JOHN ZINK HAMWORTHY COMBUSTION

Control Description

Description :	**S3-AAW-11B-128-121-14**
Customer :	**HES Hartel Tank Terminal**
Location :	**ROTTERDAM**
JZ Project Nr. :	**MVCP00112**
Customer Ref. :	**PO: HHTT-000277-000**

	Name	Date	Document -Nr.	Rev.
Drawn	[redacted]	20-Jun-19	**MVCP00112-410**	0
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JOHN ZINK HAMWORTHY COMBUSTION

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CONTROLS FUNCTIONAL DESCRIPTION E-06

FOR TWO (2) JOHN ZINK

ADSORPTION – ABSORPTION

HYDROCARBON VAPOR RECOVERY UNITS (VRU)

MODEL S3-AAW-11B-128-121-14

FOR HES HARTEL

ROTTERDAM, THE NETHERLANDS

	Name	Date	Document- Number	Revision
Originator	[redacted]	19/06/2019		0
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TABLE OF CONTENTS

1 PROCESS DESCRIPTION

1.1 OVERVIEW OF EQUIPMENT

The Vapor Recovery System utilizes the processes of physical adsorption in combination with absorption to recover VOC vapours and return the recovered product to the products lines.

Summary of equipment shown on P&IDs for this unit: -

DESCRIPTION	EQUIPMENT NUMBER	P&ID
1x K.O. DRUM	V5106	MVCP00112-150 SHEET 1 OF 4
1x SULPHUR GUARD BED	V5105	MVCP00112-150 SHEET 1 OF 4
1x VAPORS INLET BLOWER	B5101	MVCP00112-150 SHEET 1 OF 4
2x CARBON BED ADSORBERS	V5102A / V5102B	MVCP00112-150 SHEET 2 OF 4
2x BOOSTER BLOWERS	B5102 / B5103	MVCP00112-150 SHEET 3 OF 4
2x VACUUM PUMPS	P5102 / P5103	MVCP00112-150 SHEET 4 OF 4
1x SEPERATOR	S5101	MVCP00112-150 SHEET 4 OF 4
1x HEAT EXCHANGER	H5101	MVCP00112-150 SHEET 4 OF 4
1x ABSORBER TOWER	C5103	MVCP00112-150 SHEET 4 OF 4
1x SEAL FLUID PUMP	P5104	MVCP00112-150 SHEET 4 OF 4
1x ABSORBENT RETURN PUMP	P5105	MVCP00112-150 SHEET 4 OF 4

1.2 GENERAL PROCESS DESCRIPTION

John Zink Hamworthy Combustion is providing for the HES HARTEL Rotterdam site a Vapor Control System (VCS) which comprises of two (2) trains with each a single Vapor Recovery Unit (VRU) "package" and a single downstream Regenerative Thermal Oxidizer (RTO) "package". This controls description provides a narrative of the controls specifically for the VRU. It shall also summarize the controls link and interface between the VRU and the RTO control systems including enrichment line for lean vapors to save electrical power on RTO

The proposed John Zink Hydrocarbon Vapor Recovery Unit is based on the technology of **AD**sorption-**AB**sorption (**ADAB™**). This technology has gained worldwide preference by both, users and environmental quality control agencies as the most efficient, cost effective and reliable technology for evaporative hydrocarbon vapor emission control.

The Vapor Recovery Unit is designed to process an inlet feed stream as per client process design input (Gasoline, Diesel or High Benzene), consisting of hydrocarbon vapor mixed with air or inert gas. The hydrocarbon vapor is fed to the VRU via a vapors inlet blower B5101 to overcome the unit's pressure differential at the loading rate. This is done via a back-pressure control loop ensuring suction conditions. The control is governed by a client pressure signal to the VRU PLC. A maximum operational liquid loading flow rate of 8,000 m3/h to be shared by the two VRUs i.e. 4,000 m3/h per VRU with a turndown of 100 to 0 %. Expected growth factor of 1.25. Thereby the expected vapor max flow rate to the two VTS is 10,000 m3/h.

Due to the specified high amount of H_2S in inlet vapors a sacrificial sulfur guard bed is installed at inlet of each VRU. This stream of hydrocarbon vapors with sulfur components from loading operations passes via a zone 0 inlet vapors blower and then through a Sulphur guard bed V5101. This stream then passes through the VRUs, where most part of VOCs are adsorbed, followed by a downstream Regenerative Thermal Oxidisers (RTO) to oxidise the remaining VOCs to meet emissions limits.

The **ADAB™** process, when compared to other vapor control technologies, is not only very efficient but is relatively simple. It can be summarized as a two-step process. The first processing step (**AD**sorption) consists of passing the feed stream through a bed of activated carbon V5102A/B which serves to capture the hydrocarbon vapor by adsorption onto its surface while allowing the hydrocarbon free air to pass through and vent to the atmosphere. The adsorbed hydrocarbon vapor is then desorbed (removed) from the activated carbon using a vacuum system. This desorbed hydrocarbon vapor discharging the vacuum system is then subjected to a second processing step (**AB**sorption) in which it is recovered as a liquid product by absorption into a stream of circulating liquid absorbent.

The hydrocarbon vapor feed stream, consisting of both hydrocarbon vapor and inert gas, is thus displaced from the product loading operation where it is captured and piped to the VRU. Generally, this vapor feed stream is caused to flow to the VRU by a buildup of a relatively small backpressure in the transport vessel being loaded caused by the rising liquid level. In this case, a vapor assist blower is included as a motive force to cause the vapors to flow to the VRU.

The vapor feed stream, once it gets to the VRU, is caused to flow through an adsorber filled with a bed of activated carbon. In the adsorber, the activated carbon adsorbs (captures) the hydrocarbon vapor from the feed stream onto its surface while allowing the residual hydrocarbon free Air/inert gas to vent from the adsorber to the RTO.

Activated carbon can selectively attract and capture (adsorb) onto its surface the hydrocarbon vapor fraction from the hydrocarbon vapor-Air/inert gas feed stream. However, because the carbon has a finite ability to adsorb hydrocarbon molecules, it must be regenerated otherwise, it would become saturated and would not adsorb further vapor. Factors that favor adsorption include higher hydrocarbon concentrations in the inlet vapor stream and higher pressures. The John Zink vapor recovery technology can regenerate the carbon for reuse by reversing the factors that are favorable for adsorption.

During the carbon bed regeneration cycle, desorption (removal) of hydrocarbon vapor from the carbon bed is accomplished by creating a high vacuum (low absolute pressure) in the adsorber. This along with the addition of a small amount of purge (stripping) Air into the adsorber at the highest vacuum level creates a condition favorable for desorption and provides a very effective means of regenerating the activated carbon for reuse adsorption cycle after adsorption cycle.

To allow continuous and uninterrupted vapor processing capability, two (2) identical adsorbers, filled with activated carbon, are provided. While the carbon bed in one adsorber is on-line adsorbing hydrocarbon vapors, the carbon bed in the other adsorber is off-line being regenerated.

Switching valves are provided to automatically alternate the two carbon beds from the adsorption to the regeneration mode of operation. This switching typically occurs on a timed cycle lasting from 10-20 minutes. At the end of the regeneration cycle, the adsorber vessel is re-pressurized back to atmospheric pressure and then is placed on-stream.

The vacuum system provided with this John Zink S3-AAW-11B-128-121-14 LRVP includes two (2) rotary lobe booster blowers P5107A/B and two (2) Liquid Ring vacuum pumps P5108A/B to regenerate the carbon beds.

During the carbon bed regeneration cycle, the vacuum system creates a high vacuum level in the adsorber being regenerated reducing the adsorber pressure from atmospheric pressure to either approx. 33 mbarA. At these high vacuum levels, a small amount of purge (stripping) Air is introduced into the adsorber to assist in the regeneration process. Regeneration of the carbon bed results in the previously adsorbed hydrocarbon vapor being extracted from the carbon bed and the reestablishment of its adsorption capacity. This extracted rich hydrocarbon vapor stream containing only a minor amount of Air flows from the adsorber to the vacuum system and the absorber.

Non-condensed hydrocarbon vapor, with a small residual Air component, will flow from vacuum pump into the base of a downstream vertical absorber column via a separator vessel S5104. The booster blowers and vacuum pumps are a two-stage suction and compression produce the hydrocarbon condensation. The rotary equipment use Ethelyn/Glycol as a means of sealing of vacuum pumps and cooling of the booster blower.

The glycol (from now on referred to as 'Coolant/Seal fluid') loop consists of a supply pump P109 forcing the glycol liquid from the separator S5104 via a cooler E5105 as coolant to the individual booster blowers P5107A/B and as seal fluid to the individual vacuum pumps P5108A/B. Through the cooler's 667E-001 heating side flows absorbent coming directly from the supply battery limit.

As the coolant/seal fluid composition is heavier (greater specific gravity) than the condensed hydrocarbons, it settles to the bottom of the separator S5104 whereas the lighter recovered hydrocarbons spill over into the absorber vessel C5103.

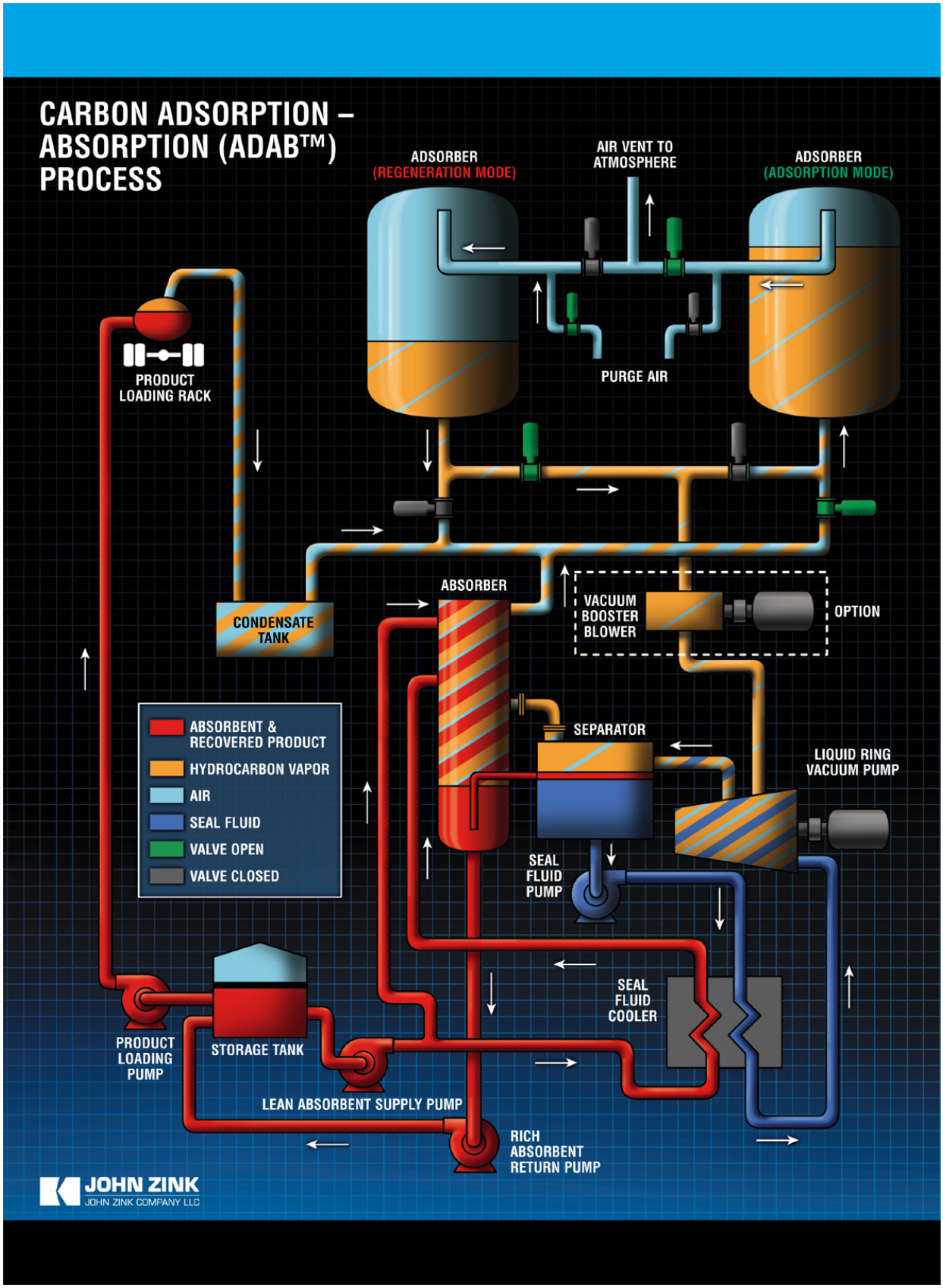
In the absorber vessel C5103, the non-condensed rich hydrocarbon vapor stream from the vacuum pump flows up through packing where it is liquefied and subsequently recovered by absorption into a down-flow liquid absorbent. The circulating absorbent containing the recovered hydrocarbon collects in the bottom of the absorber from which it is returned to the client pump circuit or vessel. A small stream of Air/inert gas containing a saturated amount of non-absorbed hydrocarbon vapor exits the top of the absorber column and is recycled to the on-stream carbon bed where the hydrocarbon vapor is re-adsorbed.

A continuous stream of lean liquid absorbent is circulated to the VRU. This liquid absorbent stream is taken a customer tank.

This absorbent is used for flow to the top of the absorber column where it is used as the primary absorbent to recover the hydrocarbon vapor. The rich absorbent containing the recovered hydrocarbon vapor is then pumped back to the tank. A return absorbent pump is provided for this purpose.

The VRU is designed for autonomous operation. It will start and run automatically when product loadings occur or in the case of tank operation with, in which case the client DCS will send a hard-wired REMOTE LOAD REQUEST signal to the VRU PLC. Refer to Start-up conditions section 3.1. Likewise, when the loading operation is completed, the VRU will automatically shut down in a standby mode when the REMOTE LOAD REQUEST SIGNAL is removed. Alternatively, the VRU will immediately start when put into manual mode sand stop when put in to VRU OFF or VRU STOP state.

