Helium Operators Familiarization Program

Unit 324 - Adsorbers

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324 – Adsorbers

- 80K Adsorbers main characteristics
- 20K Adsorbers main characteristics
- Regeneration steps: overview
- Regeneration steps: depressurization
- Regeneration steps: warm-up
- Regeneration steps: purging
- Regeneration steps: filling
- Regeneration steps: cool down
- DCS views

324 – 80 K Adsorbers

- Dual 80K Adsorbers to allow continuous operation
- Trap air impurities (N_2, O_2) by adsorption at cryogenic temperature
  - ⇨Could damage the turbo-expanders at low temperature
- Normal operation T = 65K
- Kept cold by T1, T2 and T3
- Adsorbent = Molecular Sieve 13X
- Autonomy = 14 days for 50 ppm of N_2+O_2 in the feed gas (PSA outlet)
- Need to be dried and pumped during pre-commissioning (>100℃, 10 mb) to remove water traces
  - ⇨High affinity with water
- Regeneration uses effect of Temperature (up to 220K) and Pressure to release impurities
- Regeneration time estimated to 15 hours
- In case of Temperature increase
  - Liquefier capacity is exceeded
  - Risk of pollution release

324 – 20 K Adsorbers

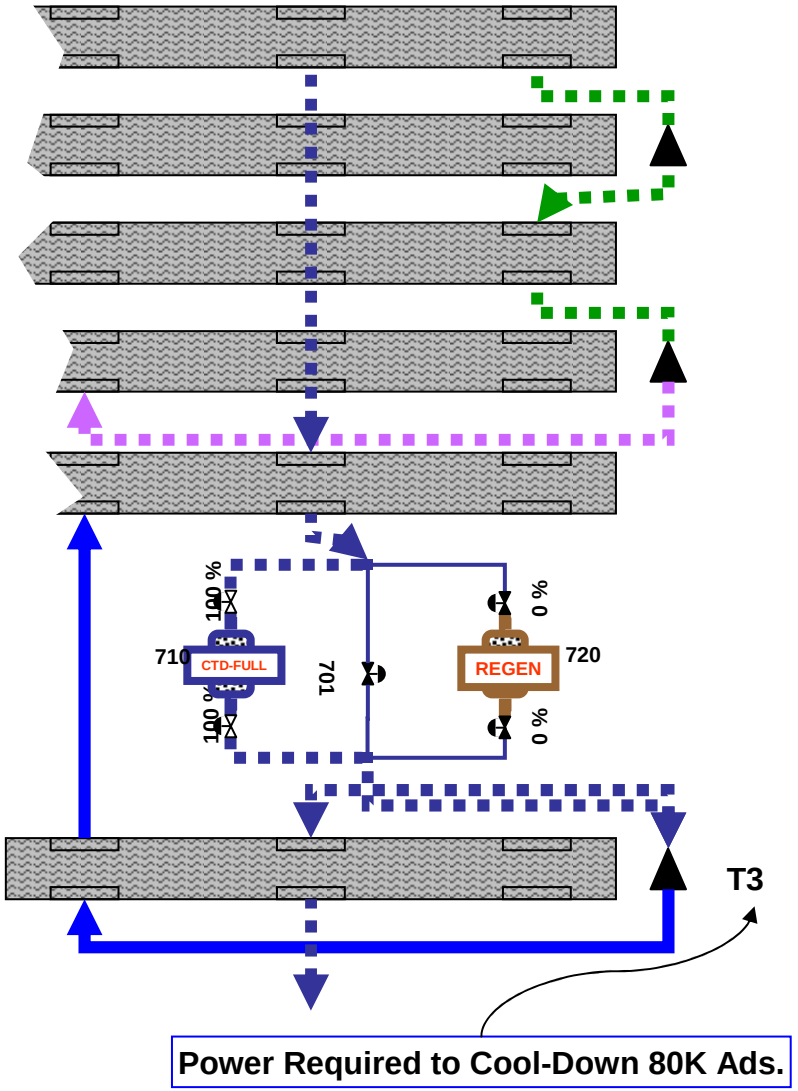
- Dual 20K Adsorbers to allow for continuous operation

- Trap Ne and H2 by adsorption at cryogenic temperature
  - ⇨Could damage the turbo-expanders at low temperature
- Normal operation T = 19K
- Kept cold by T5
- Adsorbent = Charcoal
- Autonomy = 20 days (10 days + 100% margin) for 70 ppm of Ne + H2 in the feed gas (PSA outlet)
- Need to be dried and pumped during pre-commissioning (>100℃, 10 mb) to remove water traces
- Regeneration uses effect of temperature (up to 80K) and pressure to release impurities
- Regeneration time estimated to 5 hours
- In case of Temperature increase
  - Liquefier capacity is exceeded
  - Risk of pollution release

324 – Turbines Start-up

- The Adsorbers are installed to:
  - Ensure high purity product
  - To protect the Turbines from impurities.
  - To prevent plugging the Heat exchanger with impurities.

Adsorbers are cooled down by downstream turbines.
Thus these Turbines are allowed to start before the Adsorbers have reached their nominal temperature.



324 – Nominal Mode

- In order to ensure continuous operation, 2 adsorbers are installed in parallel.
  - One is in operation
  - The other one is in regeneration or in stand-by

