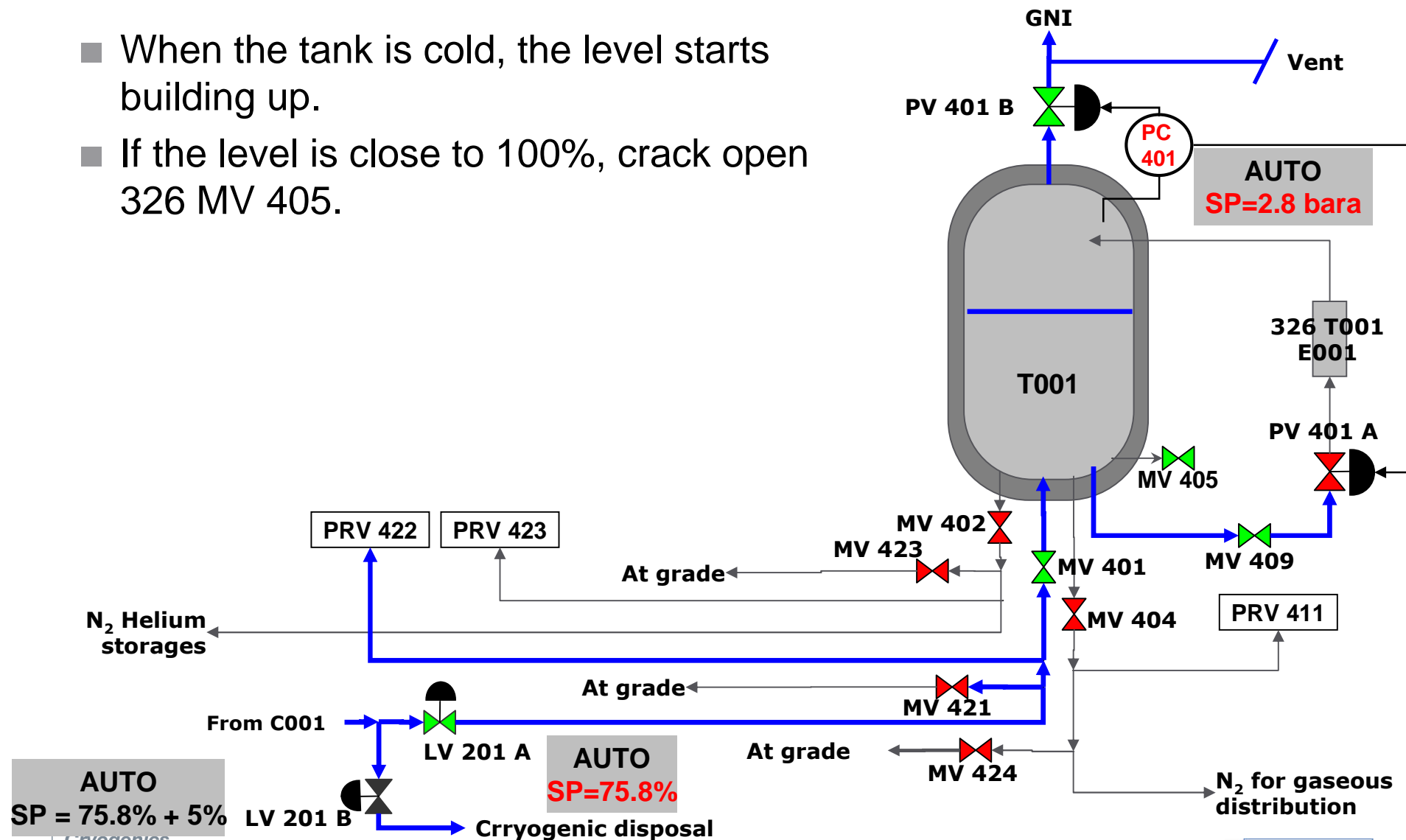
# Normal Start Up – ASU – LIN Tank

- Open 326 MV 401 **very slowly** (to avoid creating vacuum).
- As 326 T001 is still hot, during the tank's cooling down, the LIN vaporizes.
  - ▣ The overpressure is released through 326 PV 401 B
- If 326 PV 401 B is open at 100%, switch 326 LC 201 A in manu and reduce its opening until 326 PC 401 is regulating.



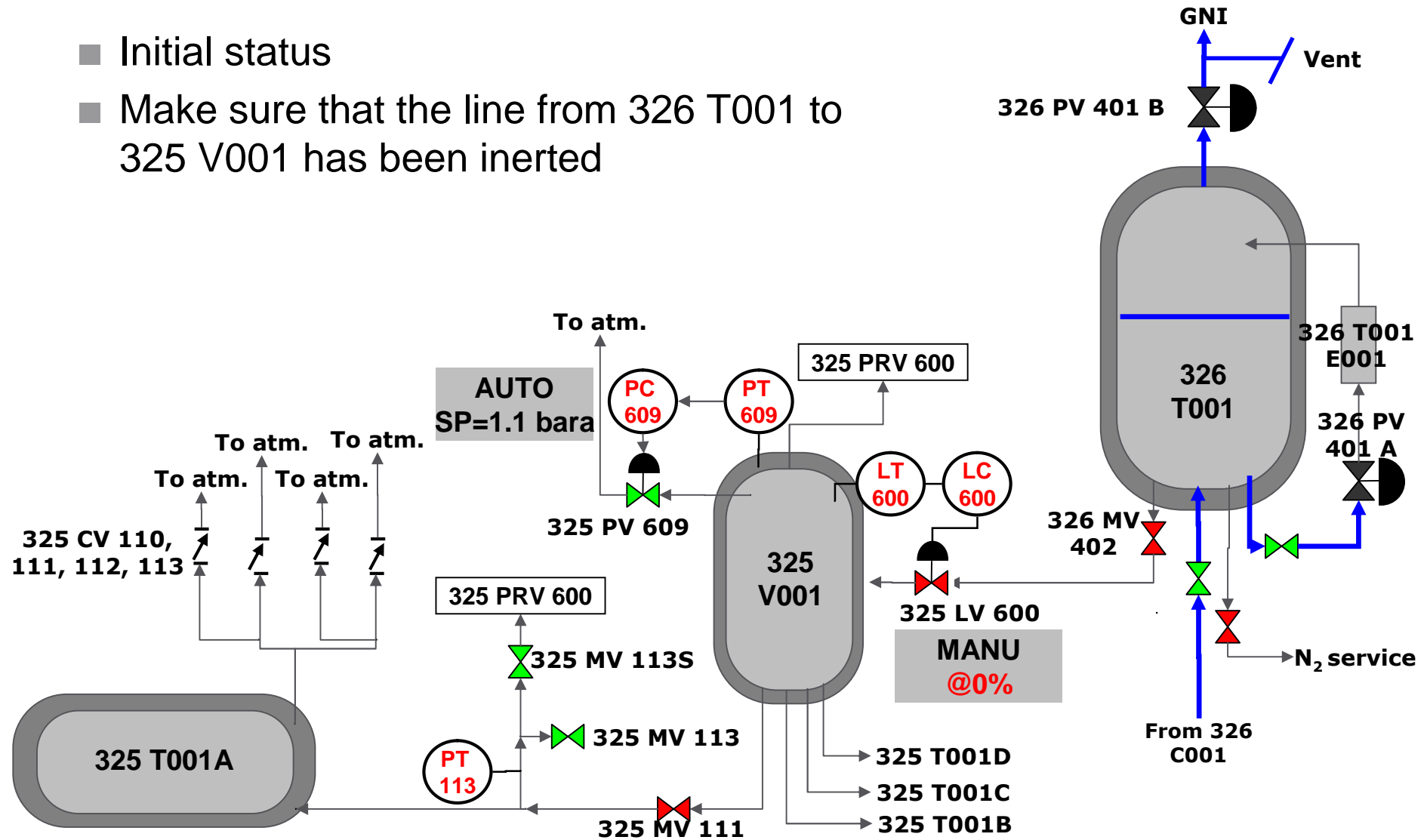
# Normal Start Up – ASU – LIN Tank

- When the tank is cold, the level starts building up.
- If the level is close to 100%, crack open 326 MV 405.



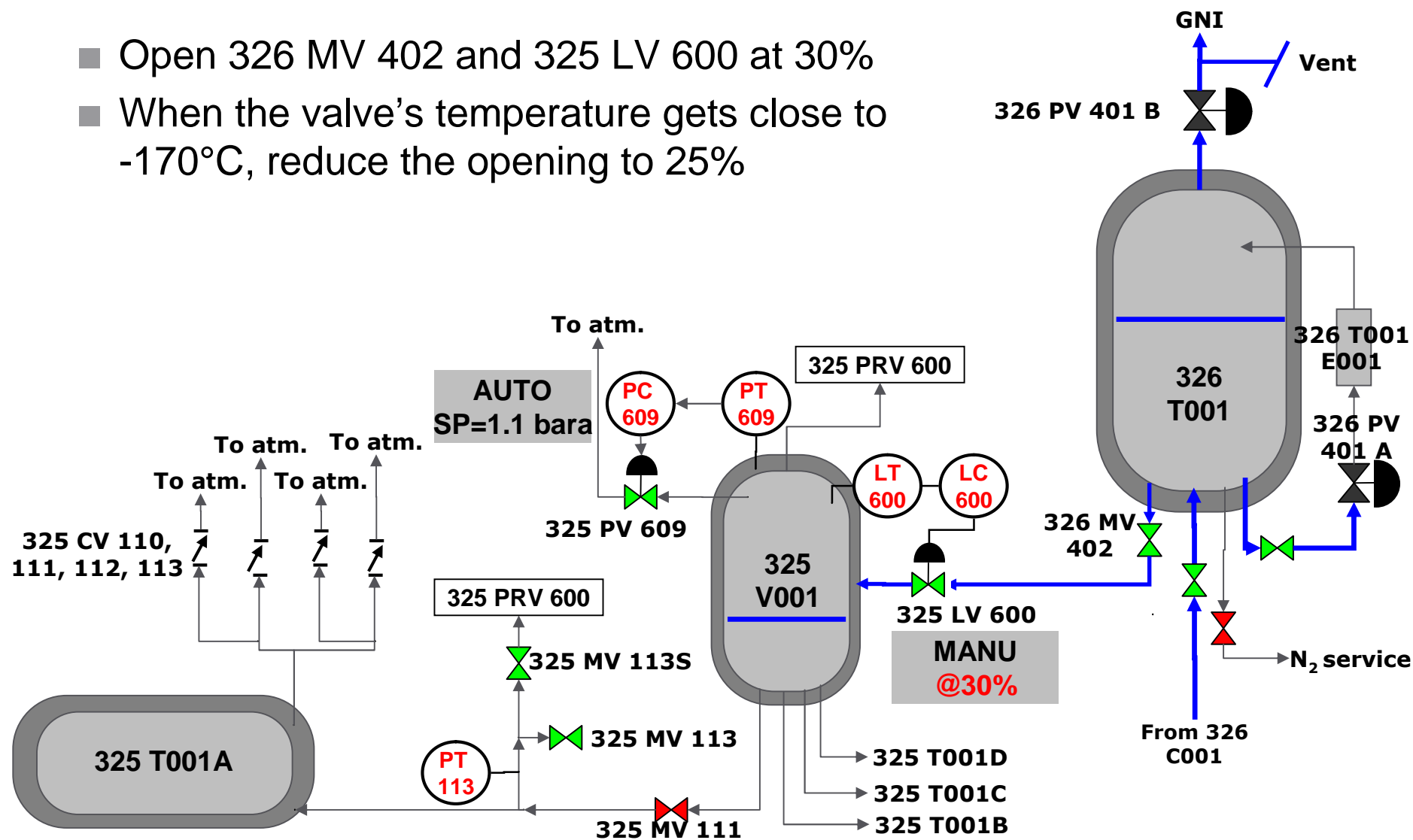
# Normal Start Up – ASU – LIN Jacketing

- Initial status
- Make sure that the line from 326 T001 to 325 V001 has been inerted



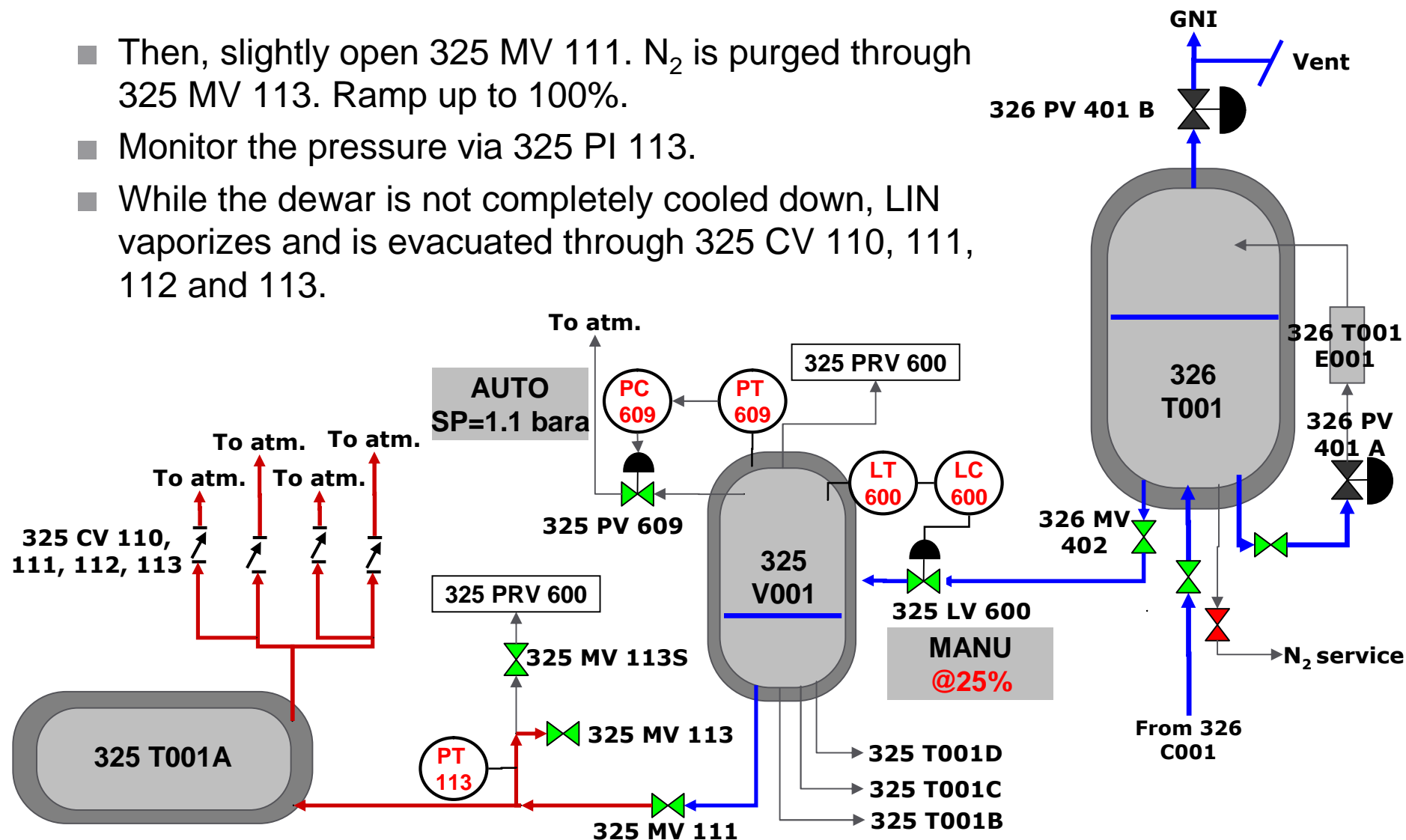
# Normal Start Up – ASU – LIN Jacketing

- Open 326 MV 402 and 325 LV 600 at 30%
- When the valve's temperature gets close to  $-170^{\circ}\text{C}$ , reduce the opening to 25%



# Normal Start Up – ASU – LIN Jacketing

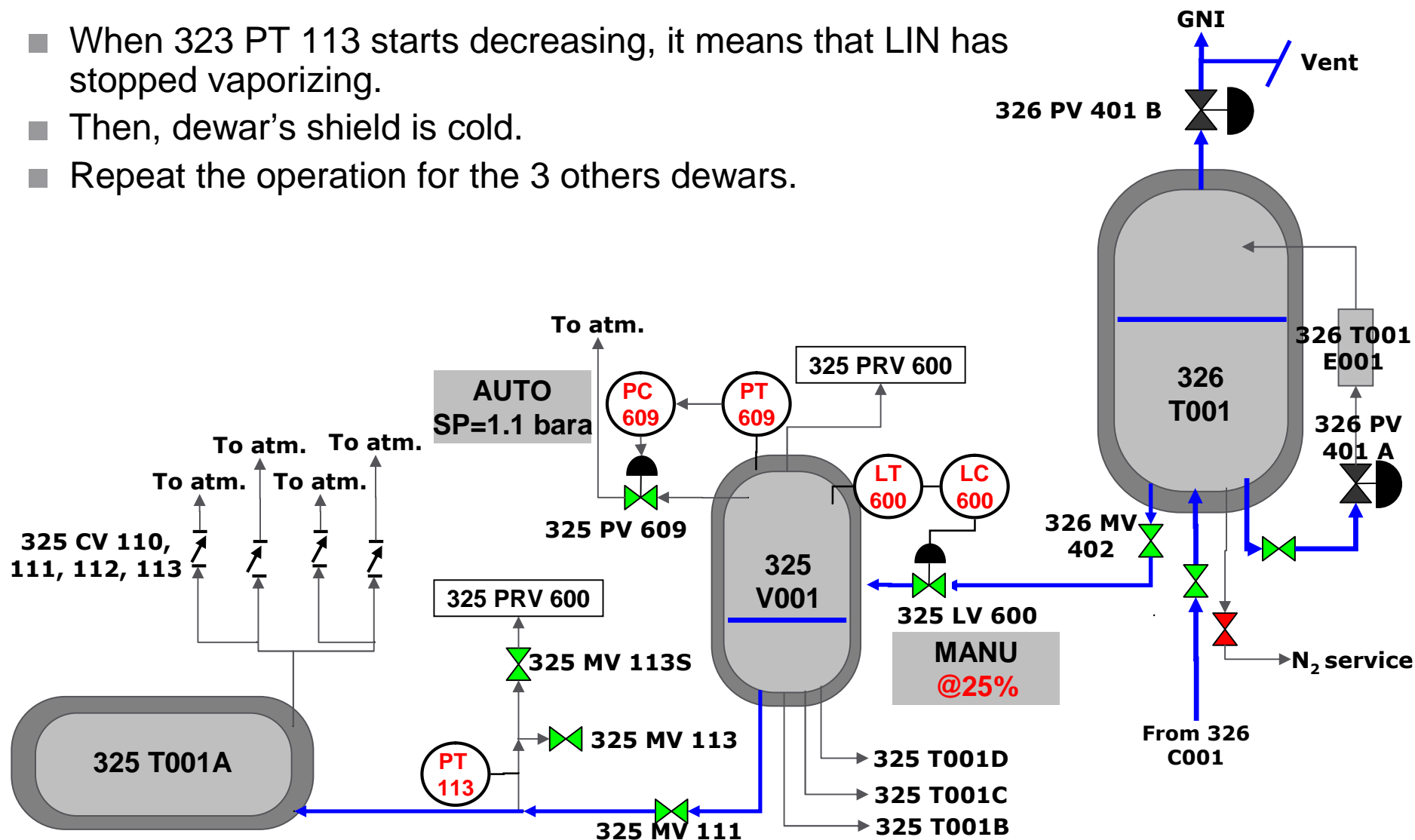
- Then, slightly open 325 MV 111. N<sub>2</sub> is purged through 325 MV 113. Ramp up to 100%.
- Monitor the pressure via 325 PI 113.
- While the dewar is not completely cooled down, LIN vaporizes and is evacuated through 325 CV 110, 111, 112 and 113.





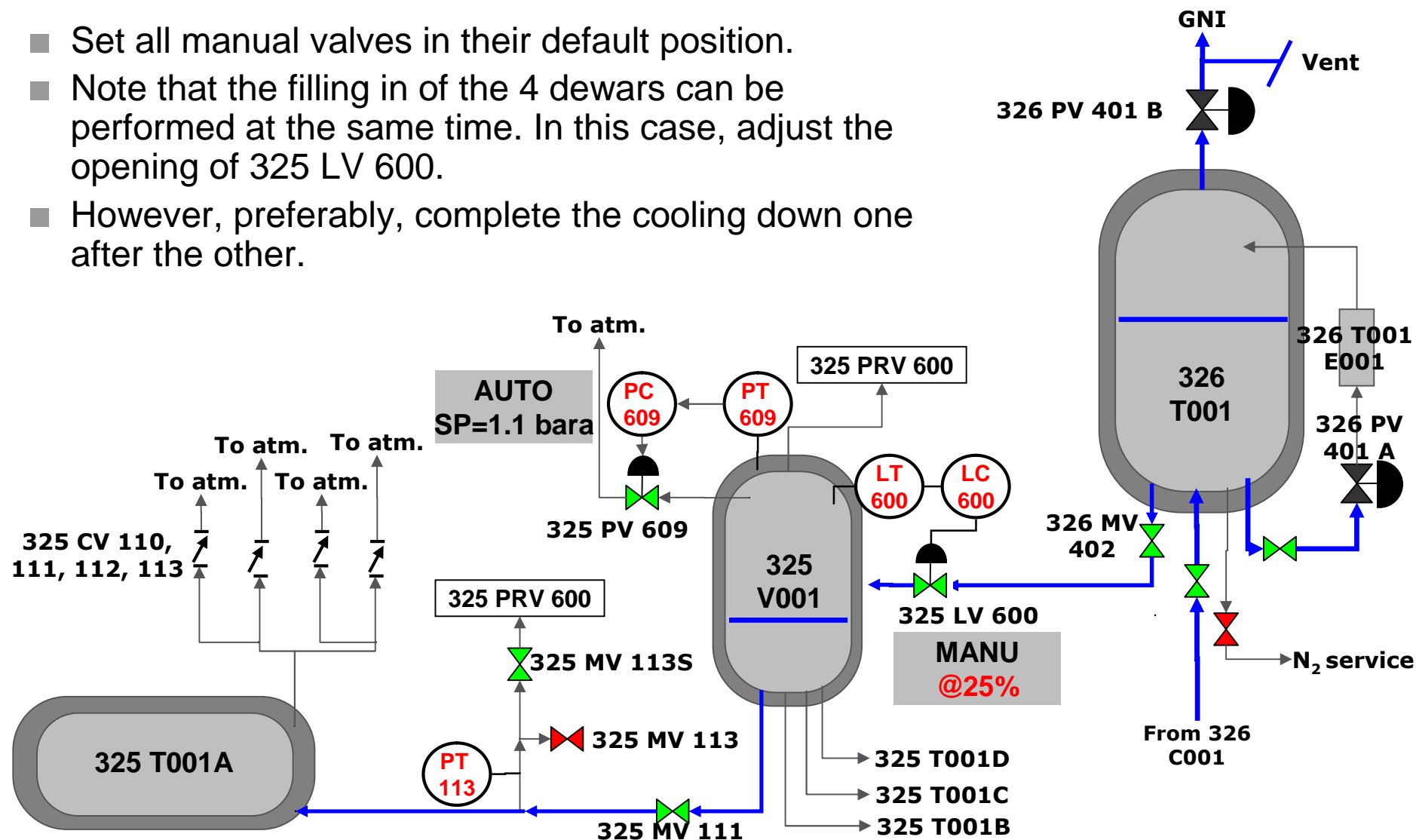
# Normal Start Up – ASU – LIN Jacketing

- When 323 PT 113 starts decreasing, it means that LIN has stopped vaporizing.
- Then, dewar's shield is cold.
- Repeat the operation for the 3 others dewars.



# Normal Start Up – ASU – LIN Jacketing

- Set all manual valves in their default position.
- Note that the filling in of the 4 dewars can be performed at the same time. In this case, adjust the opening of 325 LV 600.
- However, preferably, complete the cooling down one after the other.



# Course Agenda

1. Normal startup
  1. General sequence
  2. Utilities
  3. ASU
  4. Inlet Compressor
  5. Unit 322
  6. Helium Compressors
2. Shutdown sequence
3. Emergency Shutdown

## Normal start up – Inlet Compressor

### ■ Checks:

- Oil level in oil tank 321 V001 shall not be low
- Electricity and Instrument Air are available
- Cooling Water is available for 321 E001, E002, KM001-E001 and Y001-E001 and the air in Cooling Water Pipes has been purged
- Feed Gas available

### ■ Condition pipes with feed gas:

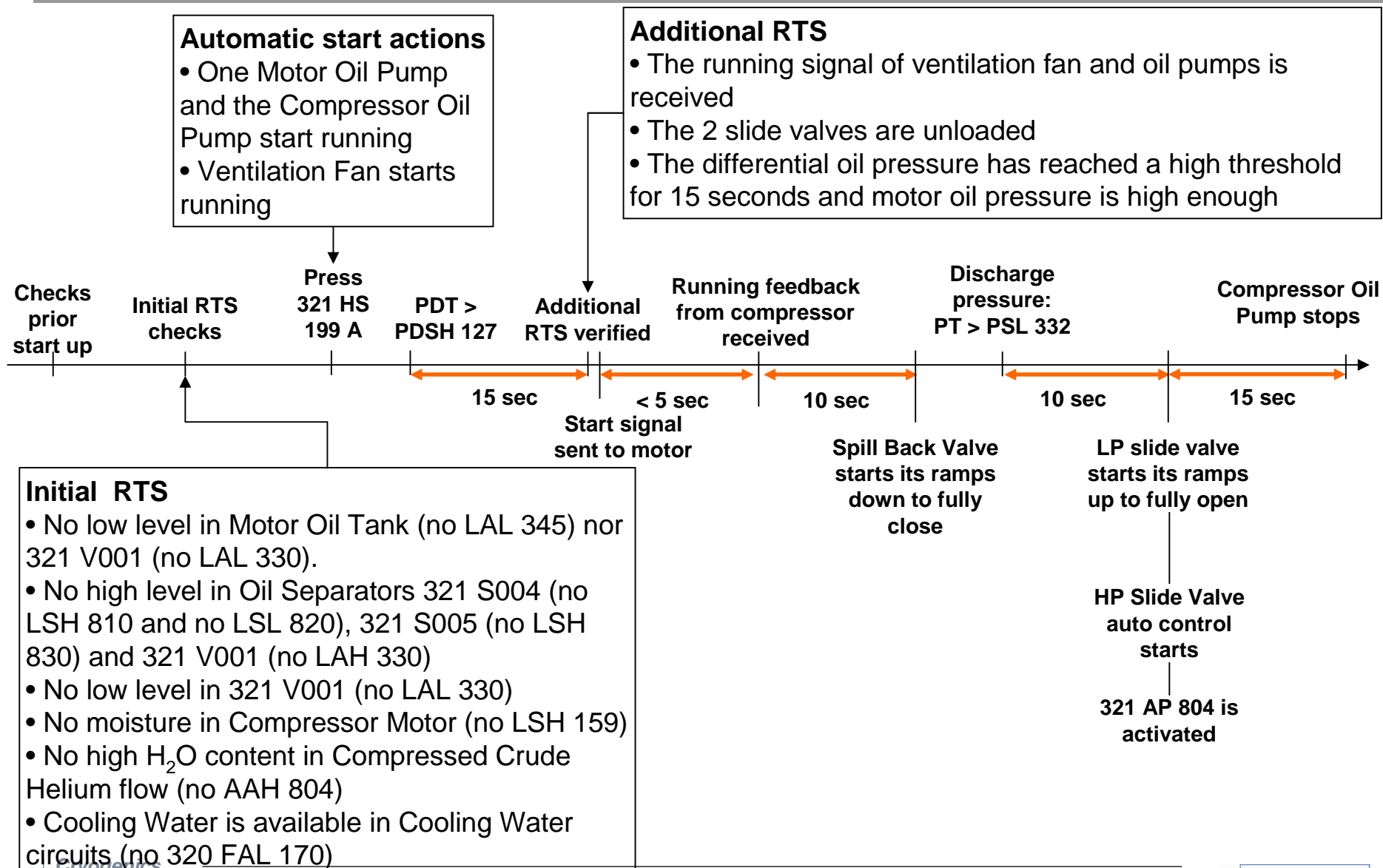
- If moisture level is too high (higher than 10 ppmw), blow pipes with feed gas
- Open drain and purge valves
- Open RasGas and/or QatarGas feed valve and blow pipes

### ■ All manual valves shall be in their default position as shown in PID

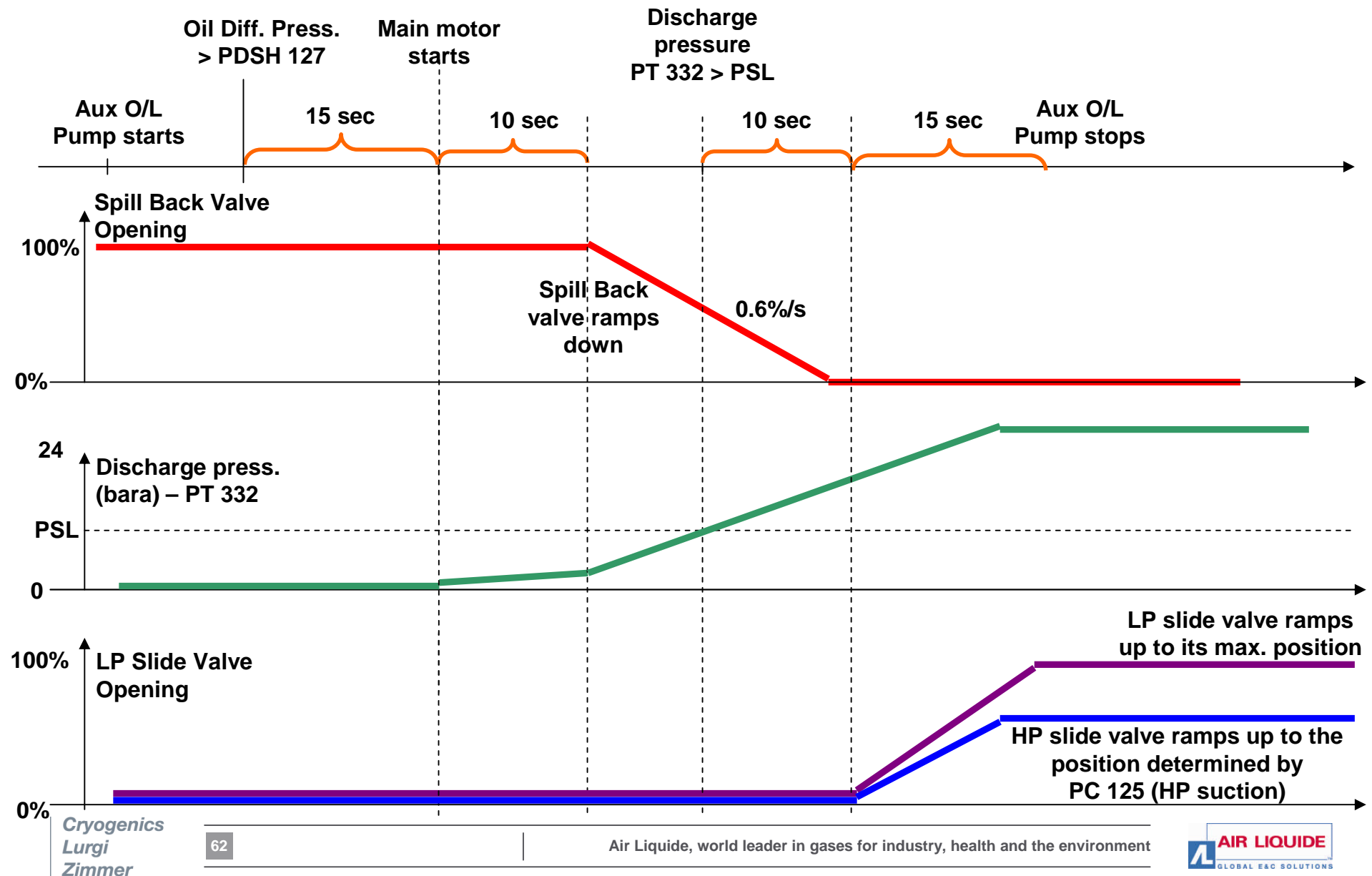
### ■ Oil pumps

- Select the back up pump with 321 HS 166
- Start the pump which is not in back up
- Start Compressor Oil pump Motor 321 PM001 by pressing 321 HS 350 from DCS.

# Normal start up – Inlet Compressor



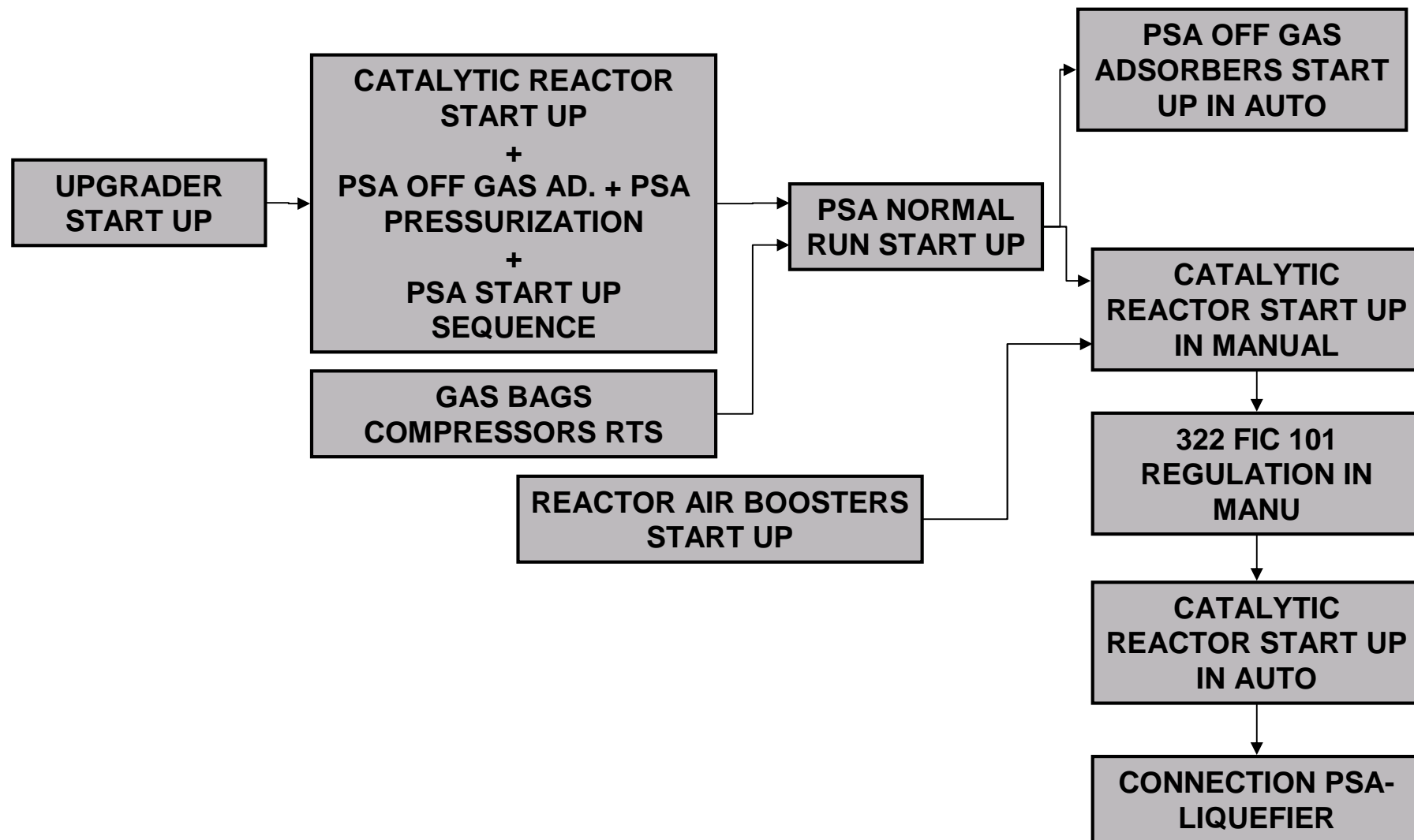
# Normal start up – Inlet Compressor



# Course Agenda

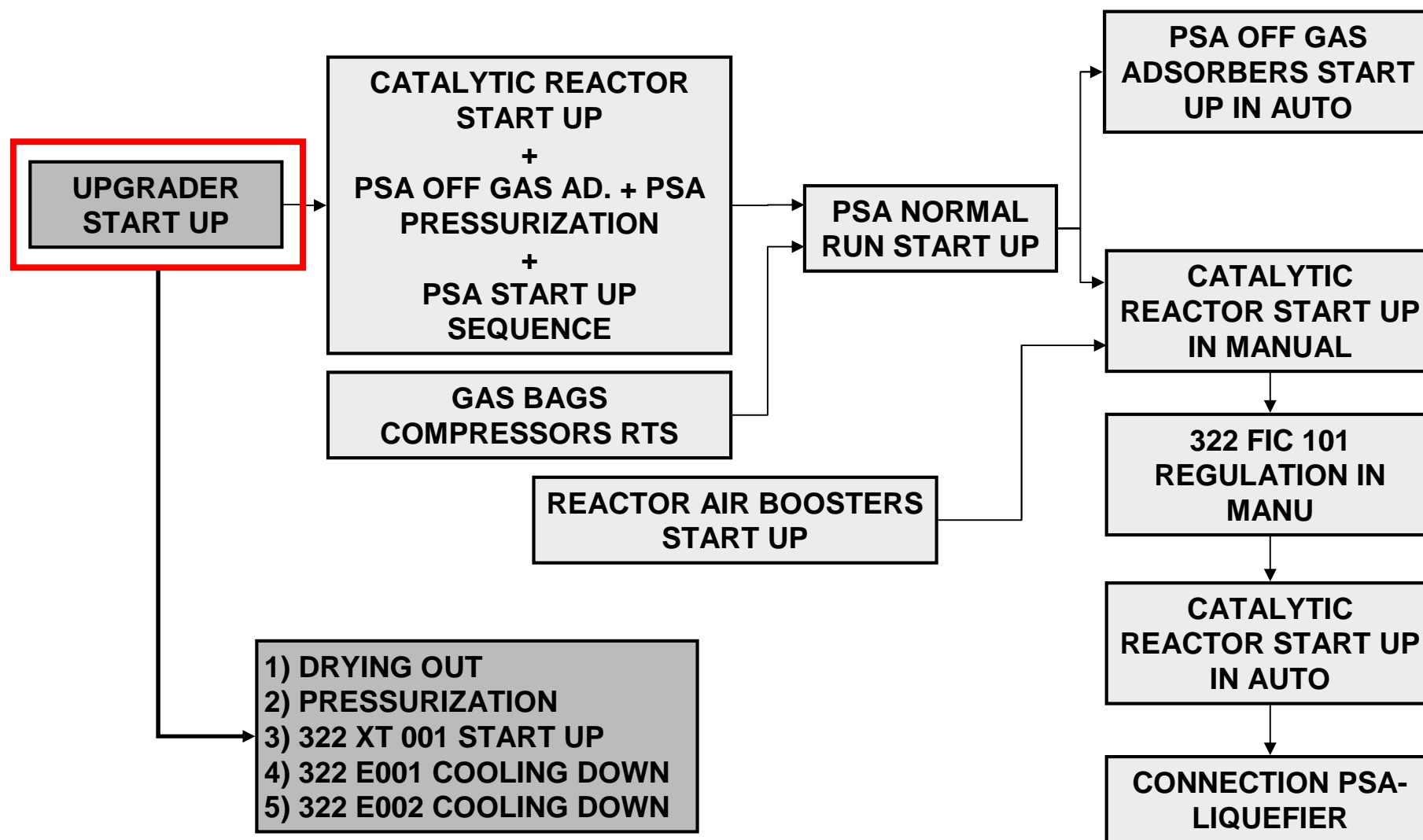
1. Normal startup
  1. General sequence
  2. Utilities
  3. ASU
  4. Inlet Compressor
  5. Unit 322
  6. Helium Compressors
2. Shutdown sequence
3. Emergency Shutdown

# Normal start up – Unit 322 – Overview





# Normal start up – Unit 322 – Overview



# Normal start up – Unit 322 – Upgrader drying out

## Drying out purpose

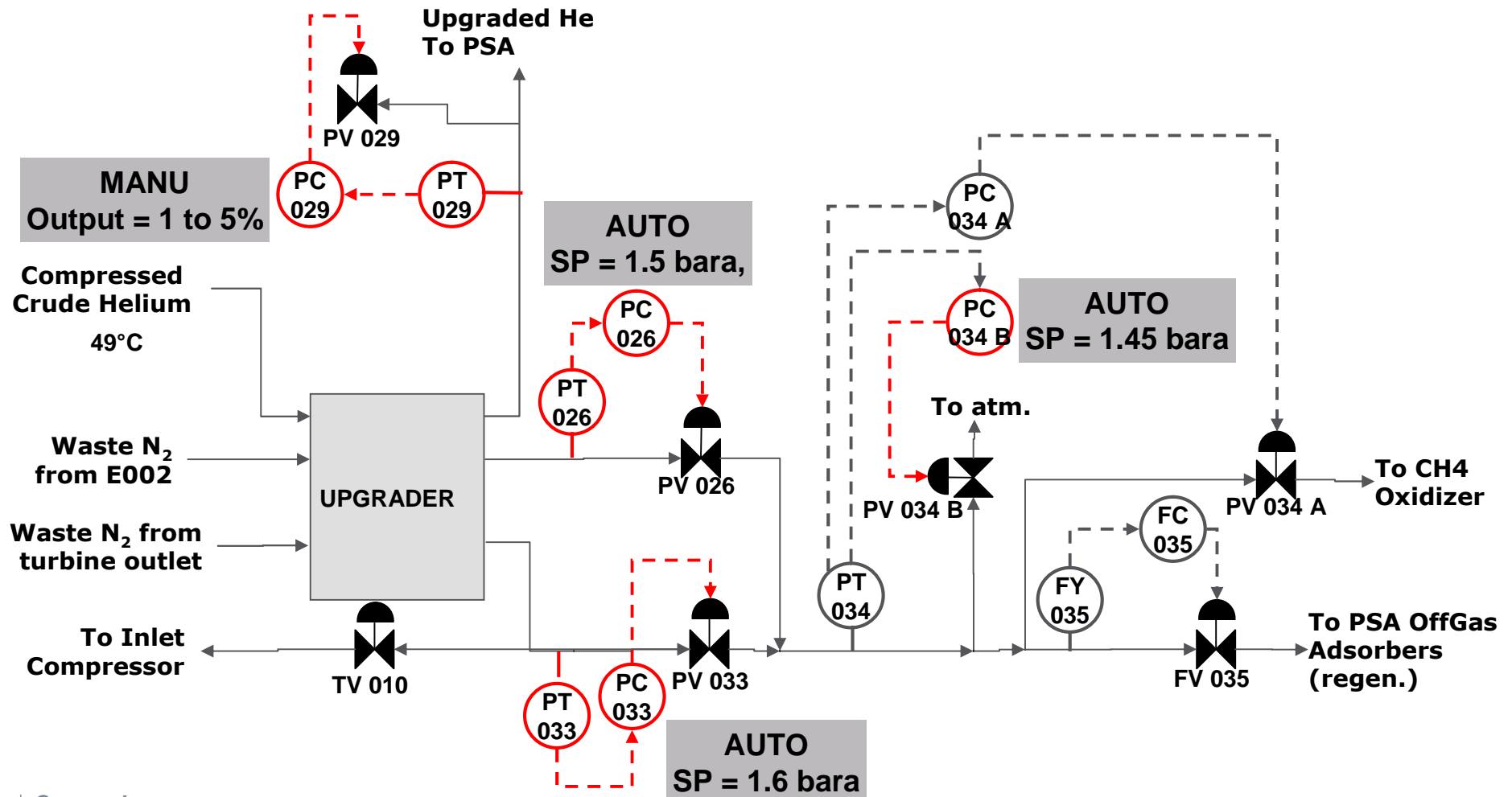
- Remove moisture and humidity
- Considered as dried out when dew point is below -60°C

## Preparation

- Open drains and vents valves
- Control pressure inside Upgrader by setting automatic controls on Upgrader outlet valves
  - ▣ If during drying out these valves do not remain open, manually increase opening by several %. The purpose is to maintain the system in slight overpressure
- Reset safety interlock:
  - ▣ Reset Upgrader interlock 322 UZ 001 via DCS button 322 HS 001 R
  - ▣ Reset all valves by pressing 322 HS RA 021, 322 HS RA 026 and 322 HS RA 033 in DCS.