This recycled vapour feed is used as enrichment gas for the downstream RTO package.


CARBON ADSORPTION – ABSORPTION (ADAB™) PROCESS
ADSORBER (REGENERATION MODE)
AIR VENT TO ATMOSPHERE
ADSORBER (ADSORPTION MODE)
PURGE AIR
PRODUCT LOADING RACK
CONDENSATE TANK
ABSORBER
VACUUM BOOSTER BLOWER
OPTION
ABSORBENT & RECOVERED PRODUCT
HYDROCARBON VAPOR
AIR
SEAL FLUID
VALVE OPEN
VALVE CLOSED
SEPARATOR
LIQUID RING VACUUM PUMP
SEAL FLUID PUMP
SEAL FLUID COOLER
PRODUCT LOADING PUMP
STORAGE TANK
LEAN ABSORBENT SUPPLY PUMP
RICH ABSORBENT RETURN PUMP
JOHN ZINK
JOHN ZINK COMPANY LLC

1.3 TERMINOLOGY

List of equipment names, control terms and abbreviations used in this document:

- HHTT HES Hartel Tank Terminal
- JZHC John Zink Hamworthy Combustion
- VRU Vapor Recovery Unit
- RTO Regenerative Thermal Oxidizer
- VTS Vapor Treatment System
- O.I.P. Operator Interface panel (Lamps, Switches & Pushbuttons + H.M.I.)
- ESD Emergency Shutdown
- PLC Programmable Logic Controller
- DCS Distributed Control System
- F&G Fire and Gas
- HMI Human Machine Interface
- SIS Safety Instrumented System
- SIL Safety Integrity Level
- PID Piping and Instrumentation Diagram
- C&E Cause and Effect (Matrix)
- RSP Remote Set point
- SP Set Point
- PV Process Variable
- MV Manipulated Variable
- REV Reverse
- ‘f(x)’ Undefined function
- X Multiplication function
- K Constant function
- Σ Summated function
- I/O Inputs/Outputs
- I/P Current to Position (electrical valve positioner)
- MCC Motor Controls Circuit
- DOL Direct On-Line
- VSD Variable Speed Drive
- VFD Variable Frequency Drive
- CCR Central Controls Room
- MOS Maintenance Override Switch

1.4 GENERALITIES

This narrative has as its purpose the description of interlocks, controls, and functional sequences required for the safe and efficient operation of the two (2) identical Vapor Recovery Units U5100 & U5200 as part of the complete Vapor Treatment Systems, each consisting of a VRU and a RTO for the HHTT site at Maasvlakte Rotterdam, The Netherlands. In this document only tags of equipment, instrumentation and control function for the 1st VRU – VRU-1 U5100 will be discussed and is typical for the 2nd VRU – VRU-2 U5200.

All tag numbers relating to the VRU are pre-fixed by unit N° or related equipment numbers which are occasionally omitted in this document in certain places.

The main objective of this narrative is to determine and detail the overall controls philosophy based on information as indicated on the P&IDs and Cause and Effect Matrix documents for HAZOP/LOPA review and for PLC programming works. The control philosophy is however subject to and limited by the control architecture (I/O signals, inter system communication, any local controls and control room or software controls) as pre-determined and shown on the P&IDs.

The narrative will be accompanied by a cause and effect matrix. Together these documents will serve as the bases for the creation of functional logic diagrams and then system programming by JZHC PLC supplier.

1.5 REFERENCE AND APPLICABLE DOCUMENTS

This control description is based on safe good engineering practices and experience and the following norms and reference and applicable documents:

DOCUMENT	DESCRIPTION
MVCP00112-411	CAUSE & EFFECT MATRIX
MVCP00112-150 SHT.1	P&ID VAPOUR RECOVERY UNIT
MVCP00112-150 SHT.2	P&ID VAPOUR RECOVERY UNIT
MVCP00112-150 SHT.3	P&ID VAPOUR RECOVERY UNIT
MVCP00112-150 SHT.4	P&ID VAPOUR RECOVERY UNIT
MVCP00112-402	INSTRUMENT I/O LIST

The control description is the master document and takes president over all others.

The control description is to be represented in diagrammatic form in the VRU logic diagram document by JZHC PLC supplier.

Modifications to the sequences or interlocks during the VRU controls development engineering work (by JZHC PLC supplier) or tests must be assimilated into the final revision of this control description.

2 OPERATING MODES

VRU unit can be put on STOP or RUN mode via a general hardware Selector switch HS-0201 mounted on the front door of the PLC cabinet:

- STOP No release for starting the unit
- RUN Release for operating via DCS or O.I.P.

Once general selector is switched on RUN position, VRU has 3 states and 2 modes of operation which can be selected by the operator via software selector switch 5100-HS-120 on HMI

1. OFF : VRU OFF
2. MANUAL START : MANUAL (Manual start and continuous run)
3. REMOTE START : REMOTE (Remote start via DSU Load request signals)

If an operator switches the VRU from one mode to another during VRU operation, the VRU will finish the current regeneration cycle and then operate according to the new selected mode.

2.1 STOP mode (Selector switch 5100-HS-101)

In this mode, the VRU is not in operation. Pumps are not running.
Valves are all in their shutdown position.

2.2 RUN mode (Selector switch 5100-HS-101)

In this mode, the VRU is ready to be in operation according selected VRU mode (OFF, MANUAL, REMOTE).

2.3 OFF mode (Soft Selector switch 5100-HS-120)

In this mode, the VRU is not in operation. Pumps are not running.
Valves and solenoids are all in their shutdown (fail or de-energised) positions: -

Carbon Adsorber V5102A
Vent valve 5102A-AOV-001 – Fail close
Regeneration valve 5102A-AOV-002 – Fail close
Vapors inlet valve 5102A-AOV-003 – Fail close
Purge Valve 5102A-AOV-004 – Fail close
Equalization Valve 5102A-AOV-005 – Fail close

Carbon Adsorber V5102B
Vent valve 5102B-AOV-001 – Fail close
Regeneration valve 5102B-AOV-002 – Fail close
Vapors inlet valve 5102B-AOV-003 – Fail close
Purge Valve 5102B-AOV-004 – Fail close
Equalization Valve 5102B-AOV-005 – Fail close

Enrichment Gas Pressure Control Valve 5100-PCV-002 – Fail Close
Feed to RTO Pressure Control Valve 5100-PCV-003 – Fail Close

Booster Blower P5107A
Coolant injection valve 5107A-SV-002 – NC
N2 to Seal Panel valve 5107A-SV-001 – NC
*NC = Normally Closed

Booster Blower P5107B
Coolant injection valve 5107B-SV-002– NC
N2 to Seal Panel valve 5107B-SV-001 – NC

Vacuum Pump P5108A
Seal fluid valve 5108A-AOV-001 – Fail close

Vacuum Pump P5108B
Seal fluid valve 5108B-AOV-001 – Fail close

Minimum flow (Anticavitation) valve 5108-AOV-001 – Fail open

Absorbent Supply Flow Control Valve 5100-FCV-005 – Fail close
Absorbent Return valve 5100-AOV-008 – Fail close

2.4 MANUAL START mode (Soft Selector switch 5100-HS-120)

As soon as software selector switch or HS-120 on HMI is set to MANUAL mode of operation, the VRU can start and to operate according the sequence detailed in section 8 'SEQUENCES'.

After completing the START-UP sequences, the unit will then continue to run based on time cycle mode (in this mode, each adsorber will alternate on a timed sequence from being on-line in adsorption to being off-line in regeneration).

When an operator switches the HS-120 selector in "OFF" position or HS-101 selector in "STOP" position, the unit will complete then the current regeneration and stop.

The permissive signal XS-105 is given to client by hard wired signal. It means that on VRU side everything is in order.

2.5 REMOTE START mode (Soft Selector switch 5100-HS-120)

When selector switch VRU-MODES (5100-HS-120) is switched to position REMOTE and RUN mode is selected (HS-101), the VRU waits for the REMOTE LOAD REQUEST signa **5100-XS-101**.

Once the REMOTE LOAD REQUEST signal 5100-XS-101 is received, then the VRU is released to start and to operate according the sequence detailed on section 3.

Once the signal REMOTE LOAD REQUEST 5100-XS-101 is removed from the unit, indicating that vapour flow to the unit is no longer expected, the unit will complete then the current regeneration and stop.

When operator switches the unit in "OFF" position (5100-HS-120) or "STOP" position (5100-HS-101), the PLC will stop in the same manner.

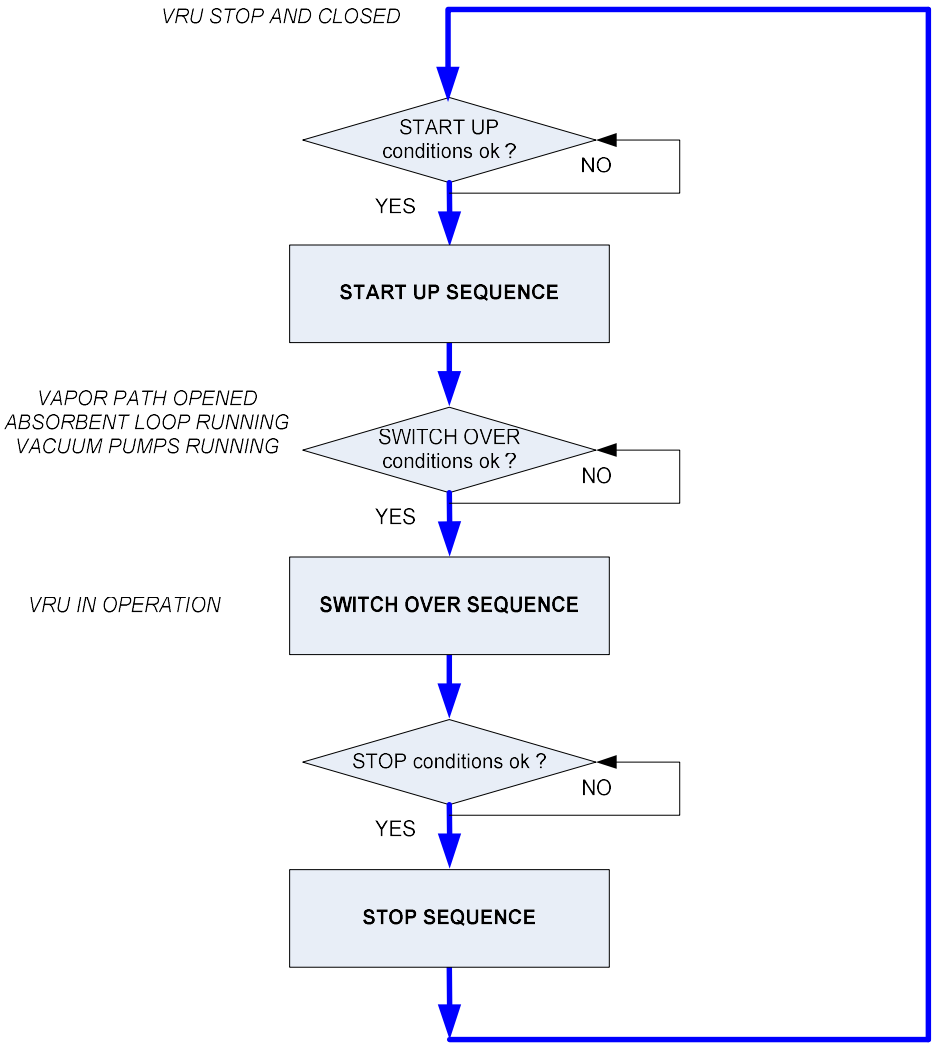
2.6 List of buttons, switches, lamps on the PLC panel door and on local control panels

On the PLC panel door are several equipment installed, summarized as follow:

5100-HS-101	STOP / RUN	(2 Pos. Selector)
5100-HS-102	ESD RESET	(Blue Push button)
5100-HS-103	ALARMS RESET	(Blue Push button)
5100-HS-104	LAMPS TEST	(Black Push button)
5100-HZS-105	EMERGENCY SHUTDOWN	(Red Mushroom Push button)
5100-XL-100	POWER ON	(White Lamp)
5100-XA-101	EMERGENCY SHUTDOWN	(Red Lamp)
5100-XA-102	VRU SHUTDOWN	(Red Lamp)
5100-XA-103	VRU WARNING	(Yellow Lamp)
5100-XL-104	VRU RUNNING	(Green Lamp)

2.7 General flow chart

In case of normal operation, VRU operation can be summarized as follow whatever the operating mode:



3 START-UP SEQUENCE

3.1 Description

Whatever is the operating mode selected (5100-HS-120) via soft selector switch, as soon as START-UP conditions are fulfilled, the START-UP sequence is initiated.

Prior to starting the operator or maintenance person shall select the booster blower(s) and vacuum pump(s) required to be running. The selection is to be made by soft selector which can be found in the HMI maintenance page.

The normal operating situation is both booster blowers and both vacuum pumps running.
A minimum of 0 booster blowers AND 1 vacuum pump must be selected to run the VRU.

The VRU may run with a minimum of no booster blower and a minimum of one vacuum pump, with any combination of either to ensure an open vapours feed from the carbon bed in regeneration to the separator vessel.

However, less than both booster blower and both vacuum pumps is insufficient for the full loading rate scenarios and can lead to high emissions alarm but allows vessel loadings to continue without VRU shutdown.

If any booster blower trips (5100-UC-02 or 5100-UC-03) or liquid ring vacuum pump trips (5100-UC-04 or 5100-UC-05) then this will immediately cause VRU shutdown 5100-UC-01.

If starting the VRU with only 1 booster blower or 0 booster blowers, the N2 seal gas supply valve will not be opened if the booster blower is not selected.

At the starting of the vacuum loop starting sequence see section 8.5 the N2 seal gas supply valve for bother blowers will be opened for '**non-**selected to run' booster blower(s) in step 2.2 of the sequence and steps 3 & 4 are skipped.

'Pump in service' selector switches are available on the HMI and must be set before VRU start. The status of selection is communicated to the DCS.
These selectors allow the inhibition of a pump to start (override of interlock 5100-UC-02/03/04/05 to prevent VRU shutdown 5100-UC-01 if the pump is tripped).