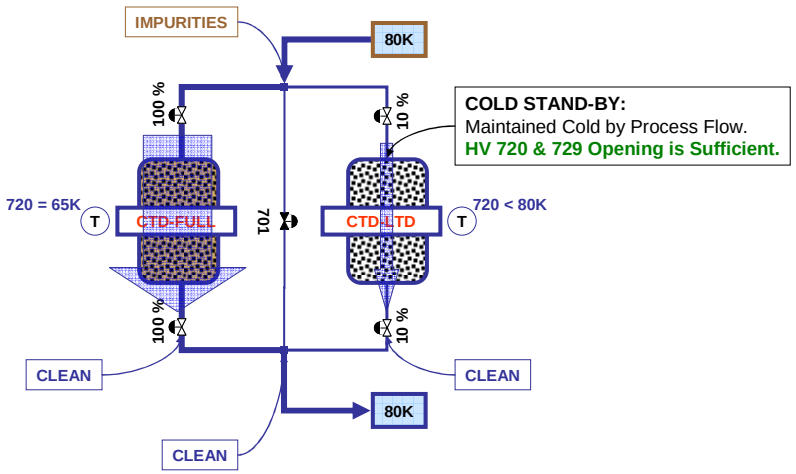
- Cold Stand-By

The flow taken from the process main stream shall be

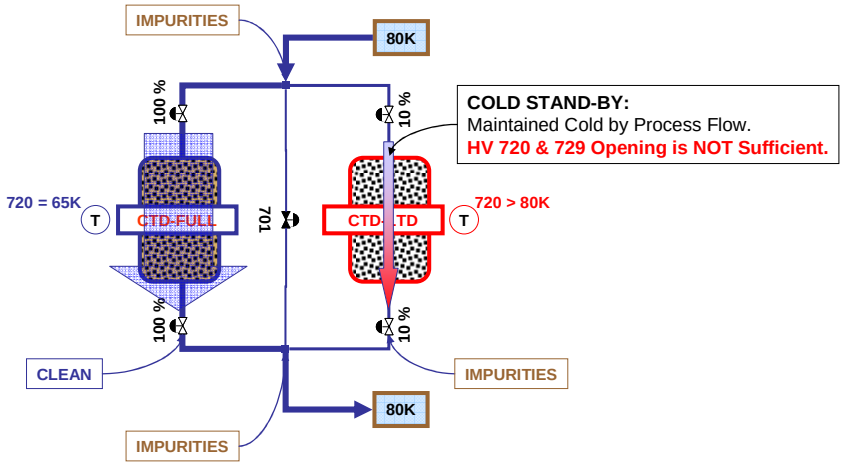
- Sufficient to maintain the adsorber cold
- As low as possible in order to keep the adsorber “clean”

➔ Opening of the valve will be adjusted during commissioning.

INLET / OUTLET Valves with Sufficient opening

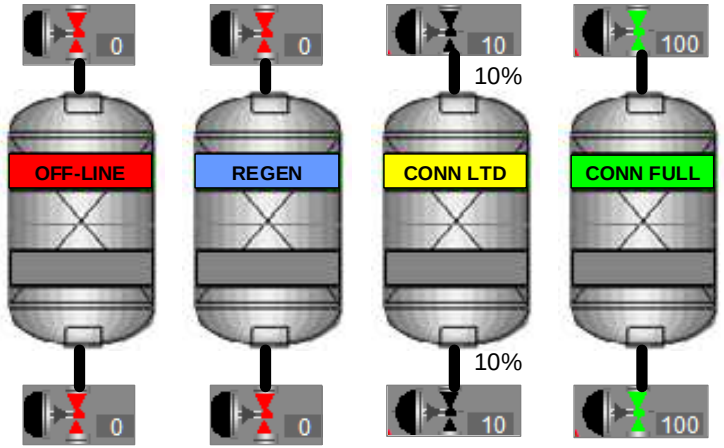


INLET / OUTLET Valves with Insufficient opening



324 – Adsorbers Sequence – Adsorbers status

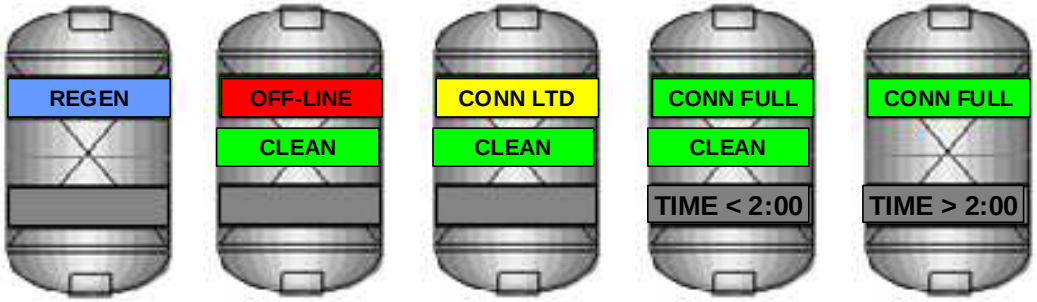
- The Adsorbers can be in one of the following status:
  - **OFF LINE**
    - Inlet / Outlet Valves are closed, and Regeneration Sequence OFF.
  - **REGEN**
    - Regeneration Sequence ON.
  - **CONN-LTD**
    - Connected Limited:Inlet / Outlet Valves @ ~10% (to be adjusted), small flow to keep the Adsorber Cold.
  - **CONN-FULL**
    - Connected Full: Inlet / Outlet Valves @ 100%, Adsorber is ON LINE.



324 – Adsorbers Sequence – Adsorbers status

- **CLEAN**
  - At the end of regeneration, the Adsorber is CLEAN.
  - The Adsorber remains CLEAN until it has been CONN.-FULL and cold for more than 2 hours.
  - If CONN.-FULL and warm, impurities does not accumulate, and the Adsorber remains CLEAN.

- **TIMER**
  - The TIMER is reset to 0 at the end of regeneration.
  - The timer runs when then adsorber is CONN.-FULL (and freezes otherwise).
  - When the Timer is > 2hours, the Adsorbers is not CLEAN anymore.



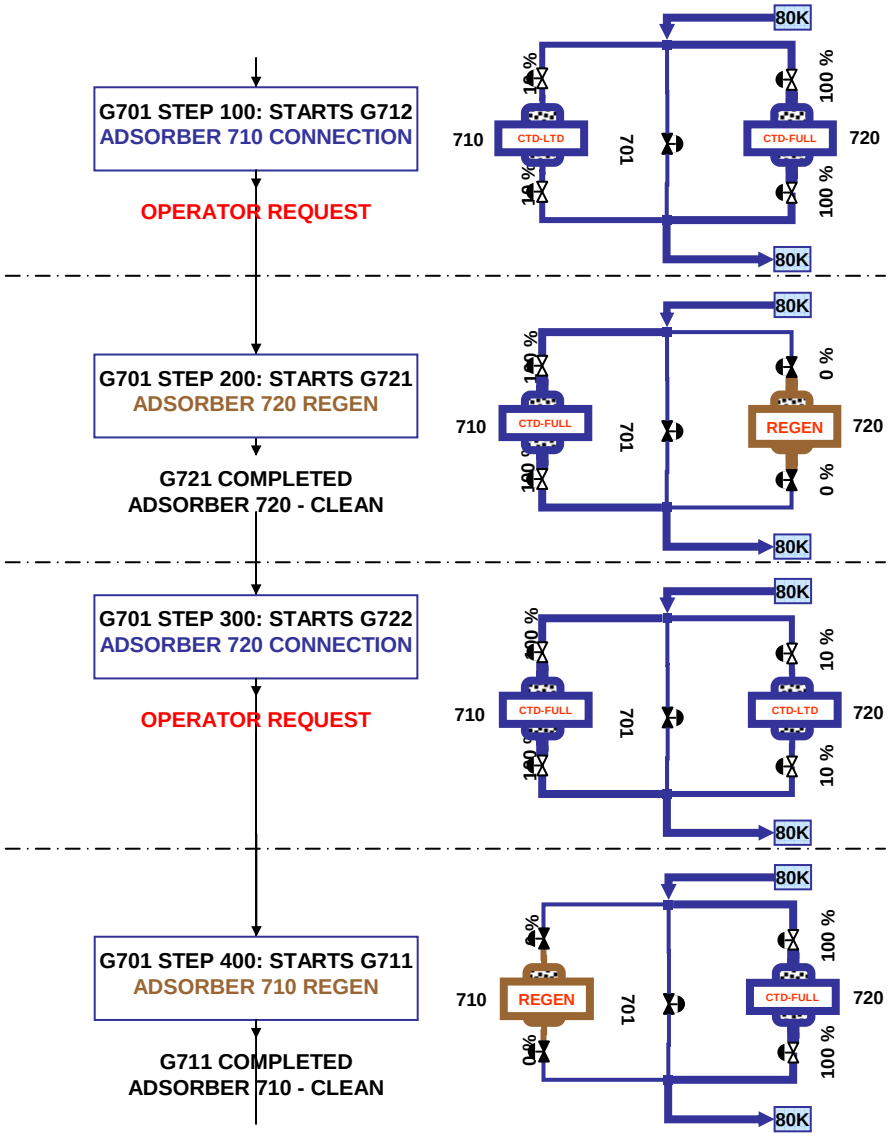
324 – Adsorbers Sequence – When Regenerate ?