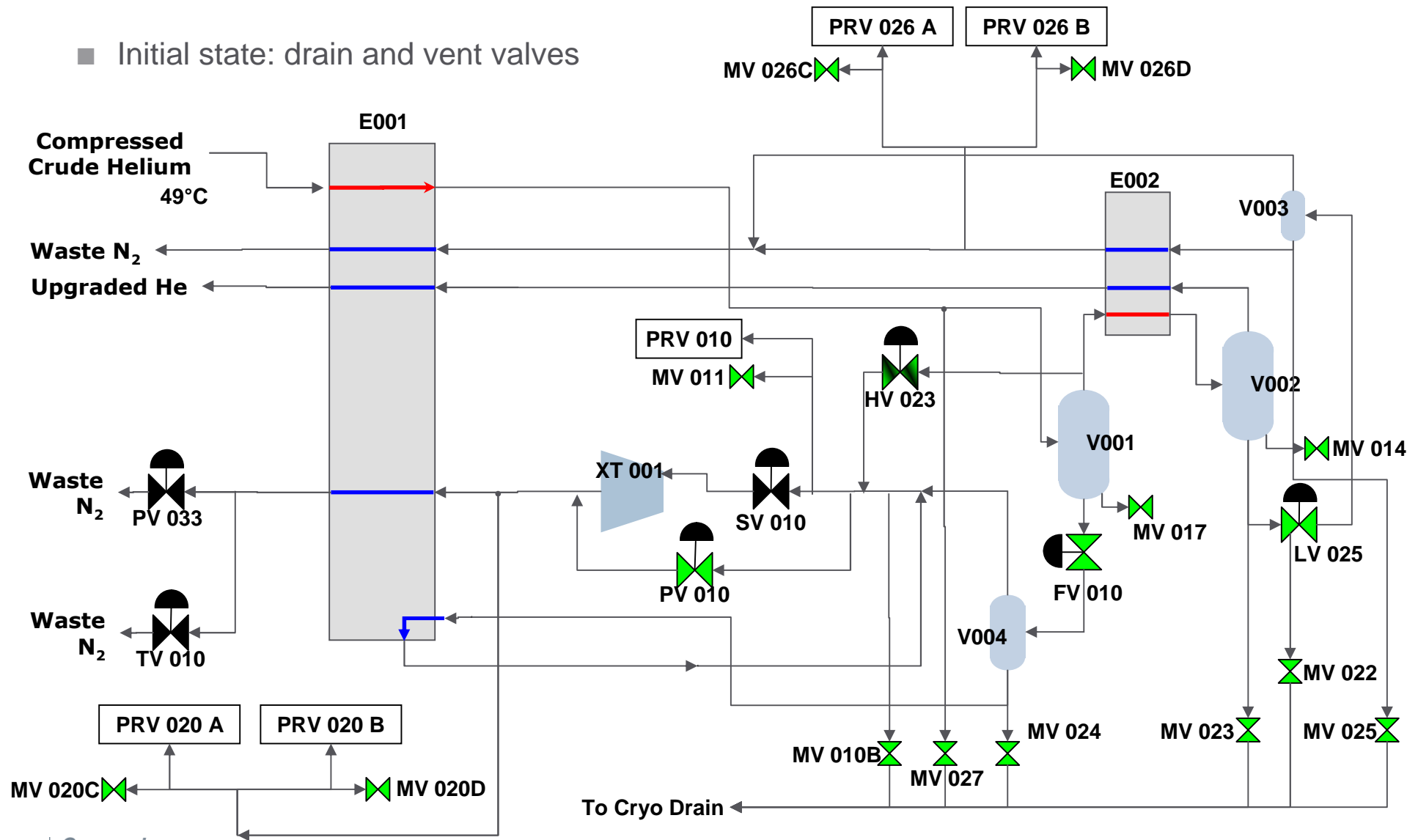
## Normal start up – Unit 322 – Upgrader drying out - Preparation

- Initial state of Upgrader connection valves



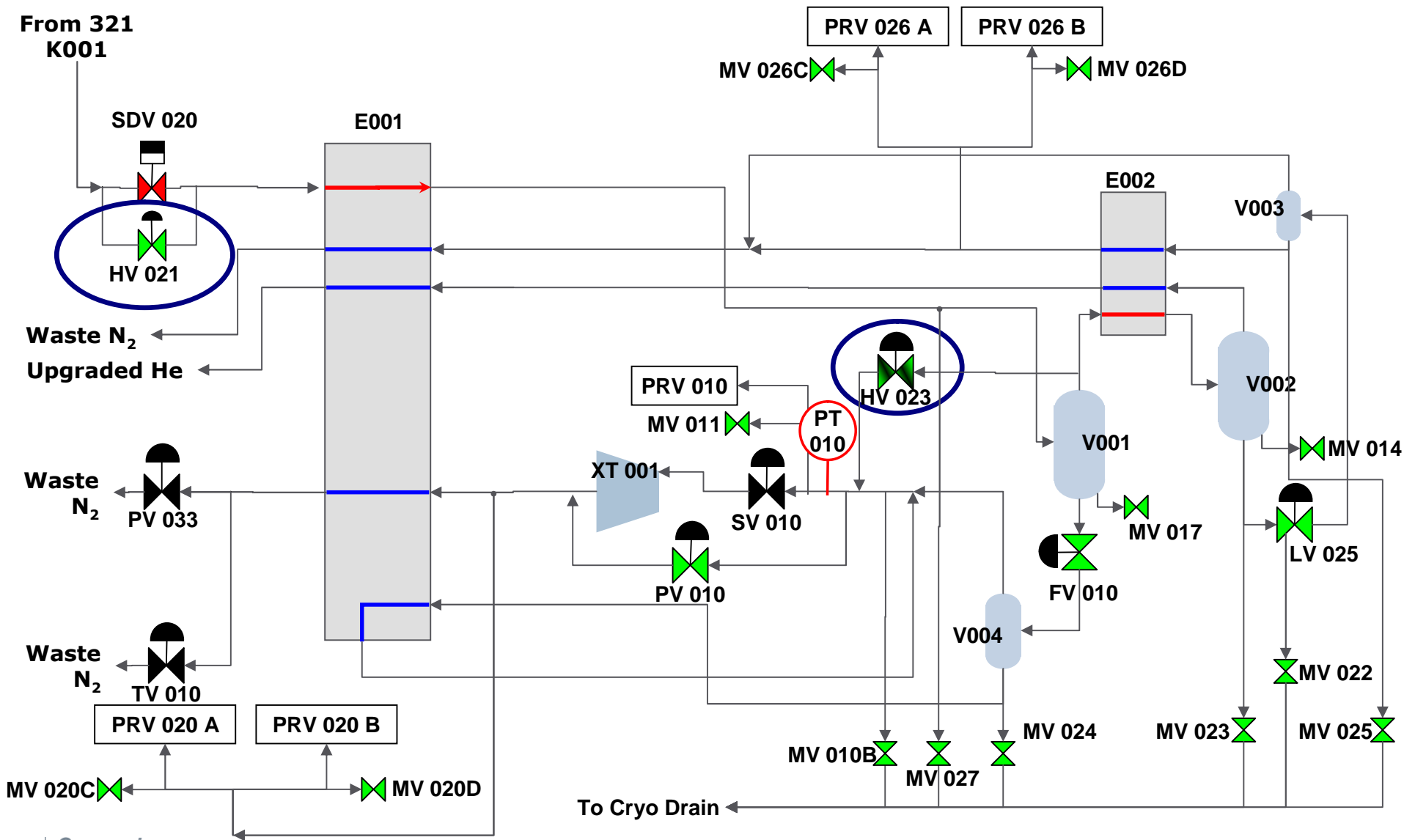
# Normal start up – Unit 322 – Upgrader drying out - Preparation

■ Initial state: drain and vent valves



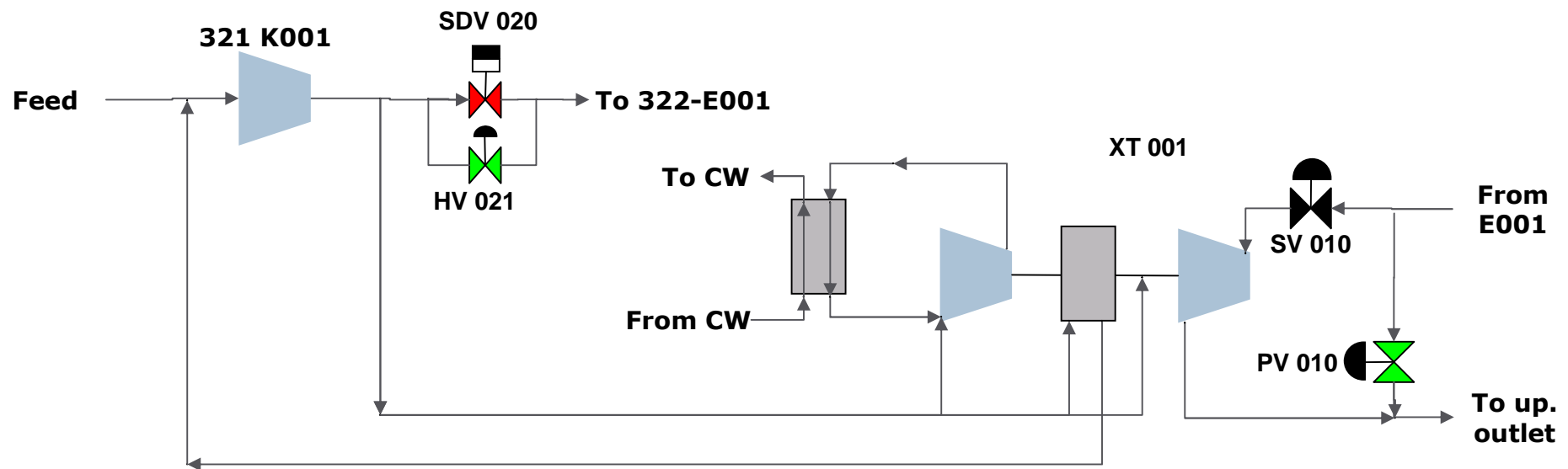
## Normal start up – Unit 322 – Upgrader drying out - Procedure

- Slowly open Upgrader inlet valve 322 HV 021 in order to start pressurizing the Upgrader.
- Check 322-PT-010 is below 6 bara (measured with vent closed). In case of overpressure, act on 322 HV 023 by reducing its opening.
- Measure dew points at 322 PT 010, 322 LV 025 and 322 FT 029.
  - ▣ Drying out is completed when dew points are lower than  $-60^{\circ}\text{C}$ .
- After drying out, put all manual valves in their default position as shown in P&ID



## Normal start up – Unit 322 – Upgrader drying out – Expander - Procedure

- The seal gas of the turbine shall also be dried out prior to cool down the upgrader.
- The drying out can be performed with the crude helium flow



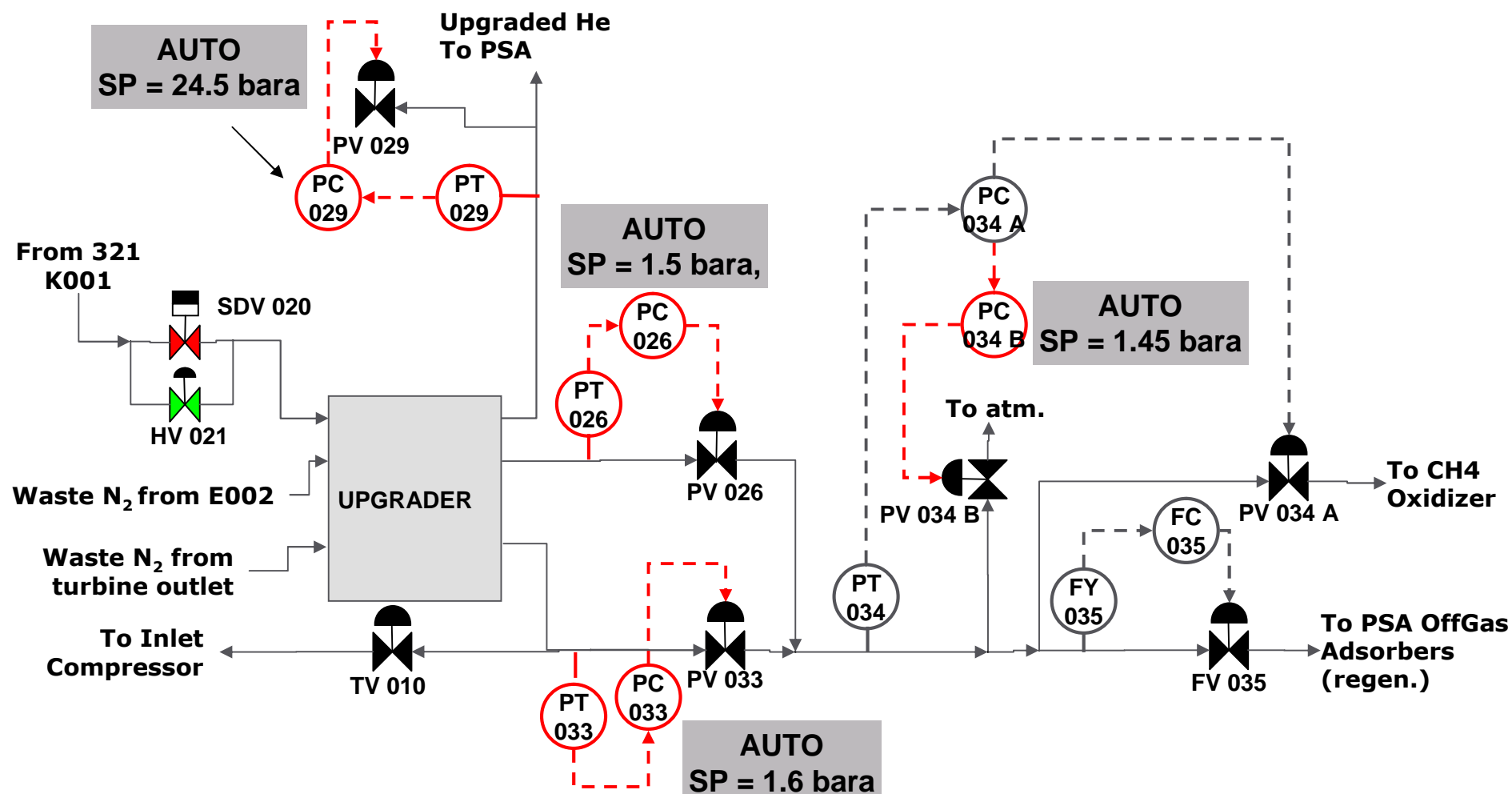
## Normal start up – Unit 322 – Upgrader pressurization

- Slowly open Upgrader inlet valve 322 HV 021 up to 100% in order to increase pressure.
- Check that all pressure valves are regulating (322-PV-010, 322-PV-026, 322-PV-029, 322-PV-033, 322-PV-034 A and B).
- 322-PDT-020 (at 322-SDV-020 limits) should decrease with pressure increase in Upgrader.
- When 322 PDT 020 is lower than 0.1 bar, reset 322 HS R 020 to open the main Upgrader inlet valve 322 SDV 020.
  - If this permissive condition to open the valve is too difficult to reached, manually increase the set point of 322-PC-034
- Finally, close the bypass 322 HV 021.

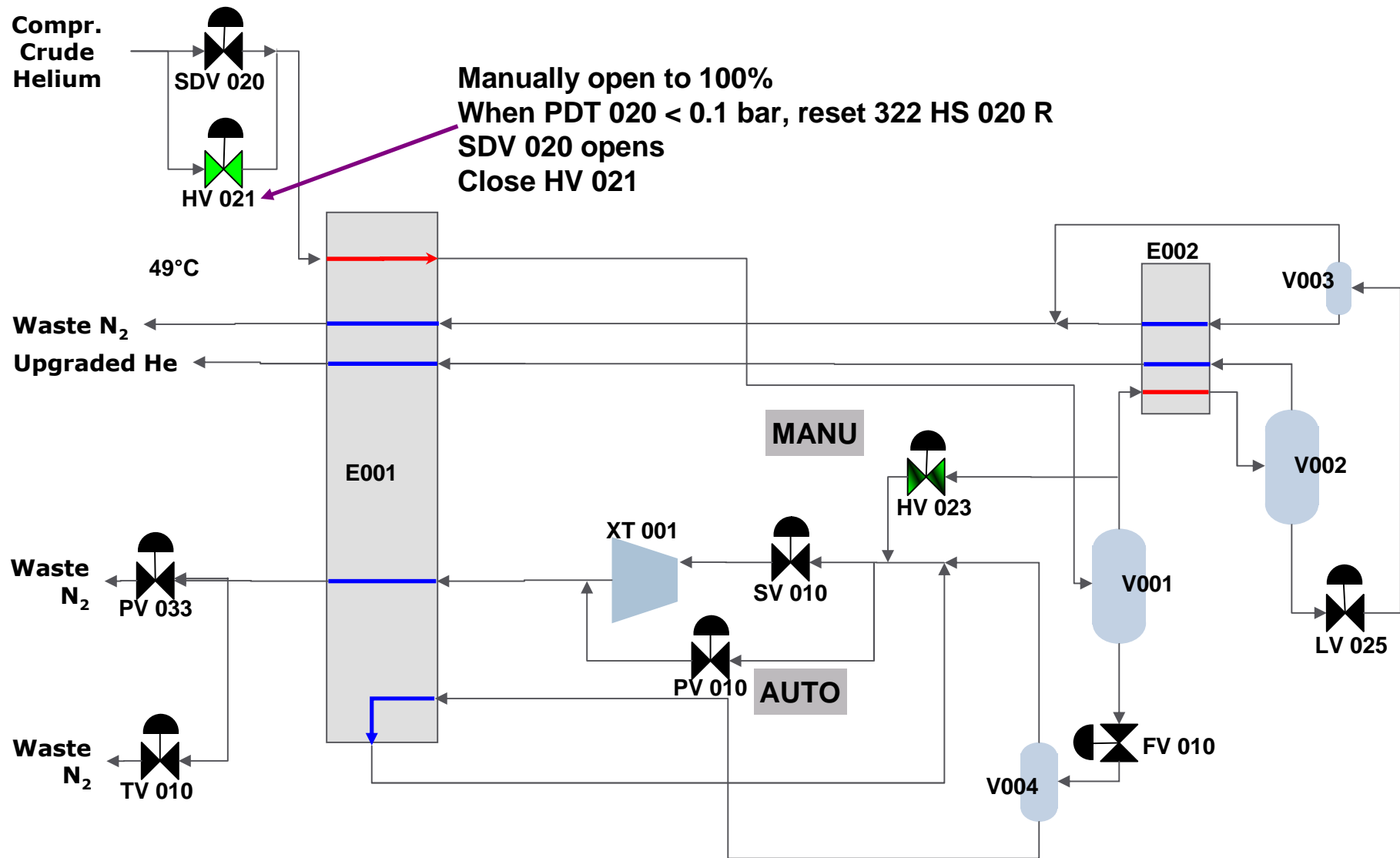


# Normal start up – Unit 322 – Upgrader pressurization

## ■ Pressure regulation at Upgrader limits



# Normal start up – Unit 322 – Upgrader pressurization



## Normal start up – Unit 322 – Upgrader cooling down

- Duration: cooling down lasts 24h from a warm start up

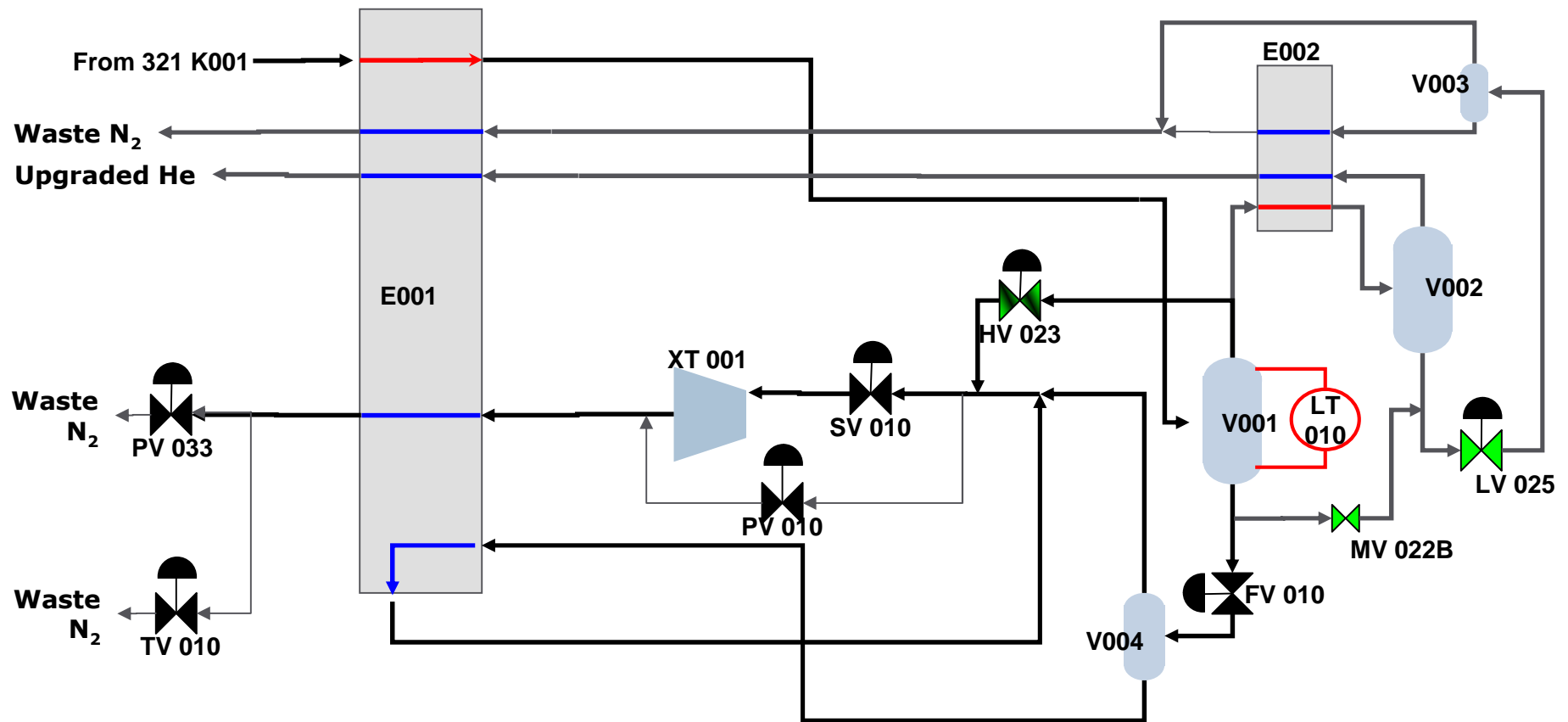
### Start turbine

- Reset 322 UY 001 by starting Upgrader
- Start the turbine → this will start the ramp up of 322 SV 010 → turbine speed will slowly increase
  - From a warm start up, an insufficient pressure at turbine inlet to feed the turbine can be detected as speed value does not manage to match its set point. Then, it is necessary to increase feed flow by opening 322 HV 023.
  - From a warm start up, if the inlet feed in turbine is too high, the speed is maximum. If by-pass 322 PV 010 is open, reduce 322 HV 023 opening as long as the feed flow is sufficient to feed the turbine.
  - For a cold startup, keep 322 HV 023 closed. Open 322 FV 010 to maintain a sufficient flow at turbine inlet.
- Temperature will slowly decrease in the Upgrader.
- When 322 TI 022 ~ -170°C, liquid starts pouring at the outlet of 322 FV 010.

# Normal start up – Unit 322 – Upgrader cooling down

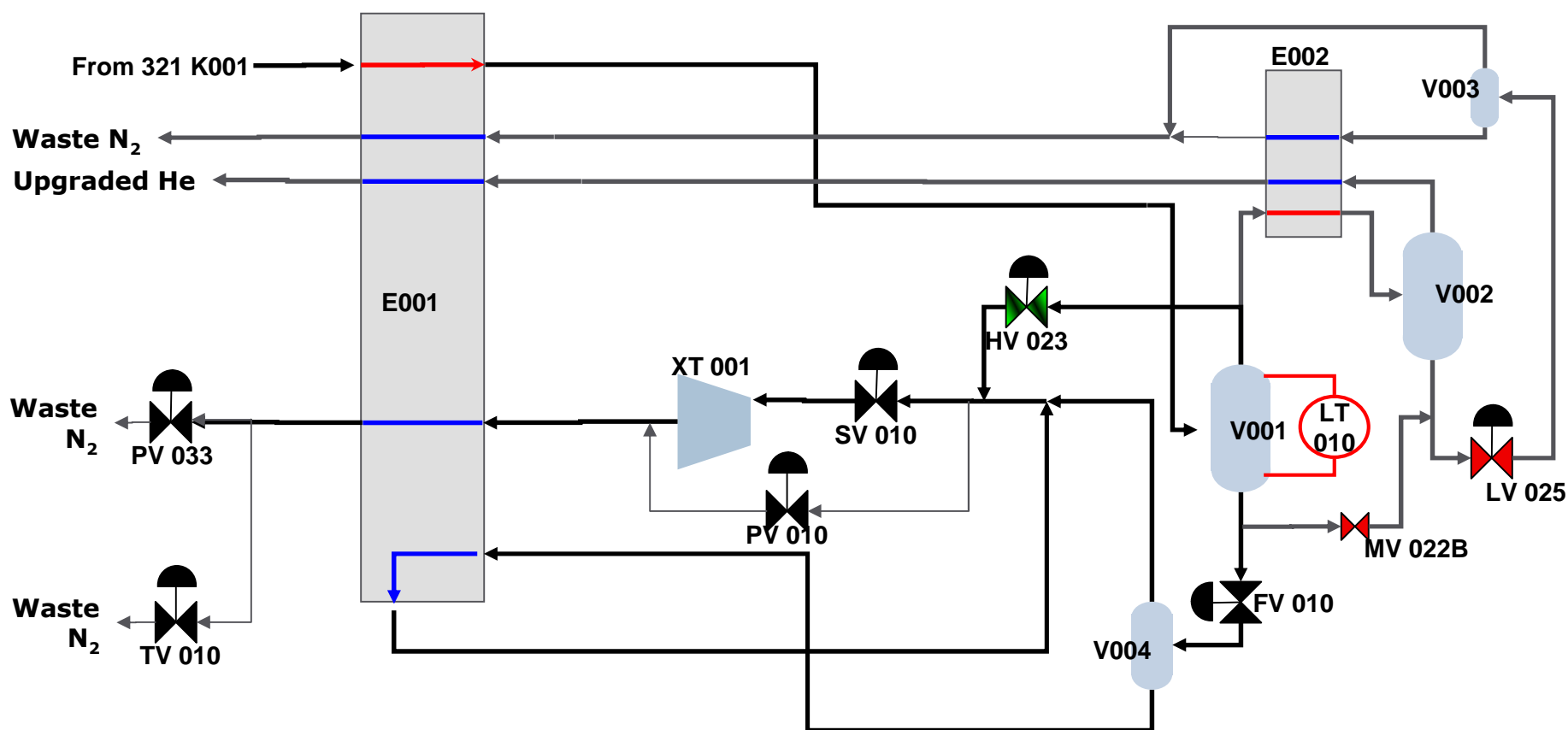
## Cool down E001

- Open the valve 322-MV-022B, connecting 322-V001 and 322-V002
- Open 322-LV-025



# Cool down E001

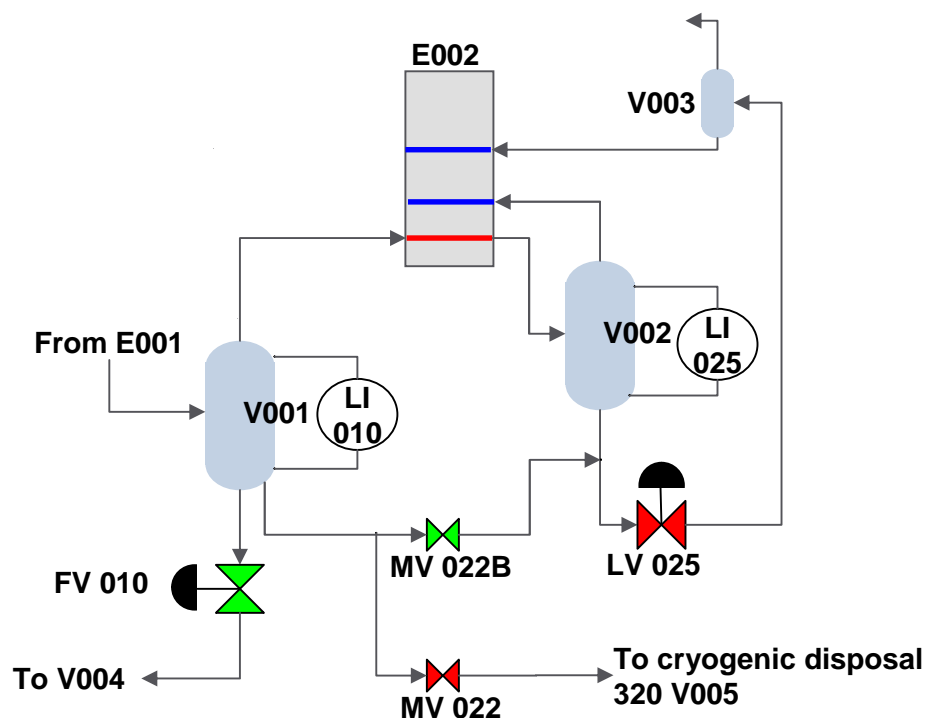
- When temperature is  $\sim -160^{\circ}\text{C}$ , close 322-LV-025 and 32-MV-022B to build up the level in 322-V001 up to 20-30%



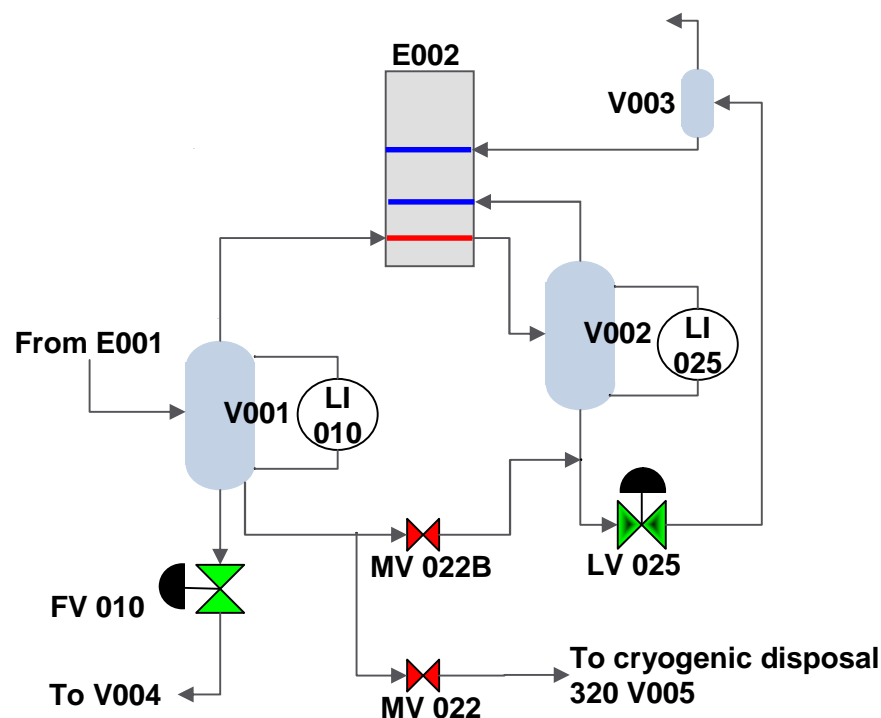
# Normal start up – Unit 322 – Upgrader cooling down

## Cool down E002

**STEP 1:** When LC 010 set point is reached, open 322 MV 022B. Liquid will pour from V001 to V002



**STEP 2:** When LT 025 = 40%, Close 322 MV 022 B. Then, open 322 LV 025 at 10-15%

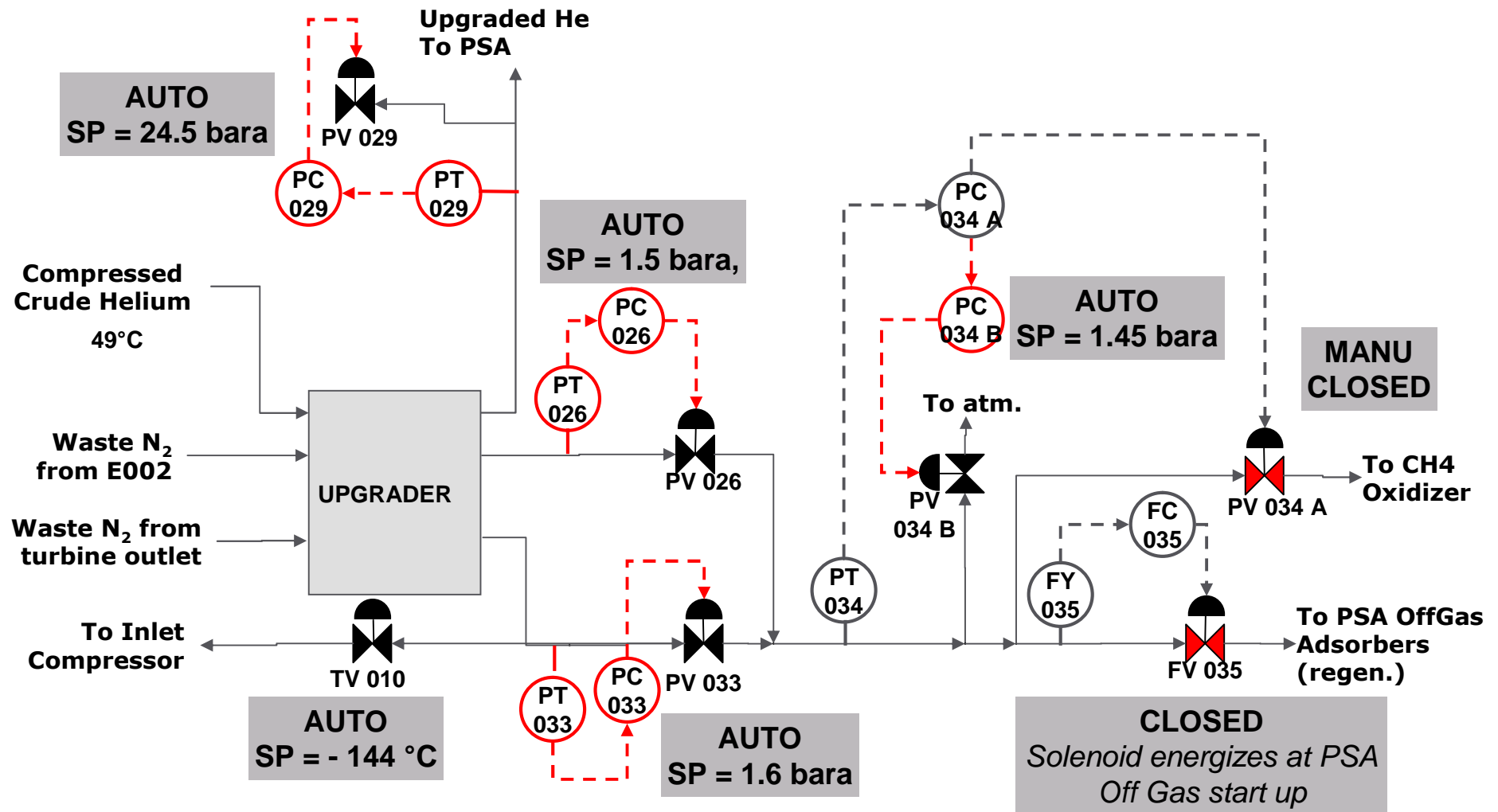


- E002 is cold when 322 TI 025 is below  $-190^{\circ}\text{C}$  or level 322 LI 025 is at 10%

## Stabilize Upgrader

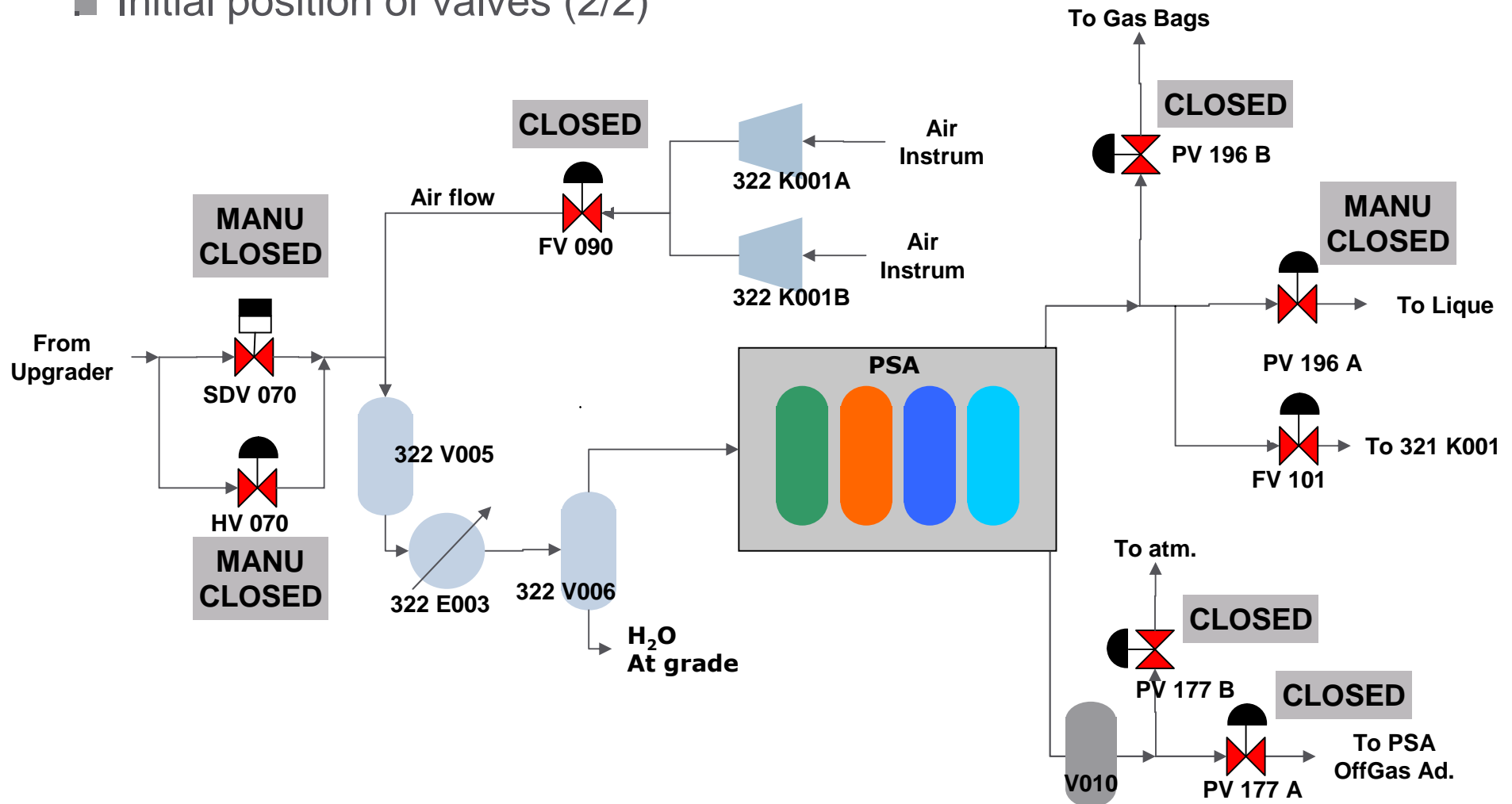
# Normal start up – Unit 322 – Catalytic Reactor, PSA and PSA OffGas Adsorbers – Preparation

## ■ Initial position of valves (1/2)



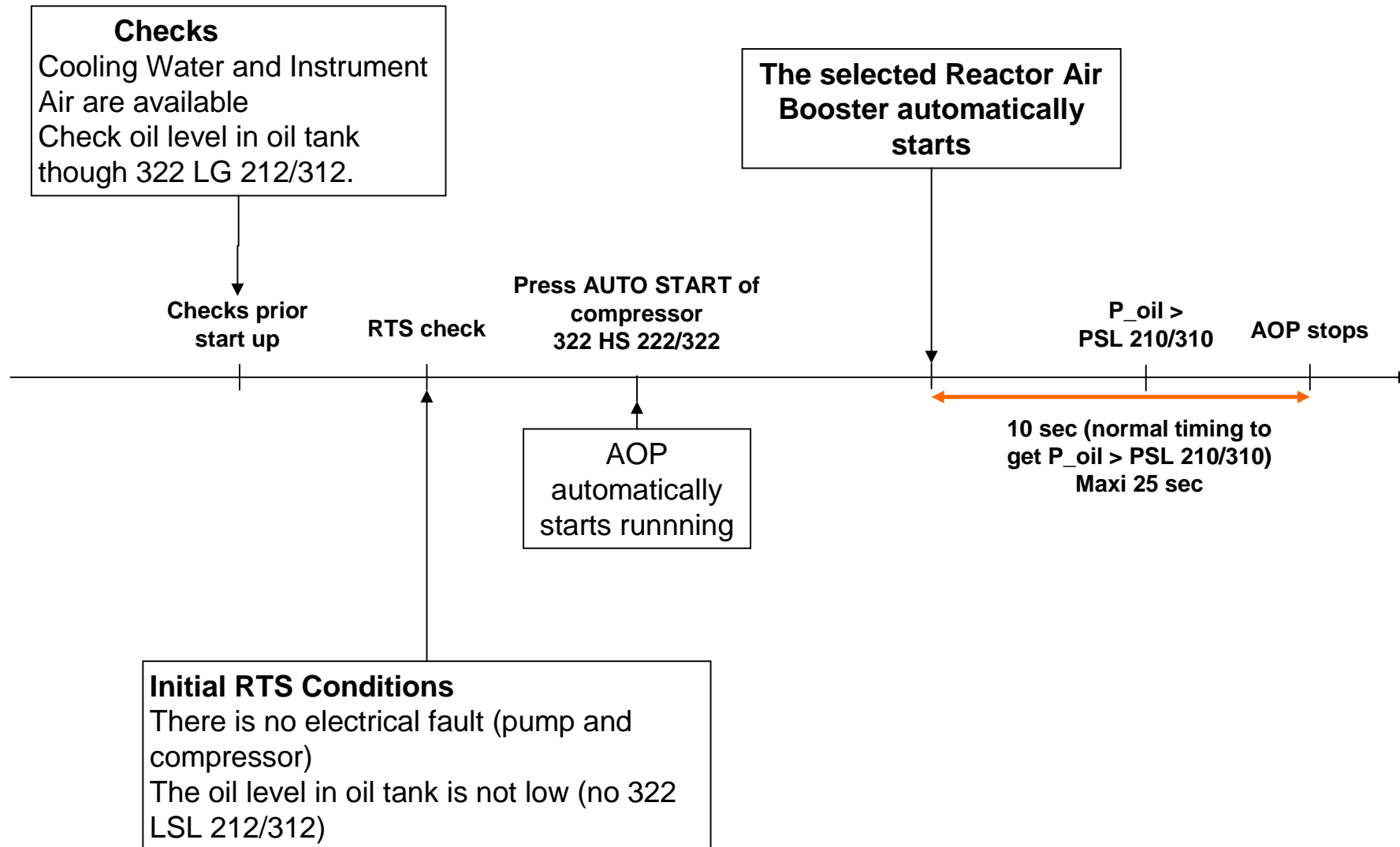
# Normal start up – Unit 322 – Catalytic Reactor, PSA and PSA OffGas Adsorbers – Preparation

## ■ Initial position of valves (2/2)





# Normal start up – Unit 322 – Reactor Air Boosters start up



## Normal start up – Unit 322 – PSA OffGas Adsorbers - Preparation

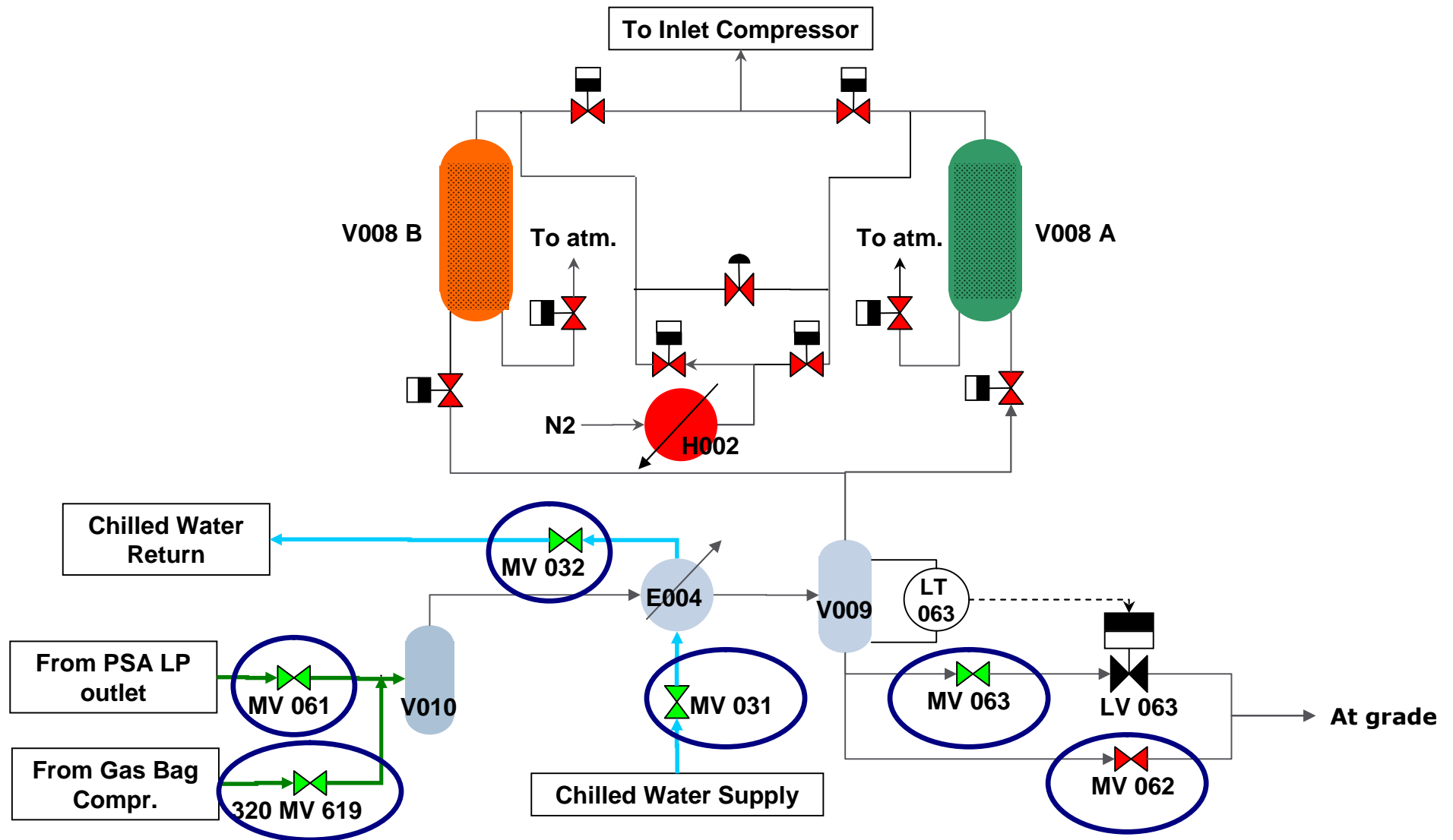
### ■ Preliminary checks

- Check that Chilled Water supply and return valves 320 MV 031 and 320 MV 032 are open. Check Chilled Water is flowing.
- Check PSA OffGas Cooler Drum 322 V009 drain valves are in the right position (as mentioned in the P&ID): 322 MV 062 and 322 LV 063 are closed, 322 MV 063 is open.
- Make sure PSA OffGas Chiller inlet manual valve, 322 MV 061 is open.
- Check manual valve 320 MV 619 from Gas Bag Compressor is open.