START-UP CONDITIONS:

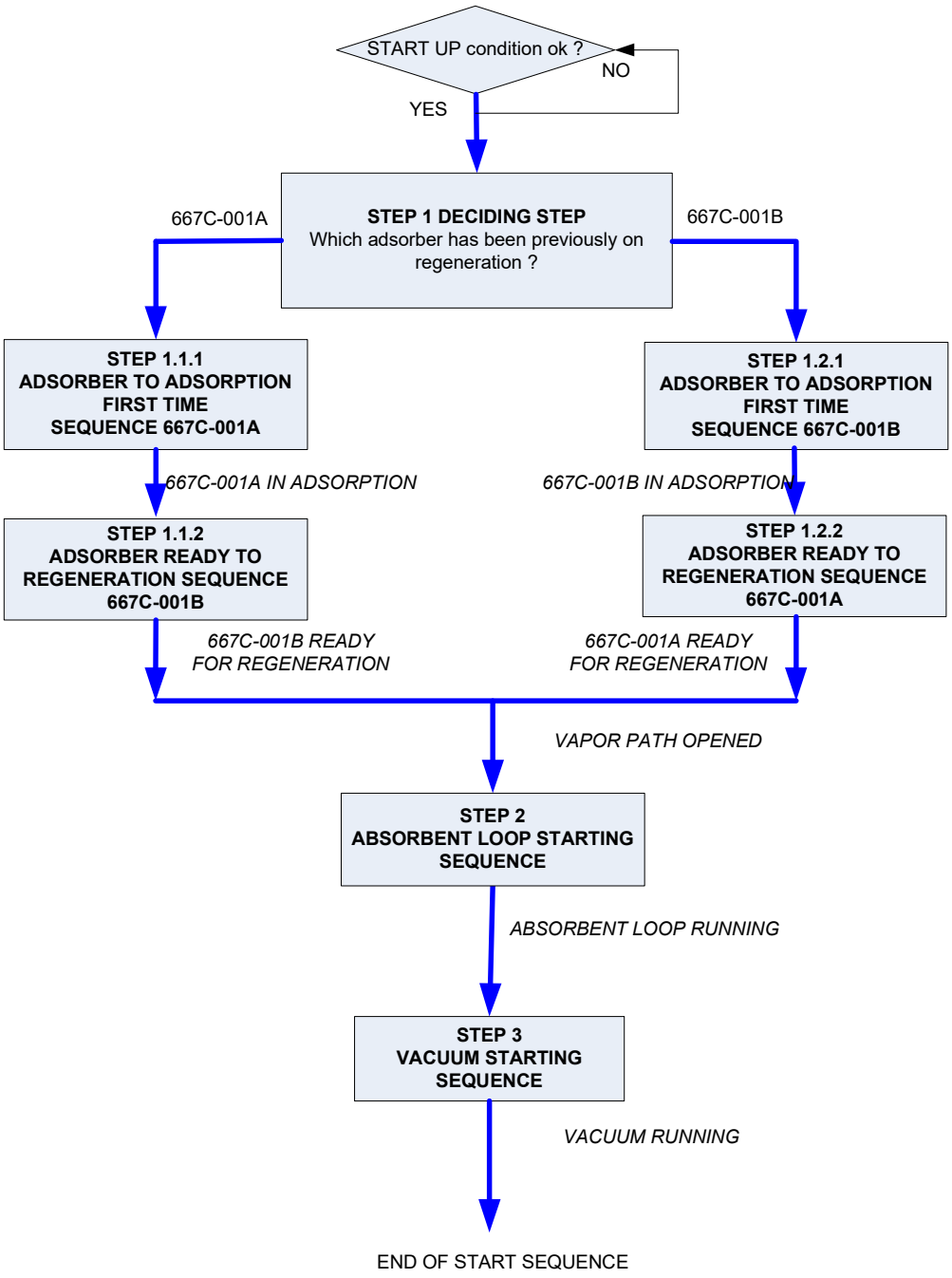
- VRU HEALTHY (NO ESD SHUTDOWN NOR VRU PROCESS SHUTDOWNS)
  AND
- RUN mode selected (5100-HS-101)

  AND
- Selection via HS-0220A/B of one of the two operating modes: -

  - MANUAL START MODE 5100-HS-120
    OR
  - REMOTE LOAD REQUEST 5100-XS-120 signal

Permissive signal 5100-XS-105 will be given if all conditions for start are met.

Note that when the REMOTE LOAD REQUEST 5100-XS-120 signal is removed the VRU will proceed to stop.


START UP condition ok ?
NO
YES
667C-001A
STEP 1 DECIDING STEP
Which adsorber has been previously on regeneration ?
667C-001B
STEP 1.1.1
ADSORBER TO ADSORPTION FIRST TIME
SEQUENCE 667C-001A
STEP 1.2.1
ADSORBER TO ADSORPTION FIRST TIME
SEQUENCE 667C-001B
667C-001A IN ADSORPTION
667C-001B IN ADSORPTION
STEP 1.1.2
ADSORBER READY TO REGENERATION SEQUENCE
667C-001B
STEP 1.2.2
ADSORBER READY TO REGENERATION SEQUENCE
667C-001A
667C-001B READY FOR REGENERATION
667C-001A READY FOR REGENERATION
VAPOR PATH OPENED
STEP 2
ABSORBENT LOOP STARTING SEQUENCE
ABSORBENT LOOP RUNNING
STEP 3
VACUUM STARTING SEQUENCE
VACUUM RUNNING
END OF START SEQUENCE

3.2 ADSORBER TO ADSORPTION (FIRST TIME) SEQUENCE

This sequence consists to open outlet and then inlet valves of one adsorber (5102A-AOV-001 & 5102A-AOV-003 for carbon adsorber V5102A and 5102B-AOV-001 & 5102B-AOV-003 for carbon adsorber V5102B).
At the end of this sequence, selected adsorber is on stream and vapour goes through.

For more details, please refer to 8.3.

3.3 ABSORBENT LOOP STARTING SEQUENCE

This sequence consists to start the absorbent supply by Absorbent Request signal 5100-XS-106 to client DCS and once feedback Absorbent Ready signal 5100-XS-107 received from client DCS, start the absorbent return pump P5110, and to release level control loop for the absorber and the flow control loop 5100-FIC-005 for the absorbent supply and open absorbent supply shut off valve 5100-AOV-009.

The absorbent supply can be Gasoline or a lower RVP fuel. There is no selection to be made in PLC, it is done in DCS. There is no signal to client to request direction of either liquid medium. The ABSORBENT REQUEST 5100-XS-106 signal is made available to client in the case that any isolation valve out of VRU battery limit needs to be opened for the absorbent supply. The absorbent supply by client has a flow control valve which is working in split range control with the JZ VRU absorbent inlet flow control valve 5100-FCV-005.

The Absorbent Request signal 5100-XS-106 is sent when the unit is in position to start the absorbent loop. Signal XS-0207 needs to be returned before the absorbent loop will be started. The sequence will wait for 2 minutes to receive the Absorbent Available signal 5100-XS-107, and if not received will cause VRU shutdown 5100-UC-01.

For the solenoid to be opened and the opening of the absorbent supply shut off valve 5100-AOV-009 the Absorbent Ready hard-wired signal 5100-XS-107 must be returned from DCS for the absorbent loop opening to proceed.
For more details, please refer to 8.1

3.4 ADSORBER READY TO REGENERATION SEQUENCE

This sequence consists to close inlet and outlet valves of one adsorber (5102A-AOV-003 & 5102A-AOV-001 for carbon adsorber V5102A and 5102B-AOV-0103 & 5102B-AOV-0101 for carbon adsorber V5102B).
At the end of this sequence, the selected adsorber is ready to be regenerated.

For more details, please refer to 8.4

3.5 VACUUM STARTING SEQUENCE

In this sequence, the selected vacuum pump(s) and the selected booster blower(s) are started as well as the seal fluid circuit.

For more details, please refer to 8.5.

SWITCH OVER SEQUENCES

3.6 Description

Whatever is the operating mode selected (5100-HS-020), as soon as SWITCH OVER conditions are fulfilled, the SWITCH OVER sequence is initiated:

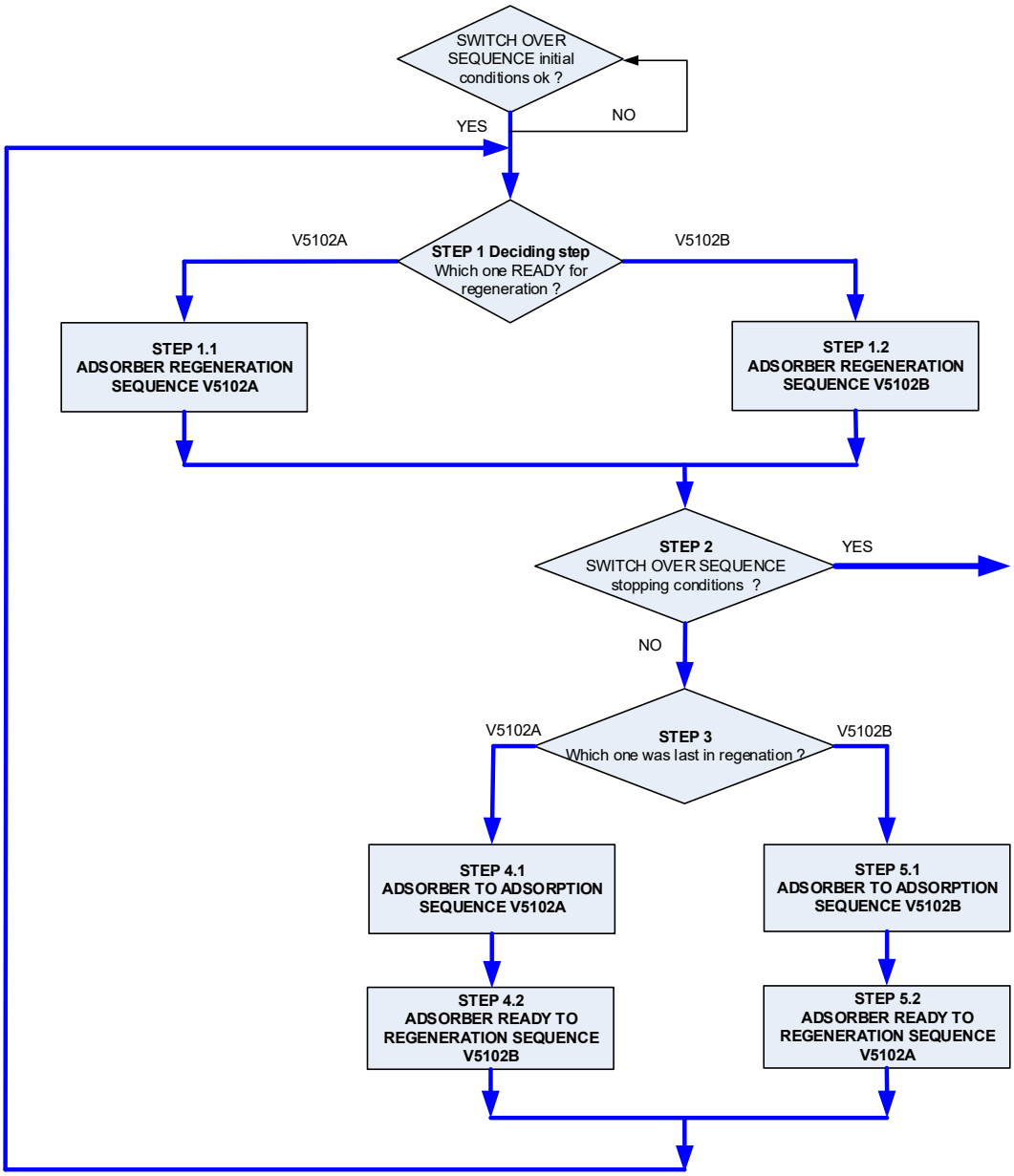
SWITCH OVER SEQUENCE CONDITIONS:

- VRU HEALTHY (NO SHUTDOWN)
  AND
- START UP SEQUENCE COMPLETED

At the end of the ADSORBER REGENERATION SEQUENCE, the SWITCH OVER SEQUENCE STOPPING conditions are checked: if they are fulfilled, STOP SEQUENCE is initiated. If not, then SWITCH OVER SEQUENCE continues.

SWITCH OVER SEQUENCE STOPPING CONDITIONS:

- STOP MODE PLC door selector switch (5100-HS-0201)
  OR
- SOFT SELECTOR HMI/DCS 5100-HS-120 set to OFF MODE (i.e. Neither MANUAL Nor REMOTE modes)
  OR
- REMOTE START MODE selected (5100-HS-120)
  AND
- REMOTE LOAD REQUEST signal 5100-XS-101


SWITCH OVER SEQUENCE initial conditions ok ?
NO
YES
V5102A
STEP 1 Deciding step
Which one READY for regeneration ?
V5102B
STEP 1.1
ADSORBER REGENERATION SEQUENCE V5102A
STEP 1.2
ADSORBER REGENERATION SEQUENCE V5102B
STEP 2
SWITCH OVER SEQUENCE stopping conditions ?
YES
NO
V5102A
STEP 3
Which one was last in regenation ?
V5102B
STEP 4.1
ADSORBER TO ADSORPTION SEQUENCE V5102A
STEP 5.1
ADSORBER TO ADSORPTION SEQUENCE V5102B
STEP 4.2
ADSORBER READY TO REGENERATION SEQUENCE V5102B
STEP 5.2
ADSORBER READY TO REGENERATION SEQUENCE V5102A

3.7 ADSORBER REGENERATION SEQUENCE

In this sequence, whatever the operating mode selected (MANUAL or REMOTE) the adsorber is regenerated during a time-period equal to T-regeneration.

The factory set value for the T-regeneration timer xx = 600 seconds = 10 minutes can be adjusted in the PLC HMI.
For more details, please refer to 8.7.