- **REGENERATION is requested by the Operator based on Time or Analysis:**
  - 80K Adsorbers are designed for 15 Days of Operation.
  - 20K Adsorbers are designed for 20 Days of Operation (10 days +100% margins)

ANALYSIS shall be performed daily by the operator at the discharge of **CONNECTED-FULL** Adsorbers.

- **Regeneration is required if the Impurity Level rises above normal:**
  - > 3 ppm of N2 or O2 downstream 80K Ads
  - > 3 ppm of Ne or H2 downstream 20K Ads.

324 – Adsorbers Sequence – Nominal Mode



324 – Adsorbers Sequence

- **G300** – Liquefier Cool-Down [START] –will start the Adsorbers General sequences:
  - Step 200: Starts **G701 – 80K Adsorbers General Sequence**
  - Step 220: Starts **G702 – 20K Adsorbers General Sequence**

- **G701** will start first:
  - If one Adsorber is clean, it will be connected.
  - If no Adsorber is Clean, the Warmest will be regenerated and then connected.
  - When one of the 80K Adsorber is CONNECTED-FULL G702 can continue.

- **G702** will start if one 80K is on line (710 or 720 full connected):
  - If one Adsorber is clean, it will be connected.
  - If no Adsorber is Clean, the Warmest will be regenerated and then connected.

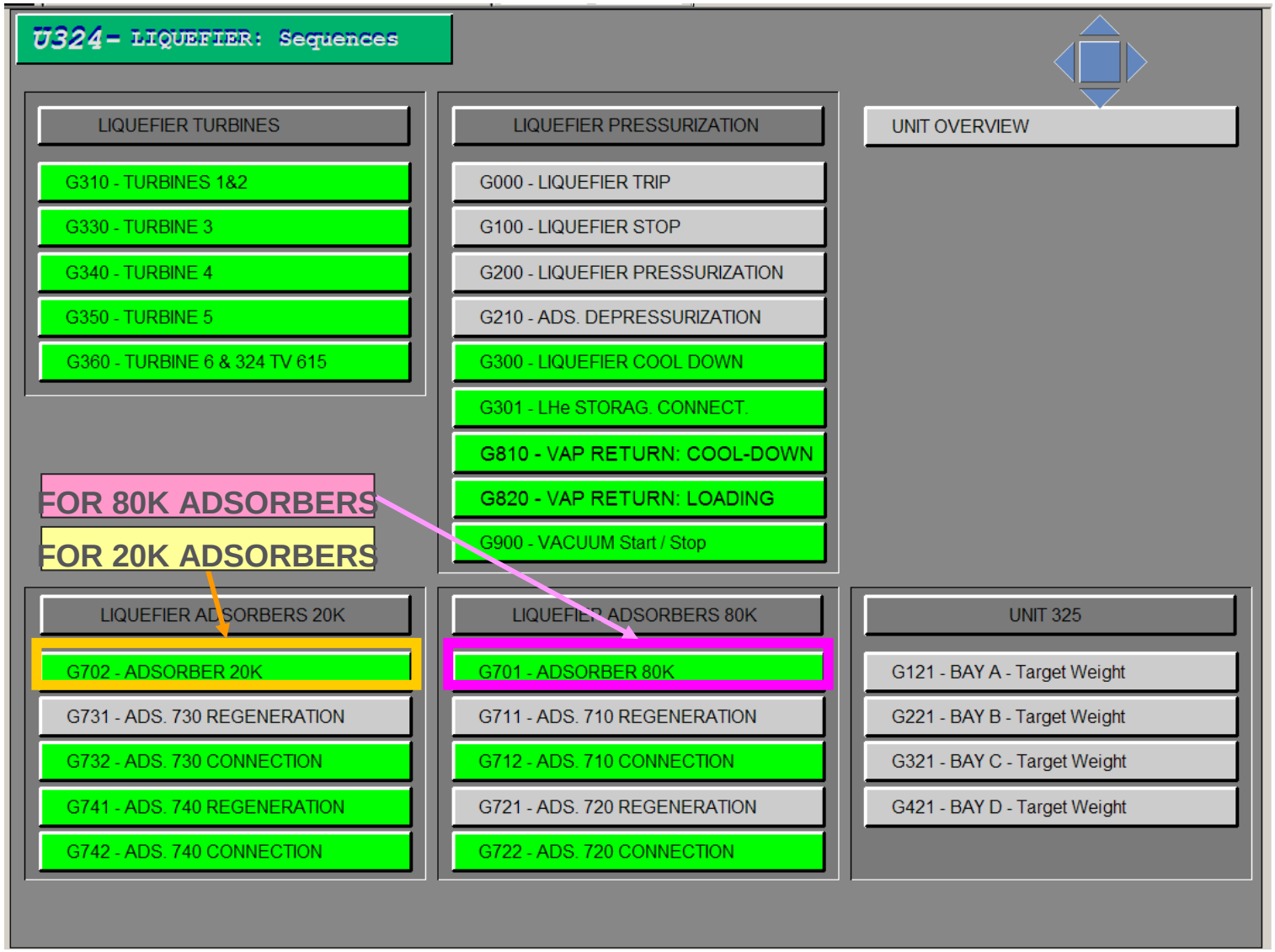
324 – Adsorbers Sequence

- **G701 and G702**
  - will then control the Adsorbers Connections and Regenerations.
  - 80K Adsorbers will have priority over the 20K Adsorbers.
  - The Sequences for the Adsorbers are as follows:

	80K Adsorbers		20K Adsorbers	
	Adsorber 710	**Adsorber 720**	**Adsorber 730**	**Adsorber 740**
REGENERATION	G711	G721	G731	G741
CONNECTION	G712	G722	G732	G742

- Regeneration is **requested by the Operator**, based on Time or Analysis:
- Analysis shall be performed daily by the operator at the discharge of CONNECTED-FULL Adsorbers.
- Regeneration is required if the Impurity Level rises above normal:
  - > 3 ppm of N2 or O2 downstream 80K Ads.
  - > 3 ppm of Ne or H2 downstream 20K Ads.