### ■ Select the bottle to be regenerated:

- First start up, both bottles are suitable
- Start up after shutdown: at shutdown, the status of the bottles must have been recorded. During a voluntary shutdown, the stop order must occur at the end of regeneration
- After an exceptional regeneration, if necessary, initialize the off gas adsorber sequence. The procedure is:
  - Close all regeneration valves and open all off gas valves
  - Initialize the sequence (press 322 HS 489 from the DCS)
  - Select the bottle which will be regenerated with switch 322 HS 480
  - Press NEXT STEP button (322 HS 481C) to isolate in “HP Isolation” the bottle that has been selected to be regenerated.

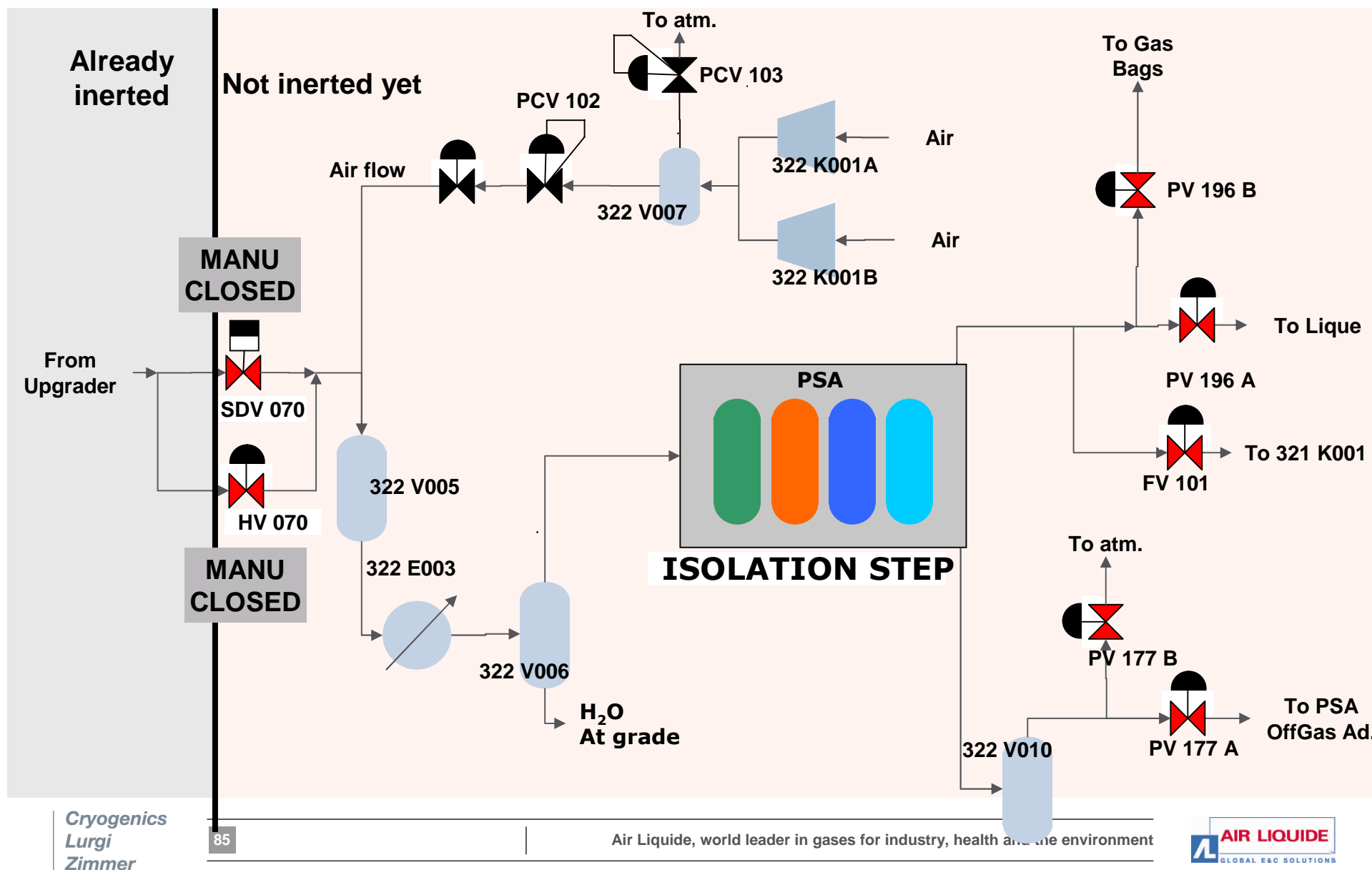
## Normal start up – Unit 322 – PSA OffGas Adsorbers - Preparation



## Normal start up – Unit 322 – PSA preparation – Inerting

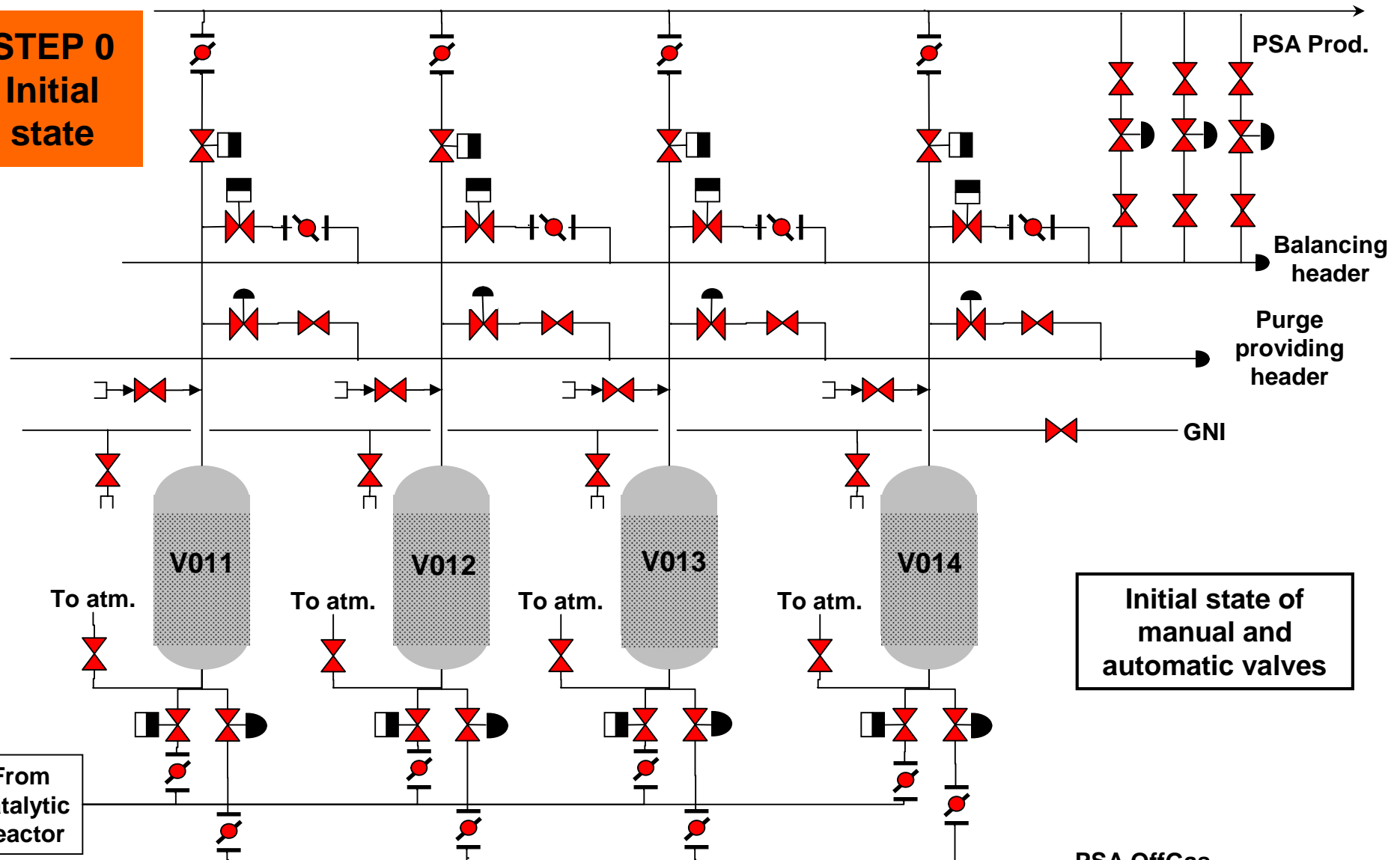
- Target: O<sub>2</sub> content < 0.3%
- Media: N<sub>2</sub> from the network or from an external source
- Procedure:
  - ▣ Inert with dry N<sub>2</sub>
  - ▣ Increase the pressure up to 2.7 bara
  - ▣ Decrease the pressure down to 1.3 bara
  - ▣ Perform this 3-step sequence 10 times.
- Pre-requisites:
  - ▣ SDV 070 is closed.
  - ▣ The plant is inerted up to SDV 070
  - ▣ Check the PSA is in isolation, i.e. all valves are closed.

# Normal start up – Unit 322 – PSA preparation – Inerting



# Normal start up – Unit 322 – PSA preparation – Inerting

## STEP 0 Initial state



From  
Catalytic  
Reactor

Cryogenics  
Lurgi  
Zimmer

86

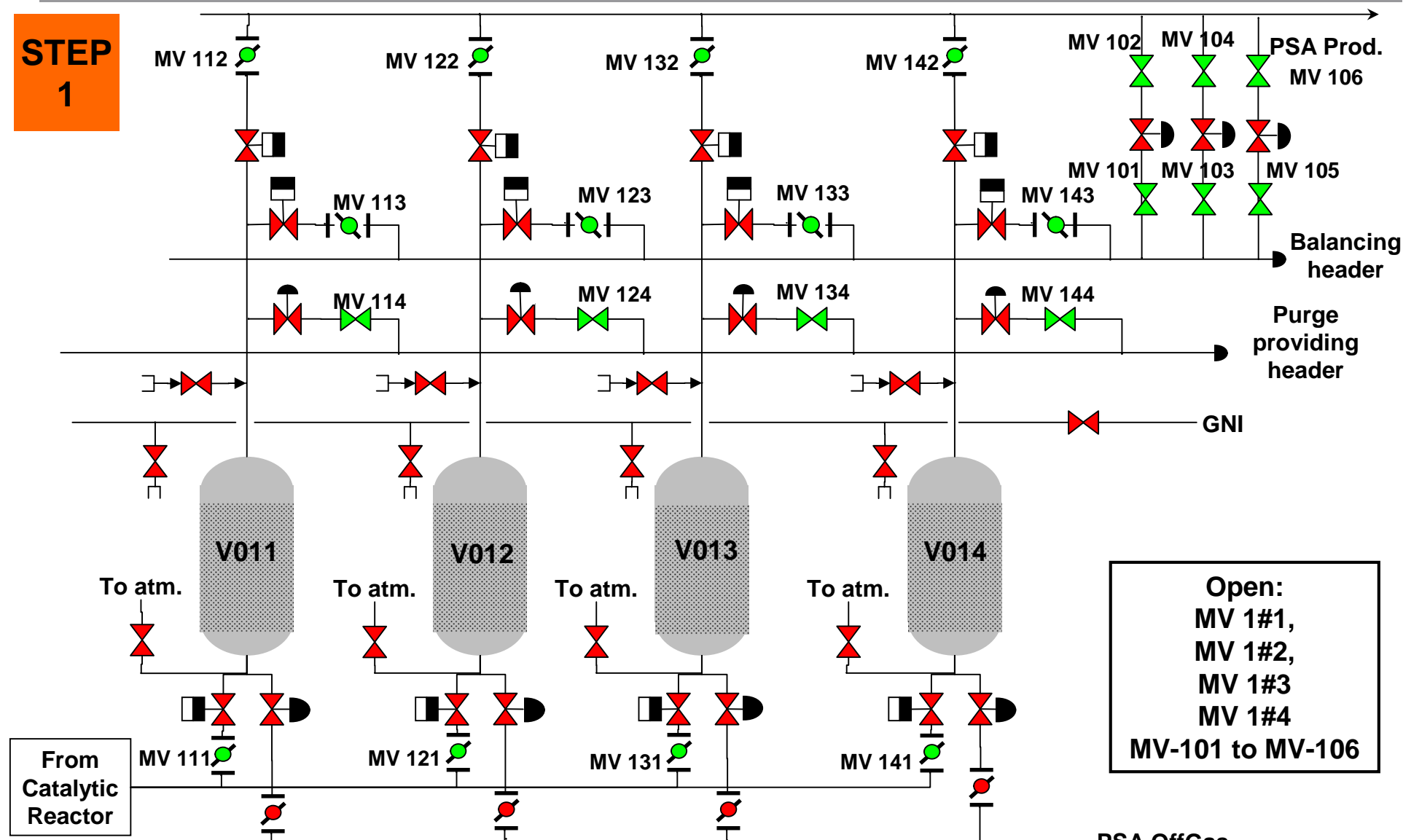
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PSA OffGas

AIR LIQUIDE  
GLOBAL E&C SOLUTIONS

# Normal start up – Unit 322 – PSA preparation – Inerting

**STEP  
1**



Cryogenics  
Lurgi  
Zimmer

87

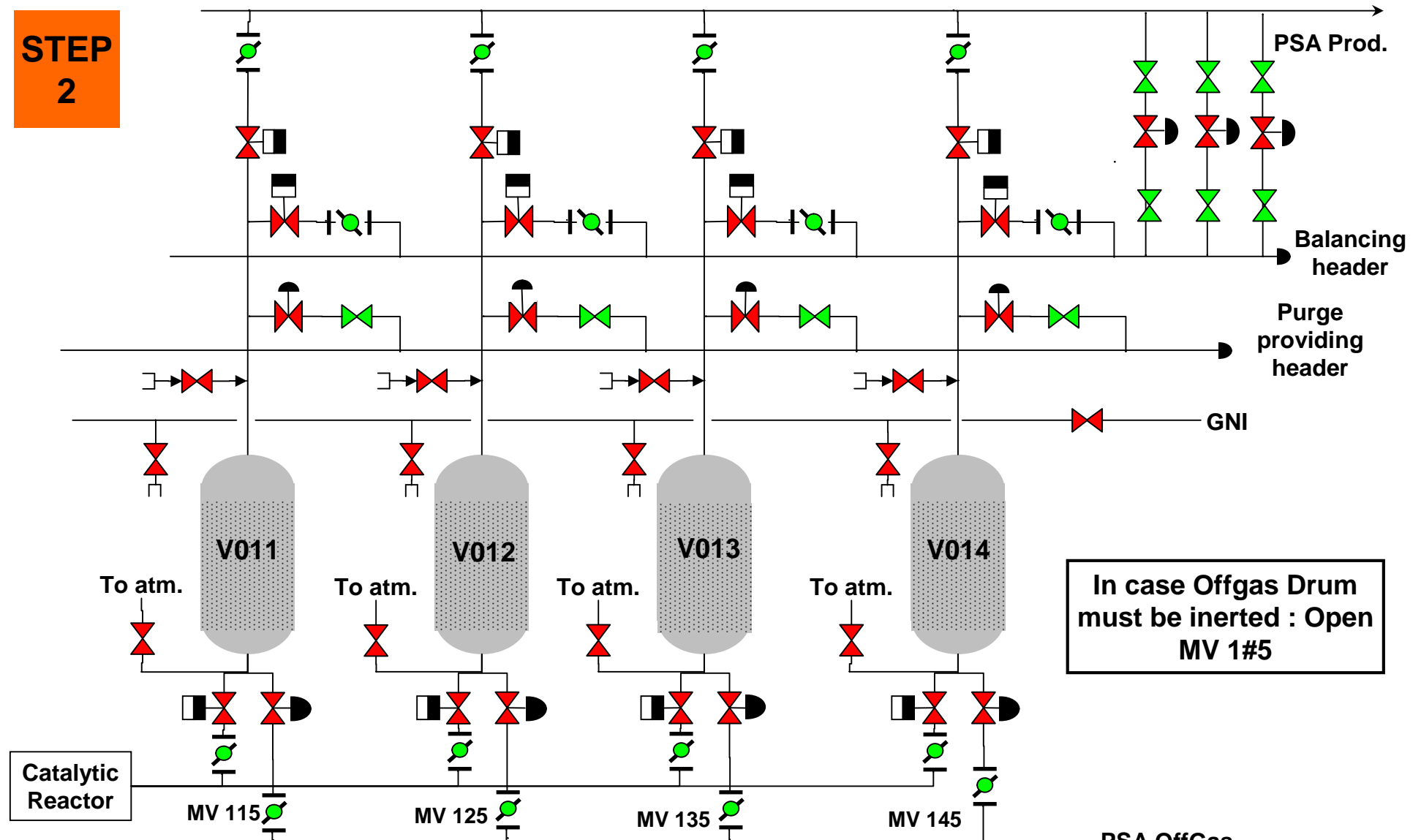
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# Normal start up – Unit 322 – PSA preparation – Inerting

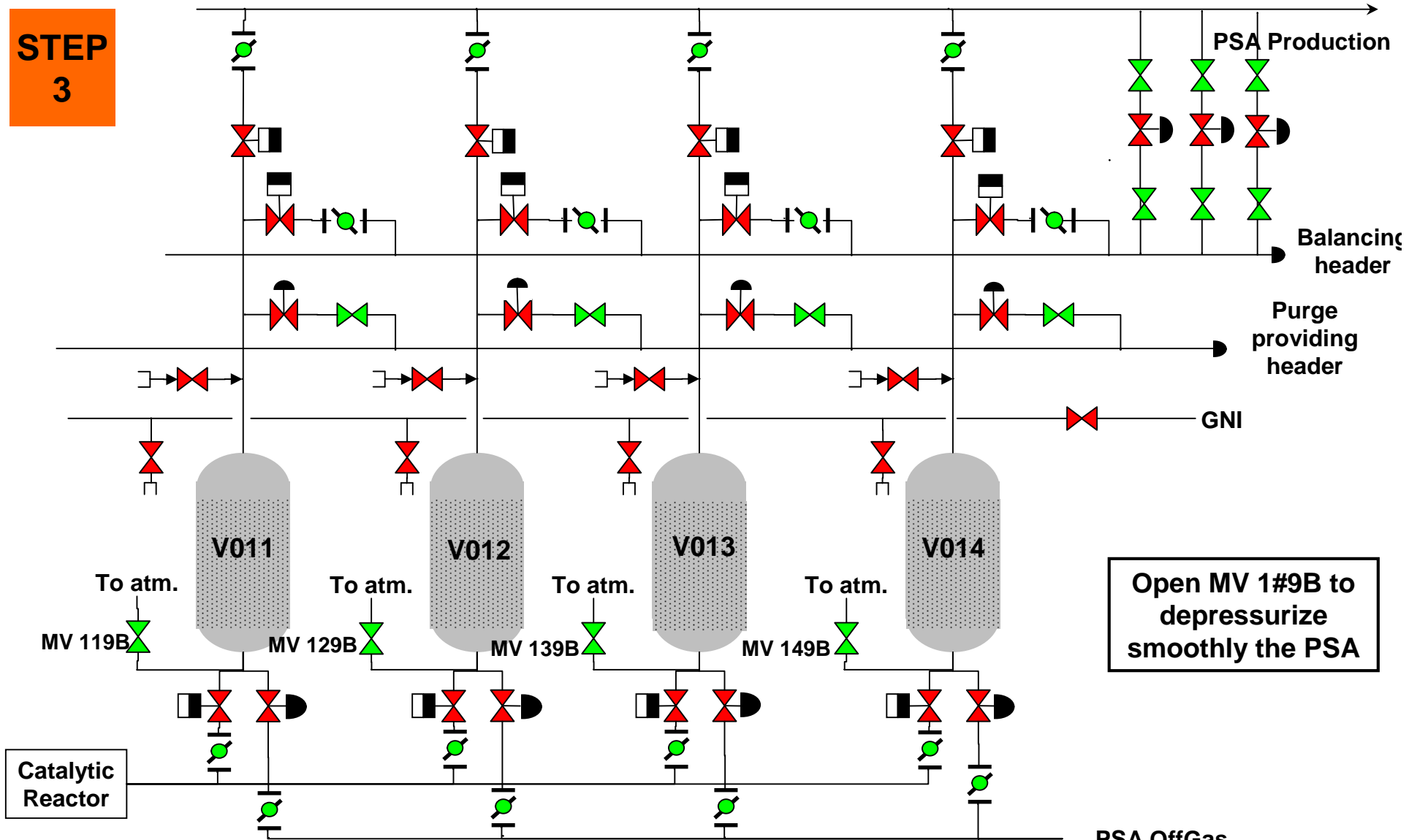
**STEP  
2**





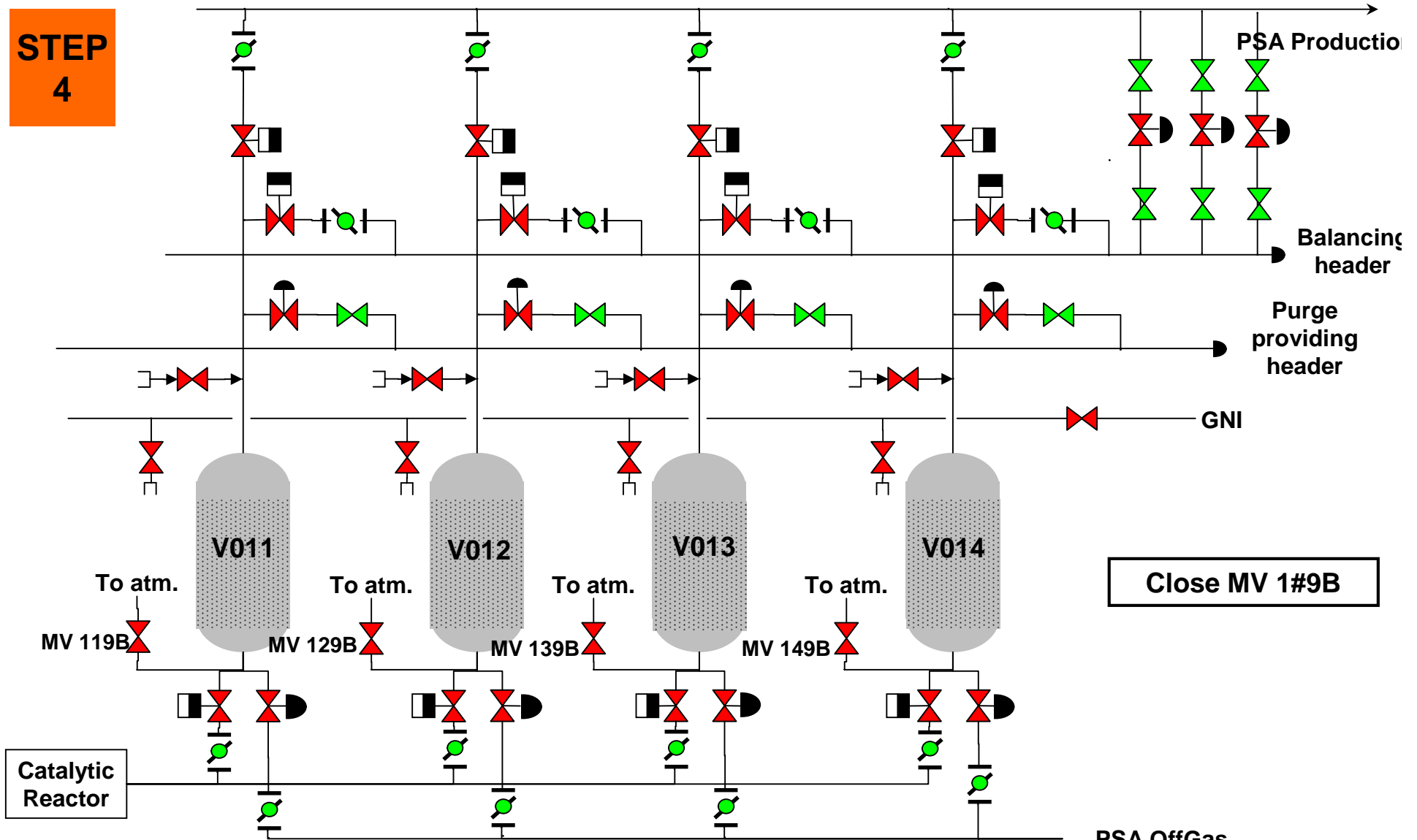
# Normal start up – Unit 322 – PSA preparation – Inerting

**STEP  
3**



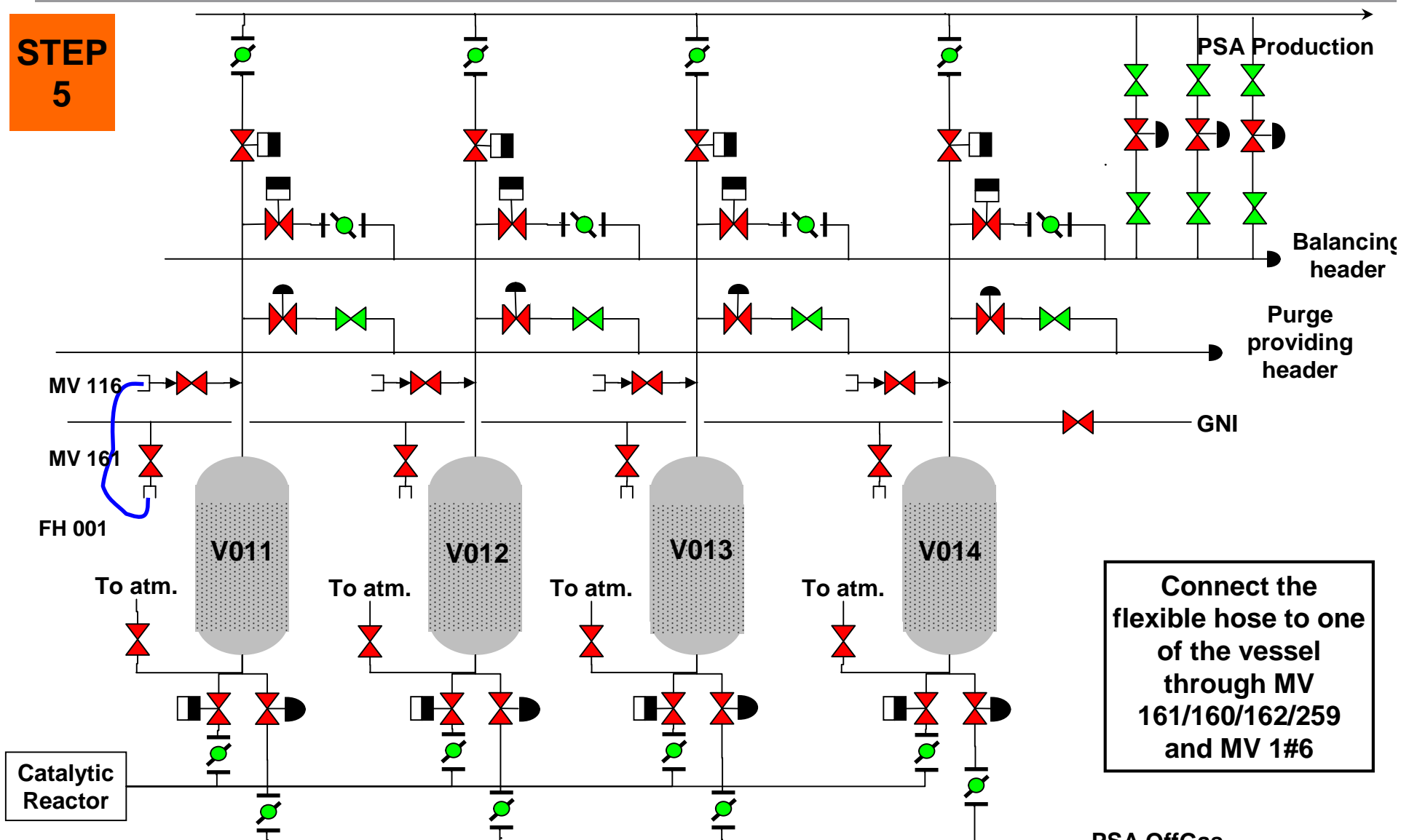
# Normal start up – Unit 322 – PSA preparation – Inerting

**STEP  
4**



# Normal start up – Unit 322 – PSA preparation – Inerting

**STEP  
5**



Connect the flexible hose to one of the vessel through MV 161/160/162/259 and MV 1#6

Catalytic Reactor

Cryogenics  
Lurgi  
Zimmer

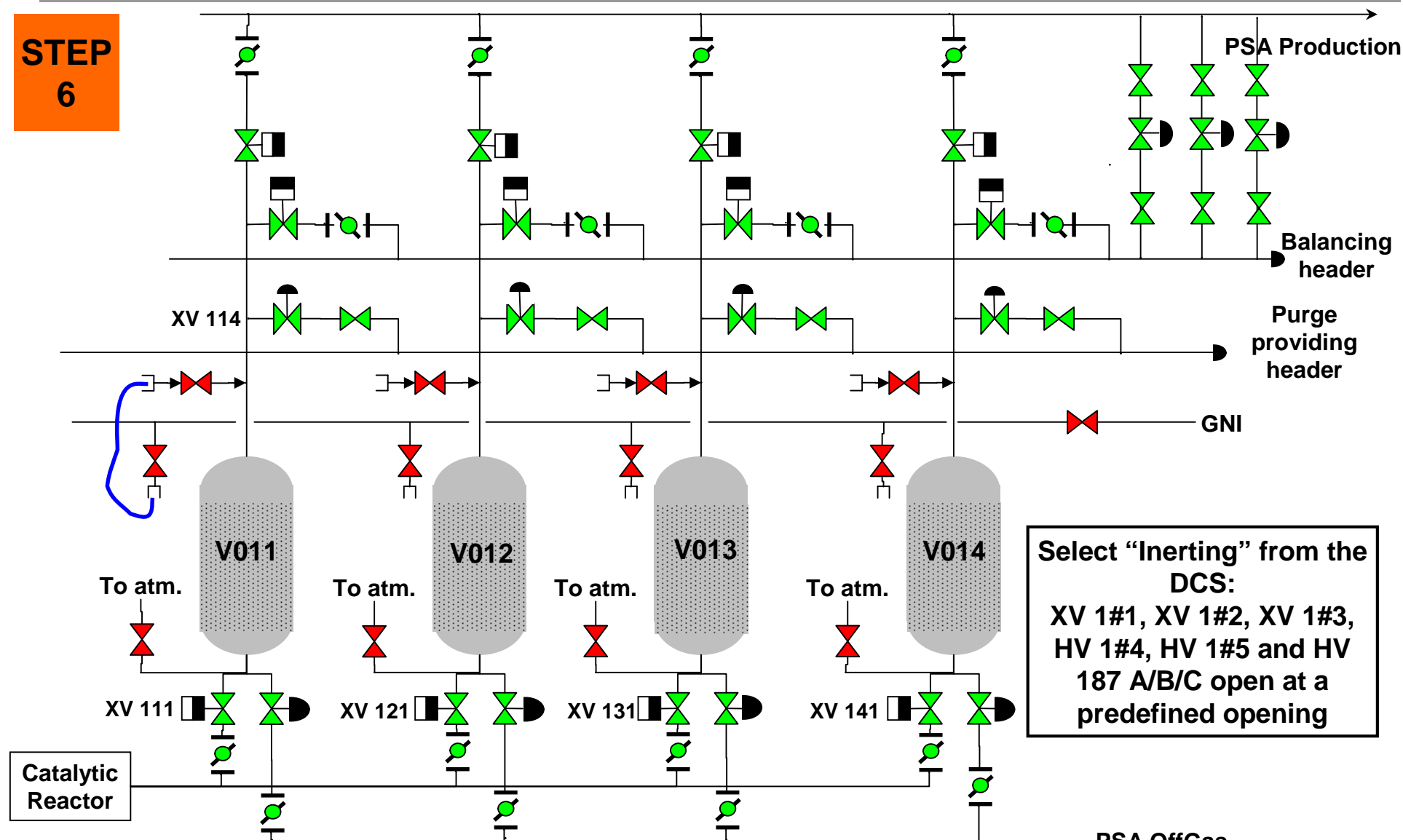
91

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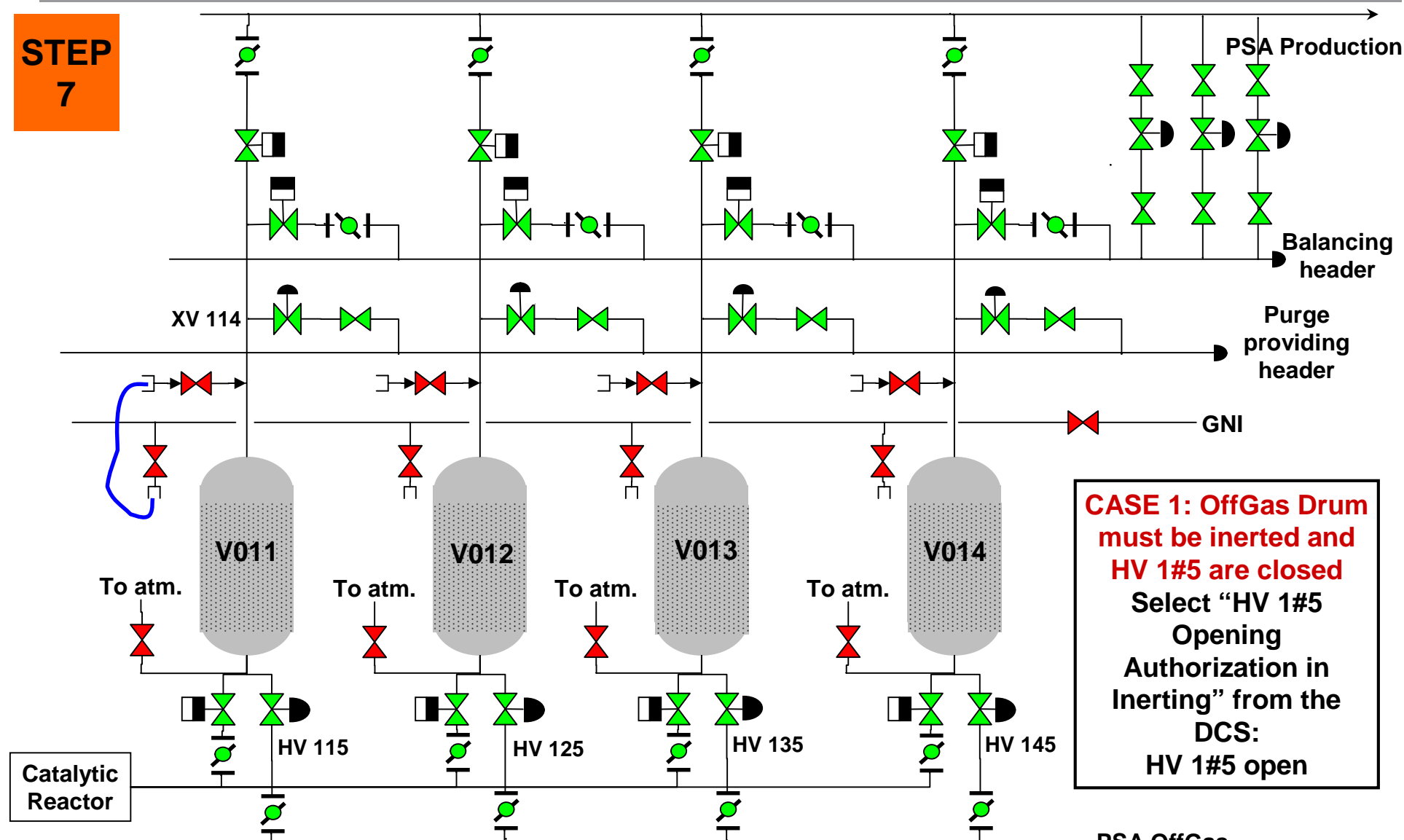
# Normal start up – Unit 322 – PSA preparation – Inerting

**STEP  
6**



# Normal start up – Unit 322 – PSA preparation – Inerting

**STEP  
7**



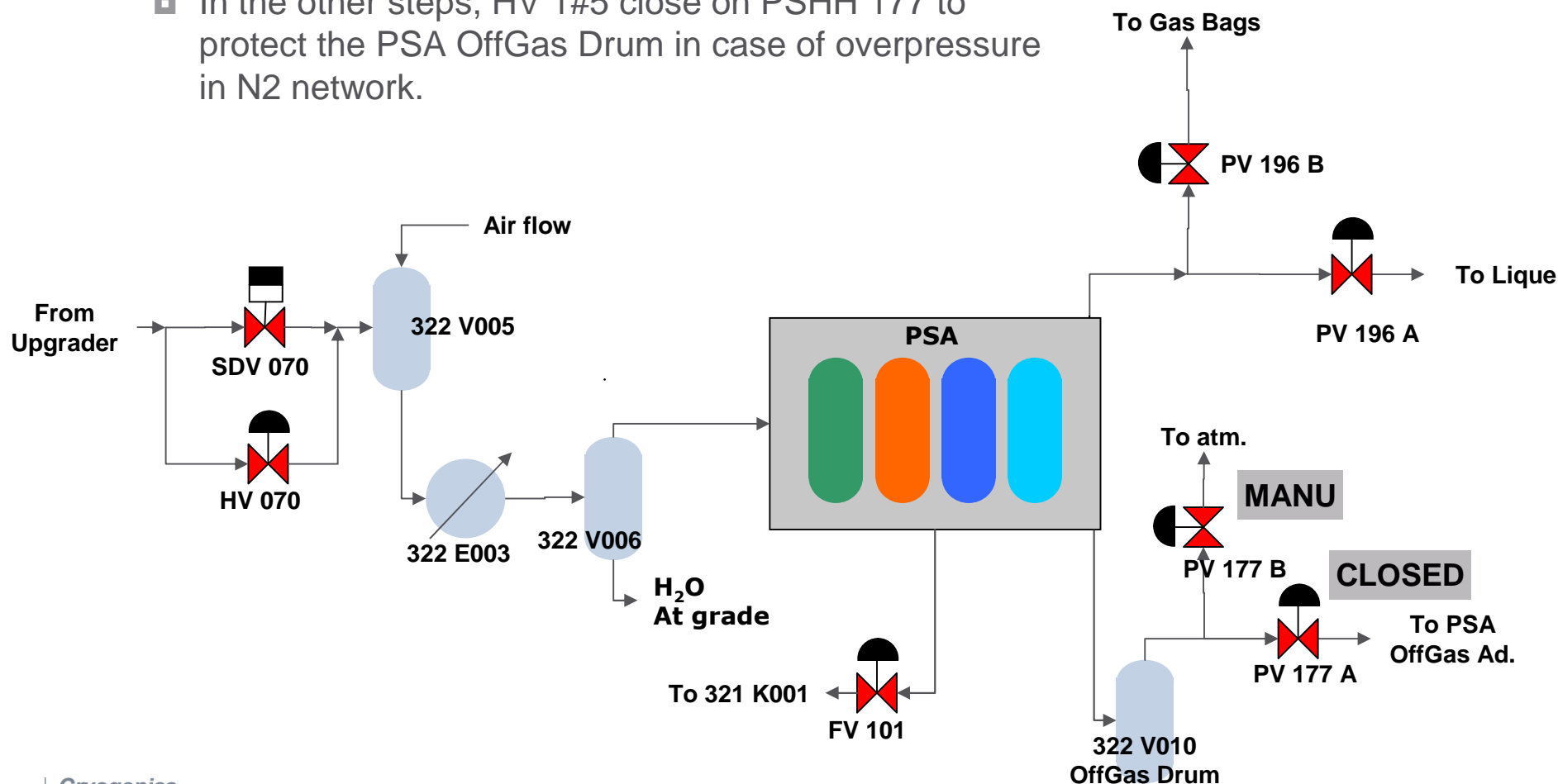
**CASE 1: OffGas Drum  
must be inerted and  
HV 1#5 are closed**  
Select "HV 1#5  
Opening  
Authorization in  
Inerting" from the  
DCS:  
HV 1#5 open

PSA OffGas

# Normal start up – Unit 322 – PSA preparation – Inerting

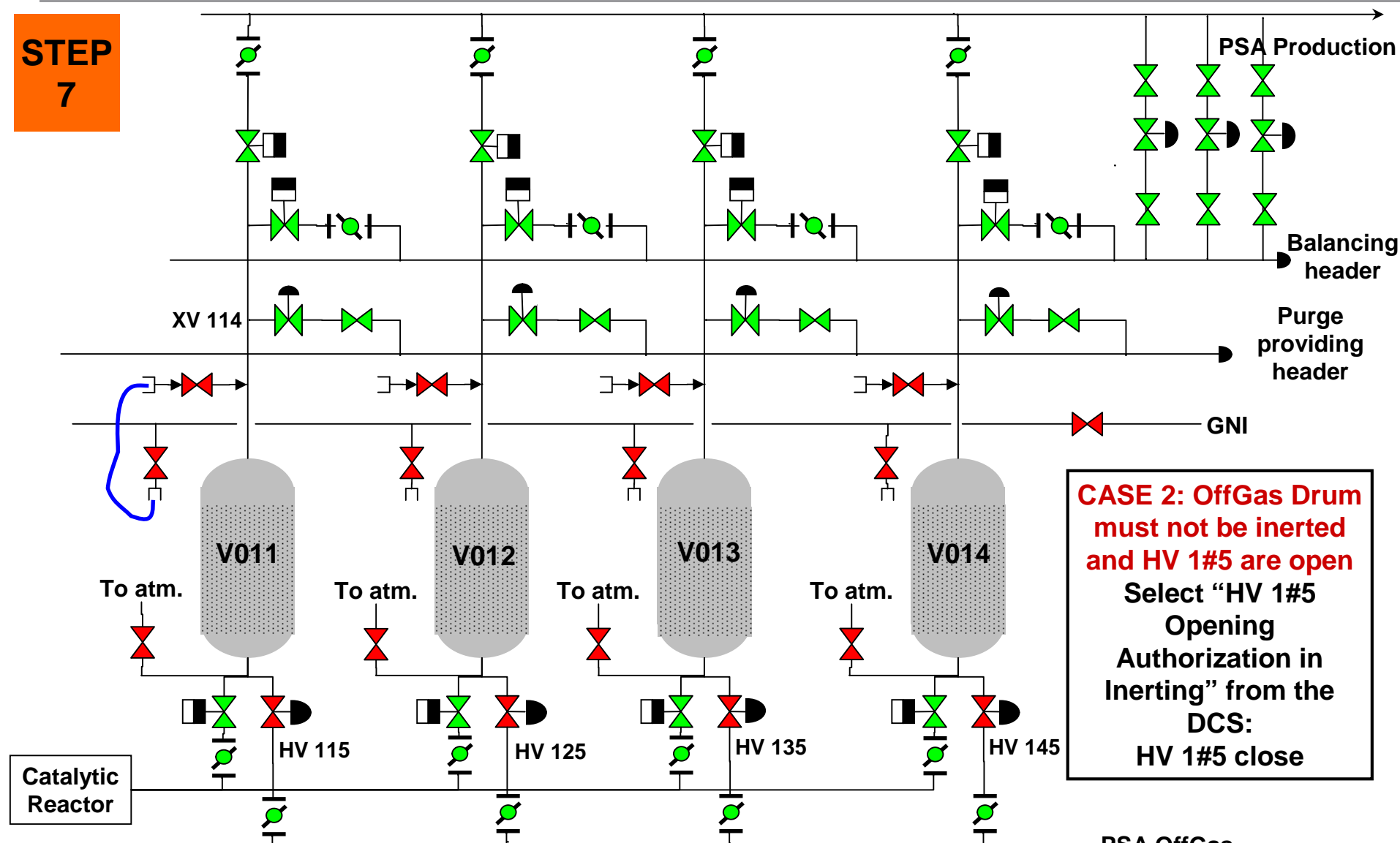
## ■ STEP 7 – CASE 1: OffGas Drum must be inerted

- Set PV 177B in manual mode.
- In the other steps, HV 1#5 close on PSHH 177 to protect the PSA OffGas Drum in case of overpressure in N2 network.