4 STOP SEQUENCES

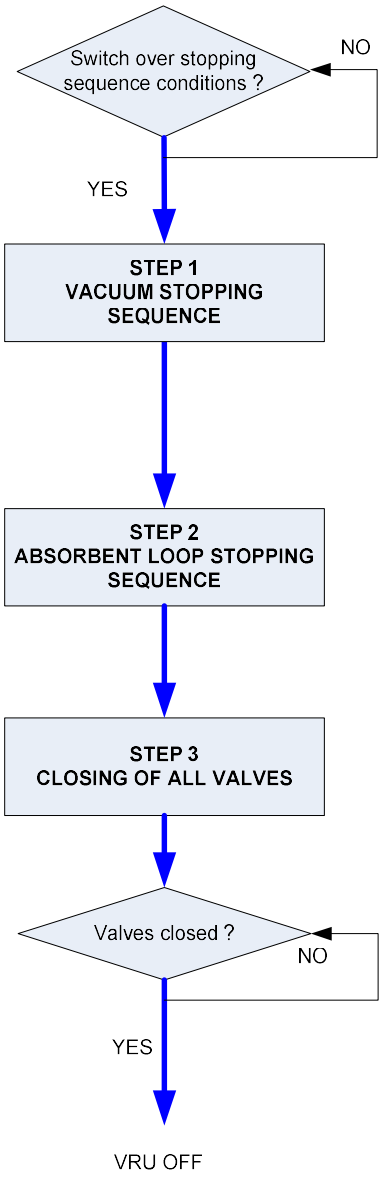
4.1 NORMAL STOP SEQUENCE

4.1.1 DESCRIPTION

Whatever is the operating mode selected (5100-HS-120), as soon as NORMAL STOP sequence conditions are fulfilled, the NORMAL STOP sequence is initiated:

NORMAL STOP SEQUENCE CONDITIONS:

- SWITCH OVER STOPPING SEQUENCE conditions
  (refer to SWITCH OVER SEQUENCE)



4.1.2 VACUUM STOPPING SEQUENCE

In this sequence, both vacuum pump and booster blower are stopped as well as seal fluid pump.

For more details, please refer to 8.6.

4.1.3 ABSORBENT LOOP STOPPING SEQUENCE

In this sequence, remove absorbent request signal and stopping of the absorbent return pump P5110, closing of the absorbent supply flow control valve 5100-FCV-005 and closing of the return valve 5100-AOV-008.

For more details, please refer to 8.2.

4.2 VRU NORMAL SEQUENCE

Whatever is the operating mode selected (5100-HS-120), as soon as NORMAL SHUT DOWN sequence conditions are fulfilled, the VRU NORMAL STOP sequence is initiated:

NORMAL STOP SEQUENCE CAUSES:

The VRU will proceed to the end of its current operating cycle in the chosen mode of operation upon the following situations: -
Operating mode soft selector 5100-HS-120 changed from MANUAL MODE or REMOTE Mode to the OFF MODE.

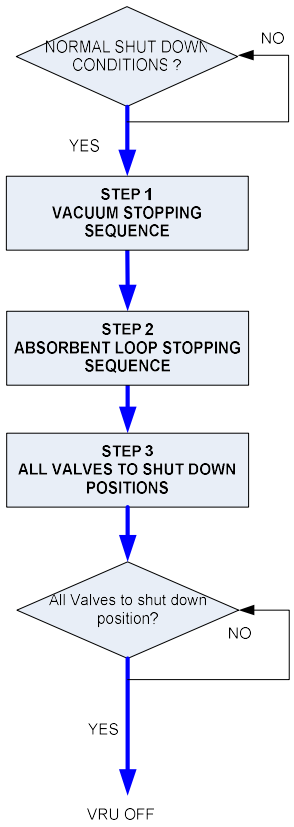
OR

PLC Door selector Switch 5100-HS-101 set to the STOP position.

OR

VALVE FAULT 'XA' on any one of the VRU vapors process AOV valves (excluding absorbent valves): -

- 5102A/B-XA-001
- 5102A/B-XA-002
- 5102A/B-XA-003
- 5102A/B-XA-004
- 5102A/B-XA-005



4.3 VRU SHUTDOWN (Process Interlock 5100-UC-01)

Whatever is the operating mode selected, the VRU is immediately stopped by the PLC if one of the following conditions appears: Refer to Cause and Effects Chart.

VRU SHUTDOWN CAUSES:

- EMERGENCY SHUTDOWN 5100-UZ-01
  OR
- NO ABSORBENT AVAILABLE (READY) SIGNAL 5100-XS-107 (only when stating)
  OR
- Voltage fault (24VDC from redundant 230VAC power circuit) 5100-XS-100
  OR
- SEAL FLUID PUMP P5109 MOTOR FAULT 5109-YA-1003
  OR
- NO SEAL FLUID PUMP P5109 MOTOR RUNNING FEEDBACK 5109-XA-001
  OR
- ABSORBENT RETURN PUMP P5110 MOTOR FAULT 5110-YA-001
  OR
- NO ABSORBENT RETURN PUMP P5110 MOTOR RUNNING FEEDBACK 5110-XA-001
  OR
- 5108-XA-001 minimum flow/Anticavitation valve 5108-AOV-001 VALVE COMMON FAULT
  OR
- ABSORBENT SUPPLY FLOW CONTROL VALVE COMMON FAULT 5100-FA-005
  OR
- ABSORBENT RETURN VALVE COMMON FAULT 5100-XA-008
  OR
- PDAHH Where PDI-001 = (5102-PT-001 – 5107-PT-002) > 250 mbar
  OR
- PXAHH Where PXI-001 = (5102-PT-001 / 5107-PT-002) Ratio >4
  OR
- BOOSTER BLOWER 667K-002A INTERLOCK 5100-UC-02
  OR
- BOOSTER BLOWER 667K-002B INTERLOCK 5100-UC-03
  OR
- VACUUM PUMP 667K-003A INTERLOCK 5100-UC-04
  OR
- VACUUM PUMP 667K-003B INTERLOCK 5100-UC-05
  OR
- ABSORBENT SUPPLY FLOW CONTROL VALVE COMMON FAULT 5100-FA-005 (Only prior to opening of the absorbent loop, when absorbent available signal is received)

VRU SHUTDOWN EFFECTS:

- Close all carbon adsorber valves (De-energize solenoid 5102A/B-SV-00x)
    - 5102A/B-AOV-001
    - 5102A/B AOV-002
    - 5102A/B AOV-003
    - 5102A/B AOV-004
    - 5102A/B AOV-005

AND

- Stop Vapors blower B5101 via signal 5101-XSP-001

AND

- Stop both Booster blower 667K-002A/B via signals 5107A/B-XSP-001

AND

- Close Coolant fluid to booster blowers valves 5107A/B-SV-002

AND

- Close N2 supply to booster blowers valves 5107A/B-SV-001

AND

- Open Minimum flow/Anticavitation valve 5108-AOV-001

AND

- Close seal fluid valve 5108A-AOV-001 TO VACUUM PUMP P5108A

AND

- Close seal fluid valve 5108B-AOV-001 TO VACUUM PUMP P5108B

AND

- Stop both Vacuum pumps P5108A/B via signals 5108A/B-XSP-001

AND

- Trip VRU process interlock
    - 5100-UC-02
    - 5100-UC-03
    - 5100-UC-04
    - 5100-UC-05

AND

- Stop Seal fluid pump P5109 via signals 5109-XSP-001

AND

- Stop Absorbent return pump P5110 via signals 5110-XSP-001

AND

- Close Absorbent supply flow control valve 5100-FCV-005 (De-energize solenoid 5100-SV-005) and force positioner signal 5100-ZY-005 set to 4mA.

AND

- Close Absorbent return valve 5100-AOV-0008

AND

- Process Interlock 5100-UC-01 Status VRU Shutdown to DCS

AND

- Remove VRU Ready (Permissive) Signal 5100-XS-105 to DCS

AND

- Absorbent Request Signal 5100-XS-106 to DCS

AND

- Activate VRU Warning Lamp PLC Door 5100-XA-103

AND

- Interlock 5100-UC-01 Status VRU Shutdown to DCS (comms link)

AND

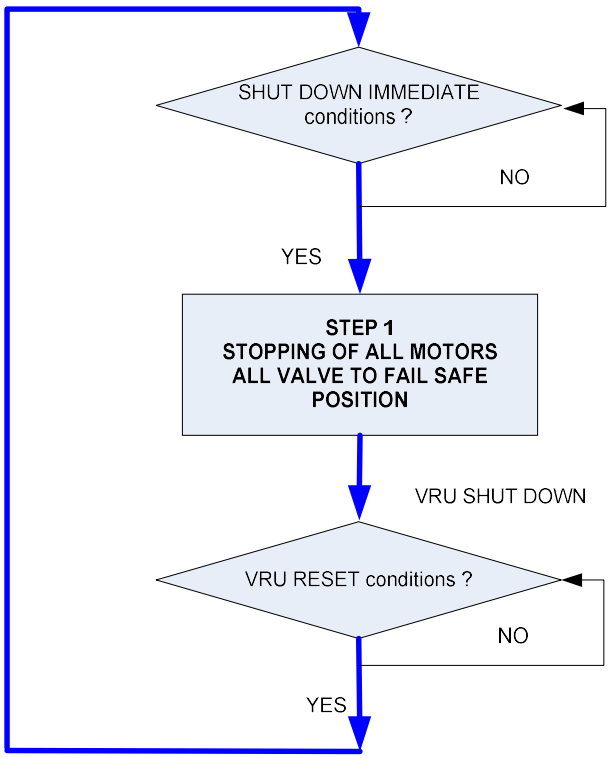
- Remove VRU Warning Hardwired Signal 5100-XS-103 to DCS

AND

- Remove VRU Shutdown Hardwired Signal 5100-XS-102 to DCS

AND

- Activate Lamp VRU Shutdown on PLC Door 5100-XA-102



VRU HEALTHY

Once a shutdown condition appears, all motors stop immediately and all pneumatic valves AOV and solenoids SV on the vapour service are commanded to fail positions by the PLC.

General note:

- To restart the VRU the alarm shall first be reset via HMI 5100-HS-102.
- Prior to being able to reset the alarms, all valves shall be in their shut down position. In case a valve is not in its shutdown position then the PLC must detect a wrong position and not allow the VRU reset. Non-safety valves (Vapor path valves shown on PID sheet 6 of 9) and DSU valves are excluded.
- The Open / Close position of the valves with limit switches is checked within 10 seconds after getting the fully open / close command signal. Not confirmed positions will cause an alarm and shut down the unit. NOT ALL CASES, not applicable for VRU Shut down 5100-UC-01.
- Running feedback of motors are checked within 5 seconds after getting start command. Not confirmed running feedback will cause an alarm and shut down the unit.
- Shutdown due to pressure and/or flow low-low or high-high value: to avoid any spurious trips phenomena, a shutdown is done only if the trip signal is present for 10 seconds.
- Shutdown due to high-high temperature: as soon as high-high value is detected; the unit is shutdown.

4.4 BOOSTER BLOWER SHUTDOWN (Process Interlocks 5100-UC-02 / 5100-UC-03)

A dedicated process interlock is attributed to each booster blower: -

- 5100-UC-02 for Booster Blower P5107A
- 5100-UC-03 for Booster Blower P5107B

Note 1: as soon as either booster blower is running, the individual vapor feed P5107A/B will shut down if either:

Interlocks Causes

5100-UC-02 for Booster Blower P5107A other causes:

- 5100-UC-01 VRU SHUTDOWN INTERLOCK
- 5107A-PALL-001 P5107A N2 INJECTION LOW-LOW PRESSURE
- 5107A-TAHH-002 P5107A DISCHARGE HIGH-HIGH TEMPERATURE
- 5107A-YA-001 P5107A MOTOR VSD FAULT*
- 5107A-XA-001 P5107A MOTOR **NO** RUNNING FEEDBACK

* Include P5107A motor P5107A E windings PTC temperature high alarm 5107A-TAHH-001

5100-UC-03 for Booster Blower P5107B other causes:

- 5100-UC-01 VRU SHUTDOWN INTERLOCK
- 5107B-PALL-001 P5107B N2 INJECTION LOW-LOW PRESSURE
- 5107B-TAHH-002 P5107B DISCHARGE HIGH-HIGH TEMPERATURE
- YA-001 P5107B MOTOR VSD FAULT*
- XA-001 P5107B MOTOR **NO** RUNNING FEEDBACK

* Include P5107B motor P5107B E windings PTC temperature high alarm 5107B-TAHH-001

Interlock Effects

5100-UC-02 for Booster Blower P5107A shutdown effects:

- 5107A-XSP-001 STOP P5107A Booster Blower
- CLOSE SV-002 P5107A Vacuum Booster Blower Coolant Fluid injection
- CLOSE SV-001 N2 to P5107A Vacuum Booster Blower N2 Seal Panel
- LIGHT VRU WARNING LAMP XA-103 on PLC door
- SEND VRU WARNING SIGNAL XS-103 to DCS
- SEND SOFT SIGNAL 5100-UC-02 to DCS via communications link.
- ACTIVATE VRU IMMEDIATE SHUTDOWN INTERLOCK 5100-UC-01

5100-UC-03 for Booster Blower P5107B shutdown effects:

- 5107B-XSP-001 STOP P5107B Booster Blower
- CLOSE SV-002 P5107B Vacuum Booster Blower Coolant Fluid injection
- CLOSE SV-001 N2 to P5107B Vacuum Booster Blower N2 Seal Panel
- LIGHT VRU WARNING LAMP 5100-XA-103 on PLC door
- SEND VRU WARNING SIGNAL 5100-XS-103 to DCS
- SEND SOFT SIGNAL 5100-UC-03 to DCS via communications link.
- ACTIVATE VRU IMMEDIATE SHUTDOWN INTERLOCK 5100-UC-01

INTERLOCK RESET conditions:

- NO SHUTDOWN conditions
  AND
- ALL MOTORS STOPPED
  AND
- ALL SHUT OFF VALVES CLOSED
  AND
- ALARM RESET (5100-HS-103 From HMI)

4.5 VACUUM PUMP SHUTDOWN (Process Interlocks 5100-UC-04 / 5100-UC-05)

Interlocks Causes

5100-UC-04 for Vacuum Pump P5108A shutdown causes:

- VRU IMMEDIATE SHUTDOWN INTERLOCK 5100-UC-01
- 5108A-FALL-0007 P5108A VACUUM PUMP SEAL FLUID LOW-LOW FLOW
- 5108A-YA-001 P5108A VACUUM PUMP MOTOR FAULT*
- 5108A-XA-001 P5108A VACUUM PUMP NO MOTOR RUNNING FEEDBACK
- 5108A-TAHH-001 P5108A VACUUM PUMP DISCHARGE HIGH-HIGH TEMPERATURE
- 5108A-XA-001 P5108A VACUUM PUMP SEAL FLUID VALVE 5108A-AOV-001 COMMON FAULT

* Include P5108A motor P5108A E windings PTC temperature high alarm 5108A-TAHH-001

5100-UC-05 for Vacuum Pump P5108B shutdown causes:

- VRU IMMEDIATE SHUTDOWN INTERLOCK 5100-UC-01
- 5108B-FALL-0008 667K-003B VACUUM PUMP SEAL FLUID LOW-LOW FLOW
- 5108B-YA-001 P5108B VACUUM PUMP MOTOR FAULT*
- 5108B-XA-001 P5108B VACUUM PUMP NO MOTOR RUNNING FEEDBACK
- 5108B-TAHH-001 P5108BVACUUM PUMP DISCHARGE HIGH-HIGH TEMPERATURE
- 5108B-XA-001 P5108B VACUUM PUMP SEAL FLUID VALVE 5108B-AOV-001 COMMON FAULT

* Include P5108B motor P5108B E windings PTC temperature high alarm 5108B-TAHH-001

Interlock Effects

5100-UC-04 for Vacuum Pump P5108A shutdown effects:

- STOP P5108A Vacuum Pump 5108A-XSP-001
- CLOSE VALVE 5108-AOV-001 SEAL FLUID TO VACUUM PUMP P5108A
- ACTIVATE VRU WARNING LAMP 5100-XA-103A on PLC door
- SEND VRU WARNING SIGNAL 5100-XS-103 to DCS
- SEND SOFT SIGNAL 5100-UC-04 to DCS via communications link
- ACTIVATE PROCESS INTERLOCK 5100-UC-02 OR 5100-UC-03*
- ACTIVATE VRU IMMEDIATE SHUTDOWN INTERLOCK 5100-UC-01

5100-UC-05 for Vacuum Pump 667K-003B shutdown effects:

- STOP P5108B Vacuum Pump 5108B-XSP-001
- CLOSE VALVE XV-0106 SEAL FLUID TO VACUUM PUMP P5108B
- ACTIVATE VRU WARNING LAMP 5100XA-103 on PLC door
- SEND VRU WARNING SIGNAL 5100-XS-103 to DCS
- SEND SOFT SIGNAL 5100-UC-05 to DCS via communications link
- ACTIVATE VRU IMMEDIATE SHUTDOWN INTERLOCK 5100-UC-01

If either Vacuum Pumps tripped (5100-UC-02 or 5100-UC-03), the unit will shut down ‘VRU Shutdown’ 5100-UC-01. Interlock 5100-UC-01 shall in-turn trip both booster blowers by activating interlocks 5100-UC-04 and 5100-UC-05.

REMARK: * when only one Liquid Ring vacuum pump is in operation then only one (1) Booster Blower is allowed to operate. THE BOOSTER BLOWER NOT IN OPERATION MUST BE ISOLATED MECHANICALLY

This depends on the selection of vacuum pumps and blowers selected to be in service before start of the VRU.

INTERLOCK RESET conditions:

- NO SHUTDOWN conditions
  AND
- ALL MOTORS STOPPED
  AND
- ALL SHUT OFF VALVES CLOSED
  AND
- ALARM RESET (5100-HS-103 From HMI)

4.6 EMERGENCY SHUTDOWN (SAFETY INTERLOCK 5100-UZ-01)

Whatever is the operating mode selected, the VRU is immediately stopped by the client fail safe ESD PLC or SIS (Safety Interlock System) if one of the following conditions appears:

ESD SAFETY INTERLOCK CAUSES:

- VAPORS INLET FEED DETONATION ARRESTOR HIGH-HIGH TEMPERATURES
  - 5100-TZAHH-001

  OR
- VAPORS INLET BLOWER INLET & OUTLET DETONATION ARRESTOR HIGH-HIGH TEMPERATURES
  - 5106-TZAHH-001
  - 5106-TZAHH-004

  OR
- SULPHUR GUAR BEDV5101 HIGH-HIGH TEMPERATURES
  - 5101-TZAHH-001

  OR
- ANY CARBON ADSORBER BED V5102A/B HIGH-HIGH TEMPERATURE
  - 5102A-TZAHH-001
  - 5102A-TZAHH-002
  - 5102B-TZAHH-001
  - 5102B-TZAHH-002

  OR
- VRU OUTLET TO RTO U 5120 HIGH-HIGH TEMPERATURES
  - 5100-TZAHH-003

  OR
- HIGH-HIGH LEVEL on absorber 5103-LZAHH-002

  OR
- LOW-LOW LEVEL on absorber 5103-LZALL-003

  OR
- ESD PUSH BUTTON (in the front door of PLC cabinet) HZS-0205

  OR
- ESD PUSH BUTTON (on CCR Console) 5100-HZS-106

  OR
- ESD PUSH BUTTON (on VRU regeneration skid) 5100-HZS-107 at local panel

ESD SAFETY INTERLOCK EFFECTS:

- The safety interlock 5100-UZ-01 shall **C**ut-**O**ff all power to all rotary equipment motors by the opening of the cut-off signal contact to MCC/VSD: -
  - XSE-001 INLET VAPORS BLOWER
  - XSE-001 BOOSTER BLOWER
  - XSE-001 BOOSTER BLOWER
  - XSE-001 VACUUM PUMP
  - XSE-001 VACUUM PUMP
  - XSE-001 ABSORBENT RETURN PUMP
  - XSE-001 SEAL FLUID PUMP

  AND
- The signal ABSORBENT REQUEST 5100-XS-106 to DCS shall be removed.

  AND
- The signal VRU Ready (Permissive) 5100-XS-105 to DCS shall be removed.

  AND
- The safety interlock 5100-UZ-01 shall directly remove power to the solenoids (SVs) of all valves (AOVs) on the VRU absorbent supply and absorbent return as directly remove power to the solenoids of all shutoff valves (AOVs) Absorbent supply Flow Control Valve 5100-FCV-005

- Absorbent return valve 5100-AOV-008

AND

- The safety interlock 5100-UZ-01 shall trip the VRU shutdown 5100-UC-01. The VRU shutdown interlock will force all process valves to their respective N2 fail positions. By the same PLC (failsafe redundancy of CPU, communications and I/O) The safety interlock 5100-UZ-01 shall trip all other process interlocks: -
- 5100-UC-01 VRU SHUTDOWN
- 5100-UC-02 BOOSTER BLOWER P5107A SHUTDOWN
- 5100-UC-03 BOOSTER BLOWER P5107B SHUTDOWN
- 5100-UC-04 VACUUM PUMP P5108A SHUTDOWN
- 5100-UC-05 VACUUM PUMP P5108B SHUTDOWN

AND

- The safety interlock 5100-UZ-01 shall send a hardwired signal 5100-XZS-109 ESD TRIPPED of **1x** dry normally closed contacts to client system. When contact open = 5100-UZ-01 tripped, contact closed = healthy.

AND

- Activate 5100-XA-101 Lamp Emergency Shutdown on PLC Door

AND

- Activate 5100-XA-103 Lamp VRU Warning on PLC Door

AND

- Activate hardwired signal 5100-XS-103 VRU Warning to DCS

AND

- Safety Interlock 5100-UZ-01 Status Emergency Shutdown to DCS

Note that **XSE** shutoff signals to VFD or MCC are dual contact (Two pair cable) for dual channel SIL rating.

INTERLOCK RESET conditions:

ESD Reset of VRU is done according to the same conditions as the reset after an IMMEDIATE SHUTDOWN sequence.

- NONE OF THE ABOVE CAUSES PRESENT

AND

- ALL MOTORS STOPPED

AND

- ALL SHUTOFF VALVES CONFIRMED IN THEIR RESPECTIVER FAIL SAFE POSITIONS

AND

- ESD RESET (5100-HS-102 push button on PLC door)

FOLLWED BY

- ALARM RESET (5100-HS-103 push button on PLC door)

5 OTHERS CONTROL PARTS

5.1 MINIMUM FLOW VALVE SEQUENCE

The function of the Minimum flow/Anticavitation valve 5108-AOV-001 is independent of the step the unit is in:
This valve opens when:

- Both regeneration valves 5102A/B-AOV-002 are both closed (confirmed by 5102A/B-ZSC-002

OR

- Regeneration (booster blower suction) pressure below (5102-PXL-001) set at 50 mbara (see figure 3)

This valve closes as soon as:

- one of regeneration valves is not closed

AND

- Regeneration (booster blower suction) pressure above (5102-PXH-001) set at 80 mbara (see figure 3)

Notes: 5108-AOV-001 is a Fail Open valve.

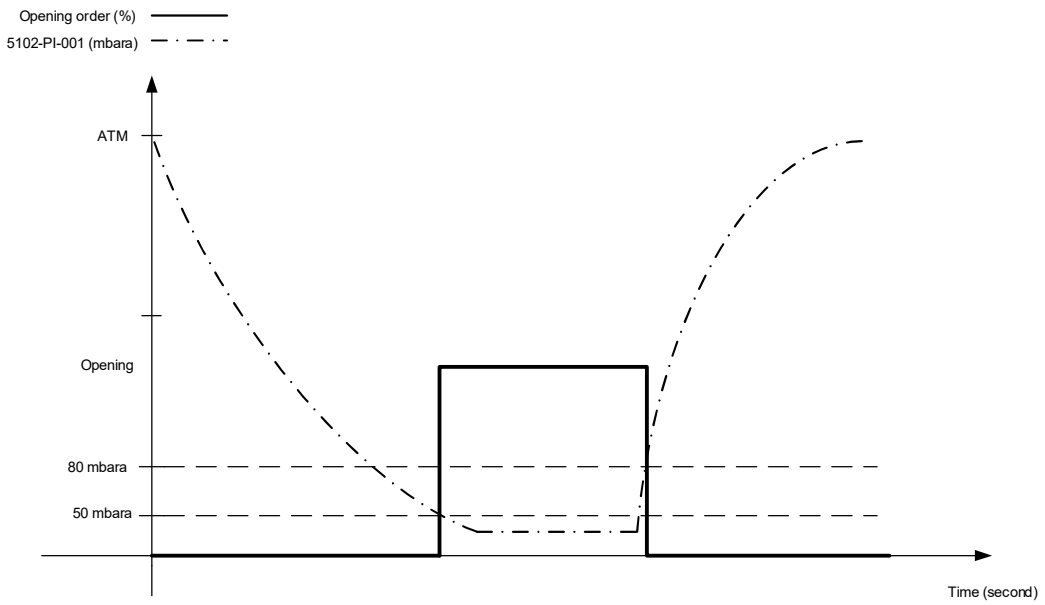


Figure 1: 5108-AOV-001 status according pressure at Vacuum pump suction (PT-001)

If pressure continues to rise above 130 mbara, then an alarm “Insufficient Vacuum” 5102-PAH-001 is displayed on the HMI.

5.2 ABSORBENT LEVEL CONTROL LOOP 5103-LIC-001

The aim of this control loop is to regulate the absorbent level inside absorber vessel C5103. It's composed of:

- one level gauge 5103-LG-001 fitted with level transmitter 5103-LT-001
- one VFD driven Absorbent Return Pump (P5110)
- one software PI controller 5103-LIC-001

Standard parameters of the control loop are:

- Set point = 50%
- Proportional action P=xxx
- Integral action Ti = xxxx
- Direct acting

Note:
- Parameters of control loop need to be adjusted at site during commissioning.
- PI controller can be put on manual mode and opening set point can be sent directly to the positioner.

5.3 ABSORBENT FLOW CONTROL LOOP 5100-FIC-005

The aim of this control loop is to regulate the absorbent flow to the 667C-003 Absorber. It's composed of:

- one DP flow transmitter 5100-FIT-005
- one flow control valve 5100-FCV-005
- one software PID flow controller 510-FIC-005

Standard parameters of the control loop are:

- Set point = xxx m3/h
- Proportional action P=xxx
- Integral action Ti = xxxx
- Derivative action D = xxxx
- Reverse acting

Note:
- Parameters of control loop need to be adjusted at site during commissioning.
- PID controller can be put on manual mode and opening set point can be sent directly to the control valve 5100-FCV-005.

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5.4 BOOSTER BLOWER TEMPERATURE CONTROLS 5107A/B-TIC-001

Booster blowers P5107A/B coolant fluid (Glycol) is injected into each booster blower according the booster blower discharge temperature:
The coolant fluid injection solenoid valve 5107A/B-SV-001 operates on an ON/OFF control command by High and Low temperature thresholds.

Temperature measurement via 5107A/B-TT-001, temperature on/off controller 5107A/B-TIC-001: -

- If booster blower 667K-002A discharge temperature > 5107A/B-TXH-001
  Then 5107A/B-SV-001 is opened
- If booster blower 667K-002A discharge temperature < 5107A/B-TXL-001
  Then 5107A/B-SV-001 is closed

Note:

- Booster blower injection fluid control loop is only activated when booster blower is running.

5.5 REGENERATION VALVE OPENING SEQUENCE AND 5102-PIC-001

The aim of this control loop 5102-PIC-001 is to keep the pressure at booster blower suction below 400 mbar abs. (this value shall not be held however – regen pressure should go down to 34 mbar abs). Prior to activating the control loop an initial crack opening set makes sure to set the suction pressure in the around of 450mbara. This crack opening step is followed by a 5 seconds' delay (HMI timer) to allow for proper stabilization. The value of the crank opening of the valve is an HMI field and will be set at start-up. This control loop is composed of:

- one pressure transmitter 5102-PIT-001
- one regeneration valve 5102A/B-AOV-002 equipped with portioner (5102A/B-ZY-002 depending of which carbon bed will be regenerated V5102A/B)
- one software PID controller 5102-PIC-001

Standard parameters of each controller are:

- Set point = 450 mbara
- Proportional action P=xxx
- Integral action Ti= xxxx
- Derivative action Td=xxxx
- Reverse acting

Note:

- Parameters of control loop need to be adjusted at site during commissioning.
- PID controller can be put on manual mode and opening set point can be sent directly to the positioner.
- This control loop is stopped when the regeneration valve (5102A/B-AOV-002) is fully opened, confirmed by limit switch feedback 5102A/B-ZSO-002.