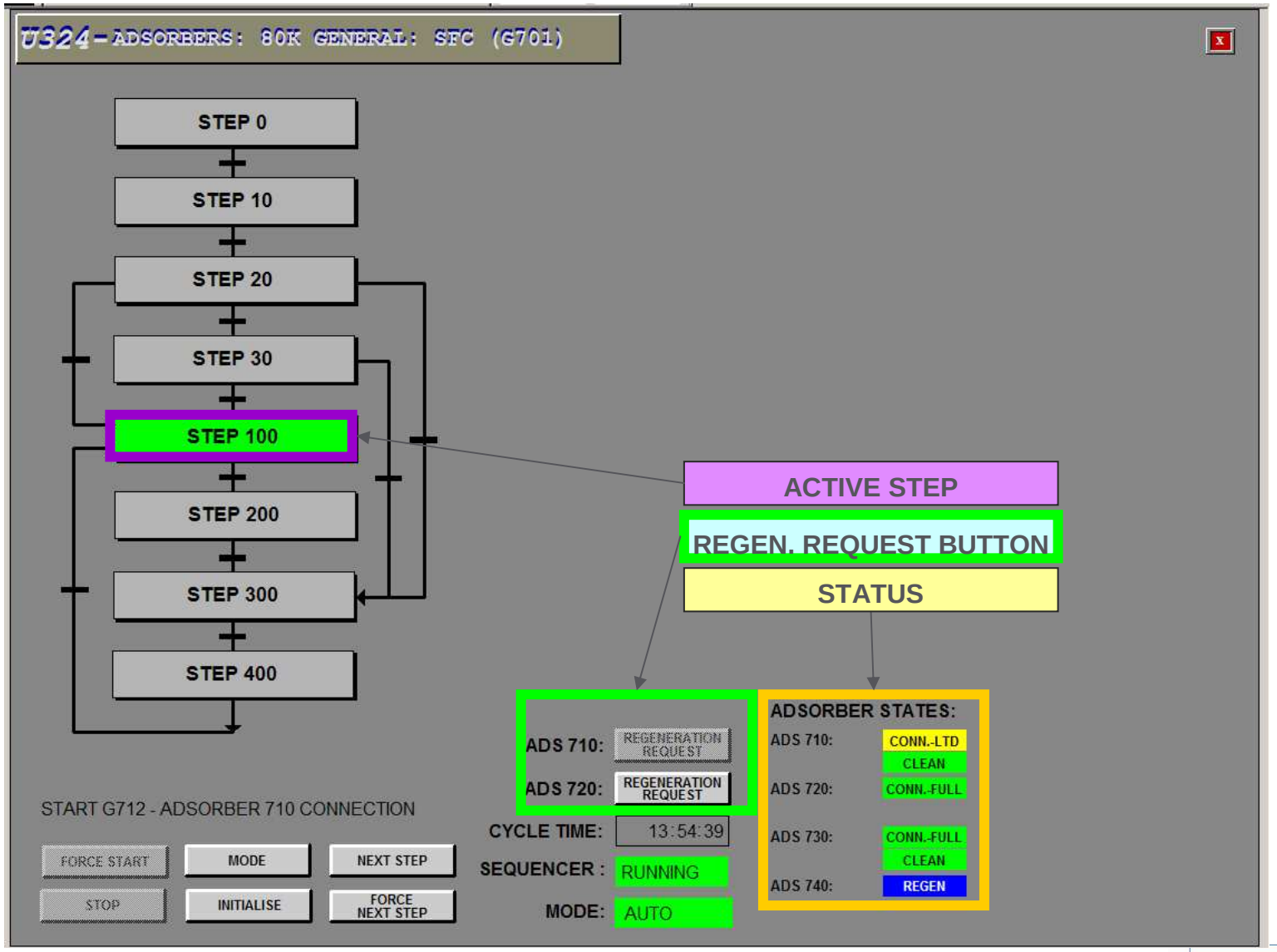
324 – Adsorbers Sequence - Start



324 – Regeneration steps

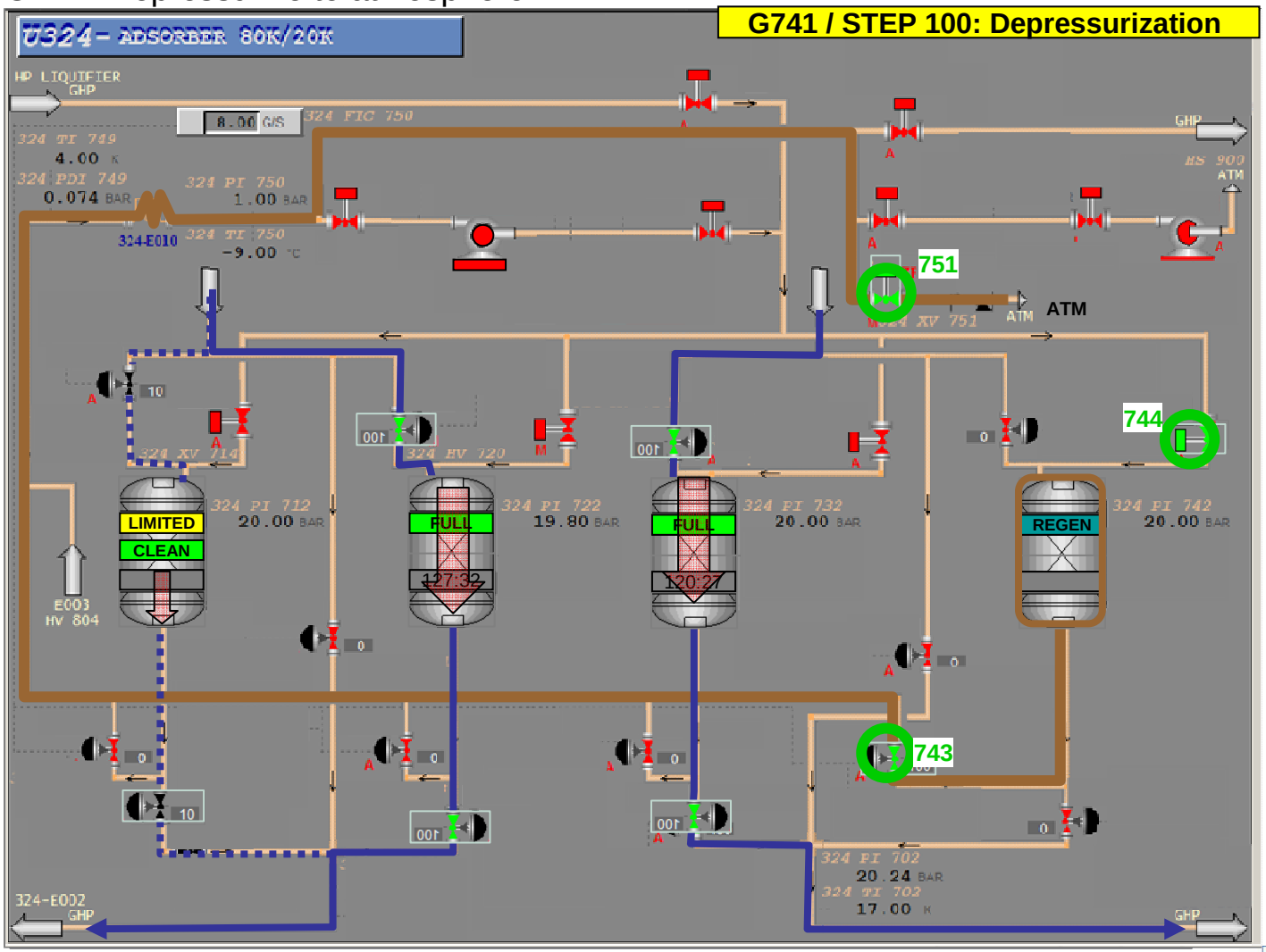
- Isolation and Depressurization
  - He gas is sent to atmosphere
- Warm-up
  - Circulation of He gas through the adsorbent bed
  - Warm-up through atmospheric heat exchanger
- Pumping / Filling with GHe
- Pressurization with GHe
  - Limit delta pressure when opening inlet valve (6” on 80K adsorbers) which could damage the adsorbent bed
- Cool down
  - Adsorbers are kept in cold stand by (connected limited)