# Normal start up – Unit 322 – PSA preparation – Inerting

**STEP  
7**



Catalytic Reactor

Cryogenics  
Lurgi  
Zimmer

95

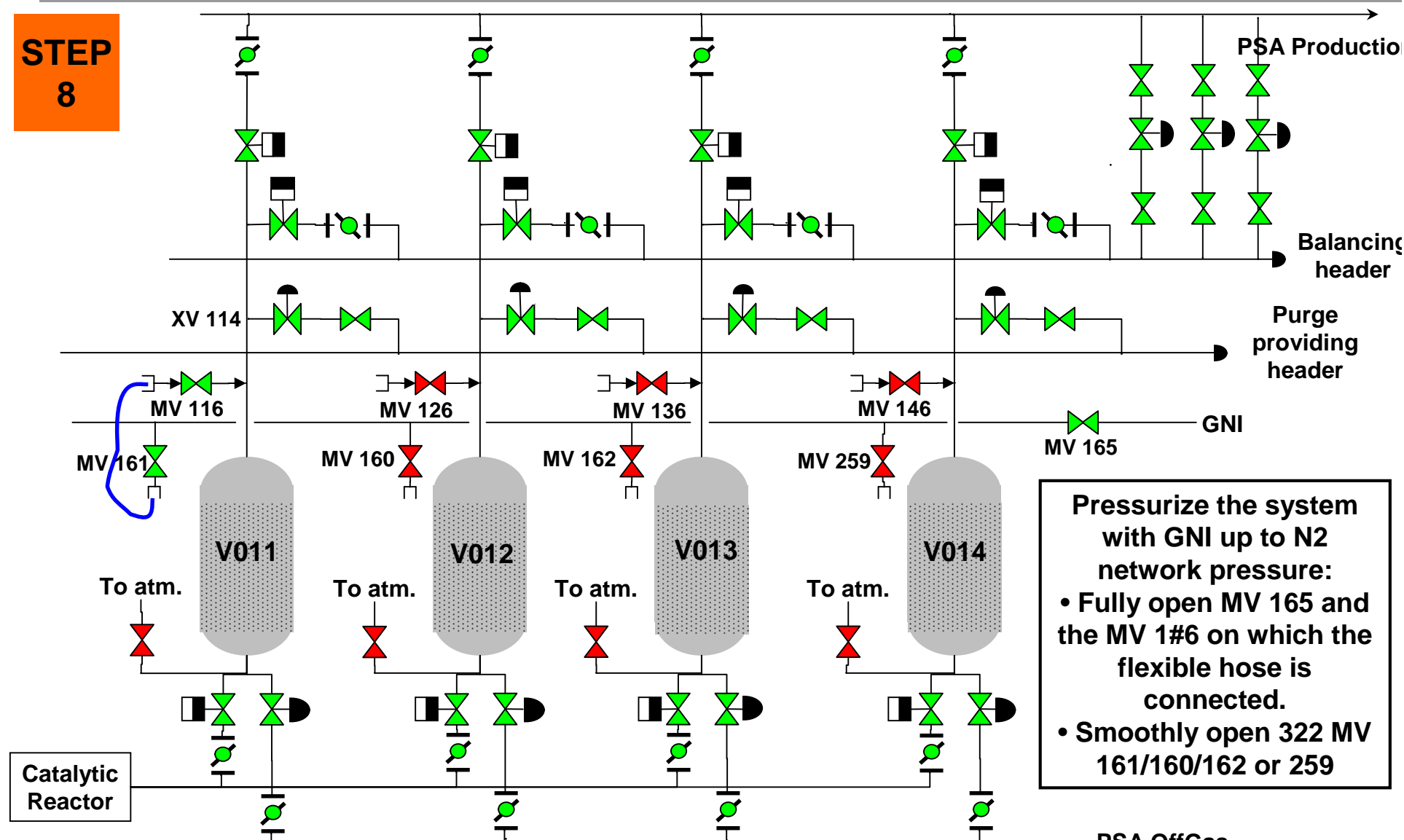
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PSA OffGas

# Normal start up – Unit 322 – PSA preparation – Inerting

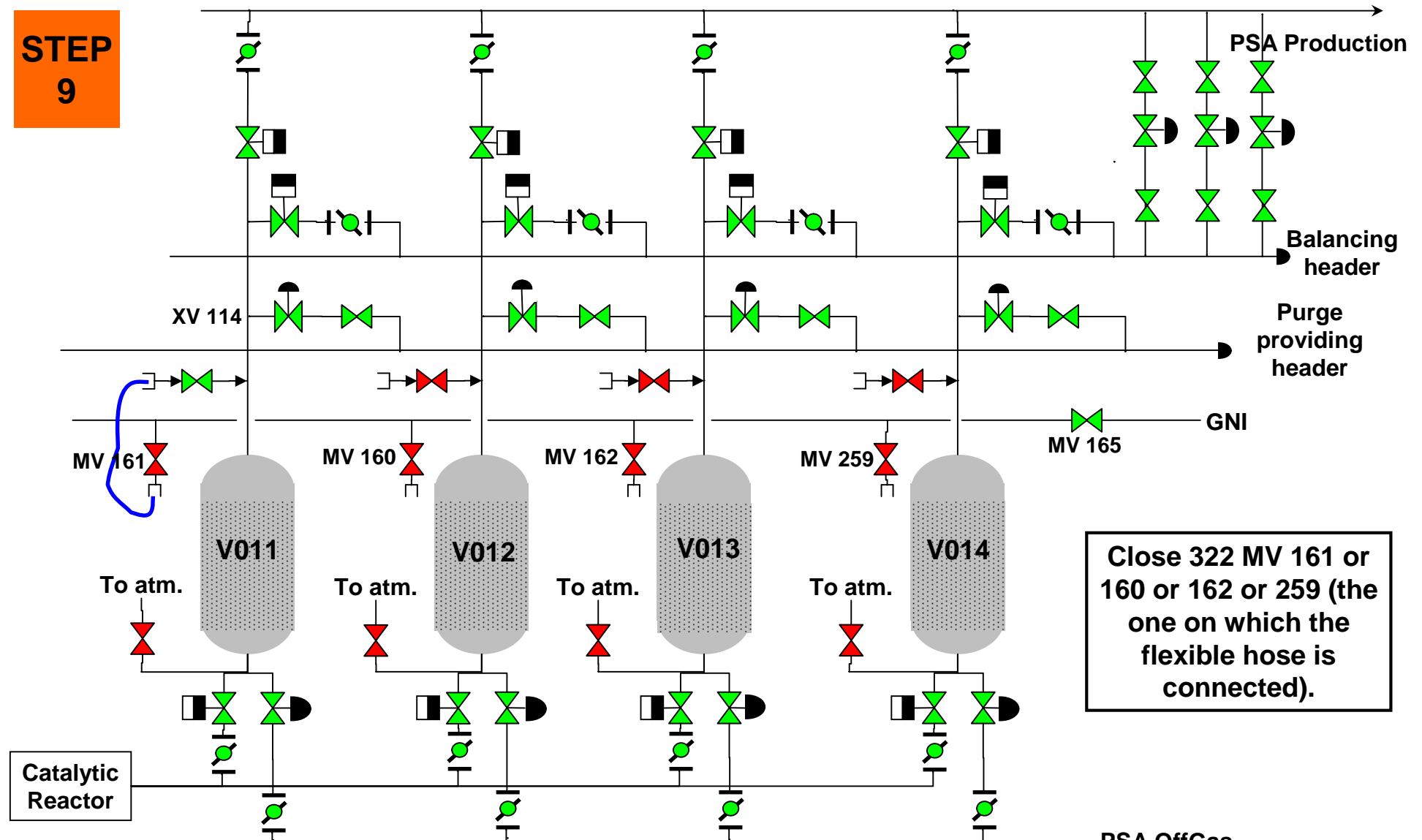
**STEP  
8**





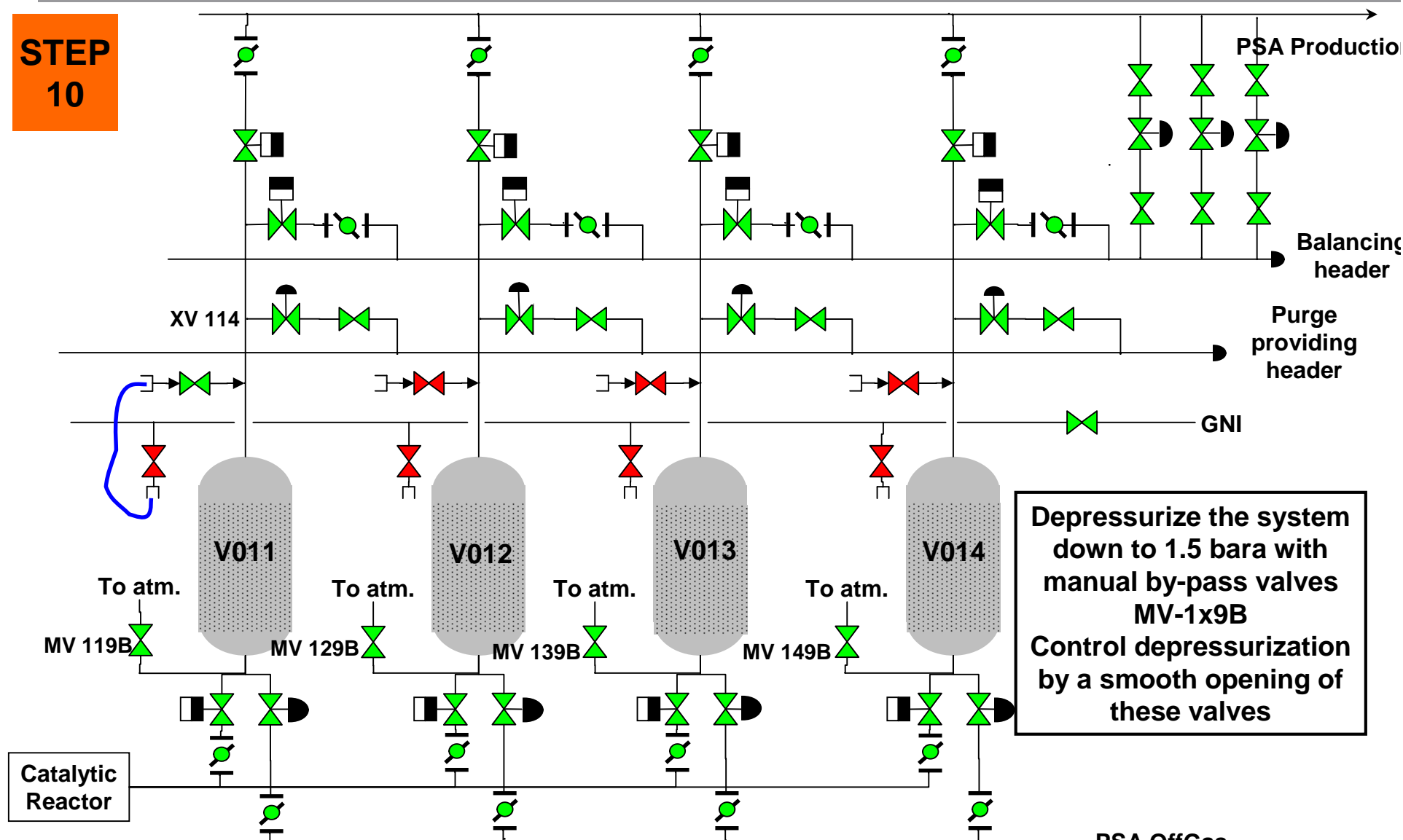
# Normal start up – Unit 322 – PSA preparation – Inerting

**STEP  
9**



# Normal start up – Unit 322 – PSA preparation – Inerting

**STEP  
10**



Catalytic Reactor

Cryogenics  
Lurgi  
Zimmer

98

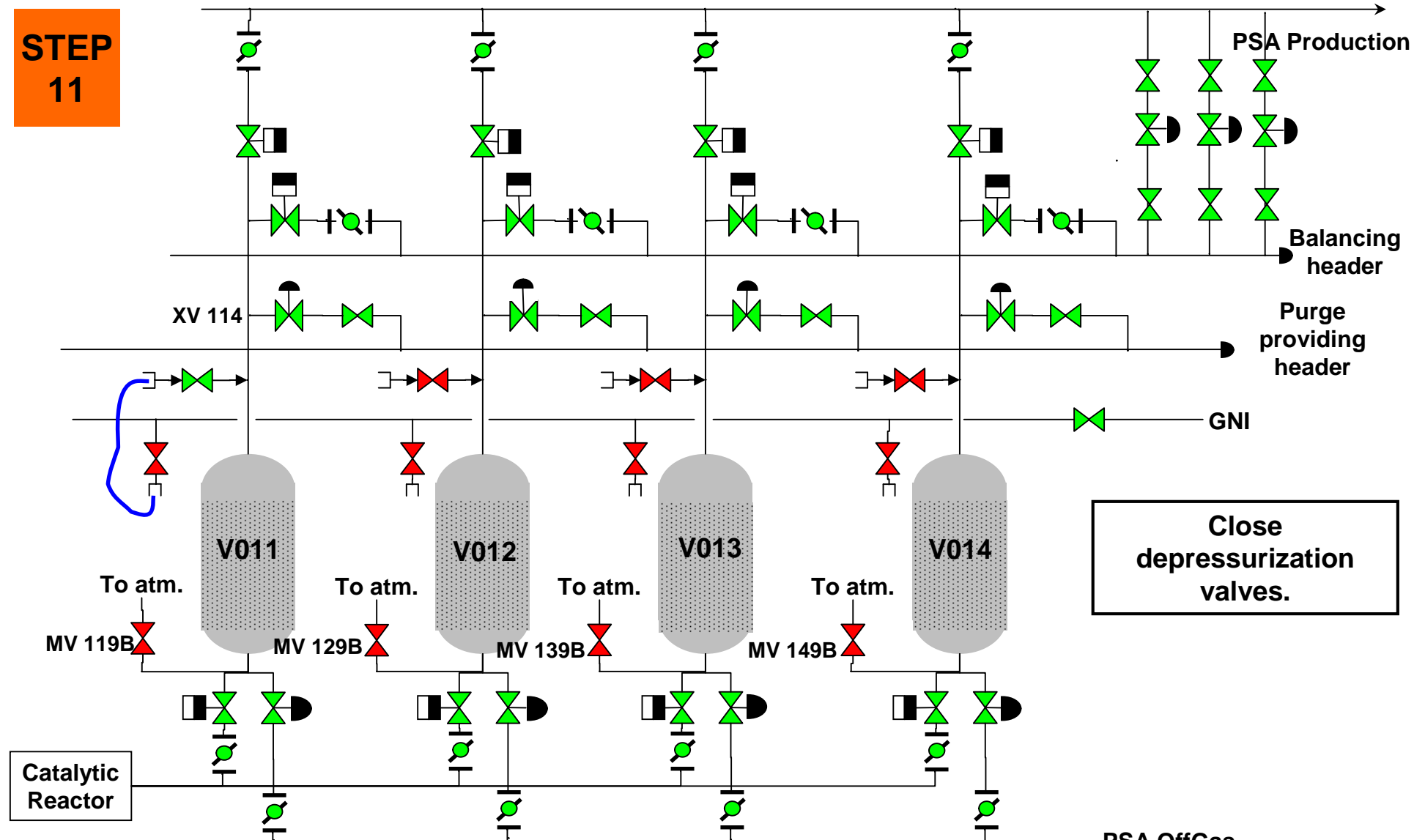
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PSA OffGas

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# Normal start up – Unit 322 – PSA preparation – Inerting

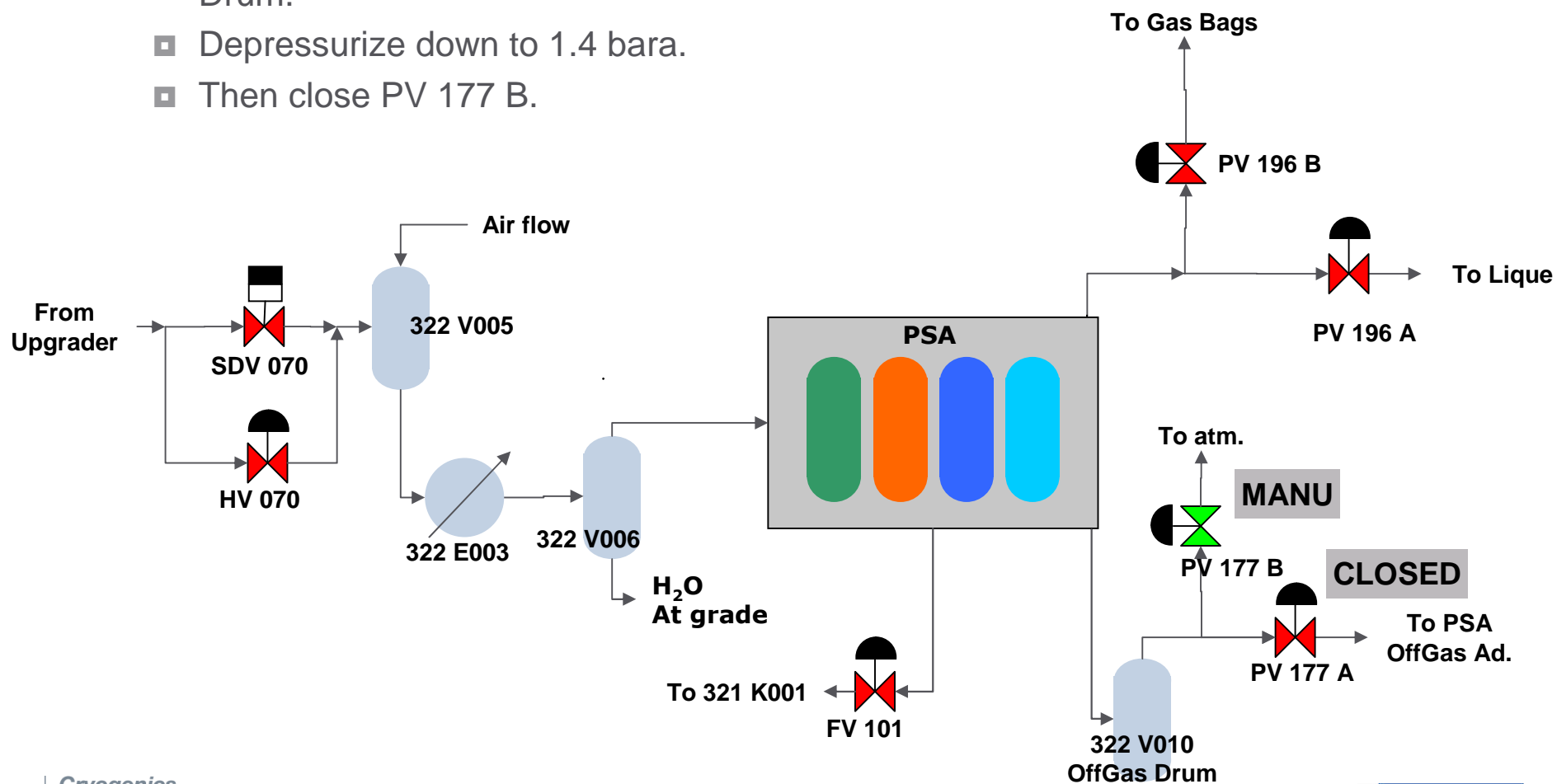
**STEP  
11**



# Normal start up – Unit 322 – PSA preparation – Inerting

## ■ STEP 12 – CASE 1: OffGas Drum must be inerted

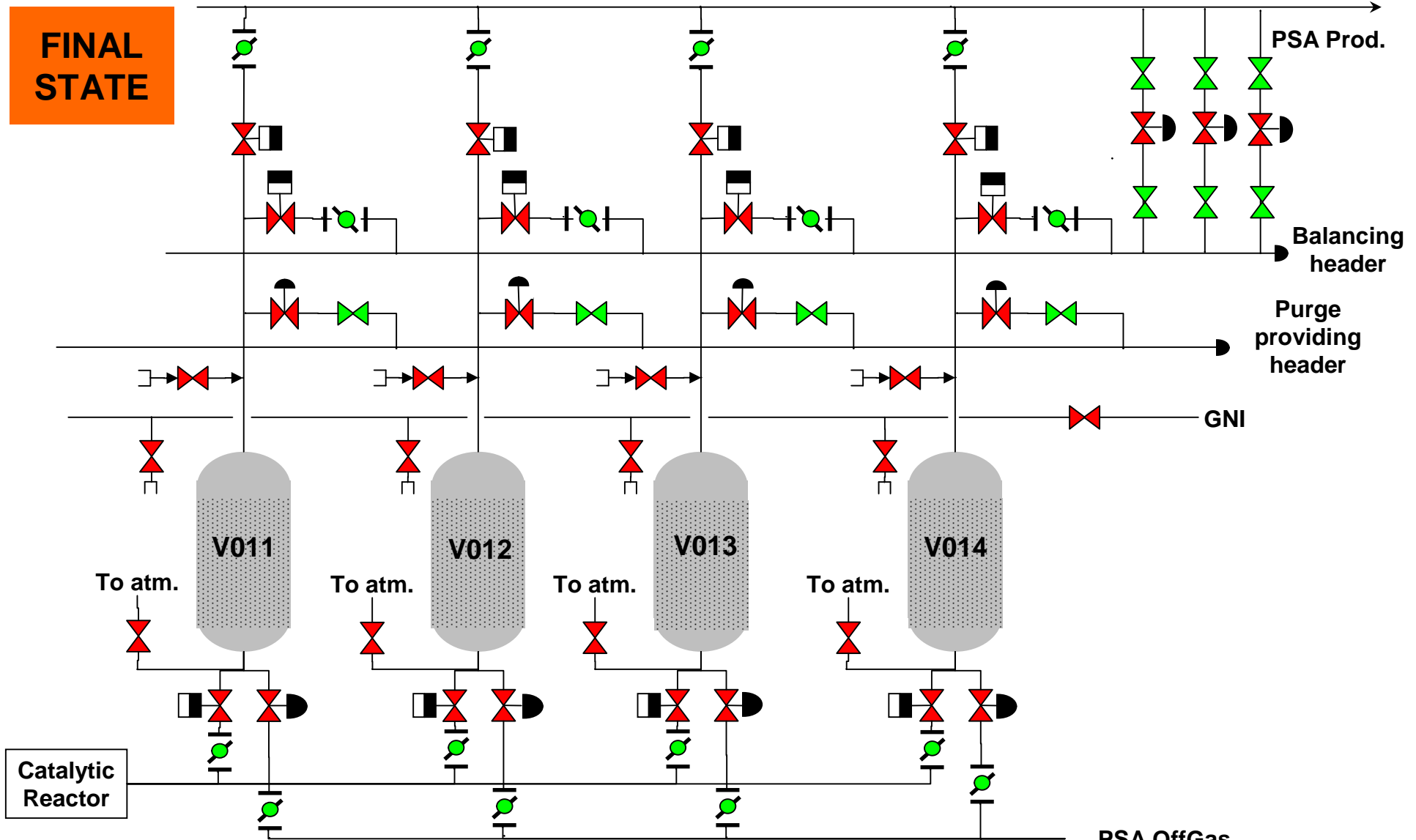
- Open PV 177 B to depressurize the PSA OffGas Drum.
- Depressurize down to 1.4 bara.
- Then close PV 177 B.



## Normal start up – Unit 322 – PSA preparation – Inerting

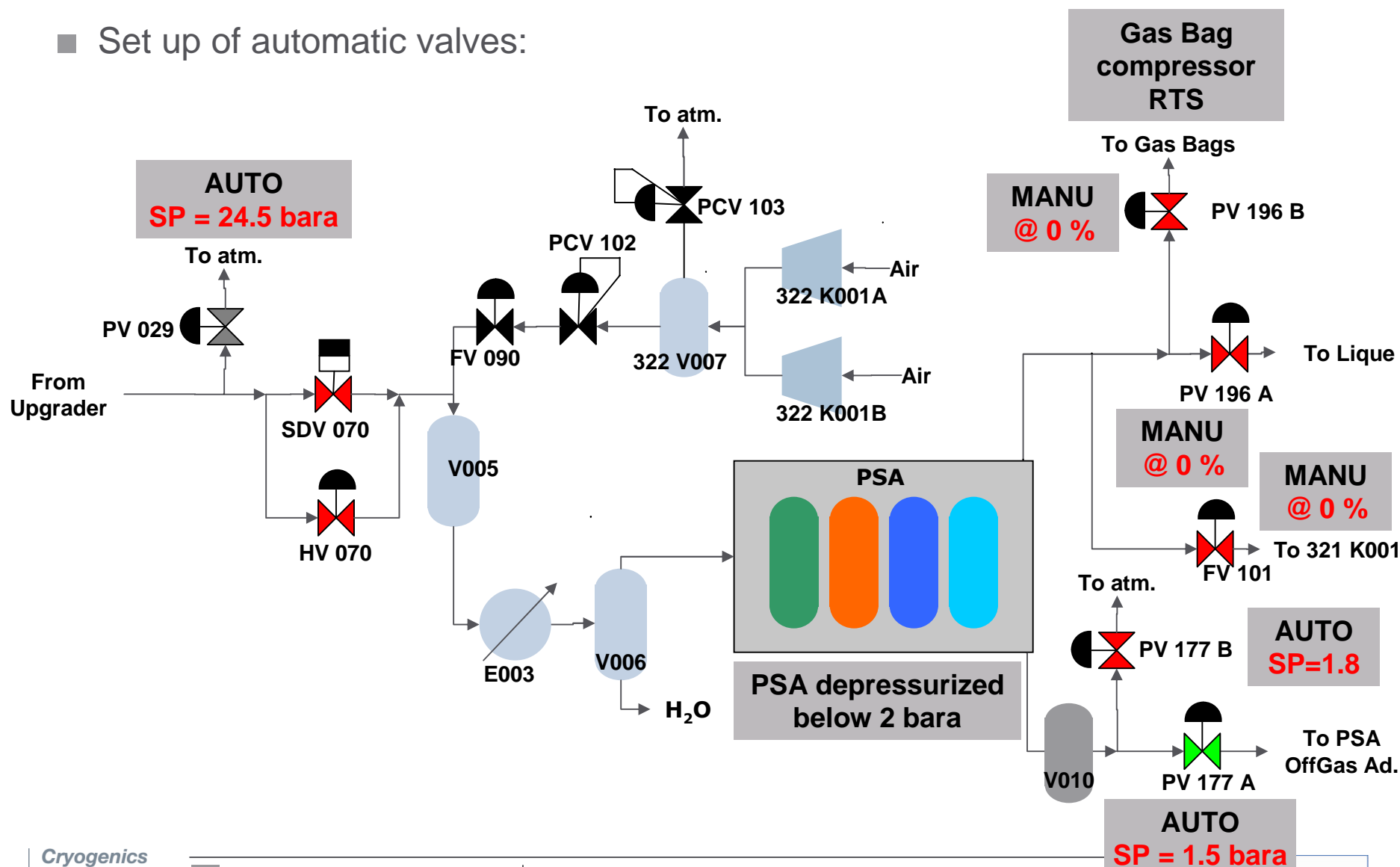
- Repeat the steps 7 to 12 four times:
  - ▣ Pressurize and depressurize the system
- Then:
  - ▣ Close all MV 1#9B,
  - ▣ Maintain a slight overpressure in the PSA:  $P \geq 1.5$  bara.
  - ▣ Close all MV 1#6 and MV 161, 160, 162 and 259.
  - ▣ Disconnect the flexible hose
  - ▣ Select ISOLATION: the valves XV 1#1, XV 1#2, XV 1#3 and HV 1#4, HV 1#5, HV 187A/B/C automatically close
  - ▣ Close MV 165
  - ▣ Open MV 161 a few seconds to depressurize the line downstream MV 165
  - ▣ Close MV 161.

# Normal start up – Unit 322 – PSA preparation – Inerting



# Normal start up – Unit 322 – PSA start up sequence

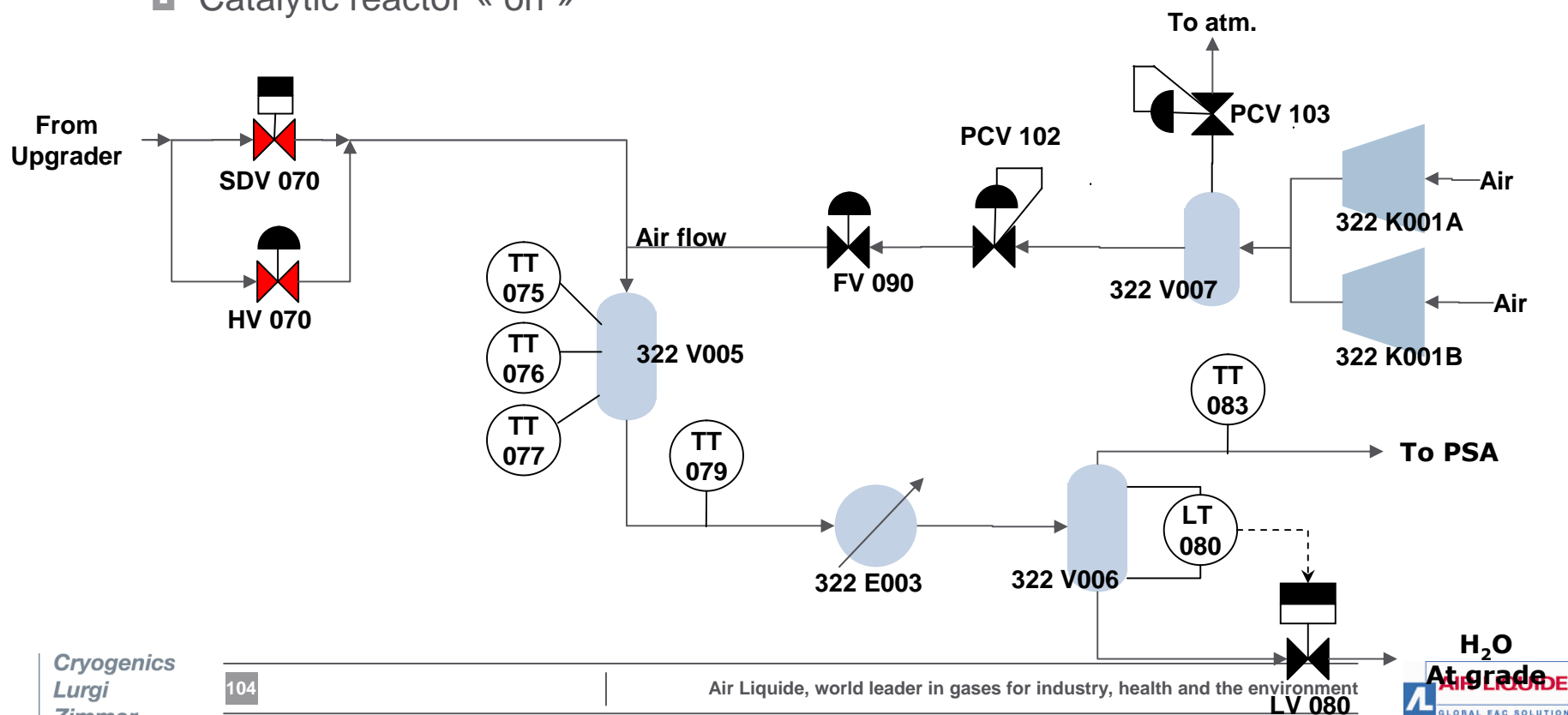
- Set up of automatic valves:



# Normal start up – Unit 322 – PSA start up sequence

## ■ Ready to start conditions:

- Valves 322 HV 070 and 322 SDV 070 are fully closed
- No TAAH 075, 076 and 077 inside Catalytic Reactor
- No TAAH 079 and 083 at Catalytic Reactor outlet
- No LAHH 081 in 322 V006.
- Catalytic reactor « on »



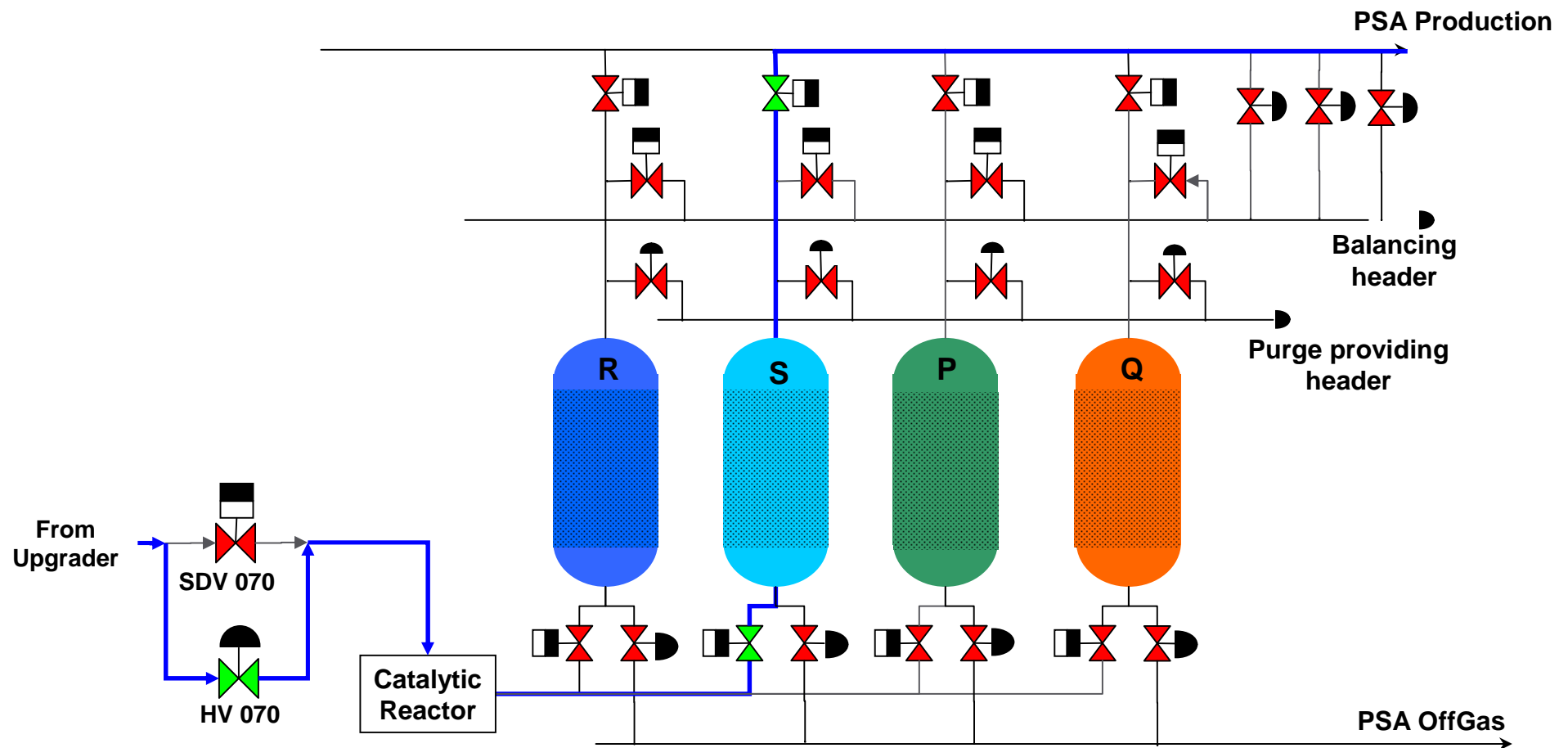


## Normal start up – Unit 322 – PSA start up sequence

- Catalytic reactor “on” is a RTS of the PSA
  - However, 322-FV-090 forced to 0% (solenoid deactivated) as long as PSA is not in “normal run”
- Put phase time in manual mode, with timer = 350 sec.
- Select the first bottle to line up in the process.
- Open inlet by-pass valve 322 HV 070 → pressurization of the Catalytic Reactor and the PSA.

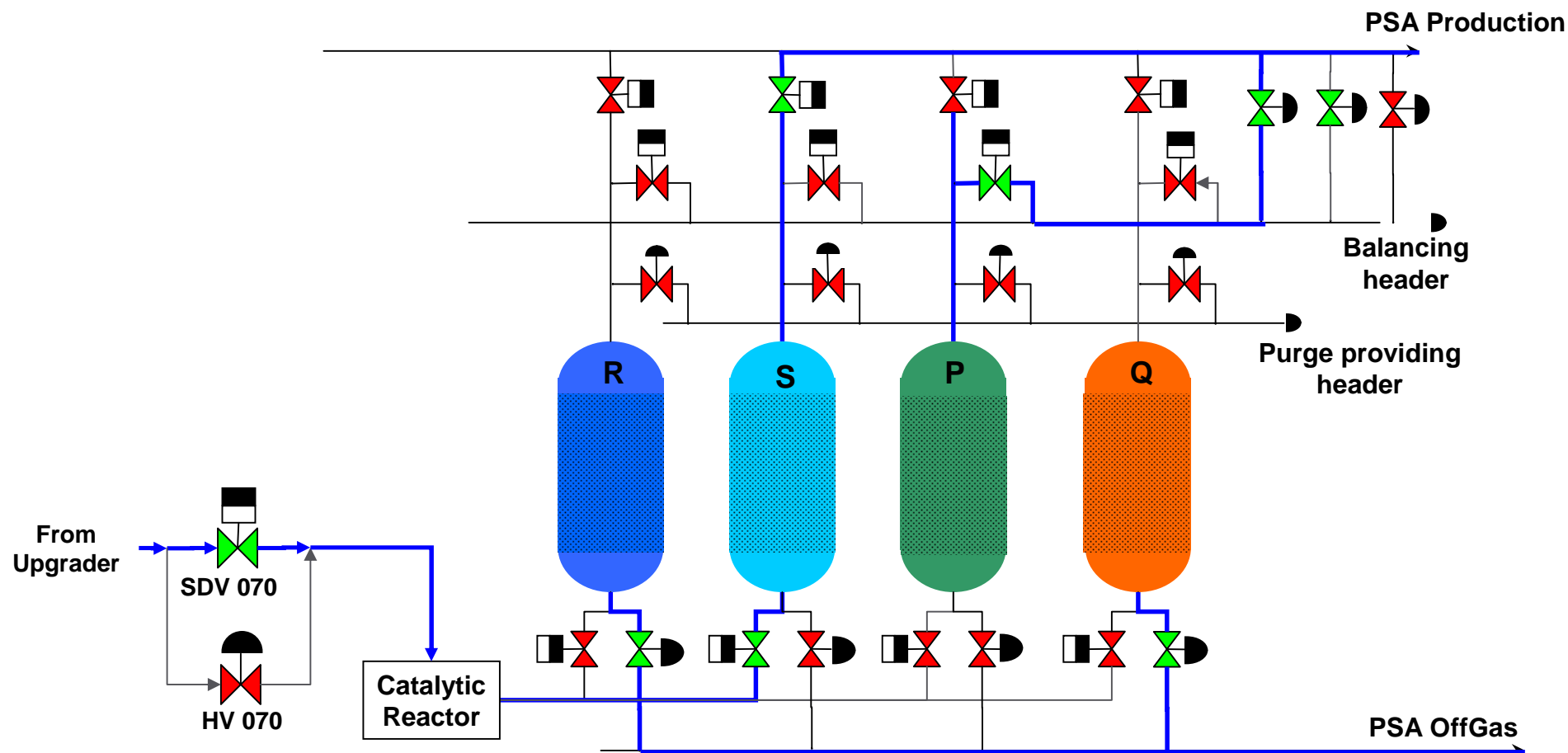
# Normal start up – Unit 322 – PSA start up sequence

- Manually open HV 070 to pressurize the system.
- The PSA valves open automatically, following the start up sequence.



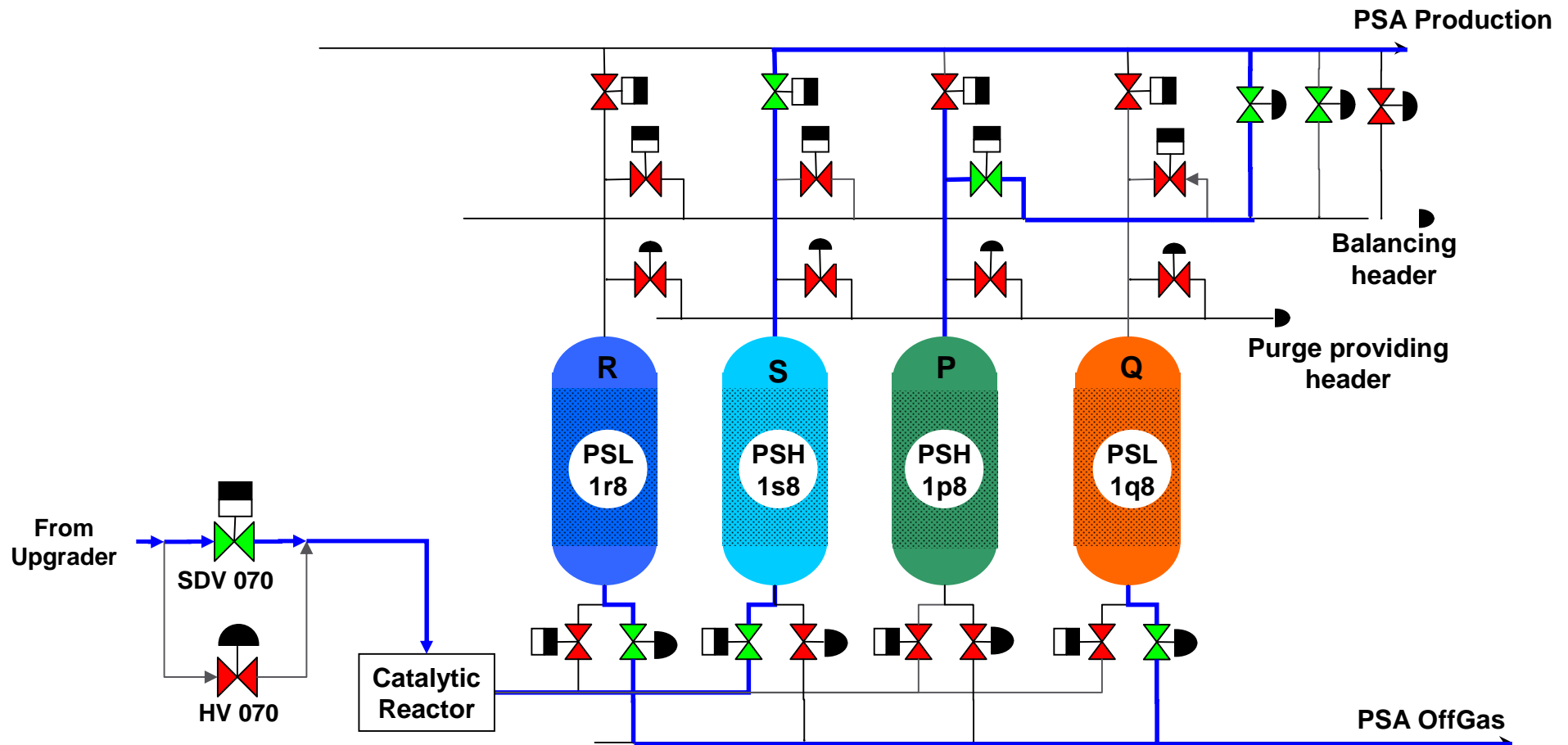
## Normal start up – Unit 322 – PSA start up sequence

- When the flow through HV 070 is high enough, the vessel S is pressurized and the pressure in the production line is not low anymore, SDV 070 automatically opens.
- Then, the operator can close HV 070.