5.6 BOOSTER BLOWER INTERSTAGE PRESSURE CONTROL 5107-PIC-002

Once the regeneration valve 5102A/B-AOV-002 is fully opened (5102A/B-ZSO-002), speed control of the booster blowers is released.
Blower is speed control by:

- one VFD
- one controller (5107-PIC-002)
- one pressure transmitter at booster blower discharge (5107-PIT-002)

Standard parameters of each controller are:

- Set point = 450 mbara
- Proportional action P=xxx
- Integral action Ti= xxxx
- Derivative action Td=xxxx
- Reverse acting

Note:

- Parameters of control loop need to be adjusted at site during commissioning.
- PID controller can be put on manual mode and opening set point can be sent directly to the positioner.

REMARK: the control scheme of the booster blowers includes the monitoring of the differential pressure across the Booster Blowers (5102-PI-001 – 5107-PI-002) to produce value 5107-DPXI-002 and the pressure compression ration across the Booster Blowers (5102-PI-002 / 5107-PI-002) to produce value 5107-PXI-002. Controllers will be frozen at 5107-DPXH-002 and 5107-PXH-002 and released when at 5107-DPXL-002 and 5107-PXL-002.

REMARK: If the VRU is started with only 1 or no booster blower, then the inter-stage pressure controller shall only be released for a booster blower which is running. Equally the differential pressure / flow ratio measurement and alarms will only be enabled when at least 1 booster blower is running.

5.7 INLET VAPOR BLOWER PRESSURE CONTROL 5101-PX-002

The inlet vapor blower (B5101) is permitted to start if:

- Pressure is greater than 5101-PXH-001
  AND
- VRU vapor path opened (to either carbon adsorber 667C-001A/B) = VRU Running indication present.

Will Stop if:

- Pressure less than 5101-PXL-001

The vapor blower B5101 is speed controlled by a variable frequency drive, operated by a PID controller based on the pressure signal 5101-PX-001.

- If the pressure rises above 5101-PXH-001 (>+10mbarg), then the blower B5101 starts.
- If the pressure falls below 5101-PXL-001 (<-25mbag), then the blower B5101 stops.

This function is to be conciliated with the inlet vapors low flow signal 5100-FAL-001 for starting and stopping of the vapours blower according to the share of loading vapour to each of the two VRUs.

Once the blower is started upon the above-mentioned conditions, the pressure to speed control PC-0015 of the vapours blower is released.
The Vapours Blower B5101 is speed control by:

- one VFD
- one pressure signal 5101-PX-001

Standard parameters of each controller are:

- Set point = xxx mbarg
- Proportional action P=xxx
- Integral action Ti= xxxx
- Derivative action Td=xxxx
- Direct acting

Note:

- Parameters of control loop need to be adjusted at site during commissioning.
- PID controller can be put on manual mode and opening set point can be sent directly to the positioner.

5.8 ENRICHMENT GAS TO RTO VOC CONTROL 5150-QIC-200

The RTO unit Off Gas inlet has a pressure measurement 5150-PIT-200. The measured value 5150-PI-200 is presented to the VRU control system either by 4-20mA signal or by communications link (to be determined). The VRU outlet to RTO pressure controller will act to ensure a back (upstream) pressure control so that the pressure of VRU vented gases to the RTO remains at the setpoint pressure.

Enrichment gas control by:

- one VOC (Analyzer) Control Valve 5150-QCV-200
- one controller (5150-QIC-200)
- one VOC Analyser transmitter in the RTO battery limit (5150-QIT-200)
- RTO ready signal

Standard parameters of each controller are:

- Set point = 3 g/Nm^3 or equivalent % LEL
- Proportional action P=xxx
- Integral action Ti= xxxx
- Derivative action Td=xxxx
- Reverse acting

Note:

- Parameters of control loop need to be adjusted at site during commissioning.
- PID controller can be put on manual mode and opening set point can be sent directly to the positioner.

The RTO VOC analyzer shall have a minimum measurement range of 0 to 20 g/ Nm^3 corresponding to 0 to 50% LEL.

The VOC (Analyzer) Control Valve 5150-QCV-200 shall be fail close but not equipped with position limit switches.

The control valve 5150-QCV-200 shall be forced to fully closed if the RTO is not sending the ready signal.

Pressure limitation of the enrichment gas is achieved by a separate pressure measurement of the enrichment gas by pressure transmitter 5100-PIT-002. In case of enrichment gas pressure rising above the threshold of high-pressure function 5100-PXH-002, the enrichment gas to RTO control valve 5150-QCV-200 shall be forced to fully closed. This function is auto resetting and shall have an adjustable hysteresis value so that the control valve reopens at a lower pressure threshold value.

To avoid too rich vapors being fed to the RTO at the start-up of the VRU, the enrichment gas control valve shall also be at first kept closed until a certain number of regeneration cycles have been accomplished. This is to be determined by a regeneration cycle counter with an adjustable set count value of 0 to 5 and a factory setting value of 1. Thereby, 1 regeneration cycle needs to be done before the 5150-QCV-200 opens and 5150-QIC-200 controls the enrichment gas flow ot the RTO.

5.9 VRU OUTLET TO RTO PRESSURE CONTROL 5150-PIC-200

The RTO unit Off Gas inlet has a pressure measurement 5150-PIT-200. The measured value 5150-PI-200 is presented to the VRU control system either by 4-20mA signal or by communications link (to be determined). The VRU outlet to RTO pressure controller will act to ensure a back (upstream) pressure control so that the pressure of VRU vented gases to the RTO remains at the setpoint pressure.

Pressure control by:

- one Pressure Control Valve
- one controller (5150-PIC-200)
- one pressure transmitter in the RTO battery limit (5150-PIT-200)

Standard parameters of each controller are:

- Set point = -5 mbag
- Proportional action P=xxx
- Integral action Ti= xxxx
- Derivative action Td=xxxx
- Reverse acting

Note:

- Parameters of control loop need to be adjusted at site during commissioning.
- PID controller can be put on manual mode and opening set point can be sent directly to the positioner.

The Pressure Control Valve 5150-PCV-200 shall be fail close but not equipped with position limit switches.

The RTO inlet pressure measurement 5150-PI-200 shall have a range of -20 to +100mbarg.

In case of RTO shutdown, the control loop is deactivated and the 5150-PCV-200 forced to fully open.

5.10 MOTOR (Pump) FAULTS YA-xxx

The vapors blower (B5101), booster blowers (667K-002A & 667K-002B) The vacuum pumps (667K-003A & 667K-003B), the seal fluid pump (667G-003), return pump (667G-002) shall each have a discrepancy alarms (Fault).

For each circuit the pump to be used in VRU operation shall be selected from the VRU PLC HMI in maintenance mode via a soft selector switch. Only one of the two pumps for each circuit shall be permitted to be selected at any moment and selecting of two in service is not permitted. The selected status of each pump shall be communicated to DCS.

Each pump motor fault function shall consist of the following features: -

Fail to Run - No motor running signal XA-xxx after command is given to run and following a timer period.

Fail to Stop - Motor running signal XA-xxx still present after command is given to stop and following a timer period.

Motor Temperature Fault- Windings temperature PTC signal.

Shall be united in as Common Fault - Electrical Fault Signal YA-xxxx from motor MCC/VFD

Above mentioned timer values shall be determined during commissioning and factory setting shall be 10 seconds.

All the above situations of fault shall be incorporated into the common motor common fault signal YA-xxx to be displayed in the alarms list and used for process interlock VRU Shutdown UC-01. The root cause such as 'Fail to Run' shall be displayed on the HMI and communicated to client DCS.

The vapors blower (B5101) is operated by variable frequency drives.
The vacuum booster blowers (667K-002A & 667K-002B) are operated by variable frequency drives.
The vacuum pumps (667K-003A & 667K-003B) are operated by variable frequency drives but at a lower than nominal fixed speed.
The seal fluid pump (667G-003) is operated by DOL (direct online) MCC.
The absorbent return pump (667G-002) is operated by variable frequency drive.

5.11 OPERATION OF BOTH VRUs SIMULTANEOUSLY

Both VRUs U 5100 and U 5200 can be operated together only if they are in the in the same mode of operation HS-020 (Manual, Remote)

If both VRUs are ready to operate with all rotating equipment ready, the controller will select a VRU to be master and the other as slave. After each shutdown, controller will change the master and slave if both are OK to operate and both have the rotating equipment ready.

The software of both VRU has a synchronisation point which is the beginning of regeneration. This is a process need that will ensure best flow distribution between both VRU's.

Each VRU inlet Vandervelde feed line is equipped with a flow transmitter 5100-FIT-001 / 52-FIT-001. Each has a measuring range of 0 to 6000 m3/h.

Normal loading service requires the operation of only one of the two VRUs. When flow to the master VRU increases to certain value (4000 m3/h, 5 min average) the slave VRU starts. If flow falls below to a value (3500 m3/h, 5 min average) slave VRU shutdowns. These flow values shall be adjusted during start-up/commissioning.

The receipt of the REMOTE LOAD REQUET signal 5100-XS-001 / 5200-XS-001 triggers the start of the regeneration sequence in the first master VRU. The start of the trailing VRU will be delayed until the regeneration counter of the leading VRU has decreased below a predefined threshold (set as entry field in the Adsorber parameters)

As the first (Leading master) VRU enters operation its vapors inlet vapors blower for that VRU shall start accompanied by the opening of the vapor's inlet and outlet valves for the carbon adsorber last regenerated.

The VRU start-up sequence shall continue, i.e. start of the absorbent loop, followed by the starting of the Vacuum pumps.

The same above-mentioned starting procedure shall be followed for the second (Trailing slave VRU) however, the regeneration valve for the last carbon adsorber online shall only be opened on both VRU sequences once both sequences have achieved the step counter for regeneration.

As the stopping or shutdown of both VRUs, the selection of which VRU is master and which is slave shall be automatically swapped. The RTO adjoined to each VRU shall always be the slave of the VRU and start (come out of stand-by) when receiving the VRU running signal of the corresponding VRU.

5.12 VALVE FAULTS XA-xxx

The Open / Close position of the N2 Operated Valves with limit switches is checked within pre-set time (adjustable, depending of valve operation time) after getting the fully open / close command signal. Not confirmed positions will cause an alarm and trip the unit. This function shall consider sequential timers for valves with partial opening i.e. adsorber regeneration and equalization valves.

Fail to Open - No open limit switch signal ZSO-xxx after command is given to open and following a timer period.
Fail to Close - No closed limit switch signal ZSC-xxx after command is given to close and following a timer period.
Both Limit Switches - Both open limit switch signal ZSO-xxx and closed limit switch signal ZSC-xxx at the same time.

All the above situations of fault shall be incorporated into the common XV fault signal XA-xxx to be displayed in the alarms list. Only in the case of the absorbent supply and return ESD valves 5100-FCV-005 and 5100-AOV-008 are these alarms used for immediate shutdown interlock 5100-UC-01. The root cause such as 'Fail to Open' shall be displayed on the HMI and communicated to client DCS.

5.13 OPERATION TIMERS

The HMI includes for dedicated hour counters (value in hours) for each point below: -

- Hours unit in operation (vapor flow through V5102A/B) i.e. any valves 5102A/B-AOV-003, and 5102A/B-AOV-001 open (open limit switch ZSO-xxx detected for both valves).
- Individual timer for the vapors blower (B5101)
- Individual timer for the vacuum pumps (P5107A/B)
- Individual timer for the vacuum booster blowers (P5108A/B)
- Individual timer for the seal fluid pump (P5109)
- Individual timer for the absorbent return pump (P5110)

5.14 INTERFACE SIGNALS

The following signals are conveyed to / from the control room via couple relay voltage free / insulated analogue signals

From Client DCS/ESD to VRU PLC:

- 5100-XS-101 REMOTE LOAD REQUEST) (1x NO Contact)
- 5100-XS-107 ABSORBANT READY (1x NO Contact)
- 5100-HZS-106 ESD REMOTE (Customer) (2x NC Contact)

Note:
Single Normally Open contacts are taken to simgle safety input cards.
Dual Normally Closed contacts (Client ESD signal & ESD push buttons) are taken separately to safety input cards.

For the VRU to start is must be healthy i.e. no shutdowns. The VRU PLC must also be set to RUN via 2 position selector switch 5100-HS-101 'VRU STOP/RUN' on PLC panel door.

5100-XS-107 VRU ABSORBENT READY
The site DCS sends this signal to VRU PLC when the supply pump is started (that there is pressure of absorbent to the VRU at battery limit, and that there is a safe return path open for the absorbent fluid returned from the VRU unit. This is to be determined by HES HARTEL Rotterdam considering the alignment of equipment out of our scope such as alignment of valves and pumps.

The typical site conditions that must be in place before the site DCS sends this signal are, tank outlet valves open and VRU return valve open, no maintenance activity in progress and sufficient level in the tank.

5100-HZS-106 ESD REMOTE (Customer Push button or Signal)
This push button or signal consists of **two (2) dry contacts** included into the dual channel ESD fail safe chain to cause ESD interlock 5100-UZ-01 when client site ESD system or control room ESD push button is activated.

The two contacts shall be opened and closed simultaneously to avoid fault condition.

5106-PY-001 INLET VAPOR BLOWER SPEED CONTROL (This control signal consists of **one (1) 4-20mA** from client DCS hardwired to the VRU PLC. It shall work in conjunction with function 5100-PXL-001 to cause the stopping of the vapors inlet blower B5106. Refer to section 6.7.

The contact shall be opened for the low vapors flow condition and closed for no low flow condition.