324 – Adsorbers Sequence - Start



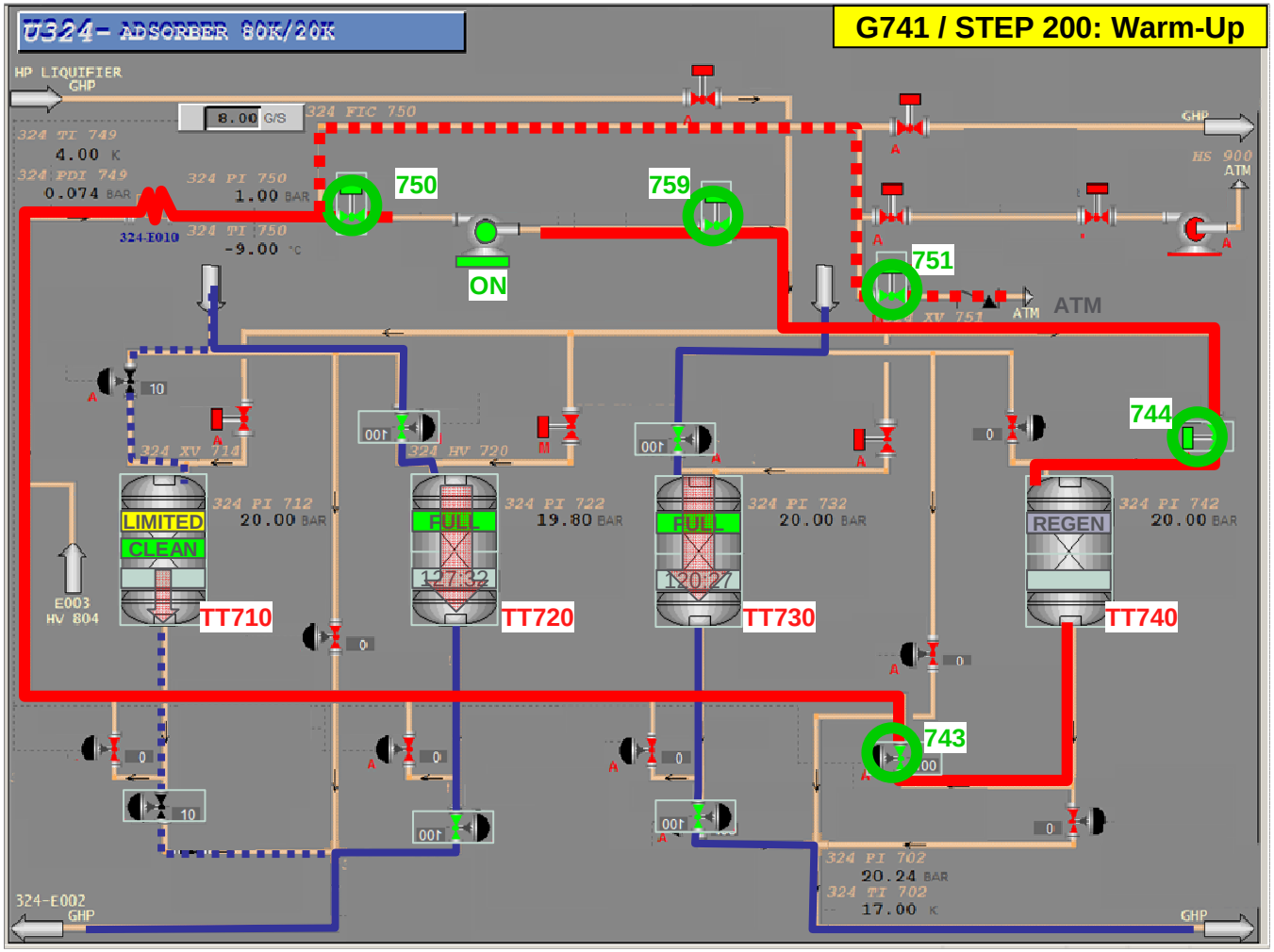
324 – Regen Adsorber : Depressurization

324 HV 743 & 324 XV 744: OPEN
324 XV 751: OPEN Depressurize to atmosphere.



324 – Regen Adsorber : Warm-Up

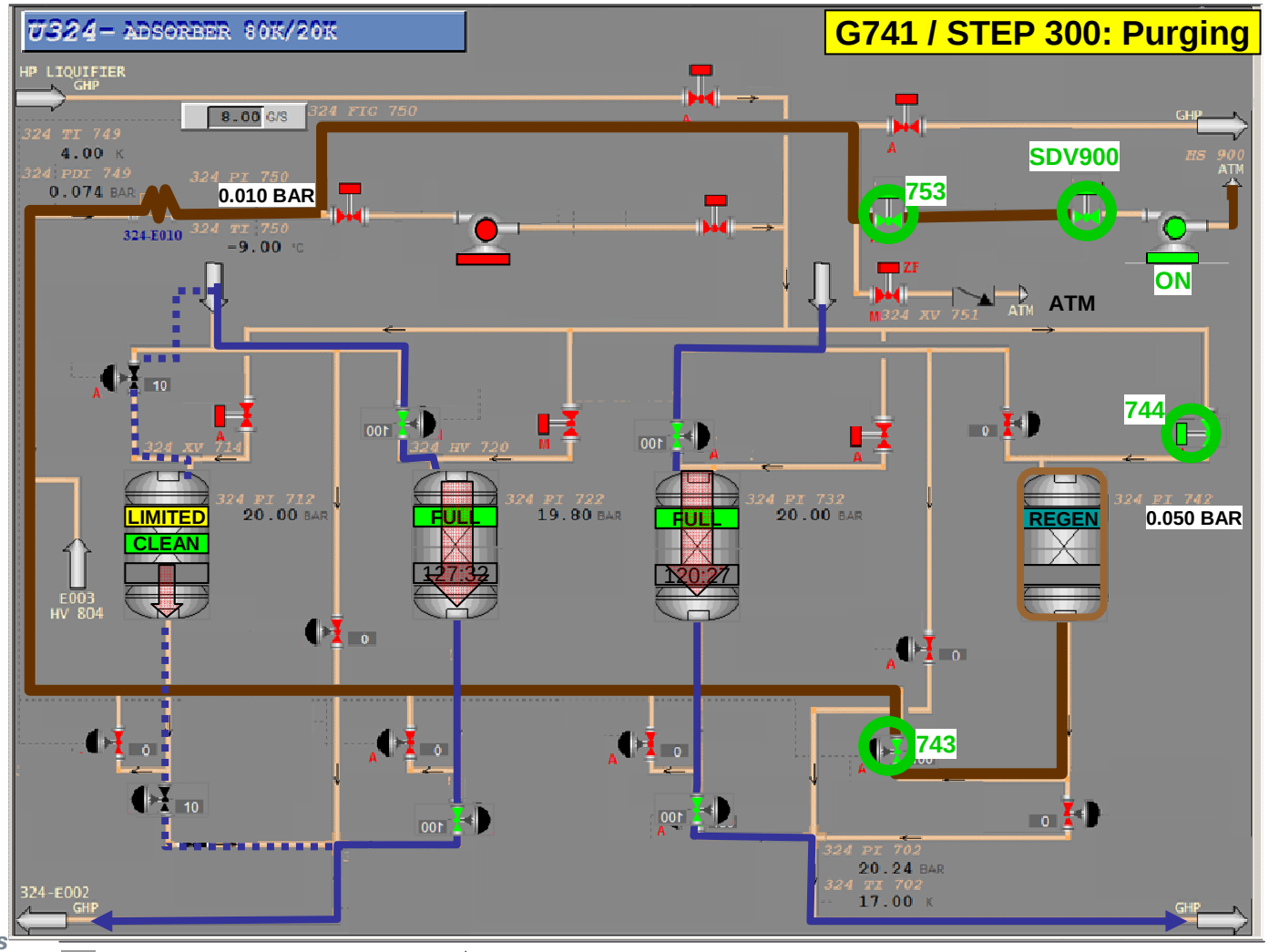
324 HV 743 & 324 XV 744: OPEN
324 K001M: ON with 324 XV 750 & 759 OPEN.
324 XV 751: OPEN vent He & Impurities while Thermal Expansion occurs. (Check Valve prevent back flow)



Ads80 K ~ 220K