# Normal start up – Unit 322 – PSA start up sequence

■ RTS: .



## Normal start up – Unit 322 – PSA start up sequence

- When the message “**He PSA READY TO START NORMAL RUN**” appears on the operator station and when all the RTS conditions of the “Normal Run” permissive are fulfilled, the start up sequence is completed and the PSA can be started up.

### NORMAL RUN

- Press « Start Up in NR » from the DCS

### EXCEPTIONAL RUN

- Select the appropriate vessel on which the start up shall be launched, according to the vessel to be isolated:

Isolated in ER	V011	V012	V013	V014
Start Up on Adsorber	V013	V014	V011	V012

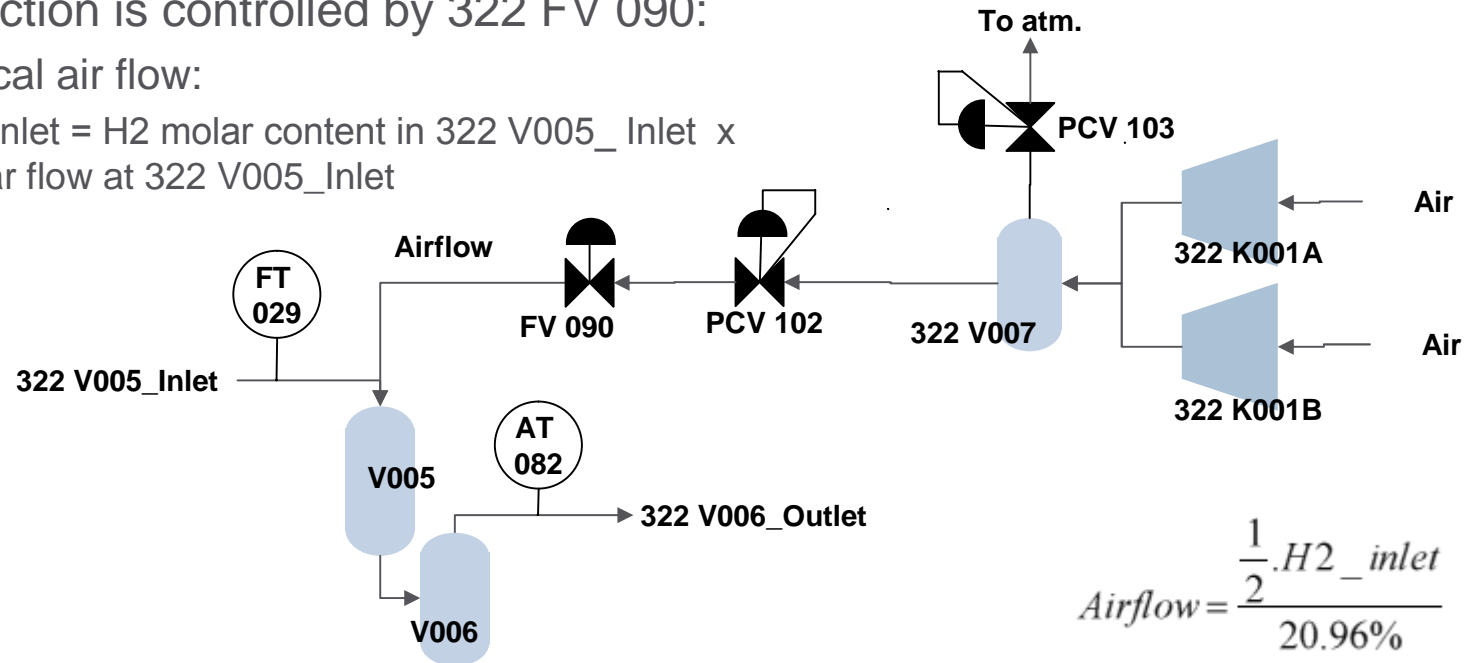
- Complete the start up sequence
- Press “Start NR”
- Immediately isolate the desired vessel via the “Adsorber Isolation” button
- The sequence switches to ER

## Normal start up – Unit 322 – Catalytic Reactor

- Air flow injection is controlled by 322 FV 090:

- Theoretical air flow:

- $H2_{inlet} = H2 \text{ molar content in } 322 \text{ V005\_Inlet} \times \text{Molar flow at } 322 \text{ V005\_Inlet}$



- As there is no  $H_2$  analyzer at 322 V005\_Inlet:

- $H_2$  content in 322 V005 ~  $H_2$  molar flow at Inlet Compressor suction (no  $H_2$  removed in Upgrader) → Given by 321 AT 022.
  - $H_2$  Inlet ~ 321 AT 022 x 321 FT 029

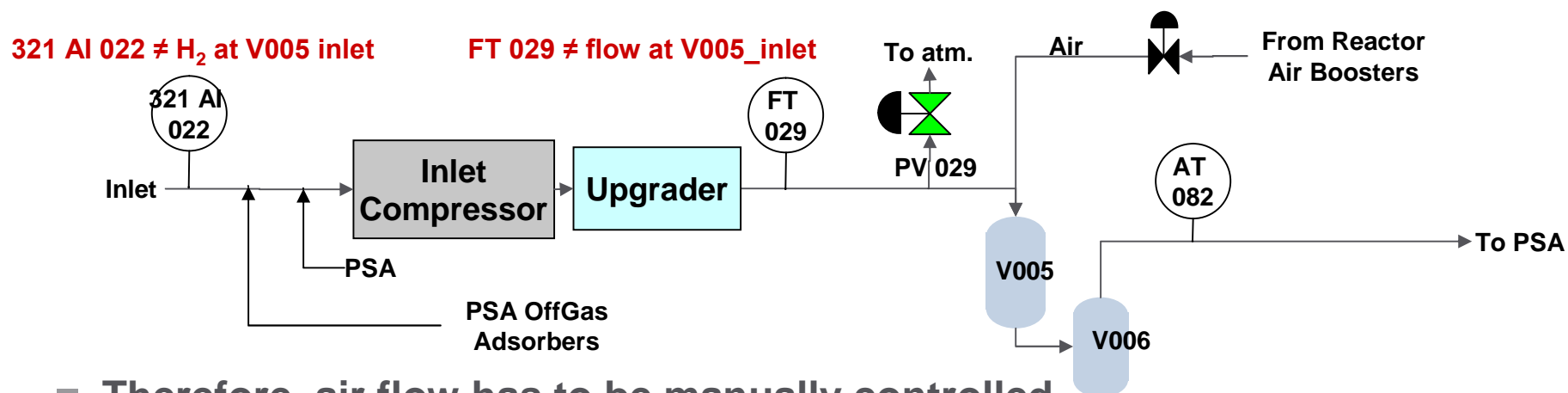
- All  $H_2$  is removed if  $O_2$  is in excess at 322 V006\_Outlet:

- 322 AT 082 measures  $O_2$  content and air flow sent in Catalytic Reactor is adjusted in order to maintain a slight excess of  $O_2$  at 322 V006 outlet

# Normal start up – Unit 322 – Catalytic Reactor

## ■ However, at start up, the air flow calculation is not reliable:

- FT 029 does not represent the exact flow through Catalytic Reactor: the vent 322 PV 029 is open.
- 321 AI 022 does not represent the H<sub>2</sub> content in the Catalytic reactor: recycled flows from PSA and PSA OffGas Adsorbers to Inlet Compressors are not taken into account.



## ■ Therefore, air flow has to be manually controlled.

## ■ Air flow injected in V005 is adapted to the O<sub>2</sub> content at V006 outlet:

- Catalytic Reactor good operation means a slight O<sub>2</sub> excess in the reaction.
- Therefore, AT 082 shall measure a small content of O<sub>2</sub> (lower than 300 ppmv, AAH = 500 ppmv)

## Normal start up – Unit 322 – Catalytic Reactor and PSA

- Slowly open 322 FV 090. Ramp up until O<sub>2</sub> is detected at V006 outlet through 322 AI 082.
- **O<sub>2</sub> content must be below 300 ppmv and must be monitored continuously.**
  - If O<sub>2</sub> content is higher than 300 ppmv, the adsorbers will not be able to adsorb all the O<sub>2</sub> and O<sub>2</sub> will be sent to the liquefier

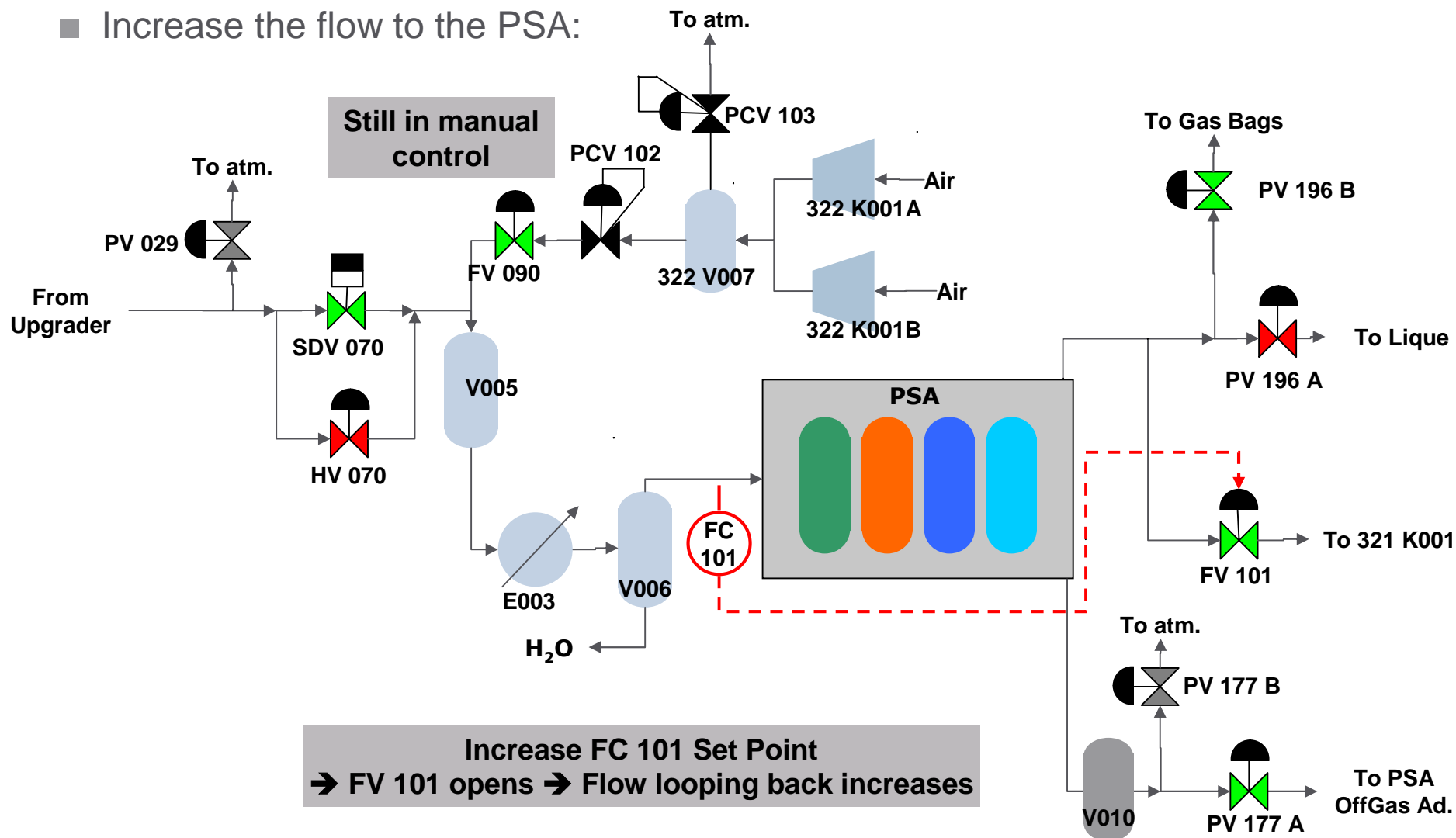


## Normal start up – Unit 322 – PSA OffGas Adsorbers

- When the PSA “normal run” sequence is launched, the PSA OffGas Adsorbers can start.
- **PSA OffGas Adsorbers must be started simultaneously with the Catalytic Reactor.**
- The sequence can be started:
  - In automatic: the operator does not need to allow the transition from one step to the next one.
  - In manual: the operator requests the transition from one step to the next by pressing the “Next step” button from the DCS. The sequence is launched.

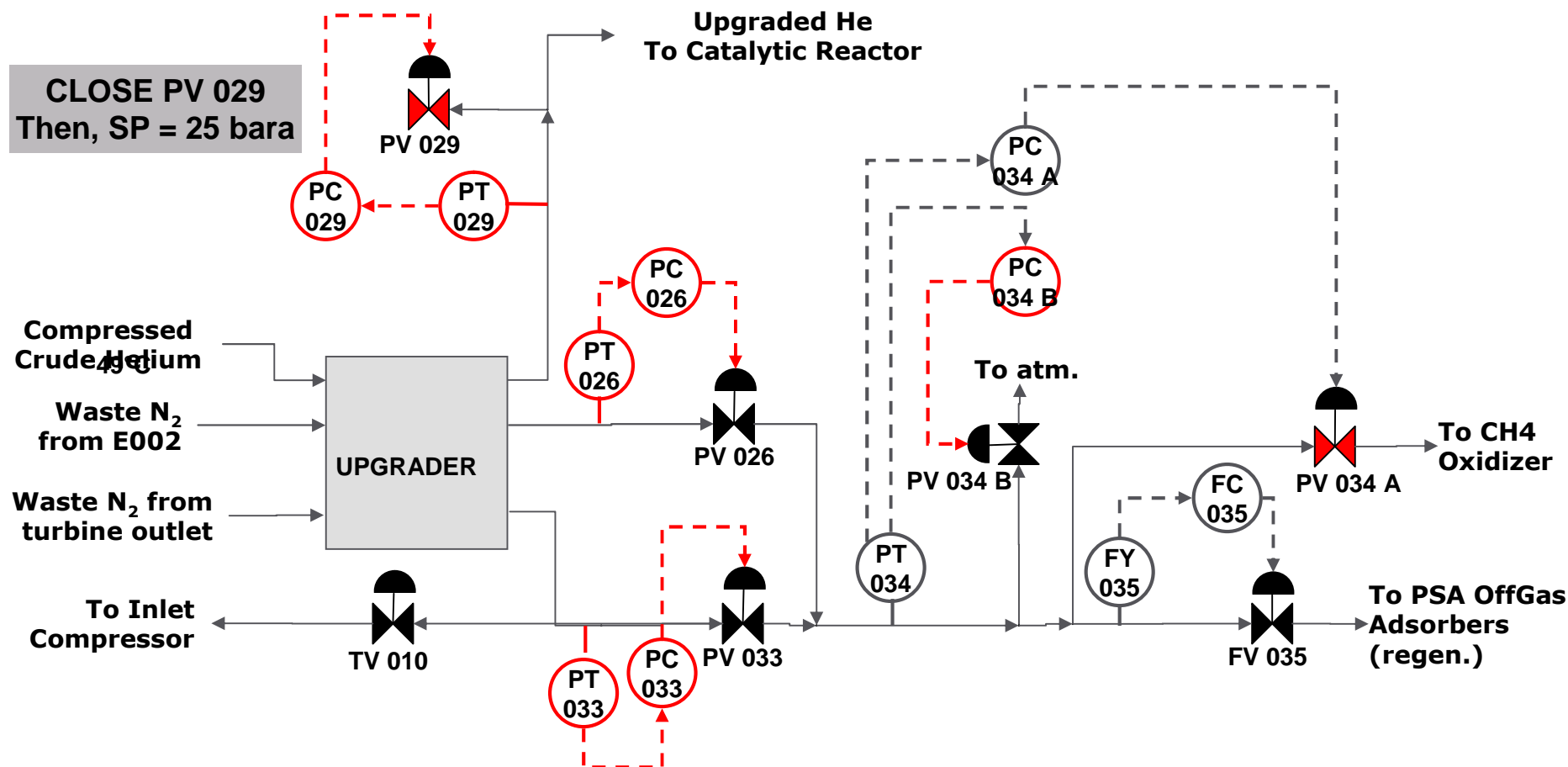
# Normal start up – Unit 322 – Finalization

- Increase the flow to the PSA:



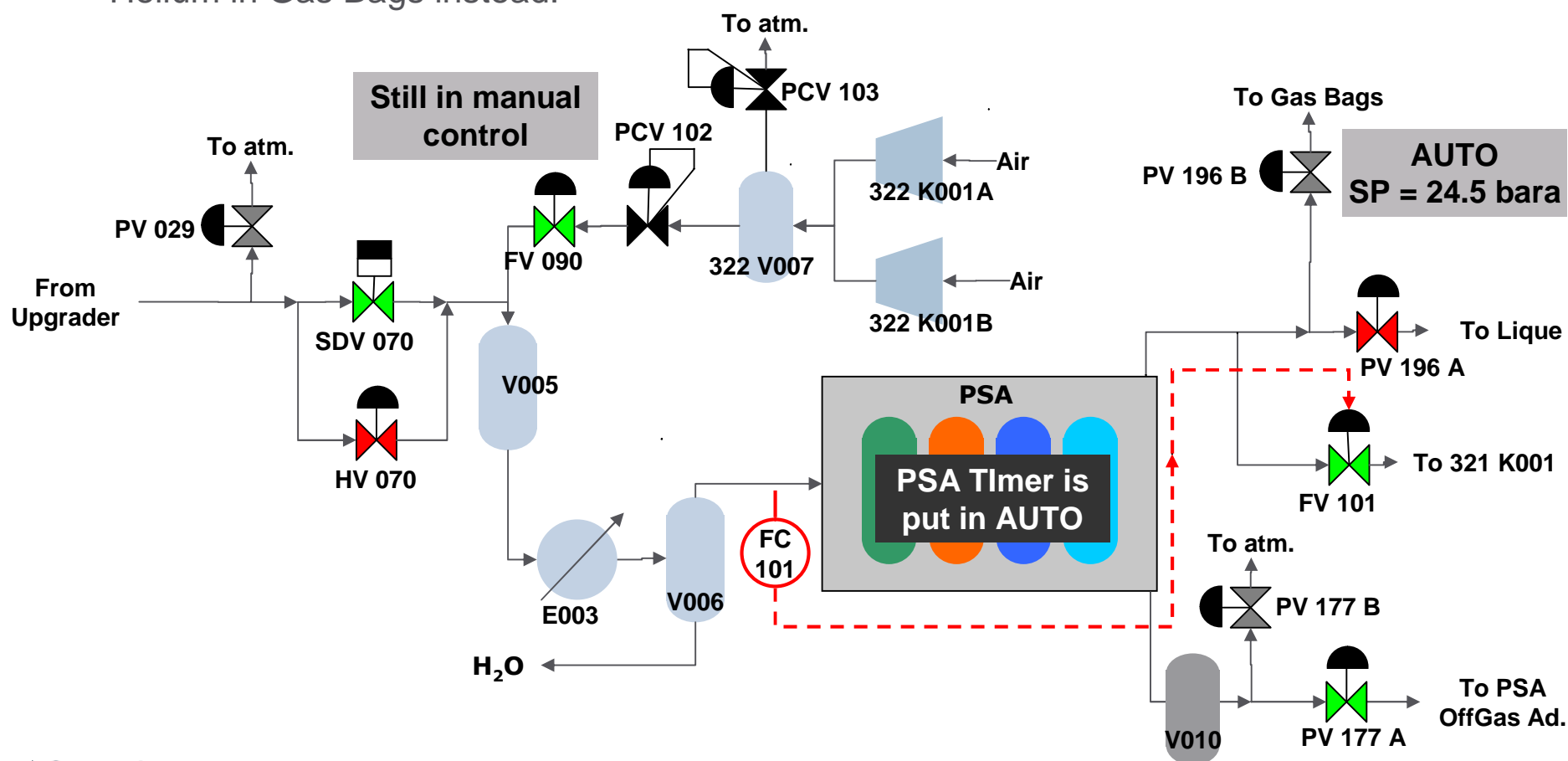
## Normal start up – Unit 322 – Finalization

- As FC 101 set point increases, the vent valve PV 029 automatically closes. Then, set 322 PC 029 in auto with SP = 25 bara. PV 029 will remain closed.



# Normal start up – Unit 322 – Finalization

- Set PC 196 B in automatic, with SP = 24.5 bara
- Note that PC 196 B set point < PC 029 set point, then PV 196 B should first open in case of overpressure. This allows avoiding venting to atmosphere and recovering Helium in Gas Bags instead.



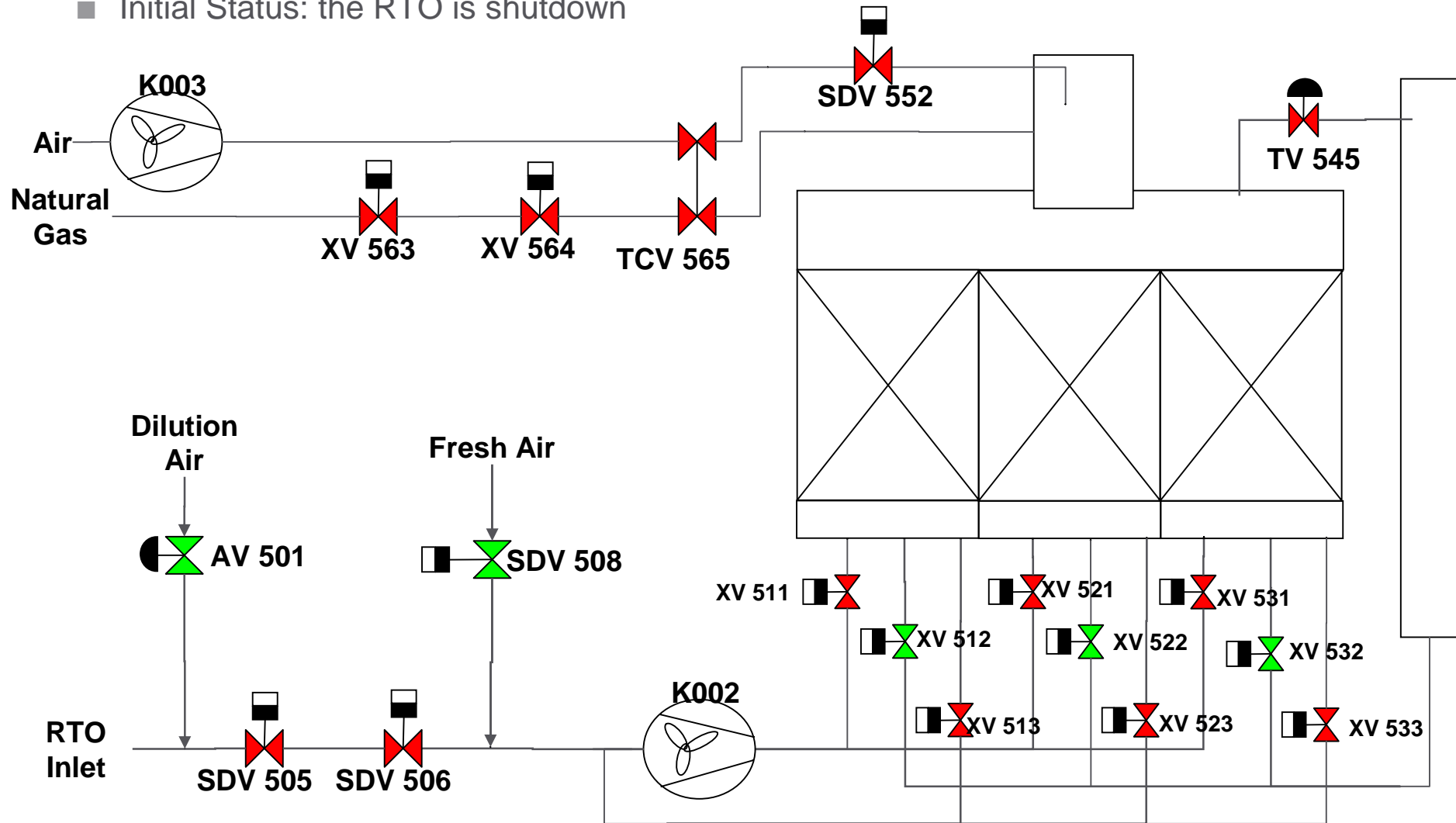
## Normal start up – Unit 322 – Finalization

- Operate Catalytic Reactor in automatic: FC 090 is switched from manual control to automatic control.
  - Closely monitor 322 AI 082 to check a small amount of O<sub>2</sub> goes through the Catalytic Reactor but does not exceed 300 ppmv.
- Monitor N<sub>2</sub> and O<sub>2</sub> contents at PSA outlet via 322 AI 196 A and 322 AI 197. When the specifications are met and PSA is stabilized, sending Helium to PSA is allowed.
- As long as 322 AI 196 and 322 AI 197 are outside their normal range, **recycle PSA production to Inlet Compressor through 322 FV 101.**
- Set 322 PV 196 A in AUTO control with SP = 23.85 bara.

Unit 322 is then connected to the liquefier

# Normal start up – Unit 322 – CH<sub>4</sub> Oxidizer

- Initial Status: the RTO is shutdown

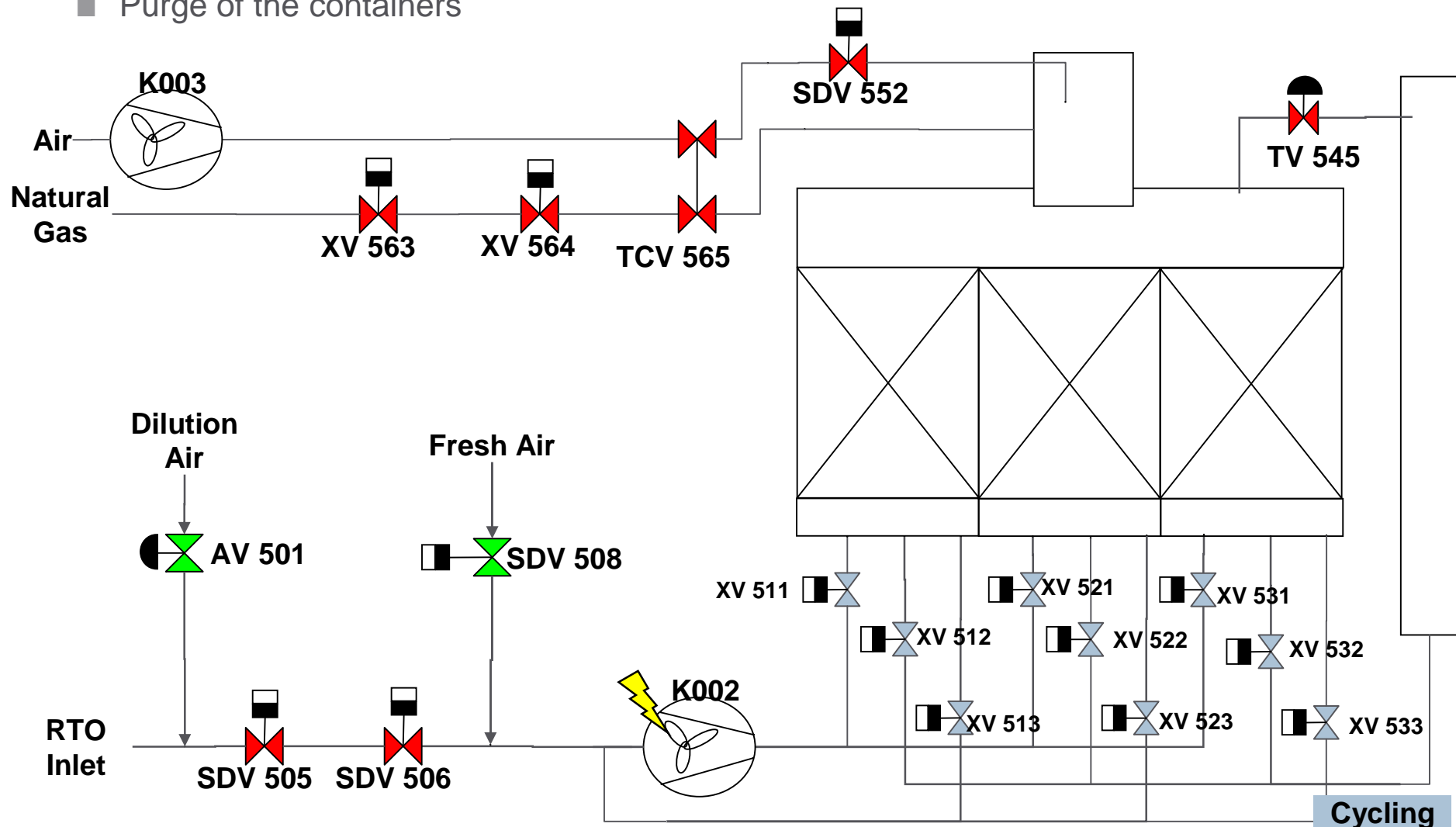


## Normal start up – Unit 322 – CH<sub>4</sub> Oxidizer

- Pressing the start button on the electrical cabinet, the fresh air fan 322 K002 starts and the poppet valves start cycling.
- When the fresh air has removed all the gas accumulated in the RTO, the burner sequence can be started up.
- However, before the burner is allowed to start, it needs to be purged in order to ensure there is no burnable gas inside the unit:
  - In addition to the fresh air pushed through the RTO by fresh air fan 322 K002, the burner itself has to be purged with the maximum volume of combustion air: TCV 565 opens, Combustion Air inlet valve 322 SDV 552) opens and Combustion Air Fan (322 K003) starts,
  - The Fuel Gas inlet Valves remain closed.
  - When the purge time is expired, the air control valve travels to its starting position (low opening).

# Normal start up – Unit 322 – CH<sub>4</sub> Oxidizer

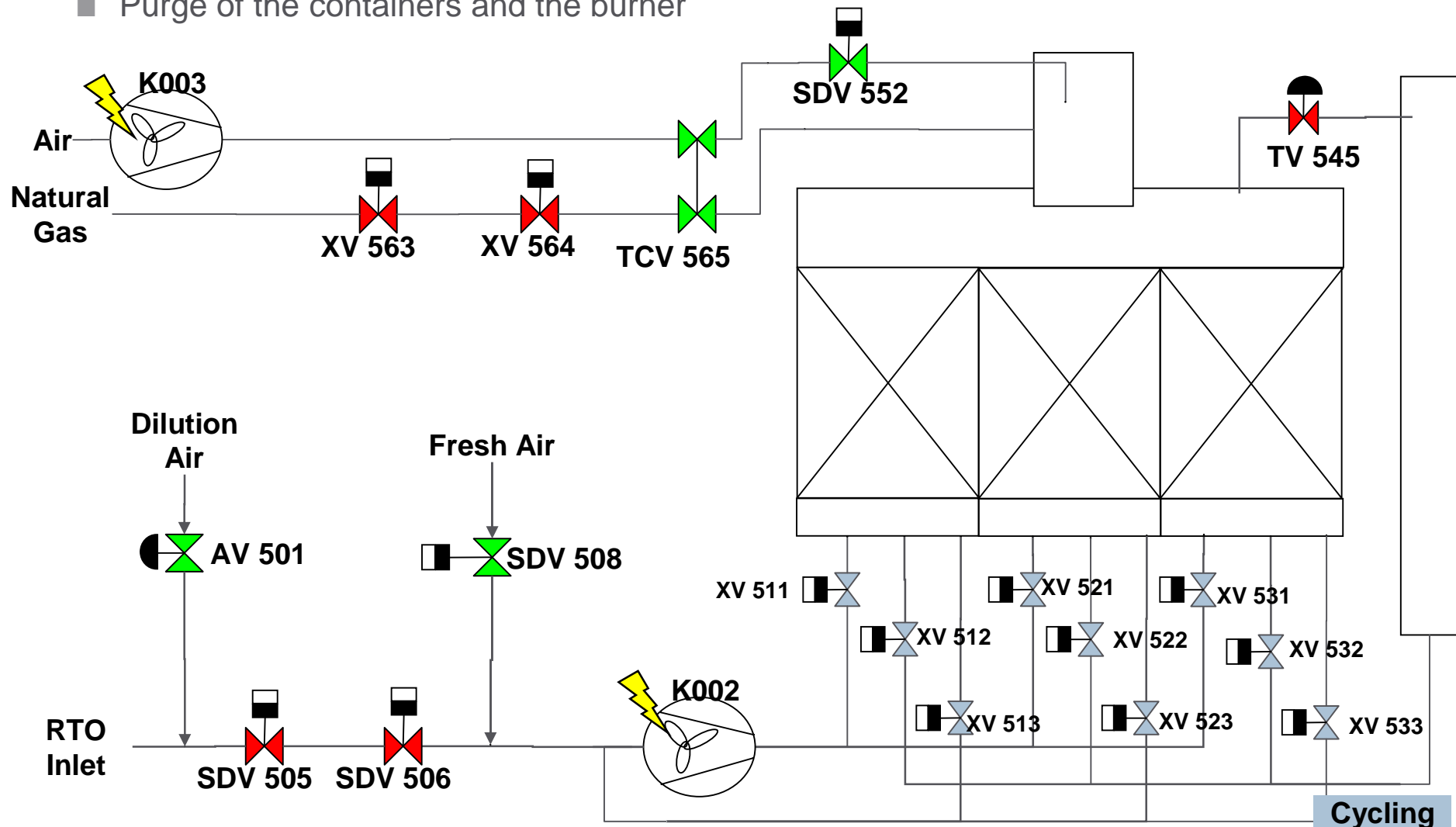
- Purge of the containers



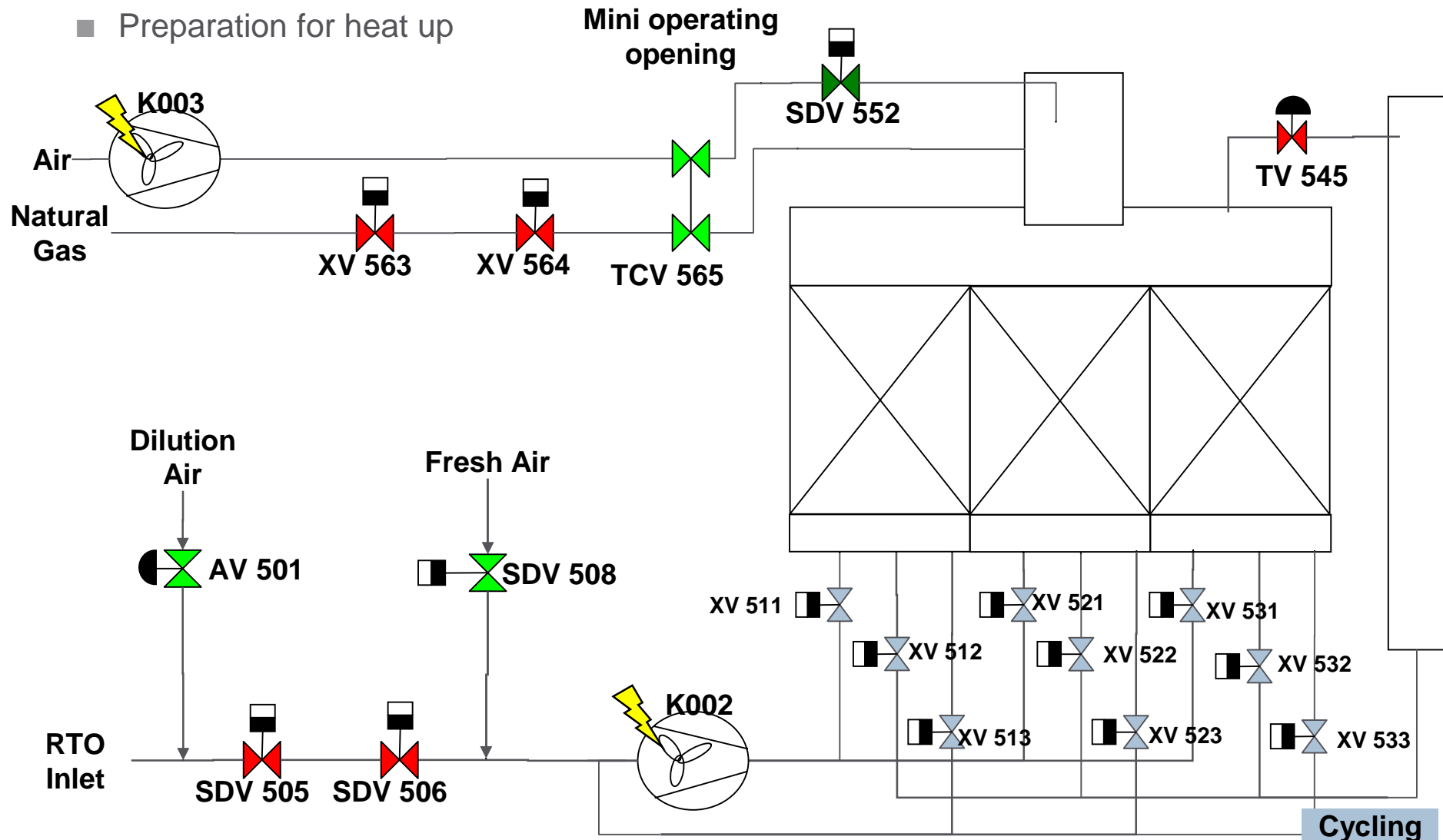


# Normal start up – Unit 322 – CH<sub>4</sub> Oxidizer

- Purge of the containers and the burner



# Normal start up – Unit 322 – CH<sub>4</sub> Oxidizer

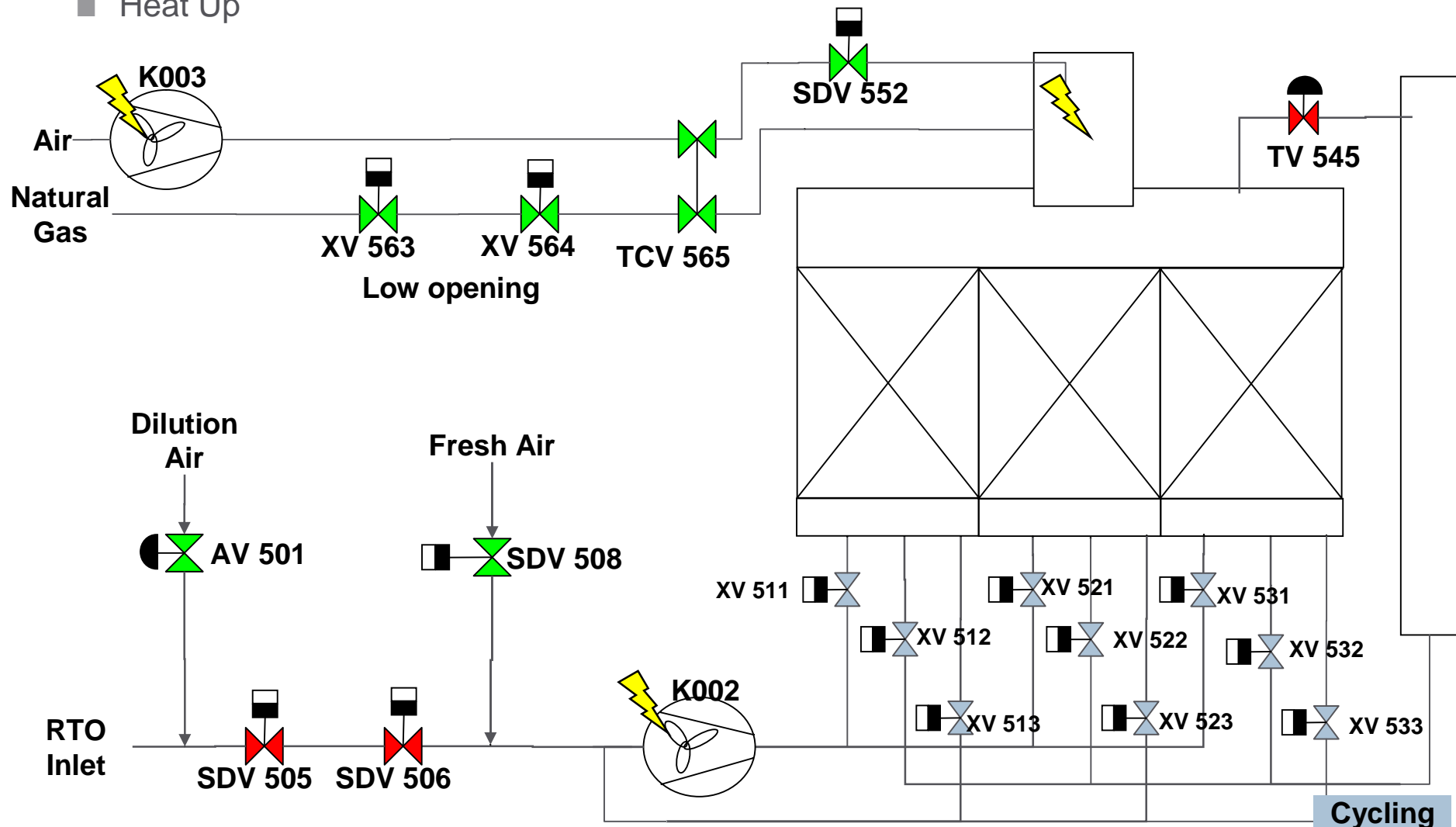


## Normal start up – Unit 322 – CH<sub>4</sub> Oxidizer

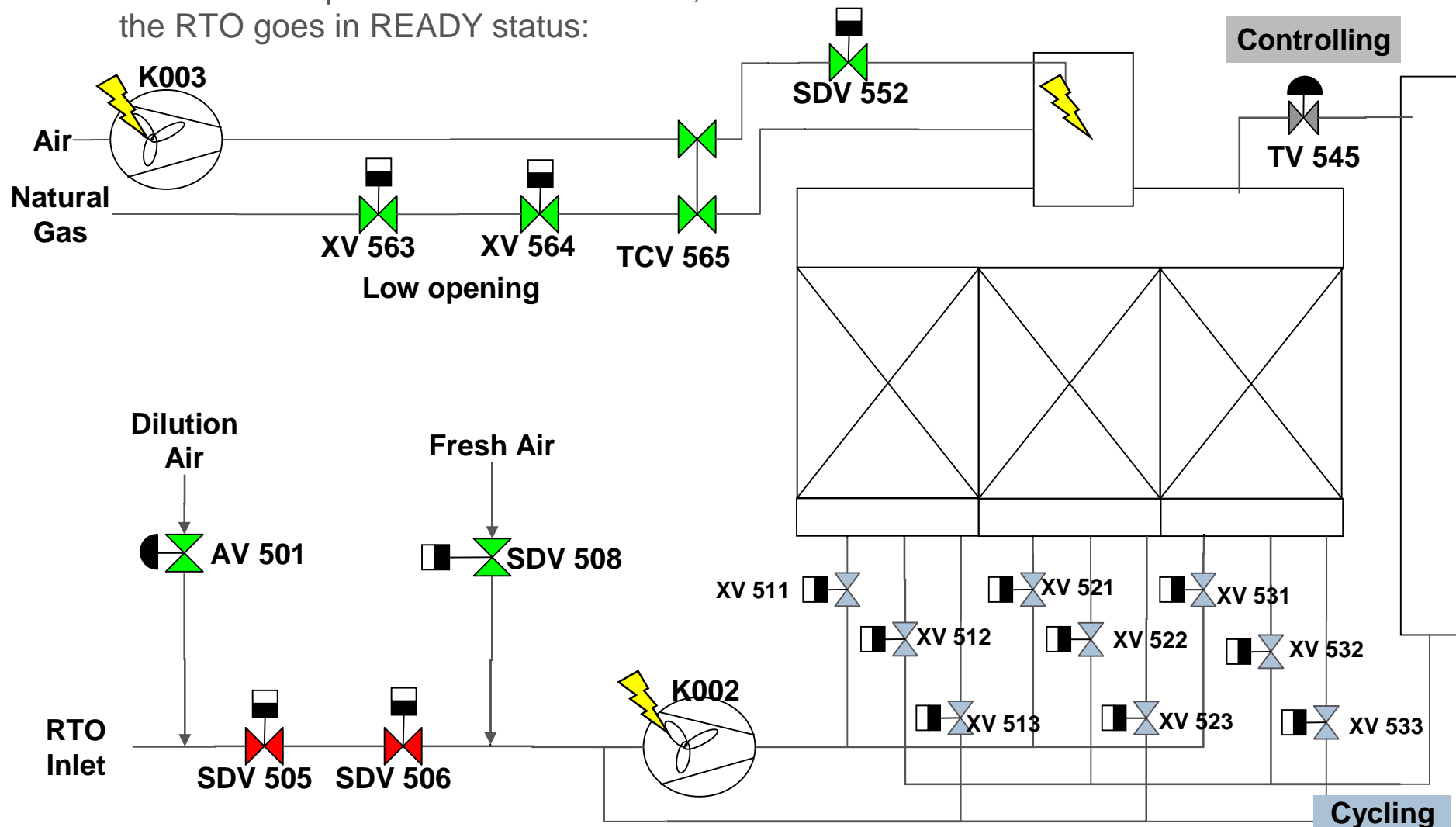
- After purging, the burner can be started up.
- The ignition electrode is energized during 2 seconds and the Fuel Gas Inlet valves open.
- The burner flame has to be stable within 3 seconds – monitored by a UV scanner.
  - ▣ If the stability test is not passed, the RTO shutdowns.
  - ▣ If the stability test is passed, a start signal is sent to the flame safe guard
- The unit enters in the HEAT UP mode.
  - ▣ Starting from the current temperature the temperature is increased by the set value of 5° C per minute.
  - ▣ The target temperature is 850°C.