From VRU PLC to client DCS or ESD:

- 5100-XS-102 VRU SHUTDOWN (1x NO Contact)
- 5100-XS-103 VRU WARNING (1x NO Contact)
- 5100-XS-104 VRU RUNNING (1x NO Contact)
- 5100-XS-105 VRU PERMISSIVE (1x NO Contact)
- 5100-XS-106 ABSORBENT REQUEST (1x NO Contact)
- 5100-XZS-109 EMERGENCY SHUTDOWN (1x NC Contact)

Note: Single Normally Open contacts are taken from redundant output cards. Single Normally Closed contacts are taken separately from safety redundant output cards.

5100-XS-102 VRU SHUTDOWN

The VRU PLC sends this signal when either VRU immediate shutdown interlock 5100-UC-01 is activated.

This signal is always given when the red lamp 'VRU SHUTDOWN' 5100-XA-102 on the PLC panel door is lit.

The signal is removed when the shutdown has been reset via the 5100-HS-103 'Alarms Reset' push buttons on PLC panel door.

This signal is available for information and can be used by client for example to interrupt current loadings (process top), to activate DCS interlock/operation stop of any automatic loading system.

The signal contact will close = 1 when the VRU is healthy and open = 0 when VRU is in immediate shutdown 5100-UC-01 active.

5100-XS-103 VRU WARNING

The VRU PLC sends this signal once any alarm situation is signaled (PAL, PAH, TAH, LAL, LAH, FAL, AAH).

This signal is always given when the yellow lamp 'VRU FAULT (Warning)' 5100-XA-103 on the PLC panel door is lit.

The signal is removed when the alarm has been reset push button 5100-HS-103 on PLC panel door.

The signal contact will close = 1 when the VRU is healthy and open = 0 when VRU WARNING presence of an alarm.

5100-XS-104 VRU RUNNING

The VRU PLC sends this signal once the remote start (load request) signal has been received and the VRU start sequence is underway as soon as there is an open passage (i.e. valves open) for the flow of vapors from the VRU inlet to the VRU vent via one of the two carbon adsorber vessels V5102A/B.

This signal is always given when the green lamp 'VRU RUNNING' 5100-XA-104 on the PLC panel door is lit.

The signal is removed when VRU is in 'OFF MODE' i.e. the VRU is not in operation. Pumps are not running, and vapors path closed.

Valves are all in their shutdown position. Once the VRU STOP sequence is completed, the hardwired signal to client DCS will be removed.

The client will make use of this signal to operate any loading pumps according to site controls philosophy any automatic loading system. The client can also make use of this signal to operate any vent valve (not in scope).

The signal contact will close = 1 when the VRU is running and open = 0 when VRU is not running.

5100-XS-105 VRU PERMISSIVE (READY)
The VRU PLC sends the signal once 'VRU immediate shutdown' (process interlock) has been reset ~~and~~

When the VRU is not operational, and not ready to start, the VRU Permissive signal will be deactivated.

- VRU shut-down (5100-XA-103)
- ESD shut-down (5100-XA-104)
- Switch HS-0201 on PLC door is in the stop position and the VRU is not Running (5100-XA-101).
- Maintenance mode active

When the VRU is in an operational state (OFF/MANUAL/REMOTE), the VRU Permissive signal will be activated.

The signal contact will close = 1when the permissive is given and open = 0 when VRU no permissive is given.

Once the VRU permissive signal is given and this in followed by the VRY PLC receiving the REMOTE LOAD REQUEST signal, the VRU will proceed to start. The VRU vapors path valves through one of the carbon beds 5102A/B will open, and then the PLC proceeds to the next start up step which is the starting of the absorbent loop by sending the signal 5100-XS-106 ABSORBENT REQUEST'.

5100-XS-106 ABSORBENT REQUEST
The VRU PLC sends this signal when absorbent is required from the absorbent supply circuit (by client) and absorbent supply Flow Control/shut-off valves 5100-FCV-005 & and absorbent return shut-off valve 5100-AOV-008 are due to open. Once the 5100-XS-107 'ABSORBENT READY' signal is returned from DCS then absorbent loop is ready to operate.

The signal contact will close = 1 when the ABSORBENT REQUEST is given and open = 0 when ABSORBENT REQUEST

If after a time period the ABSORBENT READY signal 5100-XS-107 is not received, then the VRU will shut down, 5100-UC-01. This is only checked at start-up of the VRU i.e. with the reception of the first REMOTE LOAD REQUEST signal. Once the ABSORBENT READY signal 5100-XS-107 is not received after this timer value, instead of shutdown the VRU PLC will proceed to stop the VRU. This will imply the immediate closing of the absorbent supply flow control valve 5100-FCV-0005, stopping of the absorbent return pump P5110 and closing of the absorbent return valve 5100-AOV-008. The VRU PLC will then proceed to stop seal fluid pump P5109, the booster blowers P5107A/B and then the vacuum pumps P5108A/B in a controlled manner (closing of liquid injection valves etc.), and finally close the vapors path valves through the carbon bed adsorber vessels V5102A/B. The vapors inlet blower B5101 shall be stopped.

5100-XZS-109 ESD TRIPPED
The VRU PLC sends this signal when VRU Emergency Shutdown interlock 5100-UZ-01 hard wired ESD signal from client SIS is given to the VRU PLC.

This signal is always given when the red lamp 'ESD SHUTDOWN' XA-0201A on the PLC panel door and XA-0201B on the VRU local panel are lit.

The signal is removed when the shutdown has been reset via the blue HS-102 'ESD Reset' push buttons on PLC panel door.

Client signal for pressure control of inlet blower B5016 (tag to be determined by client).
Refer to section 6.3

5.1 INTERFACE SIGNAL AND INTERATION BETWEEN VRU AND RTO

The VRU shall generally be used in the REMOTE mode of operation. The VRU PLC control shall be set to the VRU RUN state via the 2-position selector switch VRU STOP/RUN 5100-HS-101 on the PLC door. The VRU PLC then waits to receive from client DCS the REMOTE LOAD REQUEST signal 5100-XS-101.

This signal initiates the start of the inlet vapor blower B5106 and acts as the initial condition of the start sequence of the VRU of which the first sequence is the opening of the vapor path through the last regenerated carbon bed adsorber V5102A/B. When the VRU is set to RUN mode via the selector switch 5100-HS-101, the RTO shall be in a state of standby, meaning that the RTO has reached the temperature ready for operation. The status of RTO in standby and at temperature shall be communicate directly from the RTO PLC to client DCS. *(Tag numbers to be defined by RTO controls description).*

When the VRU receives the REMOTE LOAD REQUEST signal 5100-XS-101 and RTO ready signal, the enrichment gas control valve 5150-QCV-200 and its controller 5150-QIC-200 shall be put into automatic mode of operation and the forcing to closed of the enrichment gas control valve 5150-QCV-200 shall be removed. Secondly the VRU outlet to RTO pressure control valve 5150-PCV-200 and its controller 5150-PIC-200. shall be put into automatic mode of operation. As a result, vapors flow through the carbon bed adsorber and enrichment gas coming from recycled vapors from the absorbent column C5103. The REMOTE LOAD REQUEST SIGNAL is given to the RTO PLC as soon as it is received from client DCS. In this case the RTO shall come out of its standby mode and operate to treat the VOC venting from the RTO.

Incase of non-start-up or a shutdown of the RTO, the vapors continue to be vented out from the VRU and are sent to an Emergency stack in the RTO package. This ensures that the VRU and RTO are independent and that in al cases the VRU is available other than in the case of VRU shutdown 5100-UC-01 or Emergency shutdown 5100-UZ-01. In the case of emergency shutdown either from client system or initiated from the VRU safety trips or ESD push buttons 5100-HZS-105, 5100-HZS-106 or 5100-HZS-107, the ESD safety signal 'VRU ESD TRIPPED' 5100-XZS-109 to the client DCS shall be in turn relayed directly to the RTO for shutdown of that sub package.

As the VRU is remotely started and the inlet vapor blower started from the same REMOTE LOAD REQUEST signal, or by the VRU start in manual mode, the inlet blower speed is directly controlled by an analog signal from client (tag number to be defined by client). Equally the client DCS needs to provide independent inlet vapor blower start and stop signals to ensure that pressure at the vapors collection system manifold (for loading of vessels and for floating tank operations) remains with in operating working limits and avoid over or under pressure venting.

All VRU main status signals which are transmitted to client DCS by both communications link and by hard wired signal shall also be sent by communications to the RTO:-

5100-XZS-109	VRU ESD Tripped
5100-XS-101	REMOTE LOAD REQUEST(VRU)
5100-XS-102	VRU Shutdown
5100-XS-103	VRU Warning
5100-XS-104	VRU Running
5100-XS-105	VRU Permissive
5100-XS-106	Absorbent Request
5100-XS-107	Absorbent Ready
5100-ES-1	VRU-1 Emergency Shutdown

5100-UC-1	VRU-1 Shutdown

5.2 PLC (process interlocks and process controls)

The VRU overall controls systems must be designed to control the safe operation of the unit and seamless. The Processes to be controlled include the start/stop sequences, operational sequences, process shut down and safety interlocking.

The process interlocking functions (Non safety) are to be integrated into the PLC making used of non-safety input/output cards.

The PLC takes care of regulating controls such as the position of valves open/closed and partial opening via positioner I/P, regulating the speed (VSD) of the and on/off control of pumps (seal fluid, absorbent circulation, evaporative cooler water and liquid ring vacuum pumps).

The safety interlocking function SIL-1, SIL-2 in interlock 5100-UZ-01 are to be integrated in to the safety PLC I/O cards.

5.3 SOFTWARE ARRANGEMENT

The DCS & SIS software should be organized such that it 'flows' in an orderly manner and is arranged logically with the operation sequences. The VRU control functions can be broken down into groups and the software should be arranged into groups accordingly. Grouping as follows: -

1) DCS Analogue Inputs — Signal conditioning and scaling of analogue inputs and threshold detection for alarms and shutdowns etc.
2) DCS Analogue I/O — Signal conditioning and scaling of analogue inputs and threshold detection for discretion measurements, PID controllers
3) DCS Digital alarms — General alarms and shutdowns.
4) DCS Valve checking — Position Checking of each valve.
5) ESD Interlocks — **Safety** interlocks logic
6) DCS Interlocks — Non-safety process interlocks logic
7) DCS VFD controls — Variable Frequency Drive (speed control for vapors blower and pumps)
8) DCS DOL controls — Direct Online (MCC) for pumps
9) DCS Sequences — Sequence logic
10) DCS Interface — Control system interface indication and operator selections

Notes:

1. For the purposes of this document, analogue input signals have been scaled in engineering units. The threshold and scaling values described in this document are based on integers. If floating point numbers are used the <>= values will need to be revised accordingly.

2. Alarm/shutdown logic will be '0' for alarm/shutdown and '1' for no alarm/no shutdown.

3. The arrangements of DCS control of field equipment such as blower, pumps and instruments are shown in detail on the Piping & Instrument Diagrams.

5.4 MODBUS (Software) SIGNALS

On the O.I.P touch screen display (mounted on PLC front door) the following discrete instrument states indications:

- All transmitter (pressure, temperature, flow and level) transmitters measured values
- All transmitter alarm and trip states (interlock causes)
- All pump run status, fault status, start/stop command status, VFD speed
- All three term (PID) controllers' set-point values and control output values
- All shut off (N2 operated) valves commanded position (solenoid energized state) and position (open & closed) limit switches states and common faults
- All control valves (solenoid energized state) and position (open & closed) limit switches states
- All operating sequence timers (progress) values
- All operating sequence counters (count) values
- All interlock N° states (activated)
- All interlock causes (trip signals)

The same information is to be made available to client remote DCS system in central control room via Modbus TCP/IP communications link so that the client DCS provider may replicate all HMI graphics.

5.5 HMI ACCESS LEVEL

- Level 0: No password required, no actions possible, only synoptic of vapor, vacuum and absorbent can be viewed. Parameters and Maintenance pages are not accessible.

- Level 1 Operator: Same as level 0 + Access to Parameters and Maintenance pages (No access to maintenance mode).

ID: USER
PASSWORD: USER

- Level 2 Administrator: Same as level 1 + Full Access to Maintenance Mode. Able to select pumps and start the unit.

ID: JZ
PASSWORD: JZC95

After 30 minutes of non-use of the HMI, the HMI will be auto log off from any of the above-mentioned access level.

After 30 minutes of non-use of the HMI, the screensaver of the HMI will be activated.

6 MAINTENANCE MODE

To get to the maintenance mode, the VRU mode selector switch (HS-120A) must be moved in the “OFF” position. A Password must be entered in the maintenance screen of the OIP. The Operator will de-activate the maintenance mode when he selects one of the 3 normal modes of operation (MANUAL, REMOTE).

In maintenance mode, all motors and all valves can be operated manually.

During the course of commissioning activities, an authorized operator can manually:

- start and stop the ABSORBENT loop (according ABSORBENT LOOP STARTING sequence)
- start and stop the vacuum (according VACUUM STARTING sequence)
- fill up absorber with ABSORBENT
- drain absorber function

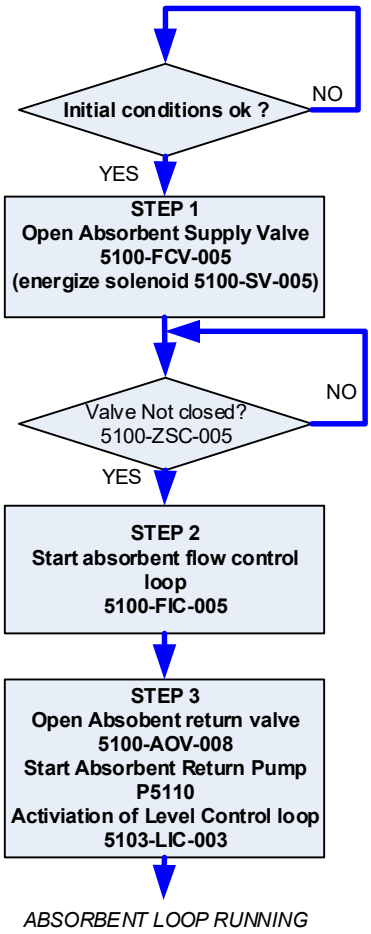
All set points, controller parameters, timers and range of instruments can be adjusted in maintenance mode.
Only VRU shutdown by the safety relay chain or a high-high level in absorber vessel C5103 are active in maintenance mode.