Ads20 K ~ 120K

324 – Regen Adsorber : Purging

324 HV 743 & 324 XV 744: OPEN
324 P003: ON with 324 XV 753 & 324 SDV 900 OPEN.

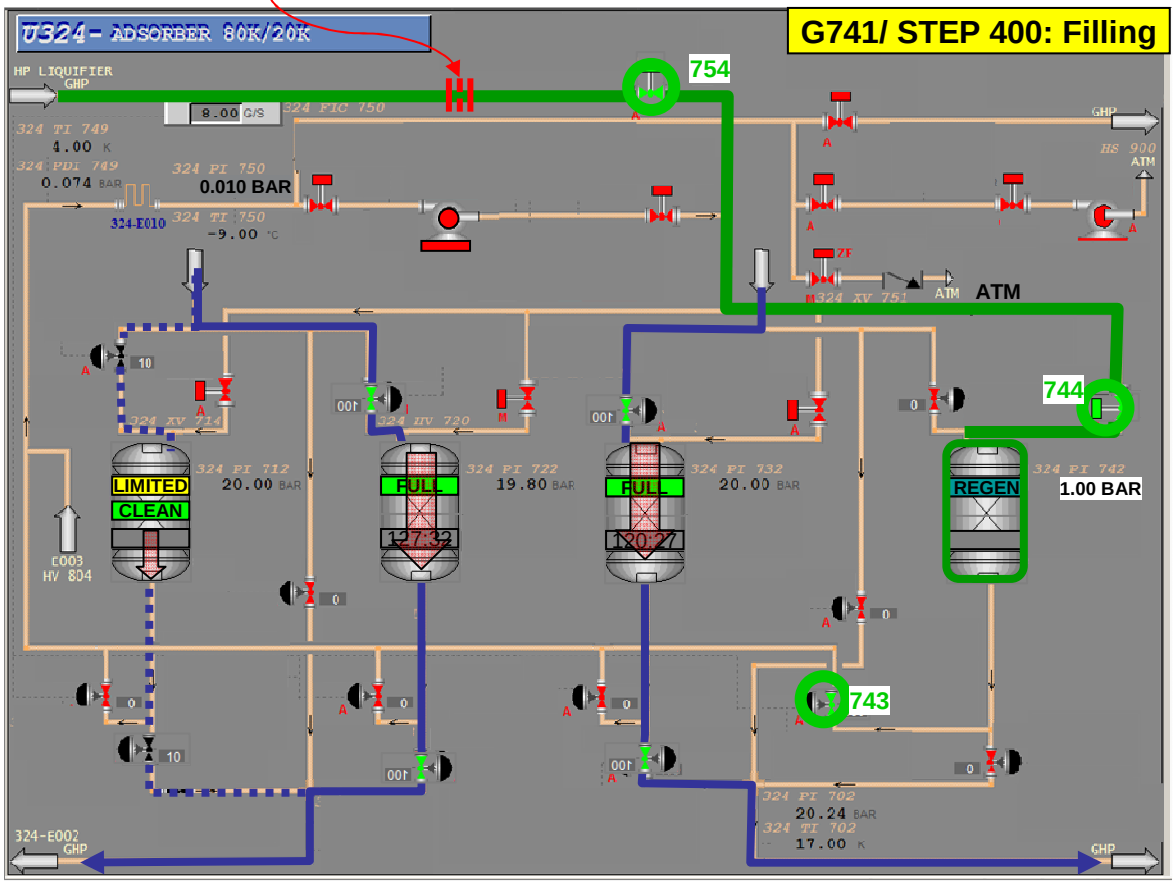


End of pumping when
PT900 ~10 mbar
& PT742 ~50 mbar

OR Time > 30 min
(for first pumping)

324 – Regen Adsorber : Filling

324 HV 743 & 324 XV 744: OPEN
324 XV 754: OPEN for Gas Filling.
FILLING LINE equipped with ORIFICE for Slow Pressurization (Avoid Degradation of Adsorbant).