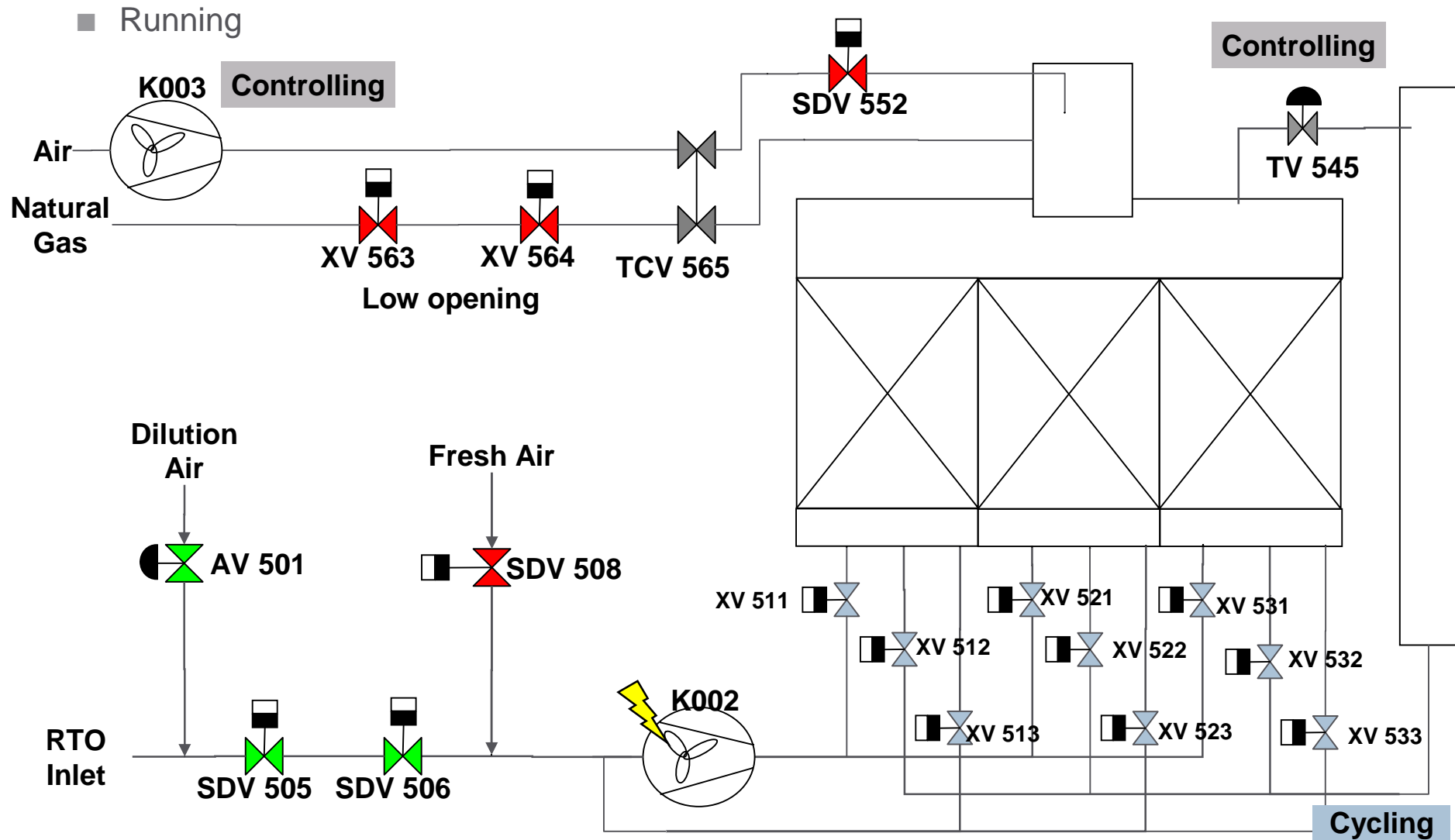
# Normal start up – Unit 322 – CH<sub>4</sub> Oxidizer

■ Heat Up



- When the temperature exceeds 850° C, the RTO goes in READY status:





# Course Agenda

## 1. Normal startup

### 1. General sequence

### 2. Utilities

### 3. ASU

### 4. Inlet Compressor

### 5. Unit 322

### 6. Helium Compressors

## 2. Shutdown sequence

## 3. Emergency Shutdown

# Normal Start Up – Unit 323 – Preliminary checks

## ■ Make sure that:

- ▣ Oil tanks are filled in
- ▣ Instrument Air and Electricity are available
- ▣ Cooling Water is available and the air in Cooling Water circuits has been purged
- ▣ Helium is present in the surge drum at a pressure ~20 bara.
- ▣ If the start up follows a shutdown due to a scheduled maintenance, charcoals adsorbers have been dried out (323 V003 A, B, C, D, E, F)
- ▣ All manual valves are in their default position as shown in the P&ID.

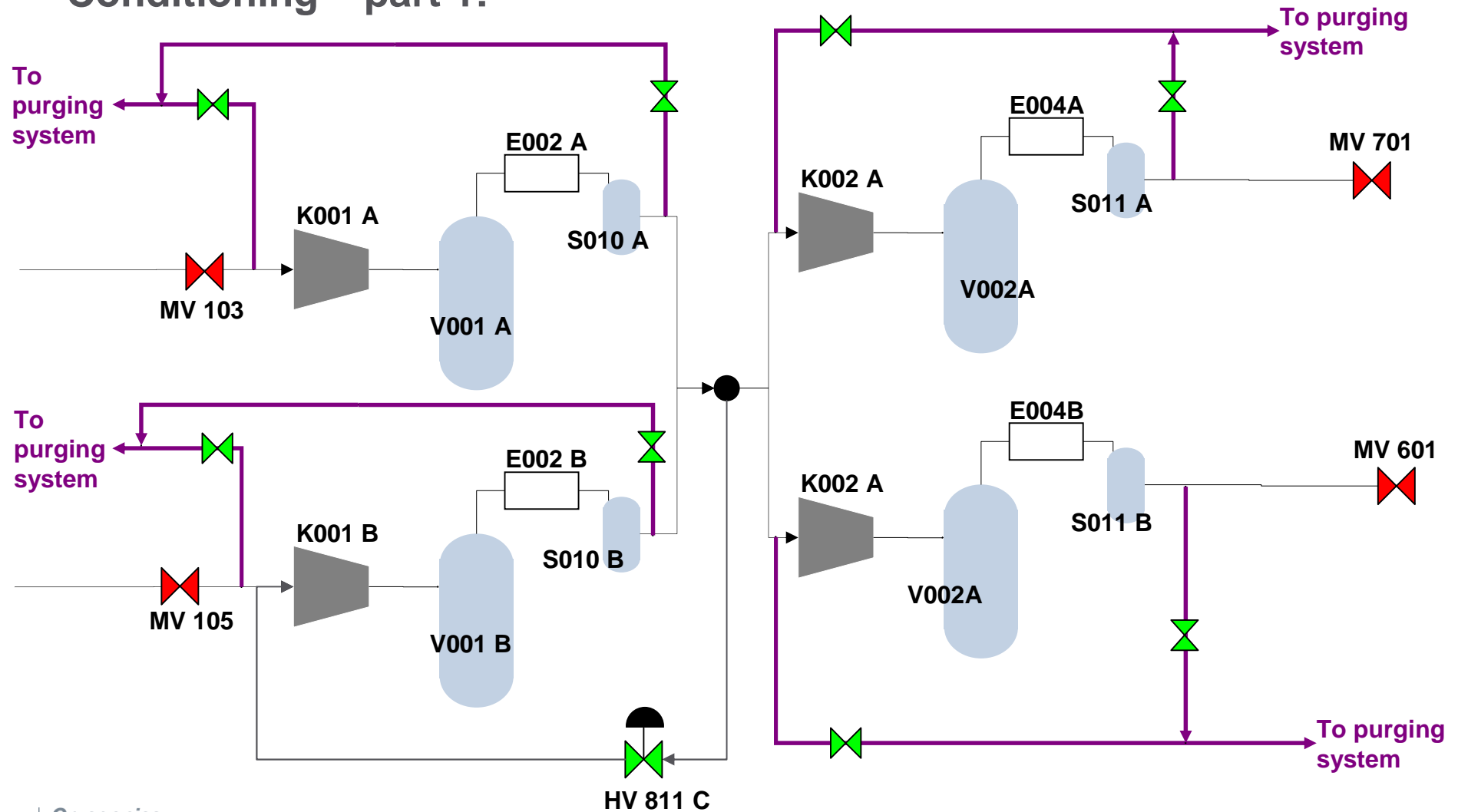
## ■ Conditioning:

- ▣ Principle:
    - Pump the lines down to 100 mbara
    - Fill in with Pure Helium, at atmospheric pressure
  - ▣ Perform 3 cycles of pumping + filling in
  - ▣ In order not to contaminate the oil-free circuits, the system is divided into 2 parts. Each part must be conditioned separately:
    - Upstream the Oil Removal Systems
    - Downstream the Oil removal Systems
- For conditioning, close manual valves 323 MV 701 and 323 MV 601.



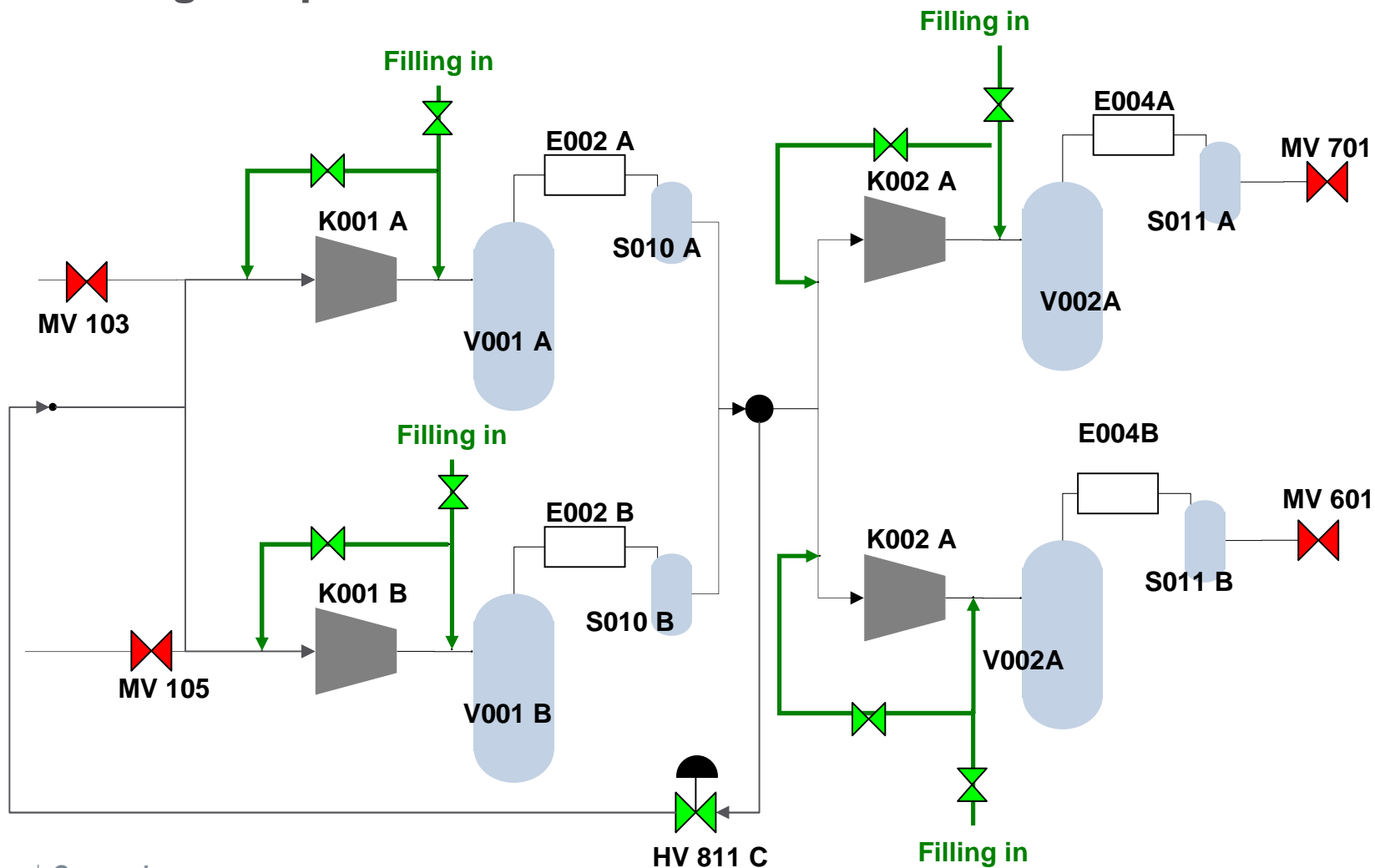
# Normal Start Up – Unit 323 – Conditioning

## Conditioning – part 1:

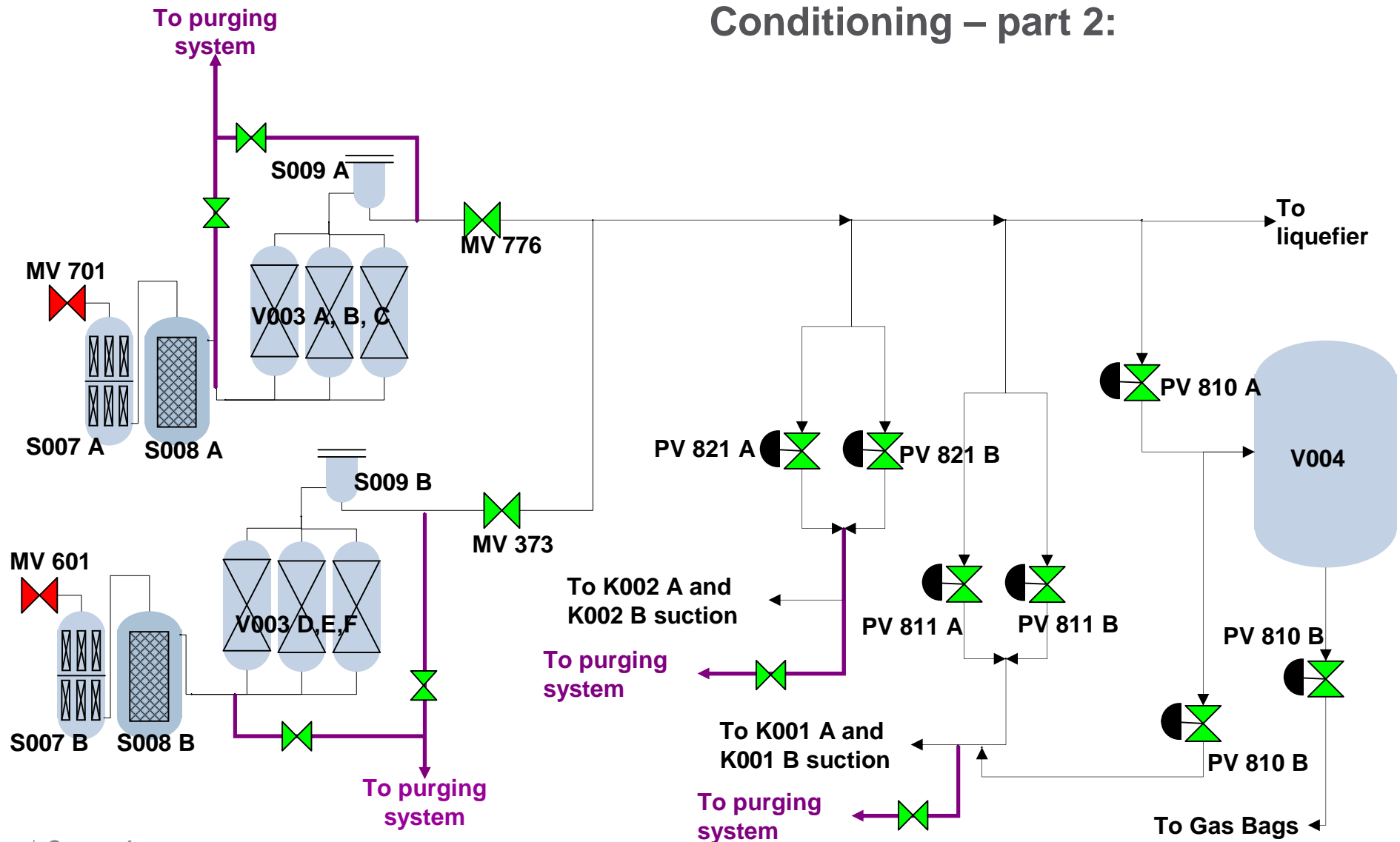


# Normal Start Up – Unit 323 – Conditioning

## Filling in – part 1:

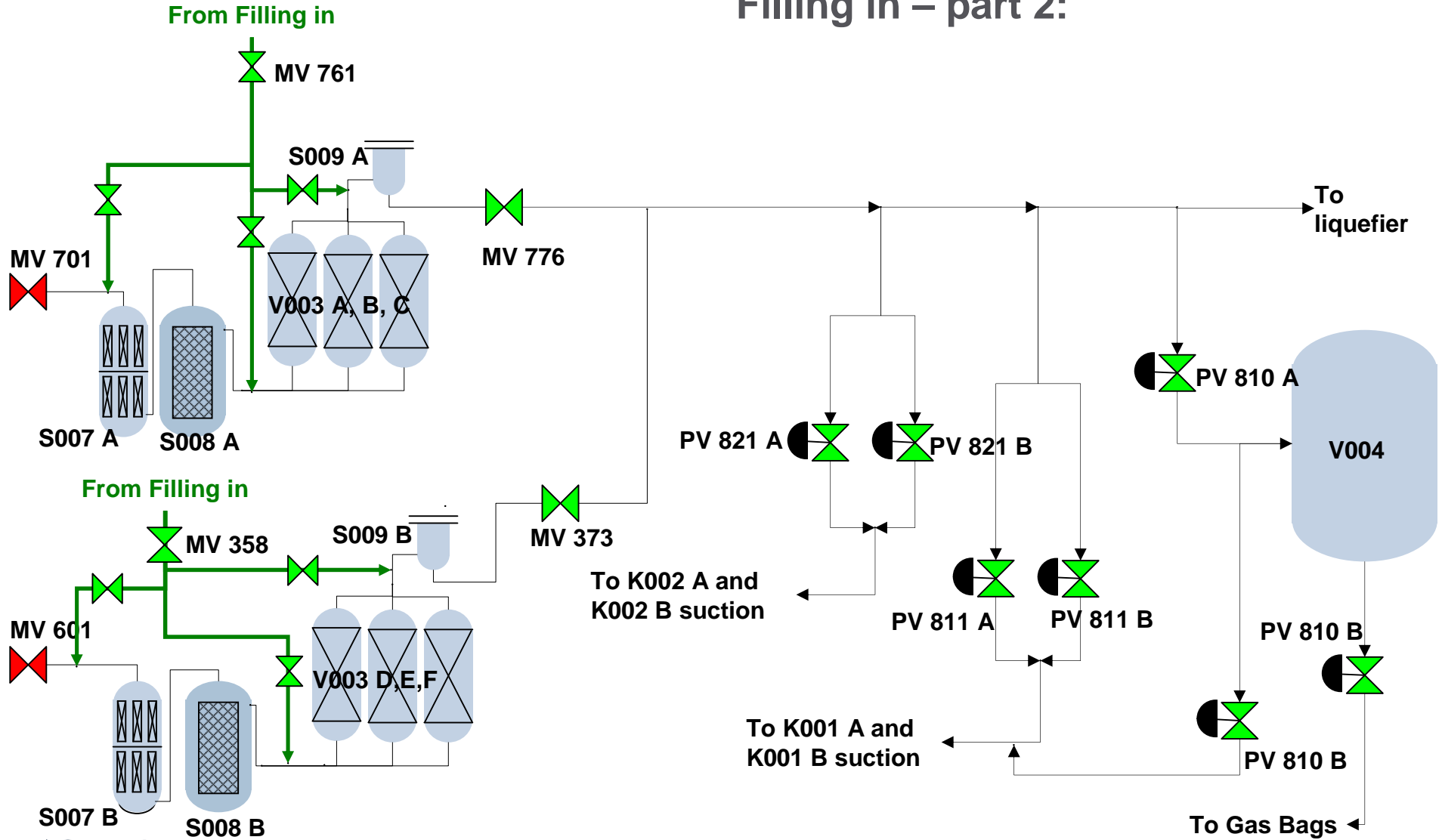


## Conditioning – part 2:



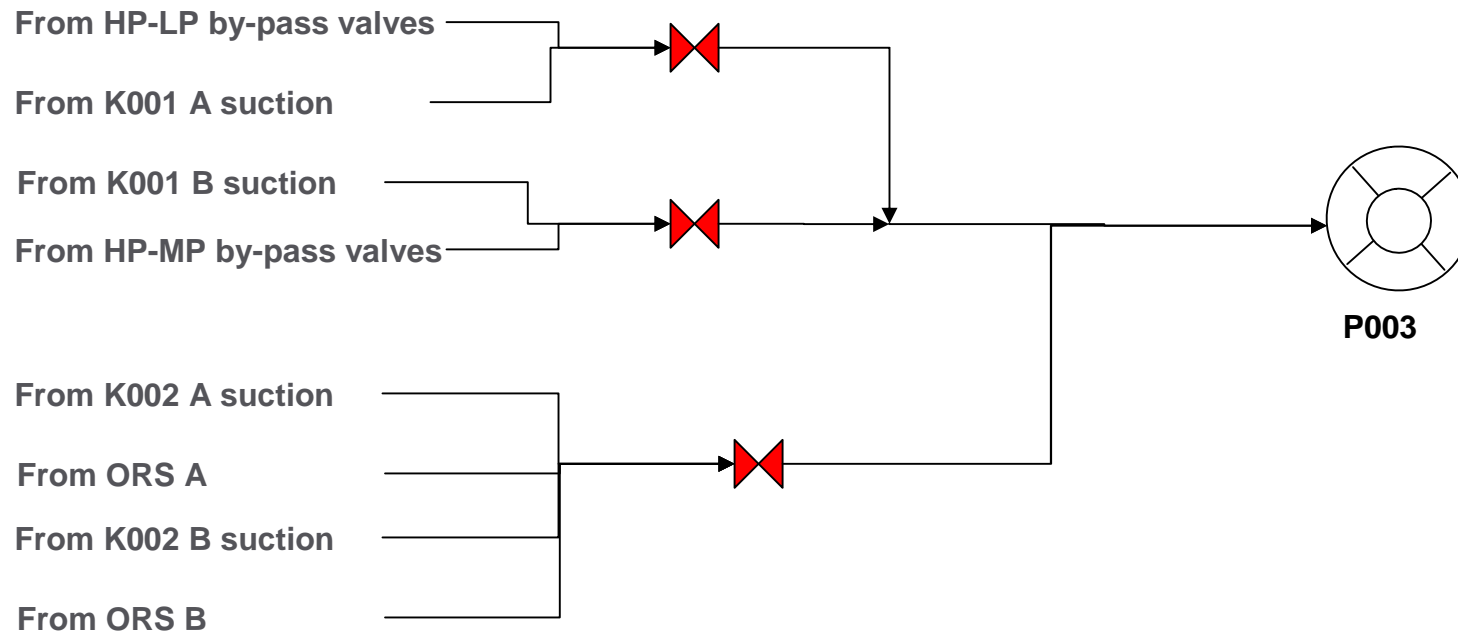
## Normal Start Up – Unit 323 – Conditioning

## Filling in – part 2:



# Normal Start Up – Unit 323 – Conditioning

## ■ Vacuum Pump:



## Normal Start Up – Unit 323 – Pressures' adjustment and Oil systems

### PRESSURES' ADJUSTMENTS

- Before starting up the Helium Compressors, make sure all the pressures are in the appropriate range:

	Monitoring device	Acceptable range
HP pressure	PT 811	[12;25] bara
MP pressure	PT 821	Not < 4.5 bara
LP pressure	PT 811	Not > 2 bara

- If needed, act on the by-pass valves and the Surge Drum valves to adjust the pressures.

### Oil Pumps

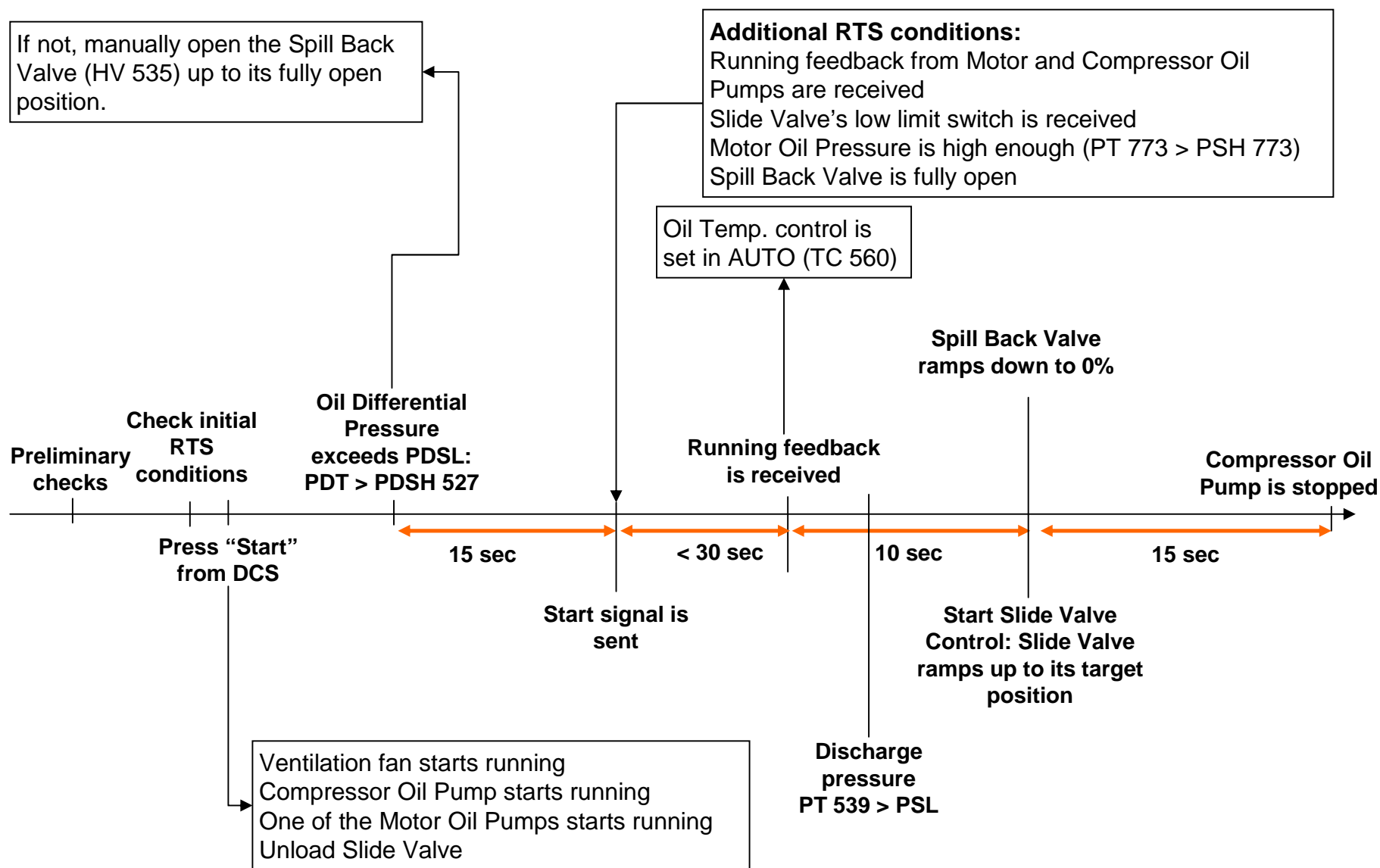
- Check Oil level in Oil Tanks and Oil Separator vessels.

**HP Compressors must be started up before LP Compressors**

# Normal Start Up – Unit 323 – HP Compressors

- Select the automatic mode
- Initial RTS conditions (TAGs are given for compressor 323 K002 A):
  - No low level in oil tank (no LSL 775) and level in Separator Vessels 323 V002 A is in appropriated range (no LSH 750, no LSL 750), no high level in Separator Vessel 323 S007A (no LSH 740 and no LSH 742) and no high level on oil coalescer 323 S008A (no LSH 744)
  - No moisture in compressor motor (no LSH 559)
  - No low flow in cooling water circuits (no 320 FAL 140)
  - No moisture in compressed helium flow (no AAHH 809)
  - In case of restart, shutdown conditions have been reset by pressing HS UY 502 A. Then, the following shutdown conditions need to be more closely checked:
    - No very high level on oil recovery tank (no LAHH 750)
    - No very high oil temperature for oil lubricating the motor bearing (no TAHH 772),
    - No very high oil temperature in oil recovery tank (no TAHH 531)
    - No very low differential pressure in Compressor Oil circuit (no PDALL 527)
    - No very low pressure in Motor Oil circuit (no PDALL 773)
    - No very high temperature in Compressor Oil (noTAHH 760)
    - No very high pressure at compressor discharge (no PAHH 530)
    - No very high temperature at compressor outlet (no TAHH 806)

# Normal Start Up – Unit 323 – HP Compressors

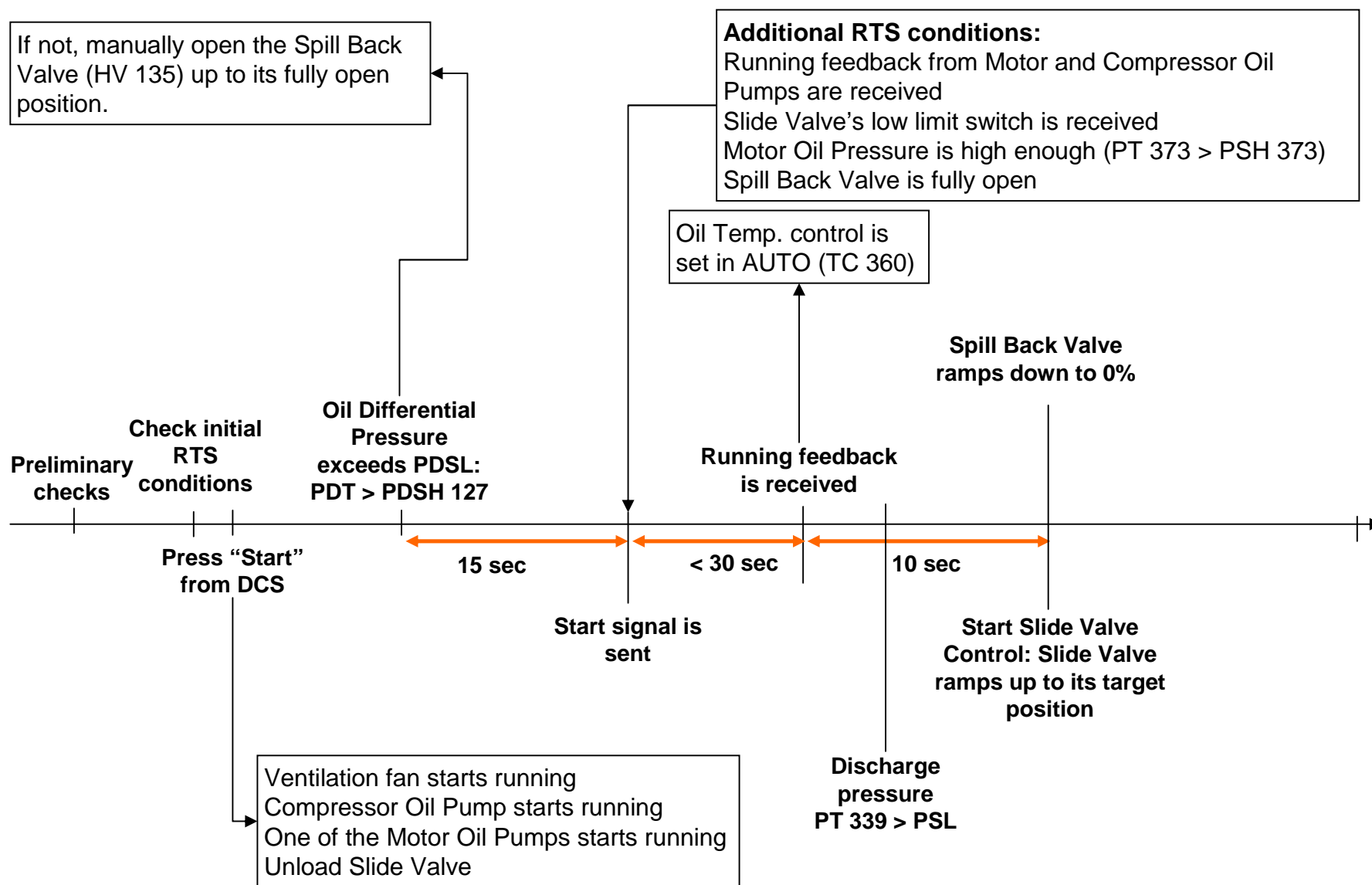




## Normal Start Up – Unit 323 – LP Compressors

- Select the automatic mode
- Initial RTS conditions (TAGs are given for compressor 323 K001 A)
  - ▣ **One HP compressor must be running,**
  - ▣ No low level in Motor Oil Tank : no LAL 375
  - ▣ No moisture in Compressor's motor: no LSH 159
  - ▣ No low Cooling Water flow: no 320 FAL 180
  - ▣ Appropriate oil level in Separator Vessel 323 V001A: no LAL and no LAH 350
- In case of restart, shutdown conditions have been reset by pressing HS UY 102 A. Then, the following shutdown conditions need to be more closely checked:
  - ▣ No very high level on oil recovery tank (no LAHH 350)
  - ▣ No very high oil temperature for oil lubricating the motor bearing (no TAHH 372),
  - ▣ No very high oil temperature in oil recovery tank (no TAHH 131)
  - ▣ No very low differential pressure in Compressor Oil circuit (no PDALL 127)
  - ▣ No very low pressure in Motor Oil circuit (no PDALL 373)
  - ▣ No very high temperature in Compressor Oil (no TAHH 360)
  - ▣ No very high pressure at compressor discharge (no PAHH 130)
  - ▣ No very high temperature at compressor inlet coming from liquefier 324 E001 (no TALL 811)

# Normal Start Up – Unit 323 – HP Compressors



# Course Agenda

1. Normal startup
- 2. Shutdown sequence**

## **1. Overview**

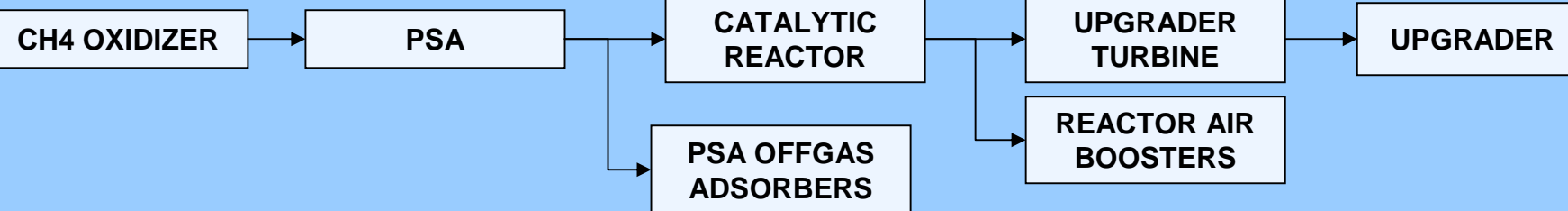
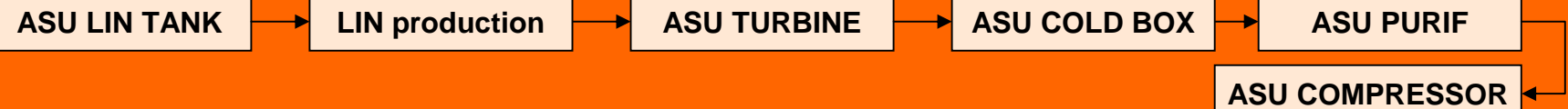
- 2. Unit 326 – ASU**
  - 3. Unit 322**
  - 4. Unit 323 – Helium Compressors**
  - 5. Unit 321 – Inlet Compressor**
3. Emergency Shutdown

# Normal shutdown – Overview

## UNIT 324: LIQUIFIER, ADSORBERS AND TURBINES



## UNIT 325: HE STORAGE AND LOADING BAYS



# Course Agenda

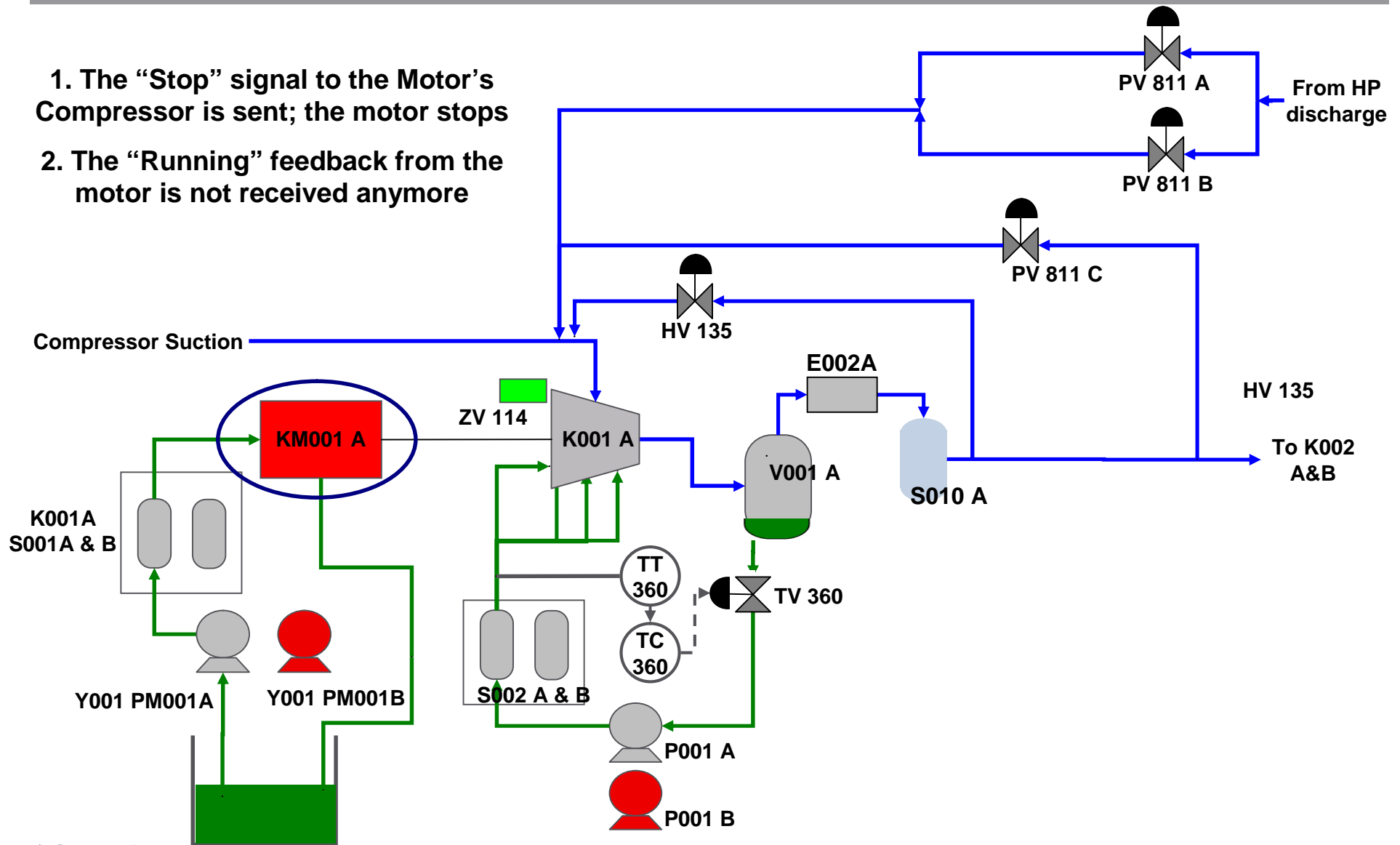
1. Normal startup
2. **Shutdown sequence**
  1. Overview
  2. **Unit 323 – Helium Compressors**
  3. Unit 326 – ASU
  4. Unit 322
  5. Unit 321 – Inlet Compressor
3. Emergency Shutdown

# Shutdown – Unit 323 –Helium Compressors

- LP Compressors shall be shutdown before HP Compressors
- If one of the LP Compressors is already off and the liquefier is still running, the shutdown of the other LP Compressor is not allowed.
- If one LP Compressor is still in operation, one HP Compressor must be running. Therefore, the shutdown of both HP Compressors is not allowed if at least one LP Compressor is running.

# Shutdown – Unit 323 – LP Helium Compressors

1. The “Stop” signal to the Motor’s Compressor is sent; the motor stops
2. The “Running” feedback from the motor is not received anymore

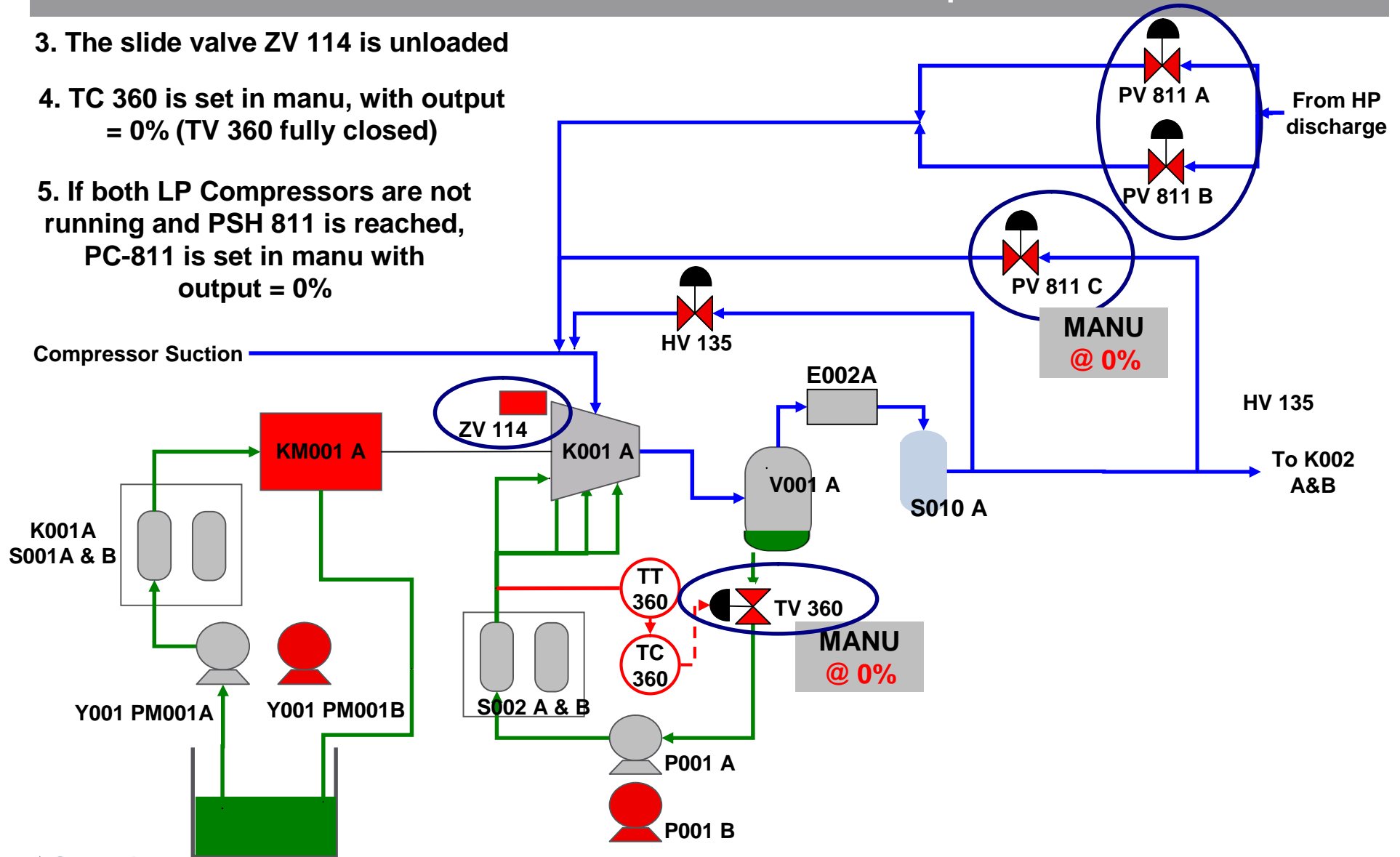


# Shutdown – Unit 323 – LP Helium Compressors

3. The slide valve ZV 114 is unloaded

4. TC 360 is set in manu, with output = 0% (TV 360 fully closed)

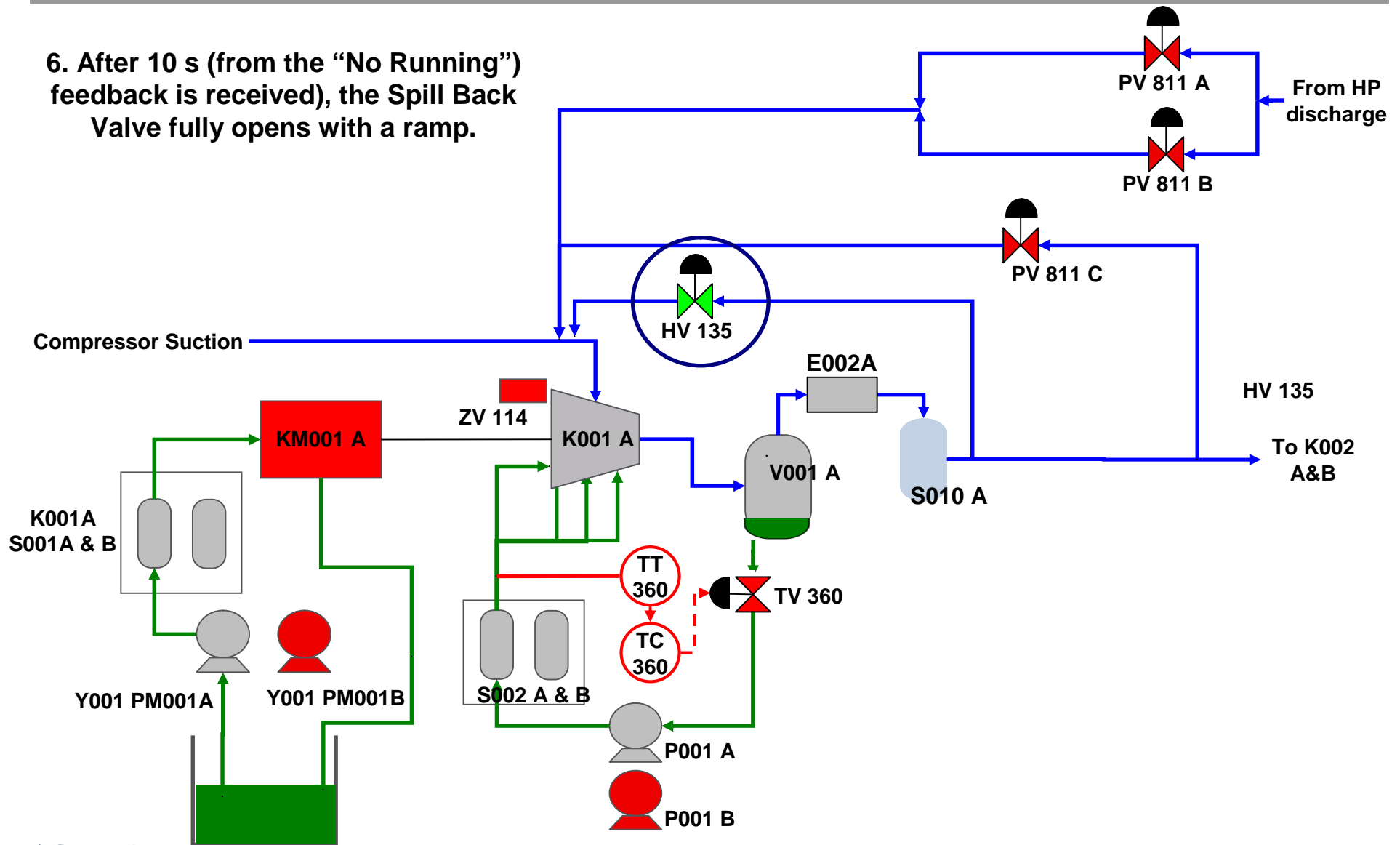
5. If both LP Compressors are not running and PSH 811 is reached, PC-811 is set in manu with output = 0%



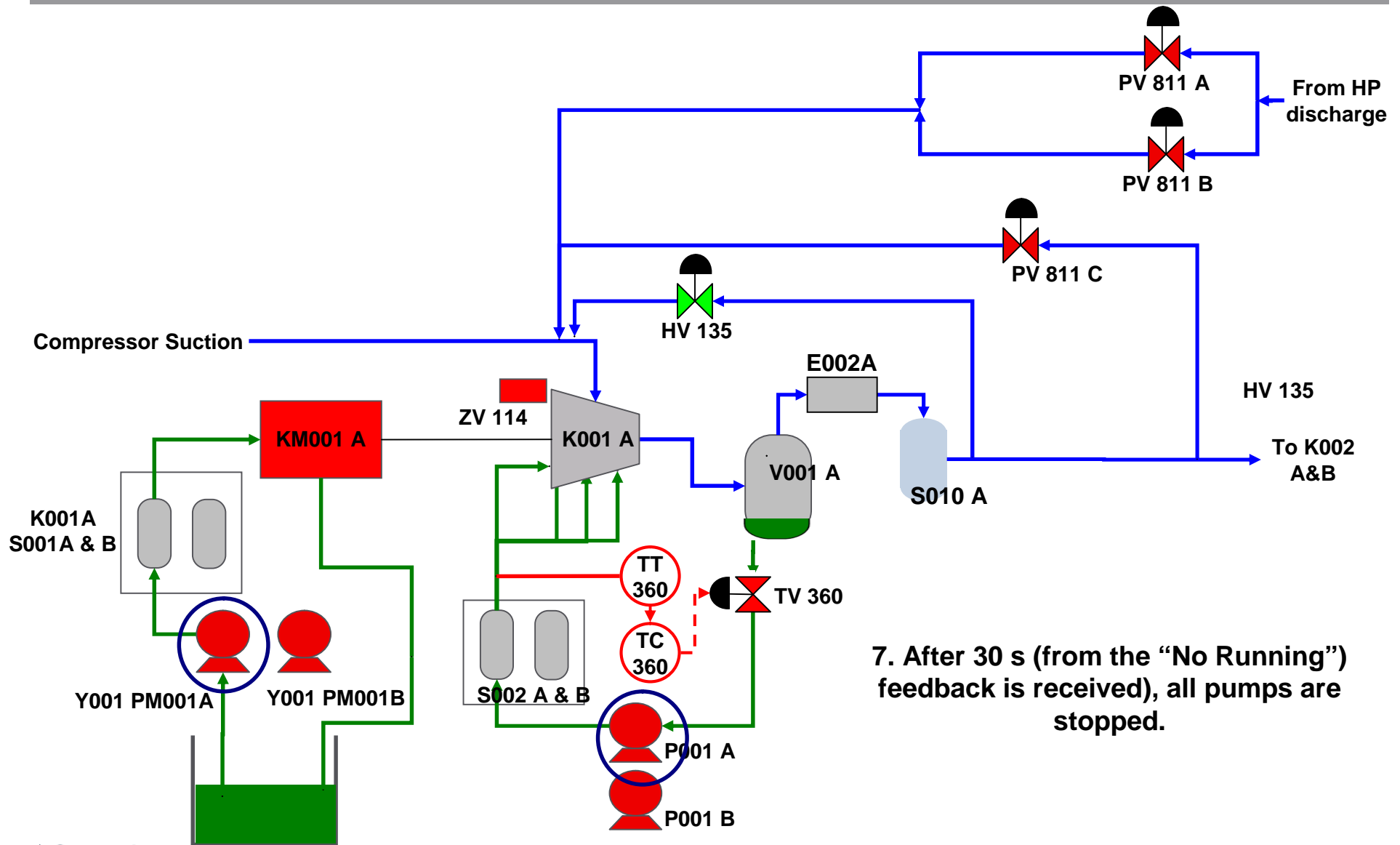


# Shutdown – Unit 323 – LP Helium Compressors

6. After 10 s (from the “No Running”) feedback is received), the Spill Back Valve fully opens with a ramp.

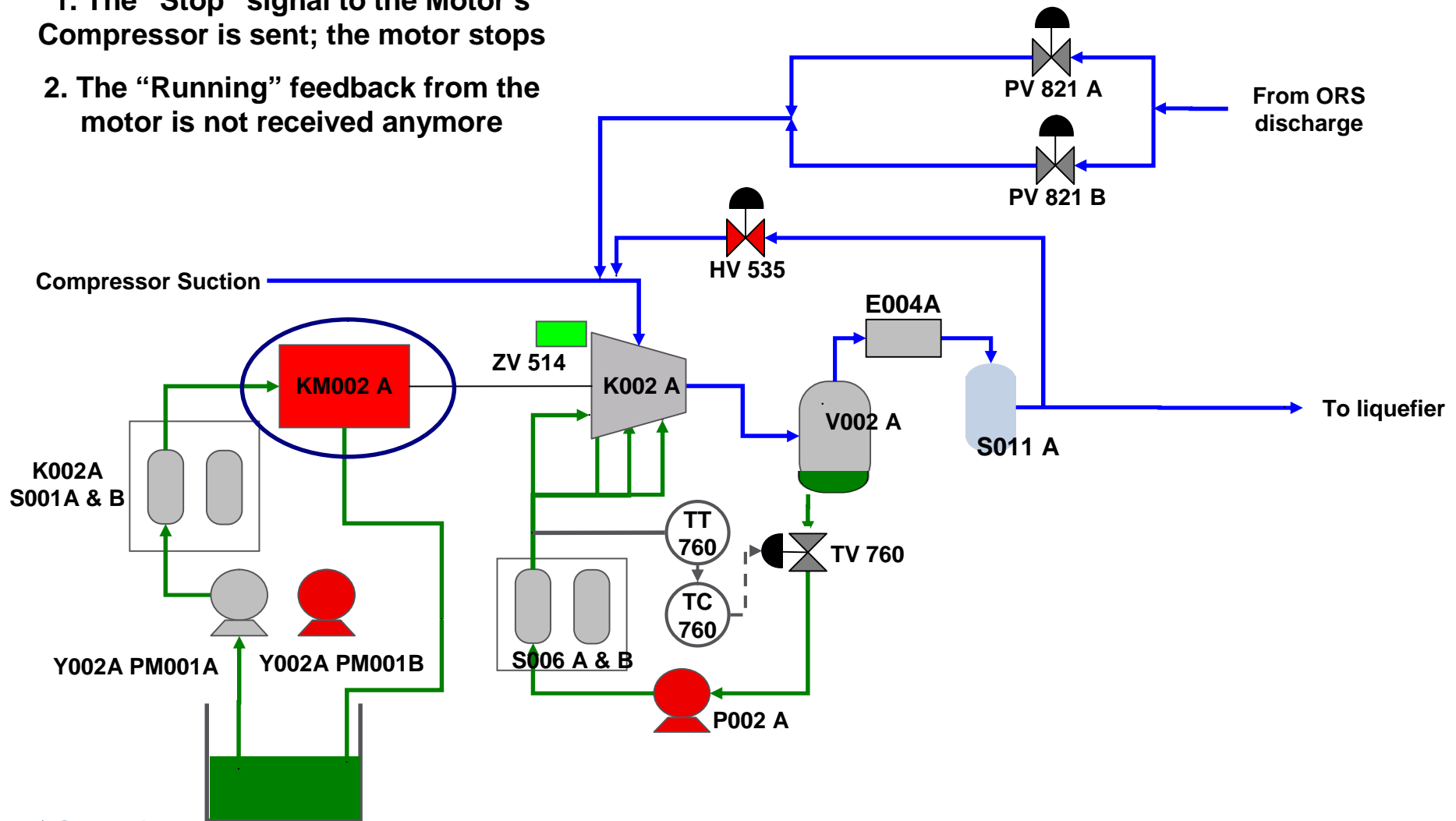


# Shutdown – Unit 323 – LP Helium Compressors



# Shutdown – Unit 323 – HP Helium Compressors

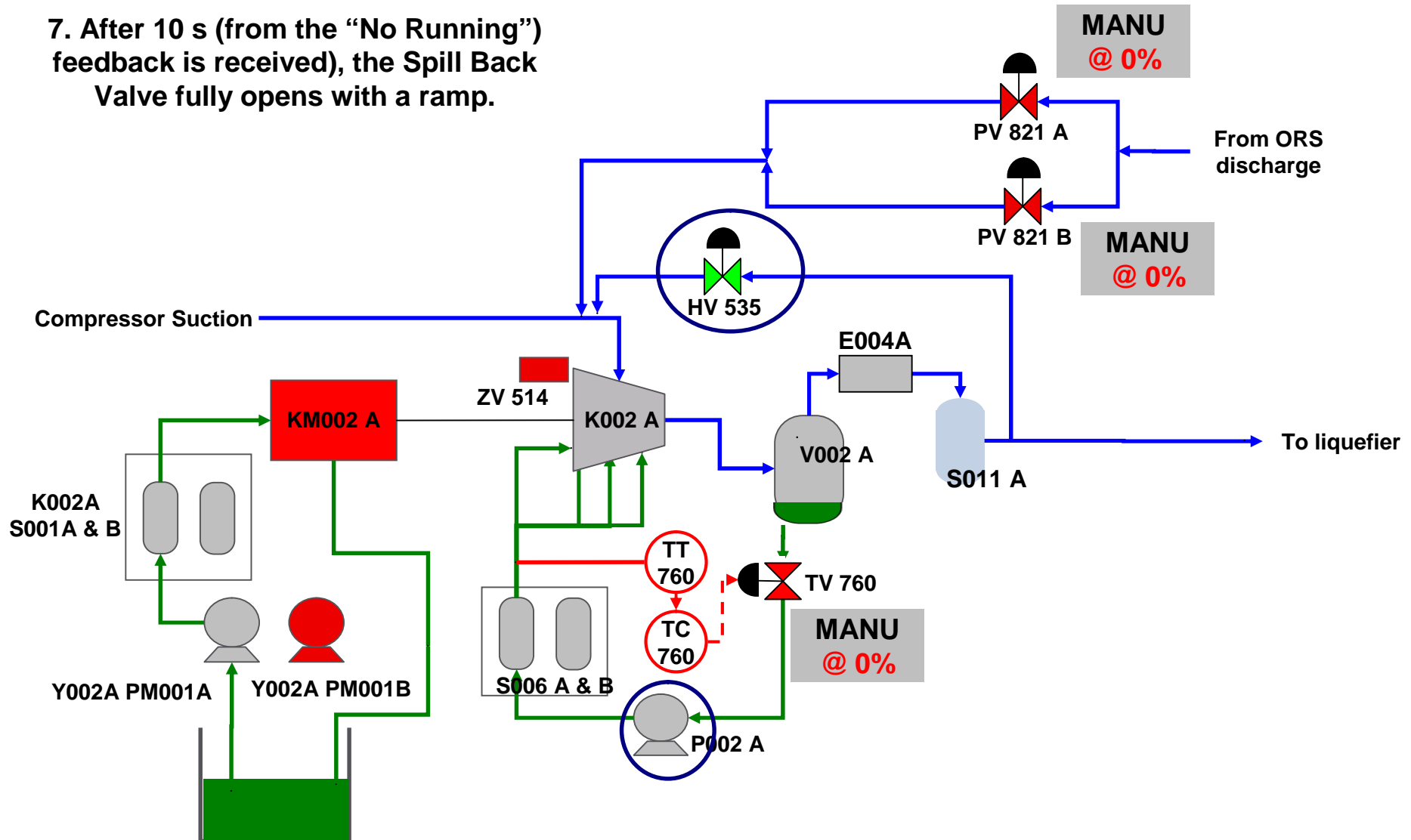
1. The “Stop” signal to the Motor’s Compressor is sent; the motor stops
2. The “Running” feedback from the motor is not received anymore



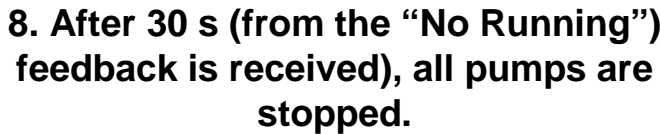


# Shutdown – Unit 323 – HP Helium Compressors

7. After 10 s (from the “No Running”) feedback is received), the Spill Back Valve fully opens with a ramp.



## Shutdown – Unit 323 – HP Helium Compressors



# Course Agenda

1. Normal startup
2. **Shutdown sequence**
  1. Overview
  2. Unit 323 – Helium Compressors
  3. Unit 326 – ASU
  4. Unit 322
  5. Unit 321 – Inlet Compressor
3. Emergency Shutdown

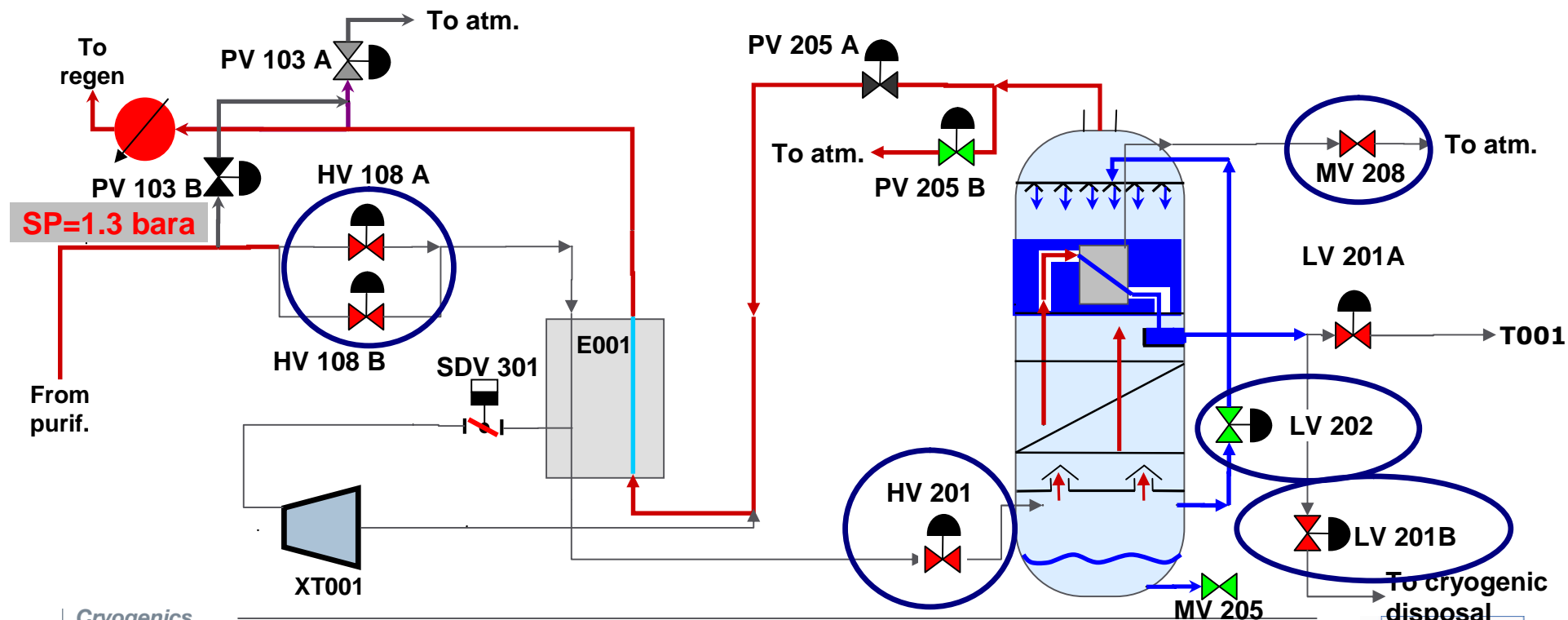
- Close LIN production
  - Close 326 LV 201 A
  - Close 326 MV 401
- The level in 326 T001 will slowly decrease as no more LIN fills in the tank.
- In order to compensate for the pressure drop, 326 PV 401 A opens to regulate the pressure.





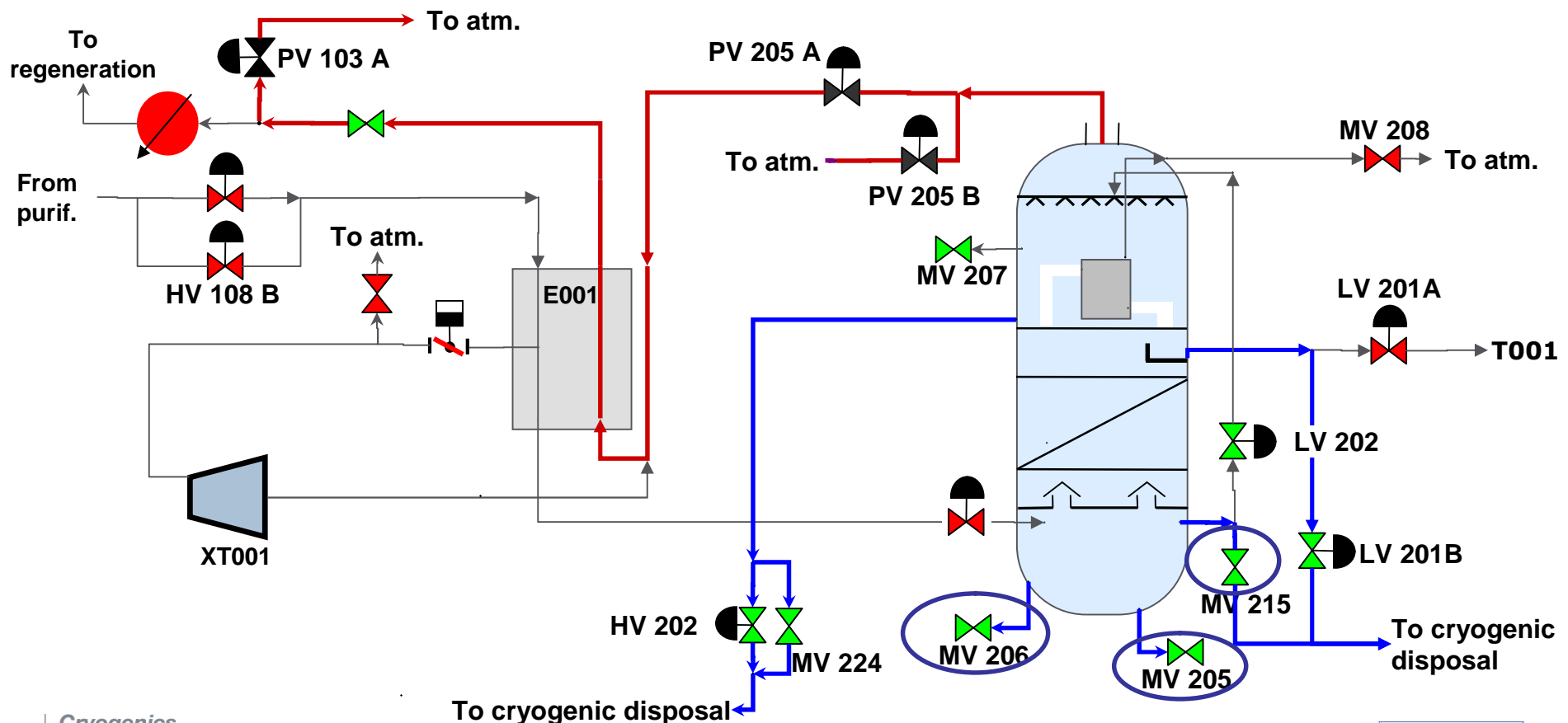
# Normal shutdown – ASU Shutdown – Cold Box

- Set PV 103 B in auto with SP = 1.3 bara.
- Stop the turbine from the DCS: inlet valve 326 SDV 301 and damper valve 326 HV 302 close.
- Slowly close 326 HV 201, 326 HV 108 A. Then, stop the Cold Box from the DCS.
- Fully open 326 LV 202 and close 326 MV 208.
- No more cold is brought into the system, which slowly heats up. Some liquid in the column vaporizes → Overpressure is released through 326 PV 205 B.



# Normal Start Up – ASU – ASU Cold Box – Dry out

- If shutdown lasts less than 2 days, no need to purge the LIN and rich liquid from the Cold Box. The insulation will ensure a sufficient level in 326 E002 bath.
- If shutdown lasts more than 2 days, all liquids must be purged. And the ASU must be derimed.



## Normal shutdown – ASU Shutdown – Purification

- In order to anticipate the next start up, the shutdown must occur after one of the bottle has finished its regeneration cycle.
- Record the regenerated bottle. This will be the lined up bottle at the next start up.
- Push the “Stop” button from the DCS. All valves close.
- Then, stop the compressor 326 K001.

# Course Agenda

1. Normal startup
2. **Shutdown sequence**
  1. Overview
  2. Unit 323 – Helium Compressors
  3. Unit 326 – ASU
  4. Unit 322
  5. Unit 321 – Inlet Compressor
3. Emergency Shutdown

# Shutdown – Unit 322 – PSA

## SHORT ( $\leq 2$ days) PERIOD SHUTDOWN

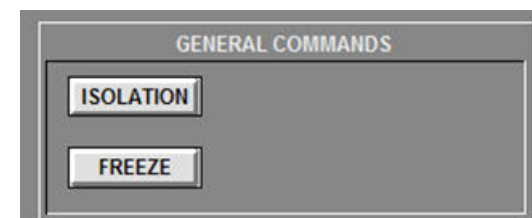
### → PSA FREEZE

- The PSA remains under pressure.
- All valves close except the PSA OffGas valves which are frozen in their last position before freezing.
- To go back to normal operation, the operator has to press “Unfreeze”.
- 3 factors cause the PSA freeze:
  - ▣ Operator request
  - ▣ PSA trip
  - ▣ PSA troubleshooting due to valves or pressures discrepancies.

## LONG ( $\geq 2$ days) PERIOD SHUTDOWN

### → PSA ISOLATION

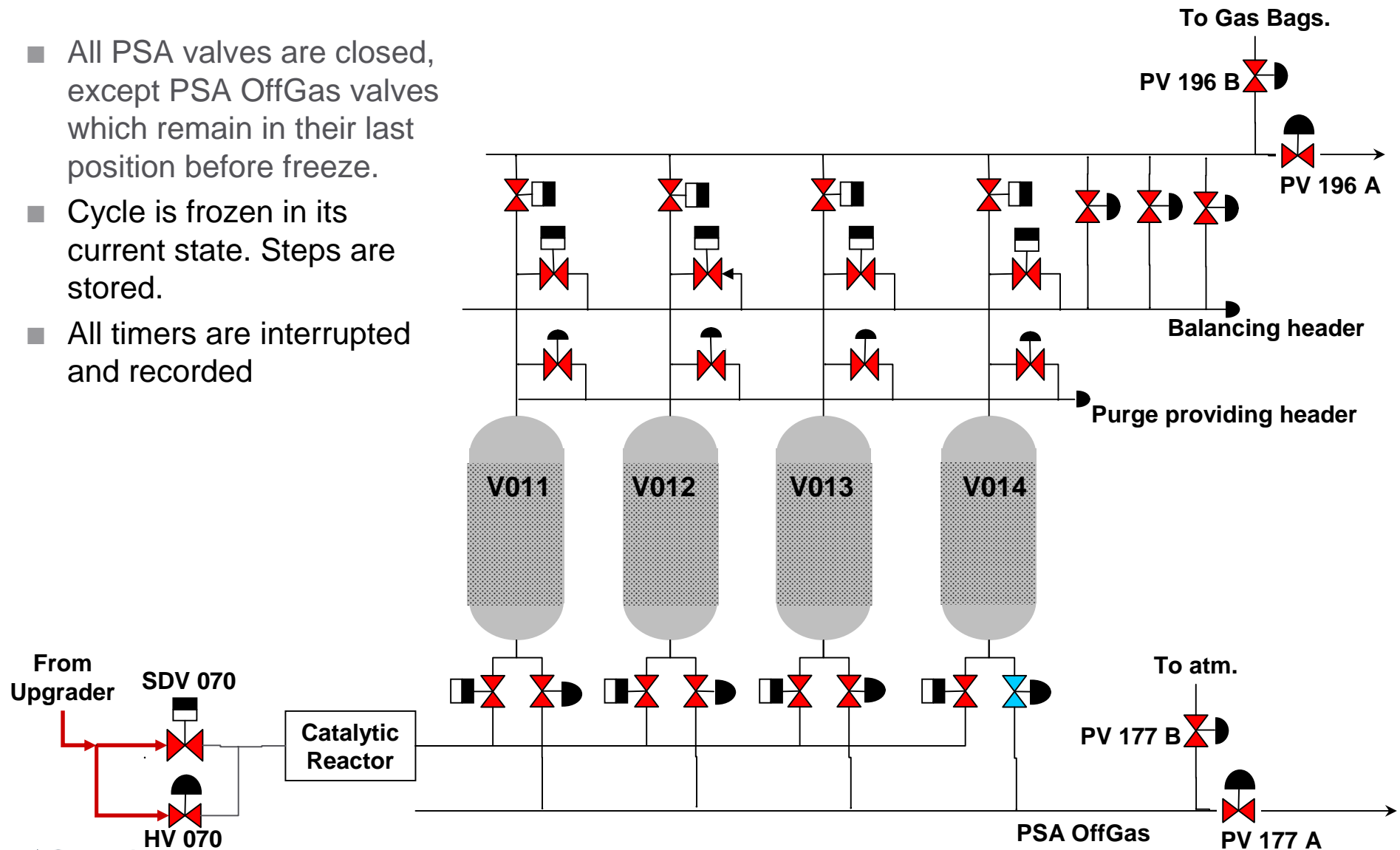
- All adsorbers must be depressurized and inerted with dry N<sub>2</sub> in order to release the toxic gas from adsorbers.
- All valves in PSA skid close
- Going back to normal operation requires the PSA pressurization.
- Only one factor causes PSA isolation:
  - ▣ Operator request.



PSA shutdown leads to Catalytic Reactor and PSA OffGas shutdowns.

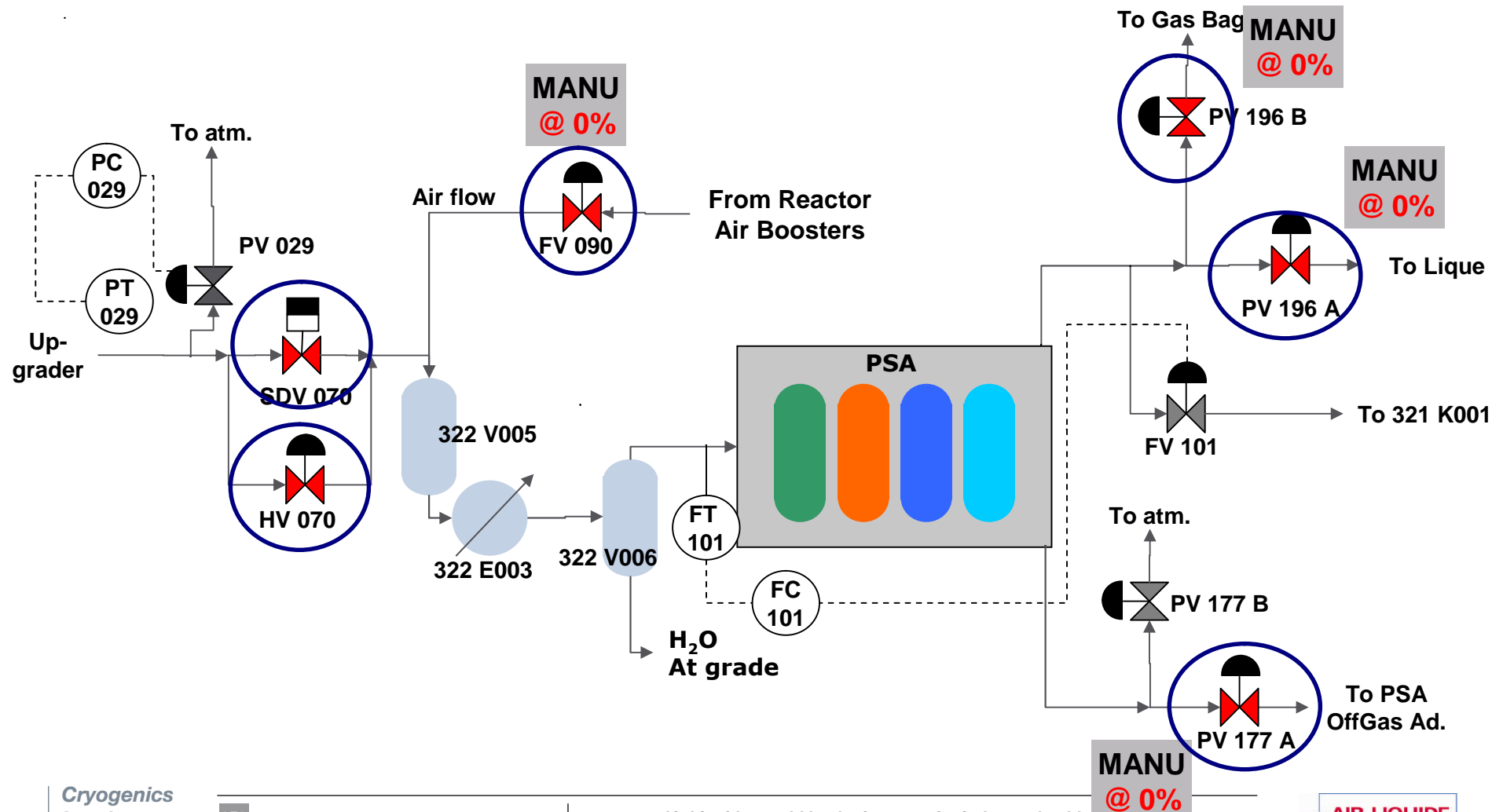
# Shutdown – Unit 322 – PSA Freeze

- All PSA valves are closed, except PSA OffGas valves which remain in their last position before freeze.
- Cycle is frozen in its current state. Steps are stored.
- All timers are interrupted and recorded



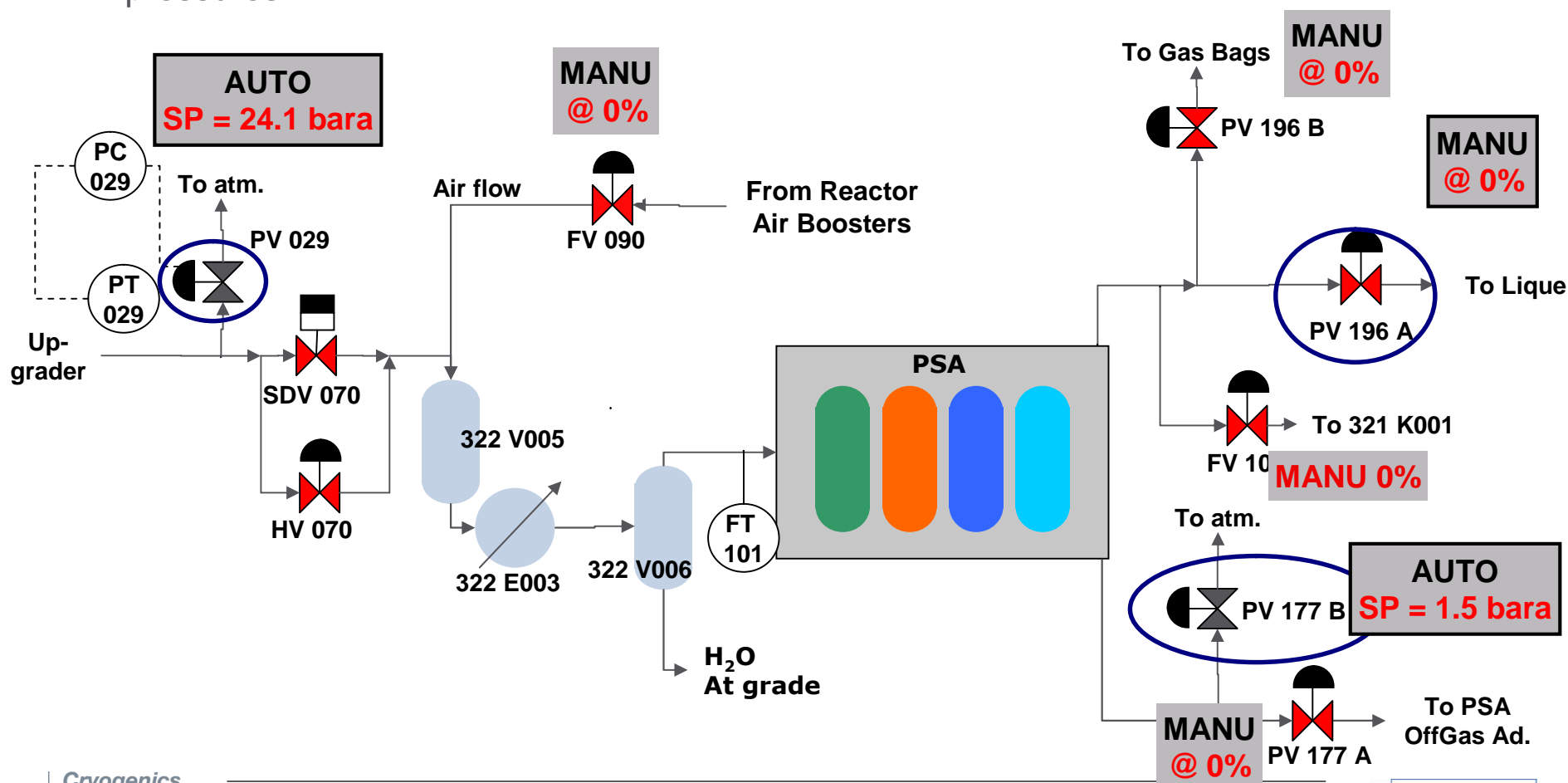
# Shutdown – Unit 322 – PSA Freeze

- Inlet valves (SDV 070 and HV 070), Pure Helium outlet valves (PV 196 A & B), PSA OffGas outlet valve (PV 177 A) and FV 090 close.



# Shutdown – Unit 322 – PSA Preparation to Unfreeze

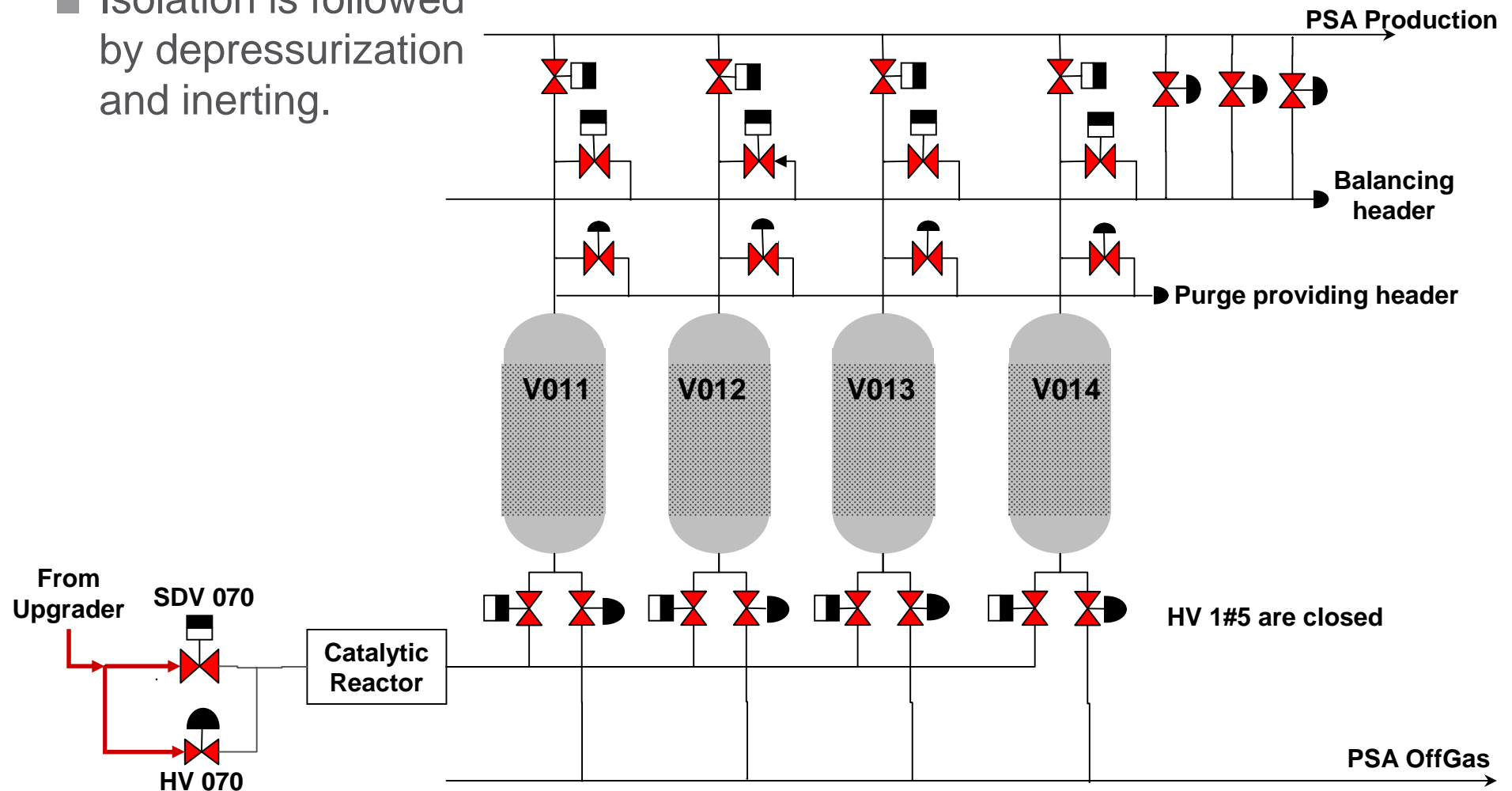
- Set PC 029 and PV 177 B in automatic mode
- PC 196 A is in manual mode, check the Set point
- Check that all RTS conditions are met. If needed, the operator can manually adjust the pressures.





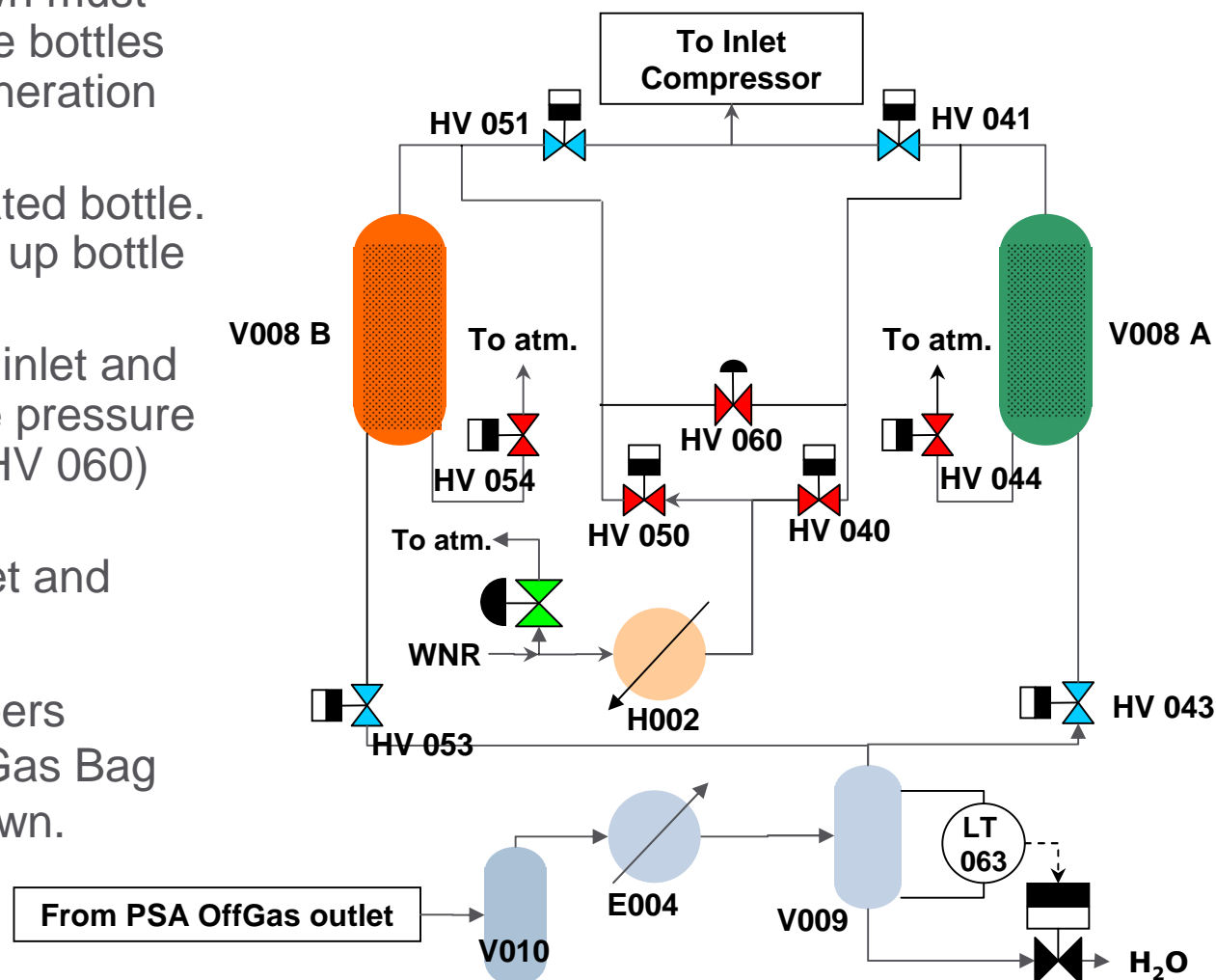
# Shutdown – Unit 322 – PSA Isolation

- Isolation is followed by depressurization and inerting.