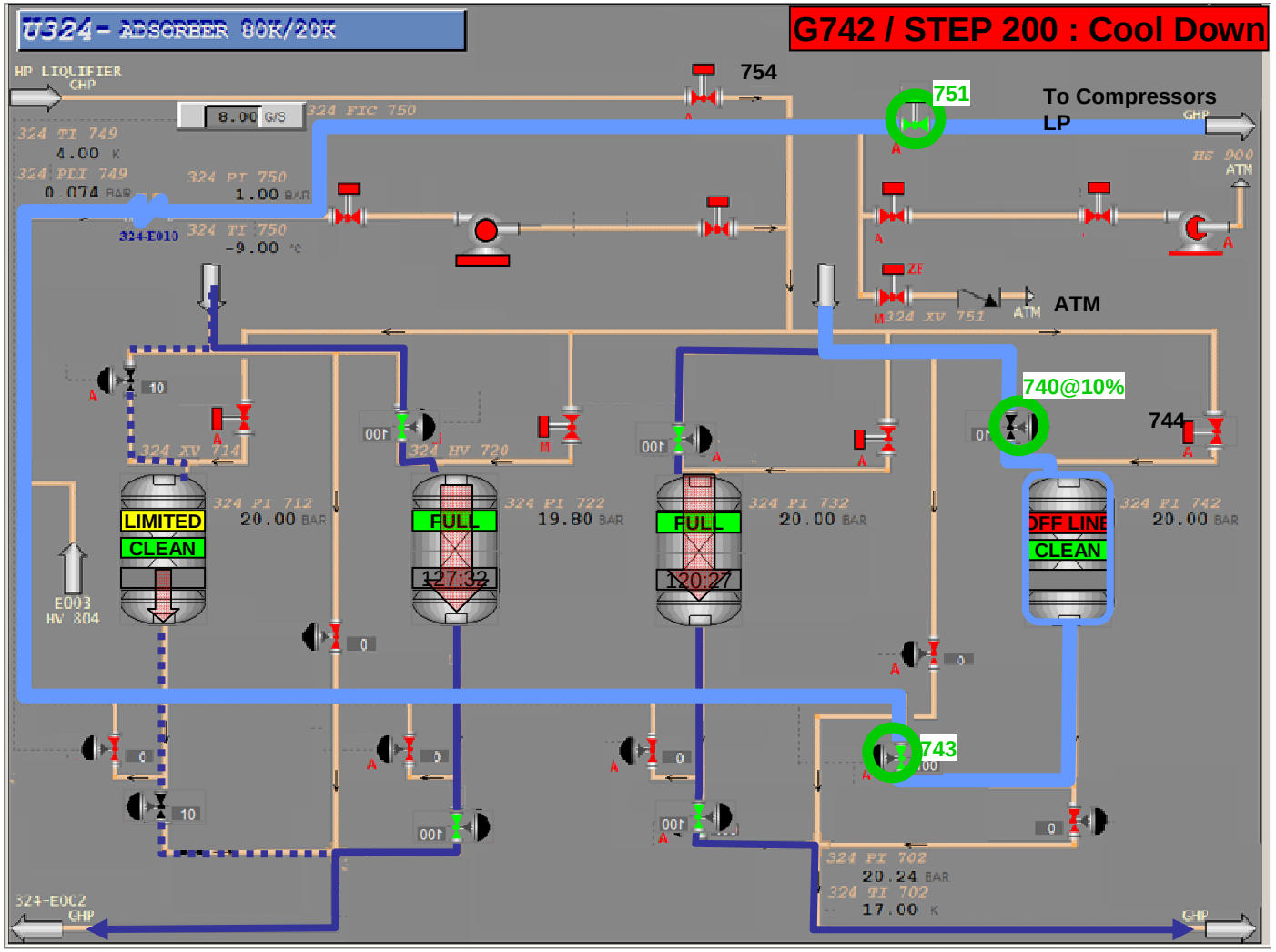


End of filling when
- PT742 ~ 1.00 Bar

NOTE: PURGING / FILLING (Conditioning) repeated 3 Times, to achieve appropriate gas Purity
NOTE: Regeneration Circuits, Pumped / Filled with Adsorber (324 XV 744 and 324 HV 743 OPEN)