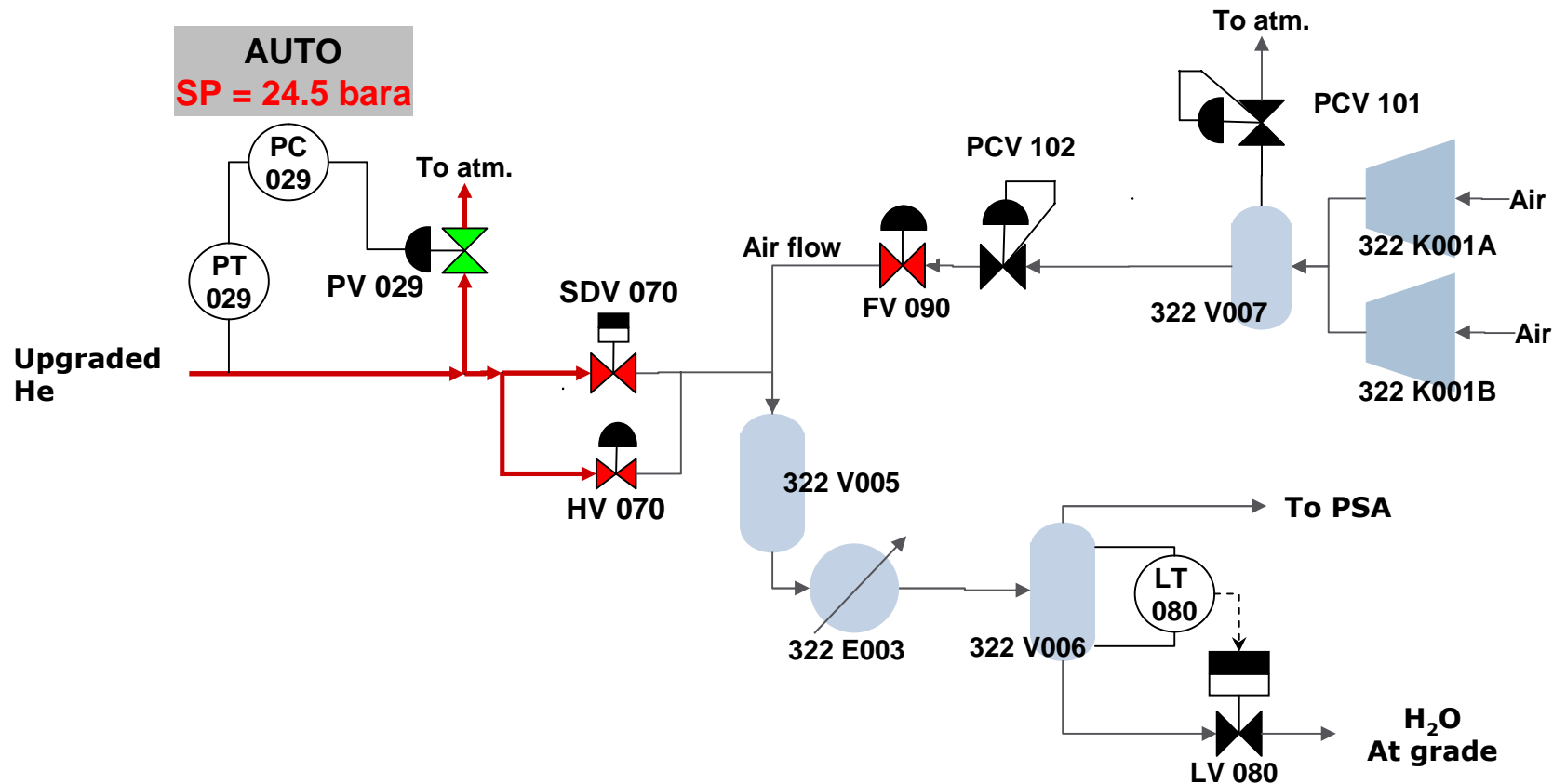
# Shutdown – Unit 322 – PSA OffGas Adsorbers

- In order to anticipate the next start up, the shutdown must occur after one of the bottles has finished its regeneration cycle.
- Record the regenerated bottle. This will be the lined up bottle at the next start up.
- The Waste Nitrogen inlet and outlet valves and the pressure balance valve (322 HV 060) close.
- The PSA OffGas inlet and outlet valves freeze.
- PSA OffGas Adsorbers shutdown leads to Gas Bag Compressor shutdown.



# Shutdown – Unit 322 – Catalytic Reactor

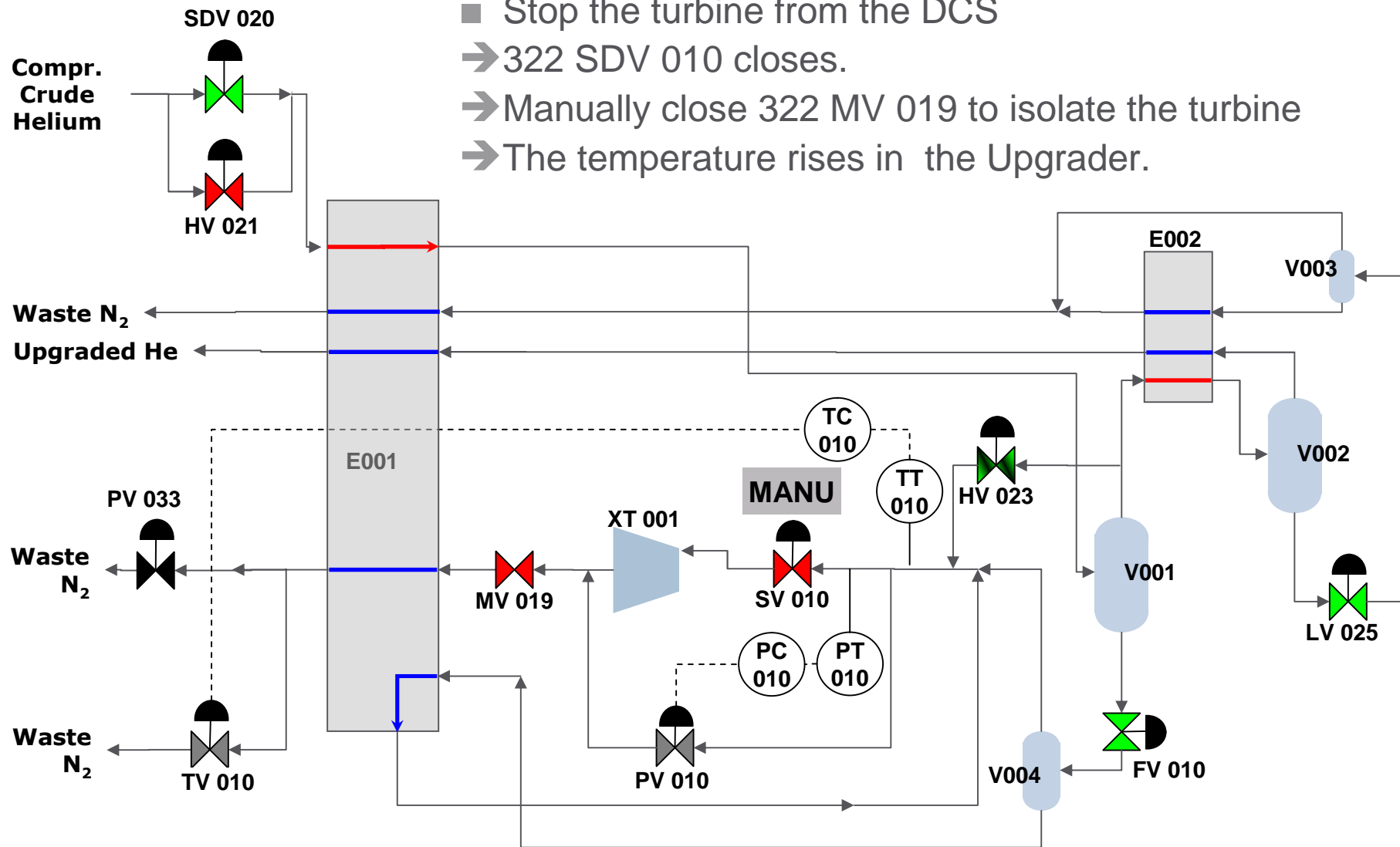
- The catalytic reactor is stopped from the DCS
  - ▣ 322 FV 090 closes
  - ▣ 322 SDV 070 and 322 HV 070 closes



# Shutdown – Unit 322 – Reactor Air Boosters

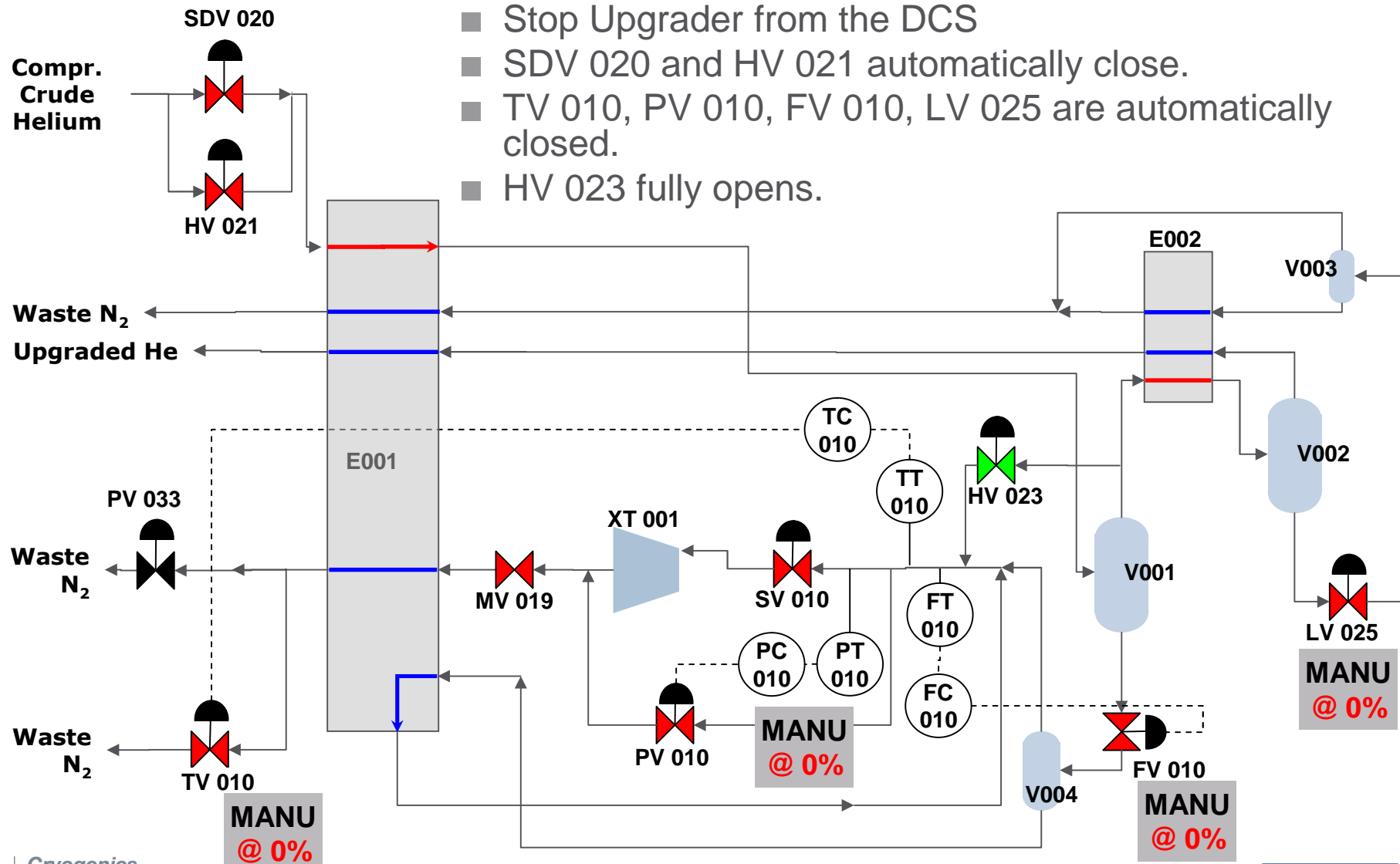
- Both Reactor Air Boosters are stopped from the DCS.
  - ▣ The appropriate Oil Pumps automatically stop.
- Reactor Air Boosters shutdown does not lead to Catalytic Reactor Shutdown.

# Shutdown – Unit 322 – Upgrader – Turbine 322 XT001



- Stop the turbine from the DCS
- ➔ 322 SDV 010 closes.
- ➔ Manually close 322 MV 019 to isolate the turbine
- ➔ The temperature rises in the Upgrader.

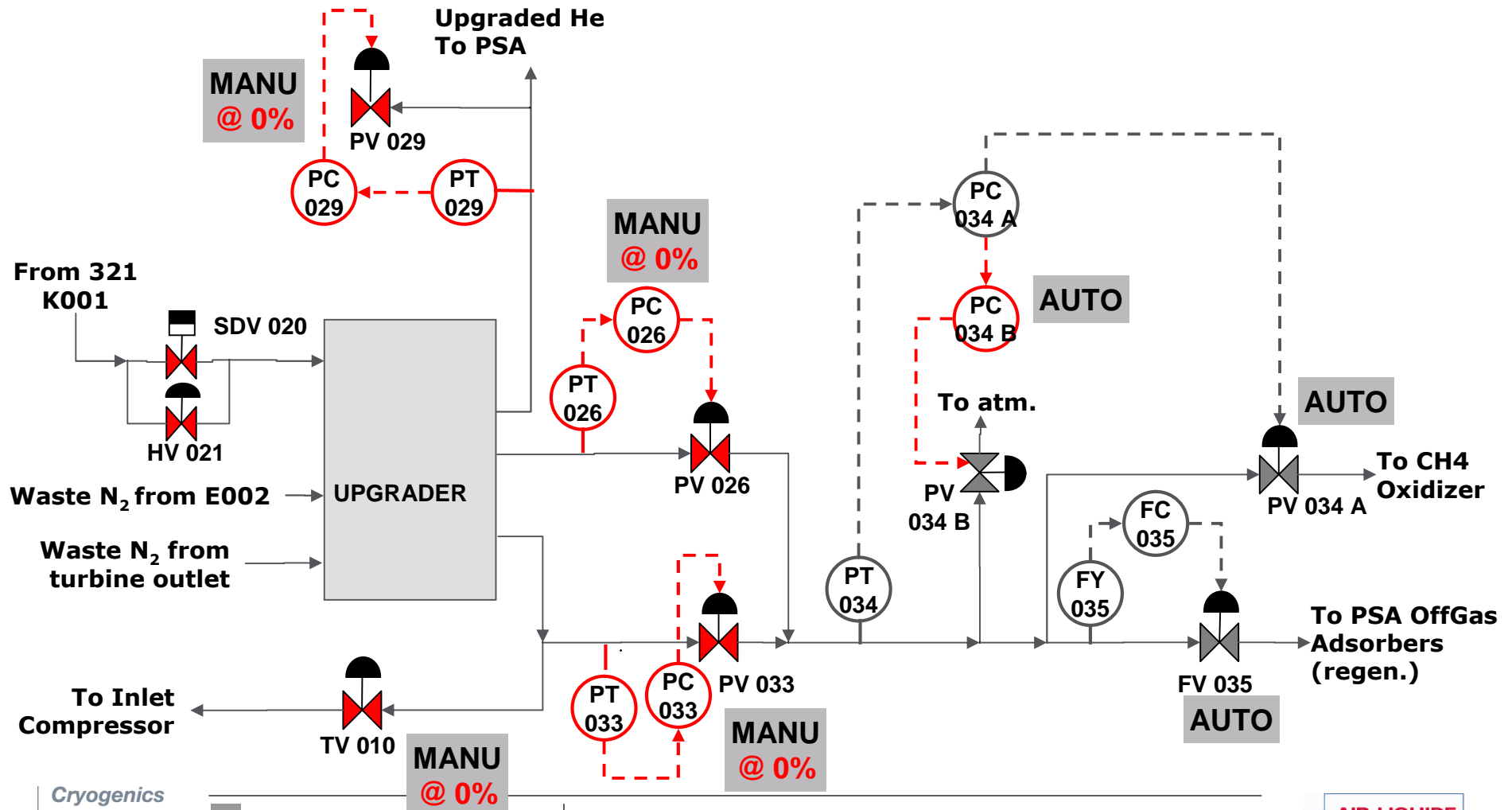
# Shutdown – Unit 322 – Upgrader



- Stop Upgrader from the DCS
- SDV 020 and HV 021 automatically close.
- TV 010, PV 010, FV 010, LV 025 are automatically closed.
- HV 023 fully opens.

# Shutdown – Unit 322 – Upgrader

- PV 029, PV 026 and PV 033 automatically switches to manu, 0%
- PV 034 A, PV 034 B and FV 035 remain in automatic control.



# Shutdown – Unit 322 – Upgrader

## PRESSURE CONTROL

- Monitor the pressure within the Cold Box
- If pressures rise too much and are likely to go above the PRV setting, reset the safety interlock and manually open the vent valves.

## LIQUID DRAIN

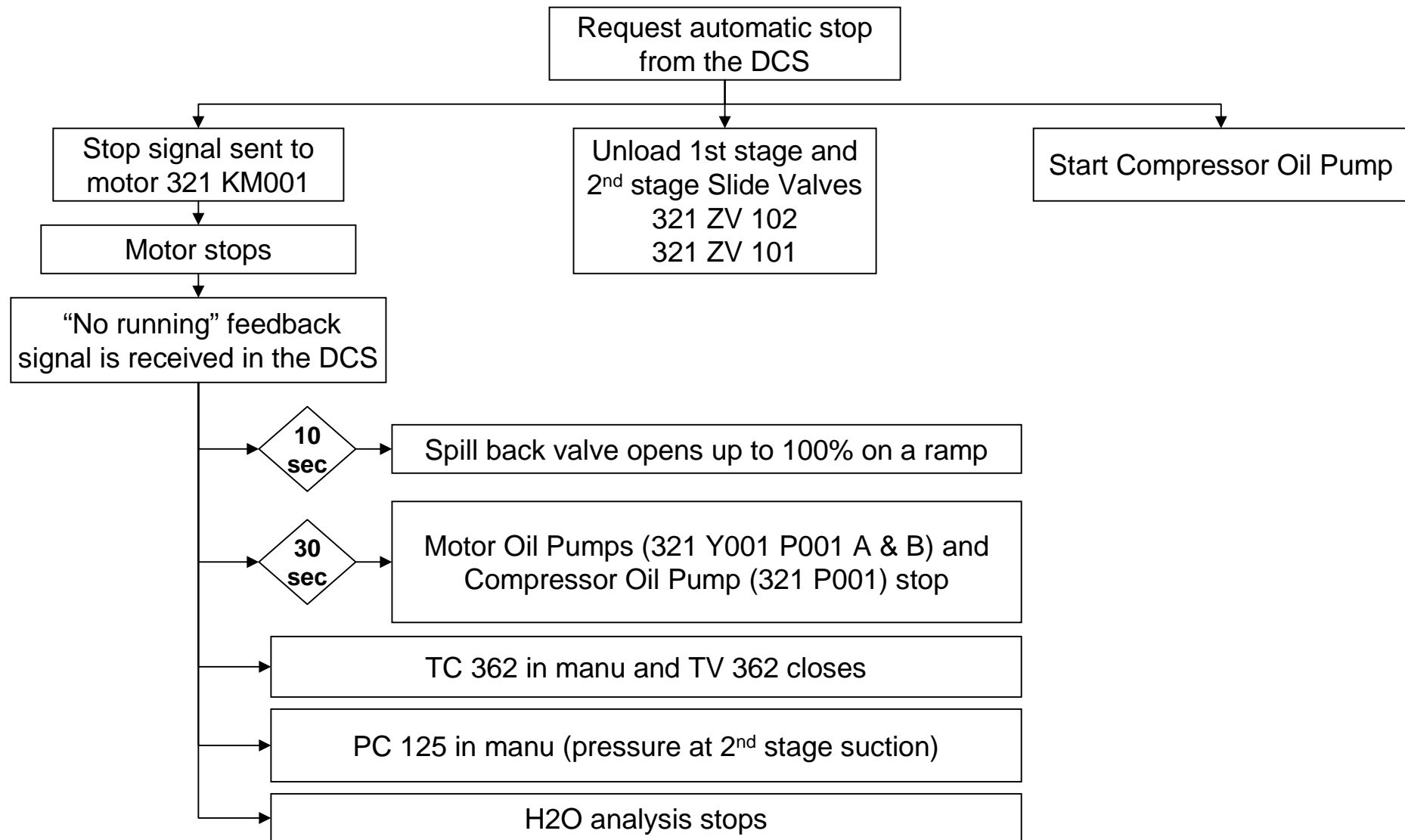
- If the shutdown lasts more than 2 days, drain all liquids and derime.



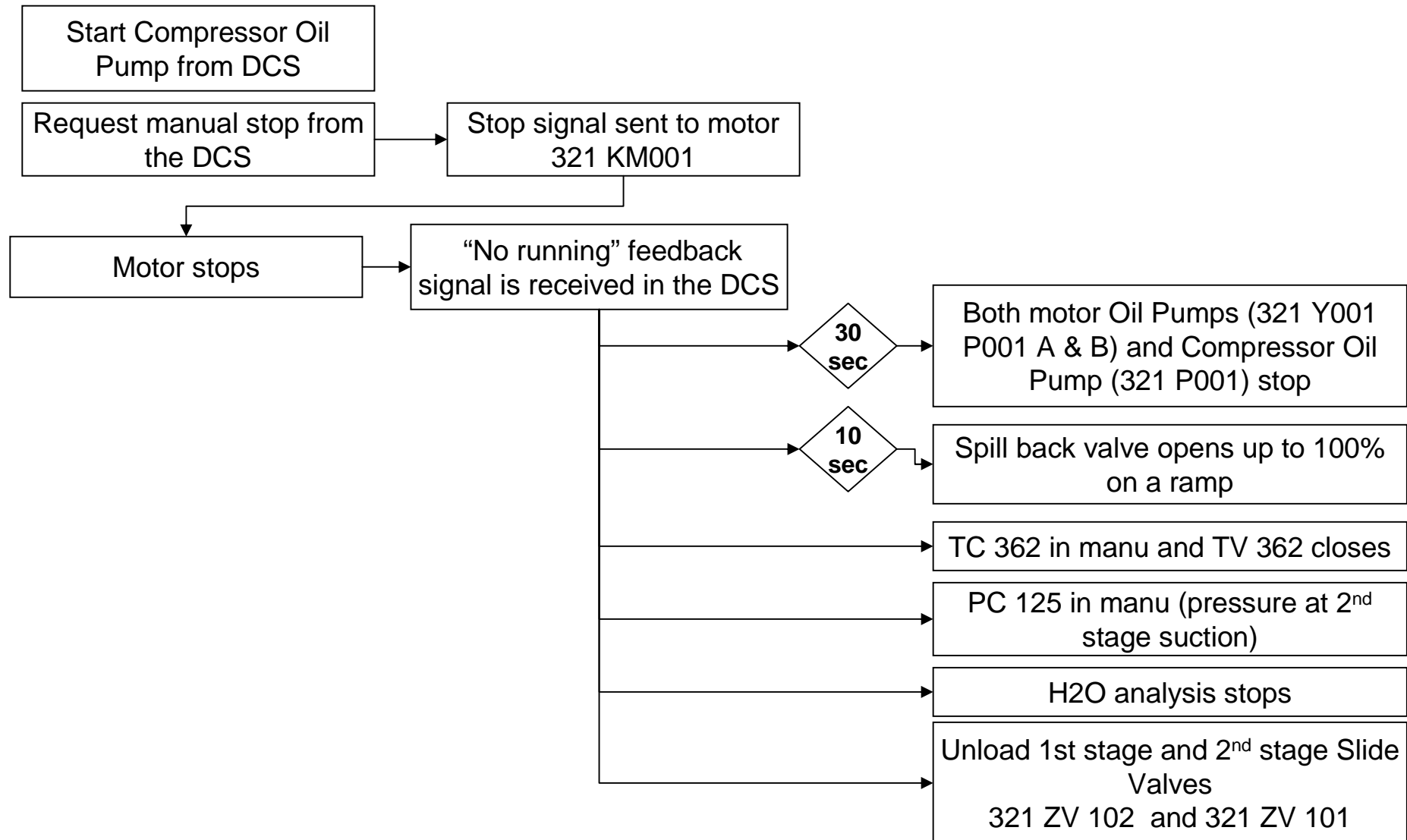
# Course Agenda

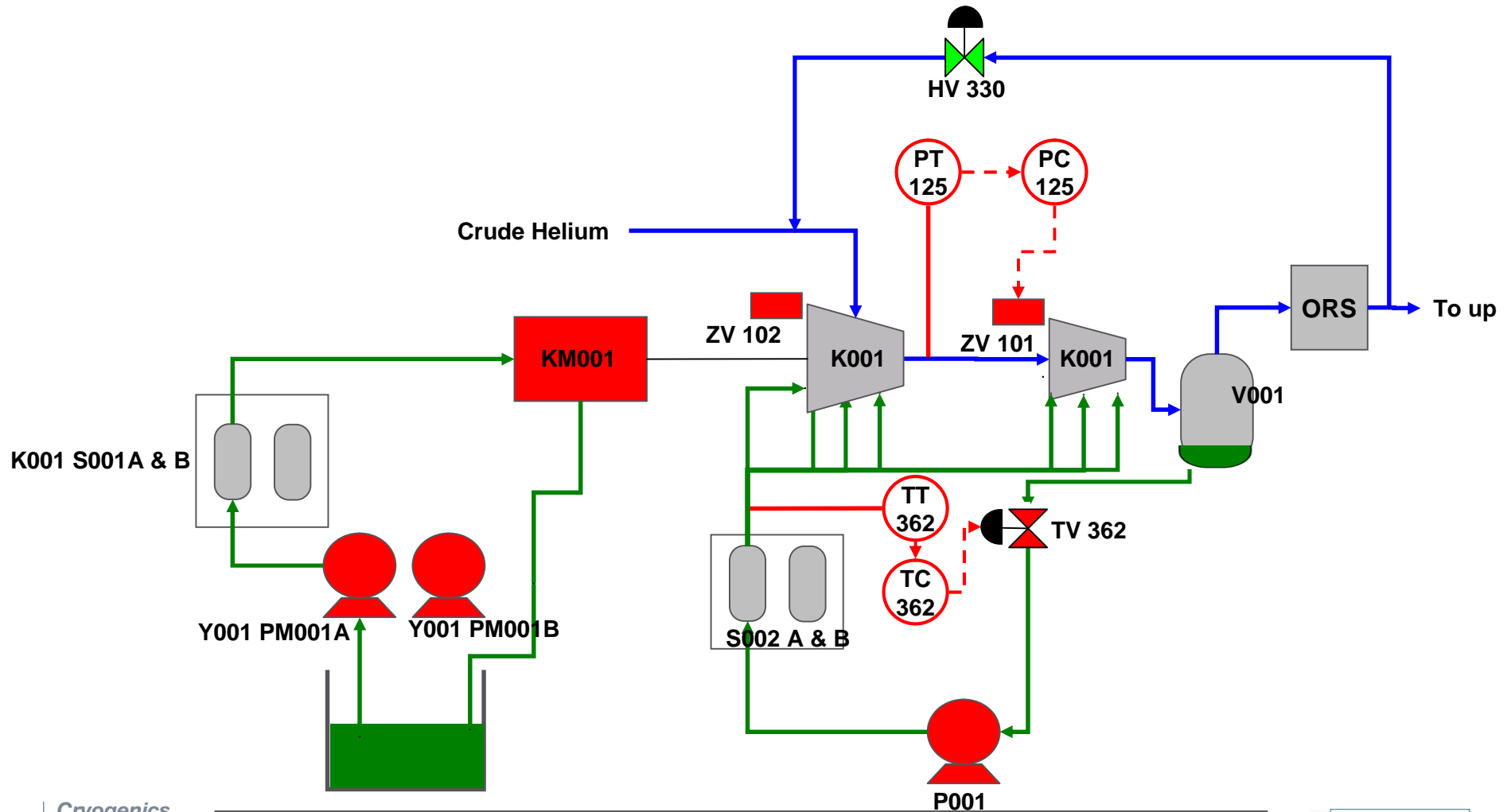
1. Normal startup
2. **Shutdown sequence**
  1. Overview
  2. Unit 323 – Helium Compressors
  3. Unit 326 – ASU
  4. Unit 322
  5. Unit 321 – Inlet Compressor
3. Emergency Shutdown

# Shutdown – Unit 321 – Automatic stop



# Shutdown – Unit 321 – Manual stop





# Course Agenda

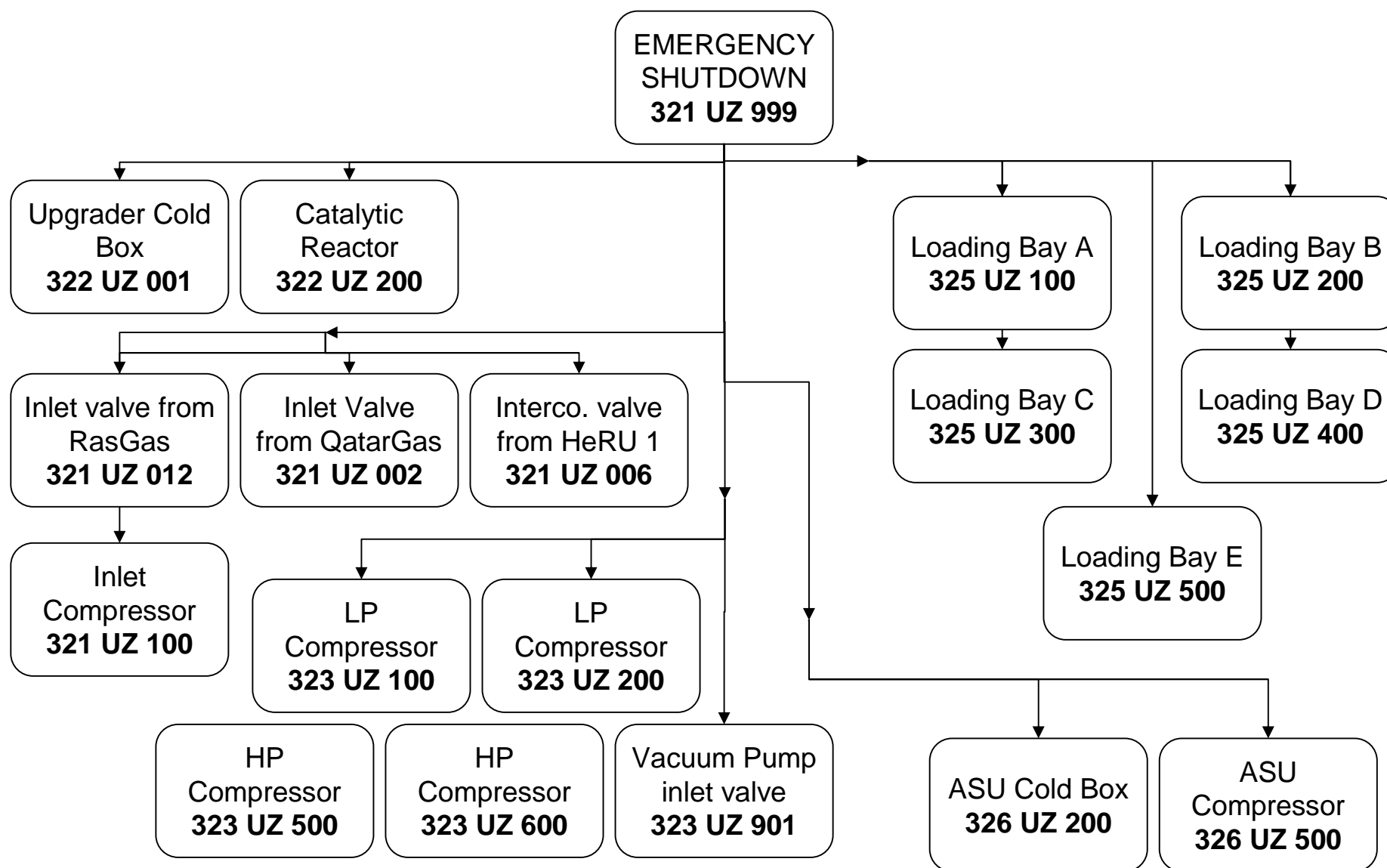
1. Normal startup
2. Shutdown sequence

## 3. Emergency Shutdown

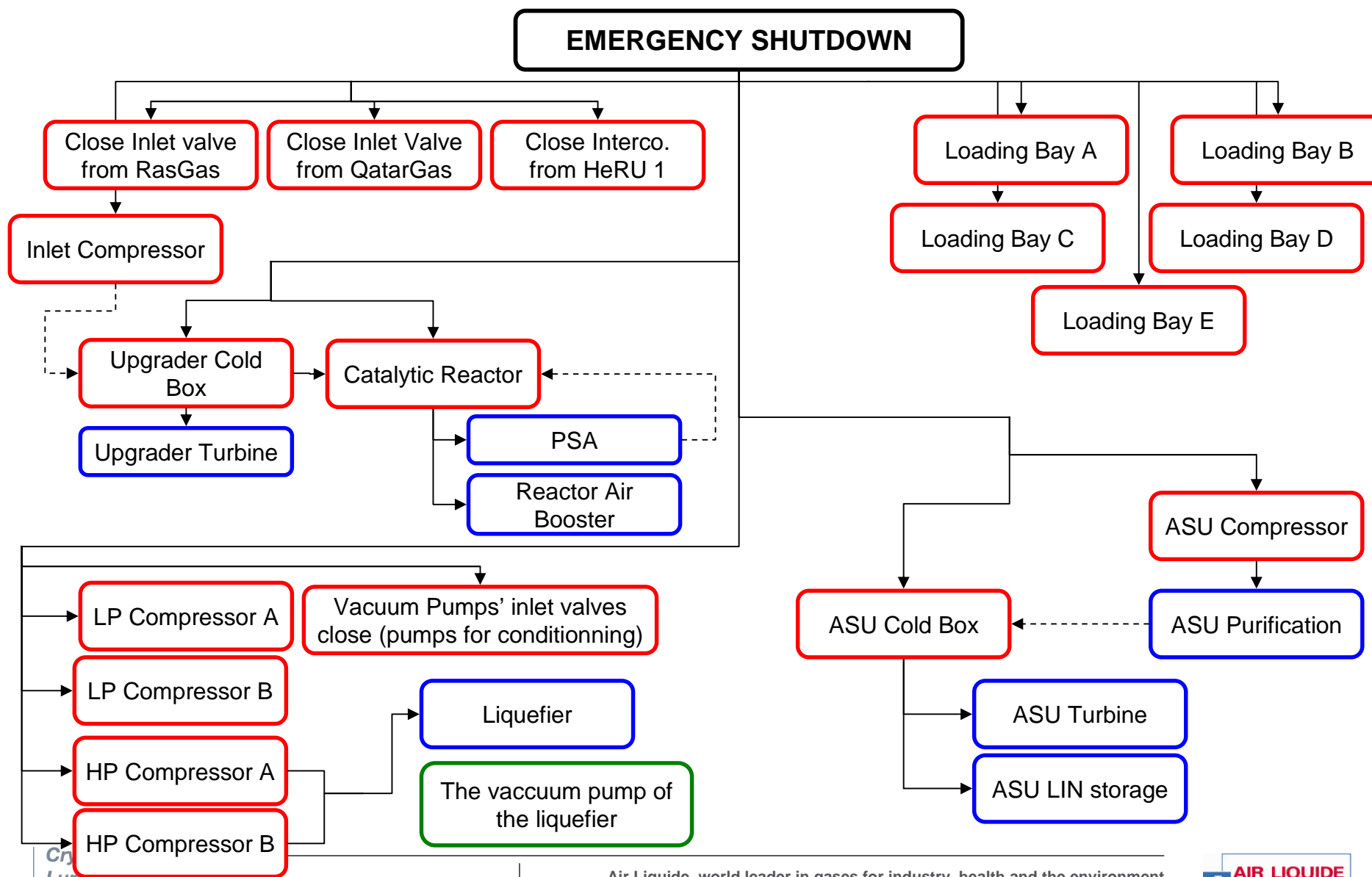
# Emergency Shutdown

- Emergency situations occur unexpectedly. There are 2 main causes of an Emergency Shutdown:
  - ▣ Major Equipment failure
  - ▣ Major and imminent danger for human safety
- If it is necessary to take the unit out of service because of an emergency situation, the procedures used for normal shutdown should be followed as closely as possible.
- Emergency Shutdowns buttons are located on site:
  - ▣ CA
  - ▣ Upgrader area
  - ▣ Compressor area
  - ▣ Liquefier area
  - ▣ Loading Bay area

# Emergency Shutdown – Safety Interlock tree

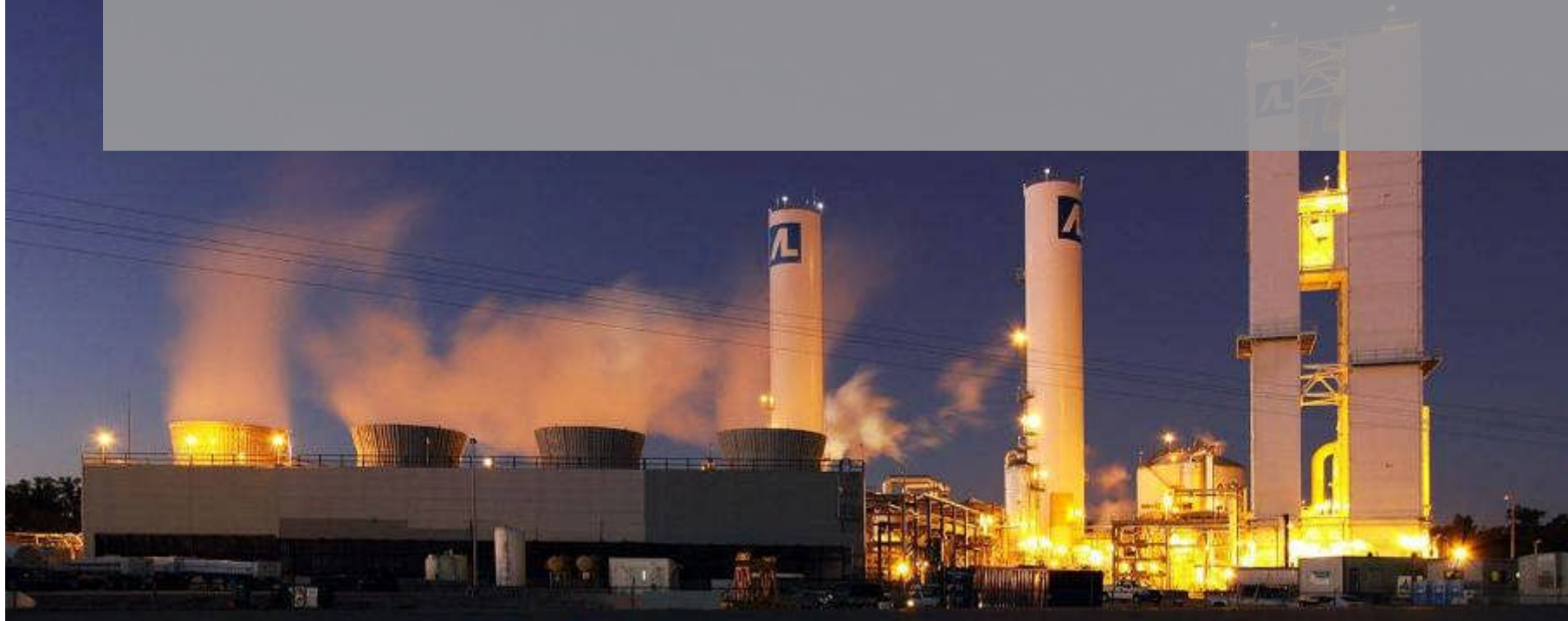


# Emergency Shutdown – Shutdown tree



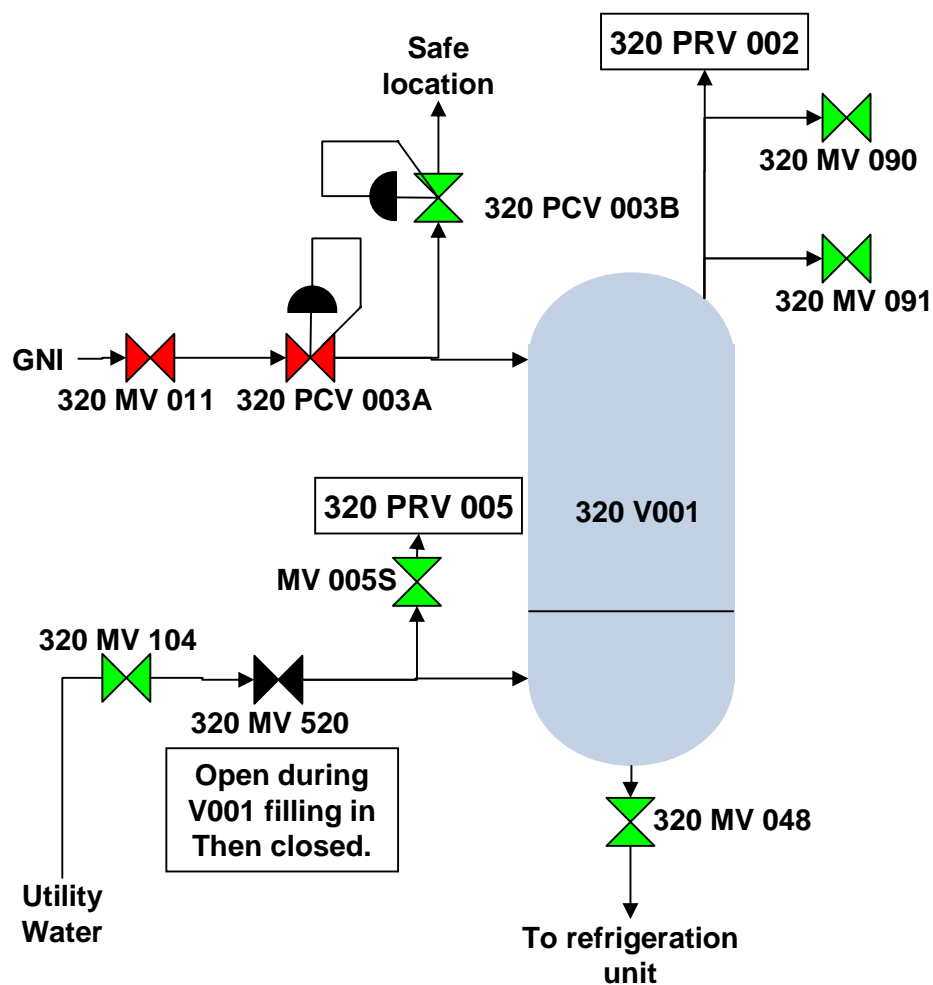


Thank you for your attention  
Questions?



# Normal start up – Utilities – Chilled Water

Start up – As long as GNI not available



Start up – GNI available