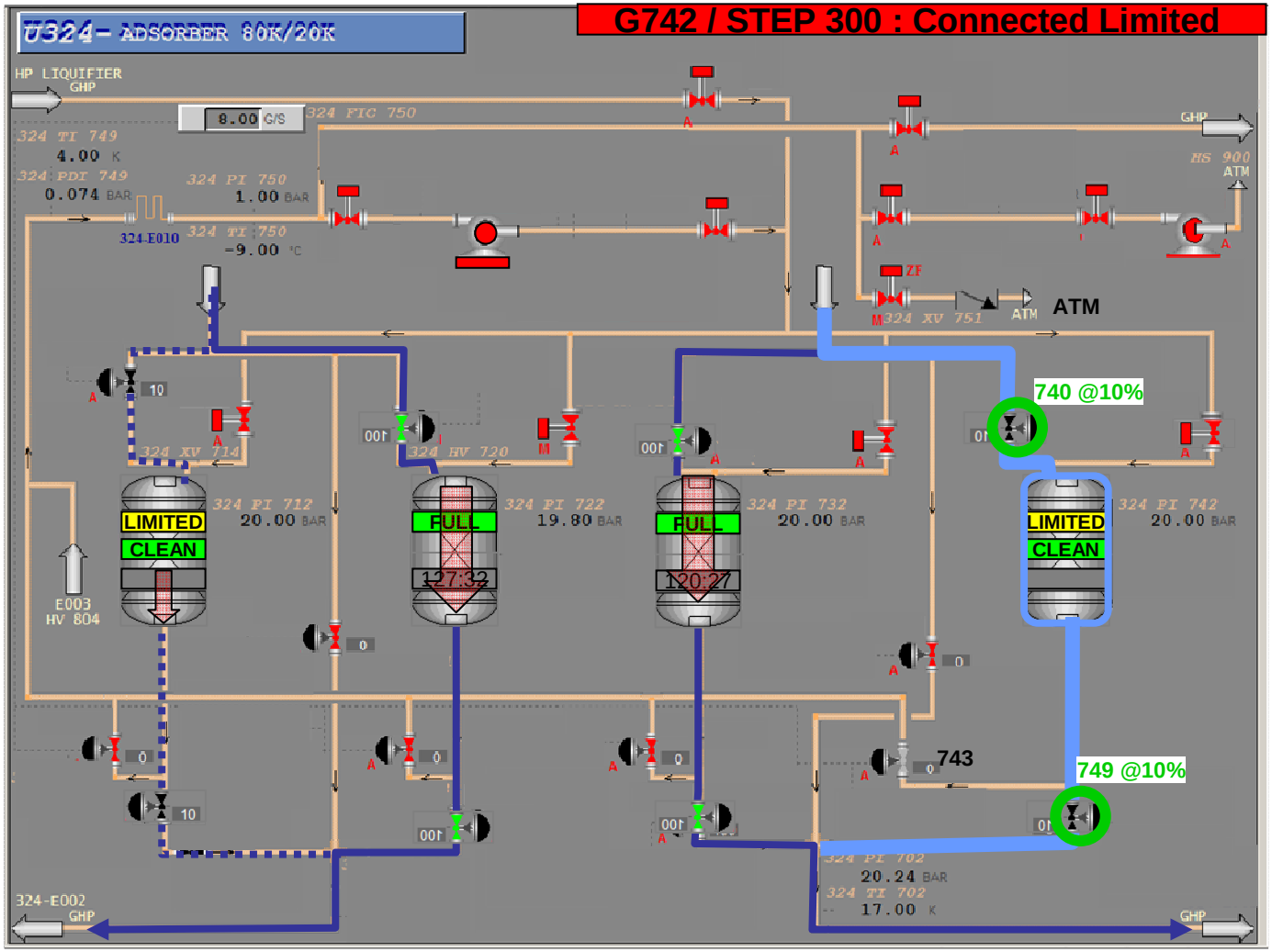
324 – Connection Adsorber : Cool Down

324 HV 740: OPEN @ 10% to Supply Cold Gas
324 HV 743 & 324 XV 751: OPEN to return Gas to LP



324 – Connection Adsorber : Connected Limited

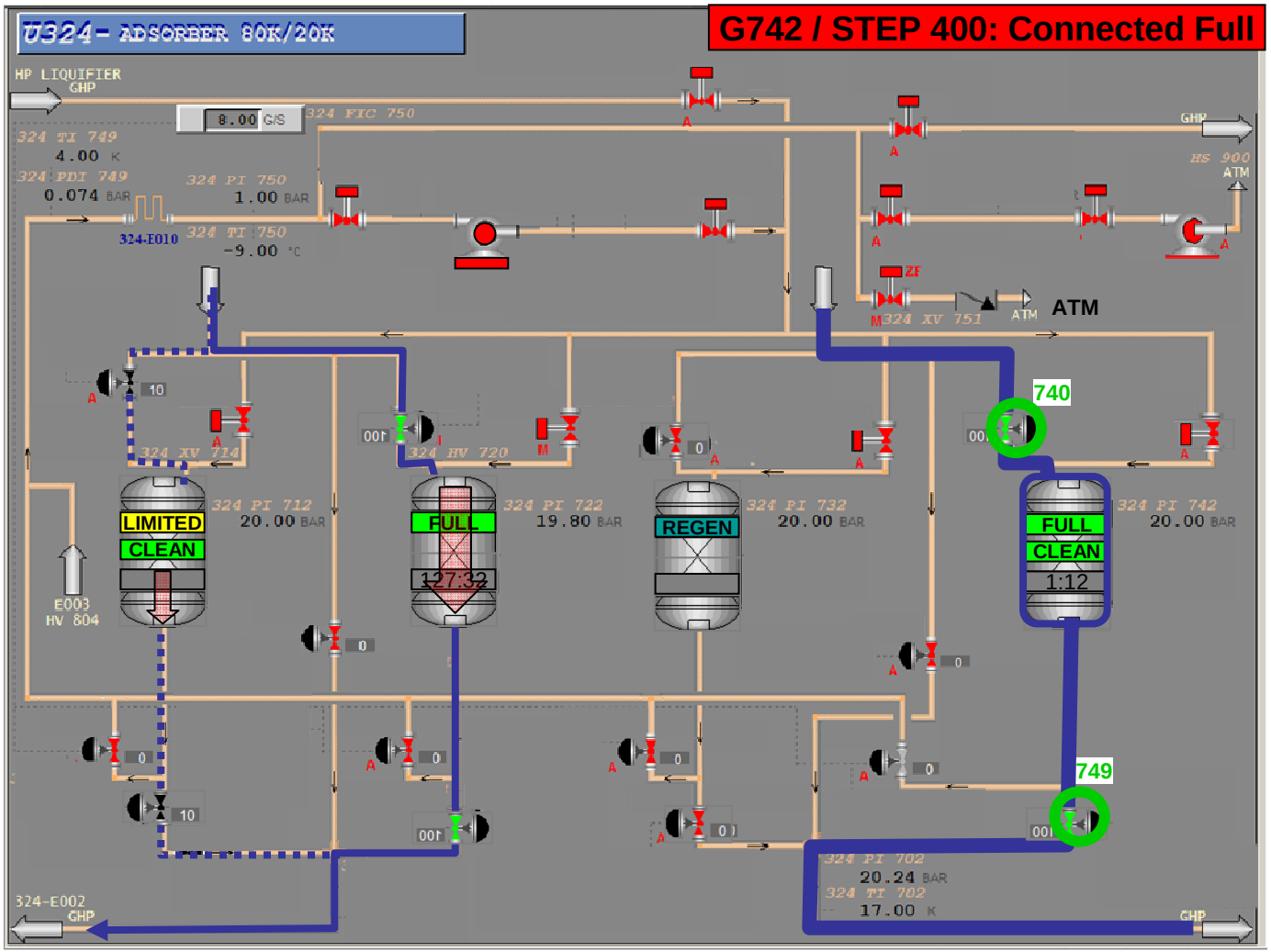
324HV 740 & 749: OPEN @ 10% to provide small cold flow, to maintain cold temperature.



324 – Connection Adsorber : Connected Full

324HV 740 & 749: OPEN @ 100%

NOTA : If the Adsorber is full connected and cold for long enough, it is not considered as clean any more.



324 – Connection Adsorber : Temperature Rise

In case of Adsorber Temperature Rise, Adsorber Is Isolated to avoid releasing trapped Contaminants.
By-Pass Is Open To Maintain Flow Through Liquefier But **FEED He FROM PSA IS STOPPED.**

324 HV 740 & 324 XV 749: CLOSE.

324 HV 702 OPEN: OPEN.