For more details about O.I.P. functionality, please refer to document O.I.P. DESCRIPTION.

REMARK: To be able to test the rotation direction of the absorbent return pump P5110, the Absorbent level transmitter 5103-LZSLL-003 can be overridden is maintenance mode by key-switch 5100-HS-122. This key is to be handed to HES HARTEL operations and should be used in conjunction with a corresponding TRA and work permit.

7 SEQUENCES

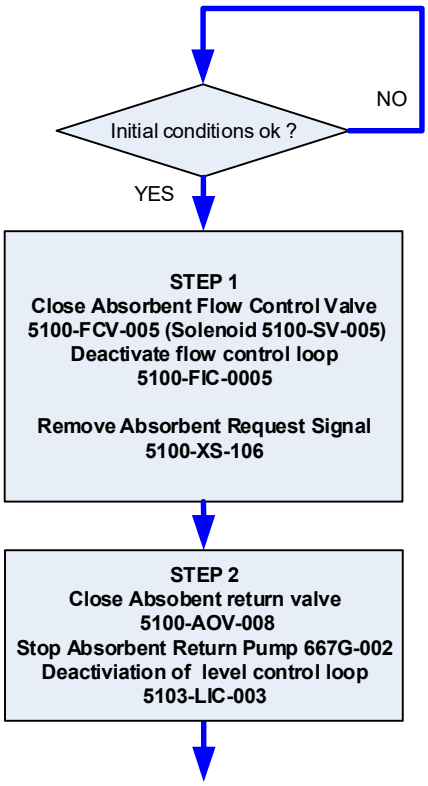
7.1 ABSORBENT LOOP STARTING SEQUENCE



Initial conditions :

- START UP CONDITIONS
  AND
- MANUAL START MODE SELECTED HS-120
  OR
- REMOTE MODE SELECTED HS-120A
  AND
- **ABSORBENT REQUEST SIGNAL XS-106 (SENT)**
  AND
- **ABSORBENT READY (AVAILABLE) SIGNAL XS-107 RECEIVED**

7.2 ABSORBENT LOOP STOPPING SEQUENCE

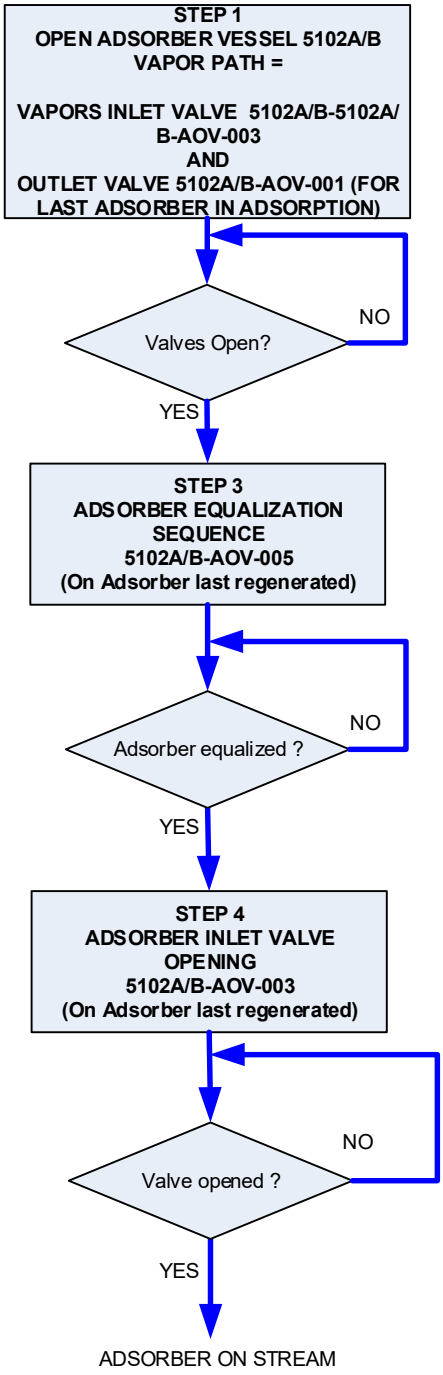


Initial conditions:

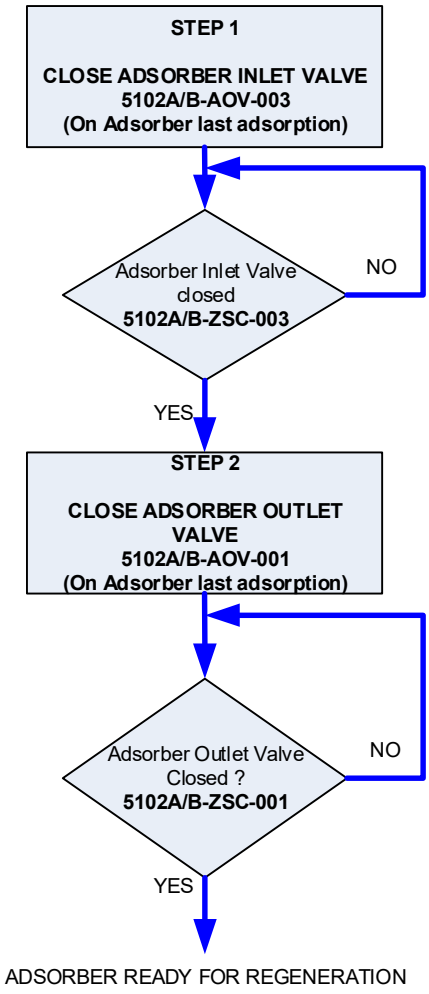
- NORMAL STOP CONDITIONS
  OR
- NORMAL SHUT DOWN CONDITIONS

  AND
- VACUUM LOOP STOPPED

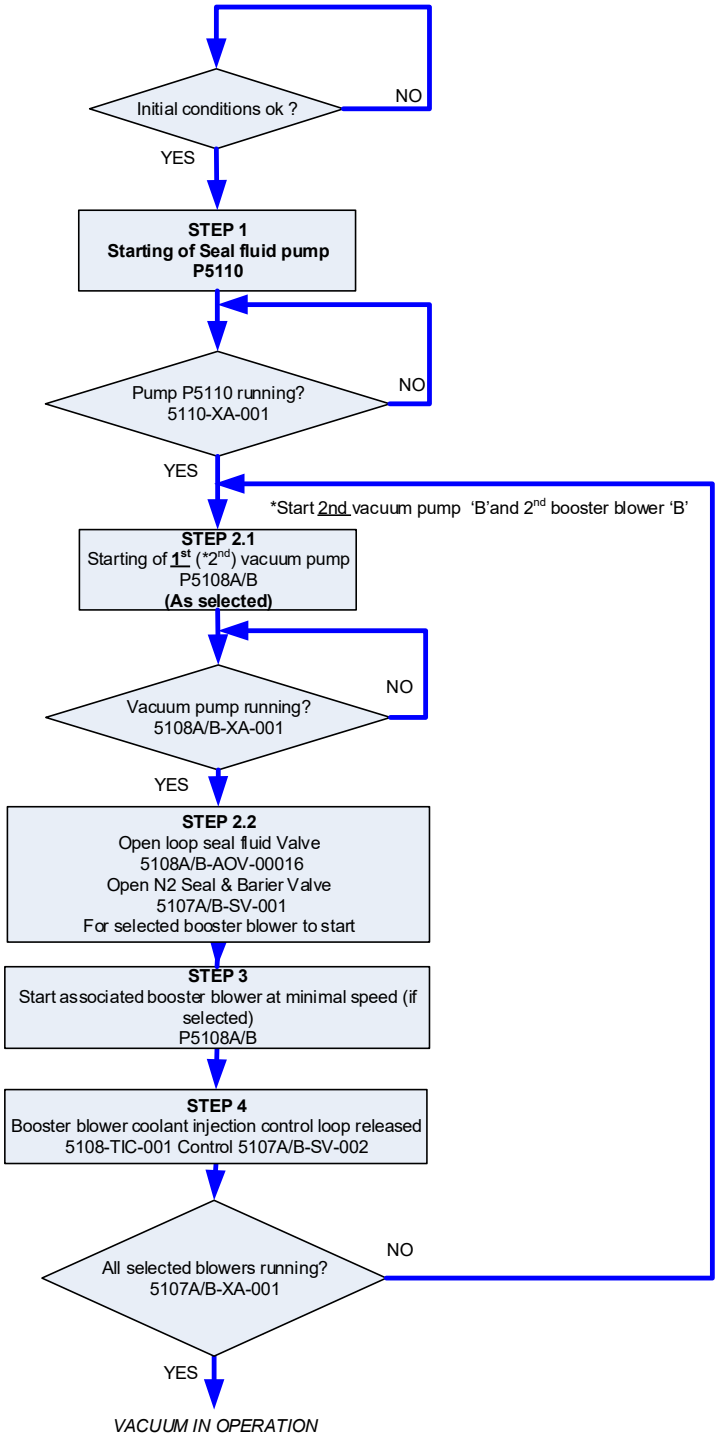
7.3 ADSORBER TO ADSORPTION SEQUENCE (FIRST TIME)



7.4 ADSORBER READY TO REGENERATION SEQUENCE



7.5 VACUUM STARTING SEQUENCE



Initial conditions:

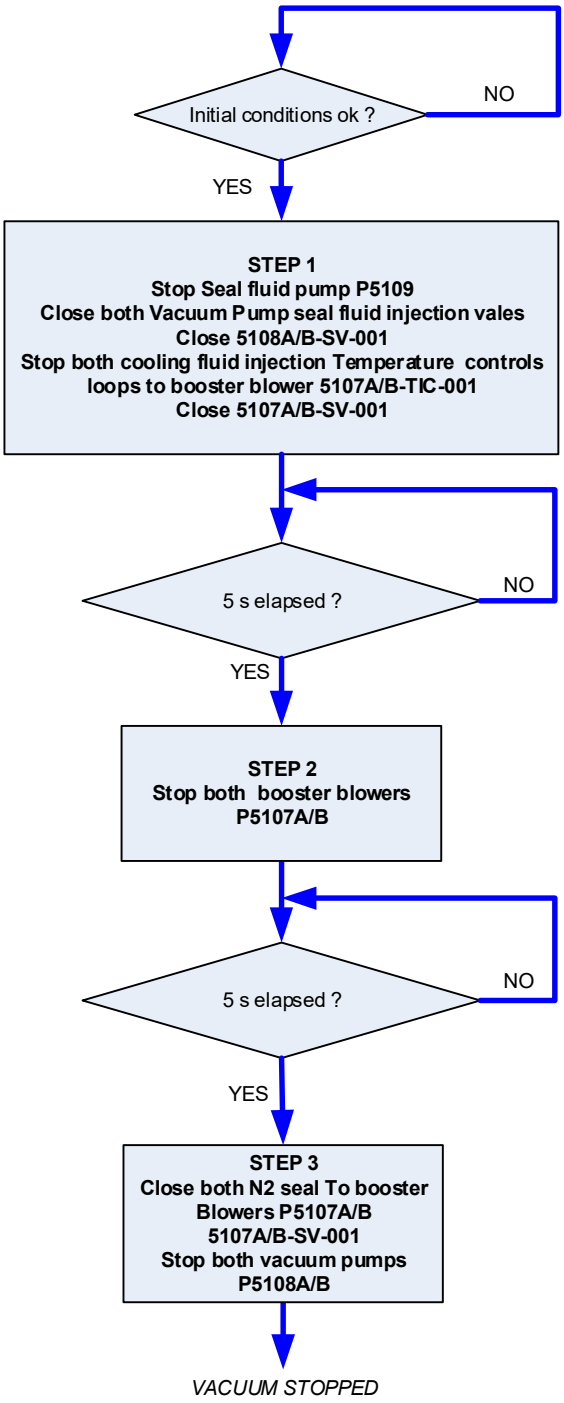
- NO VRU SHUTDOWN
  AND
  - ABSORBENT LOOP RUNNING

OR

- MAINTENANCE MODE SELECTED
  AND
- VACUUM STARTING REQUEST FLAG

Note: Minimal speed of booster blower is adjustable but not less than 20 Hz.

7.6 VACUUM STOPPING SEQUENCE



Initial conditions:

- NORMAL STOP SEQUENCE CONDITIONS

OR

- NORMAL SHUT DOWN SEQUENCE CONDITIONS

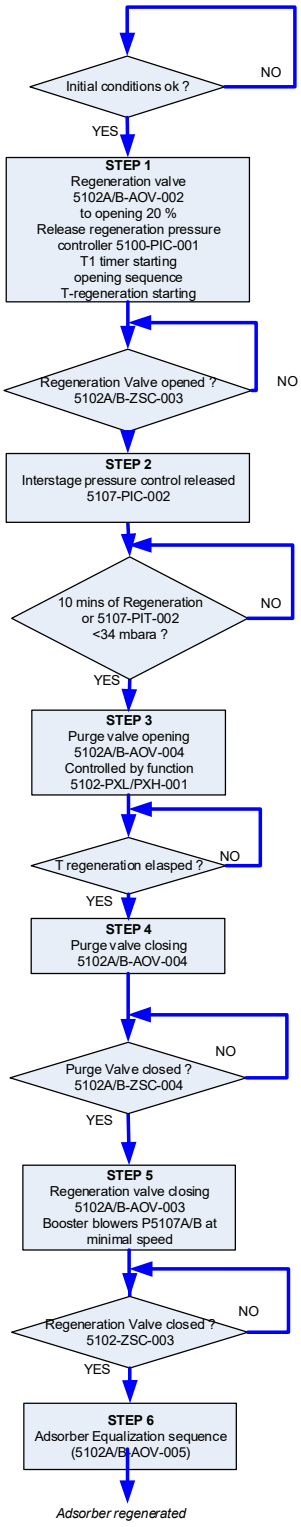
OR

- MAINTENANCE MODE SELECTED

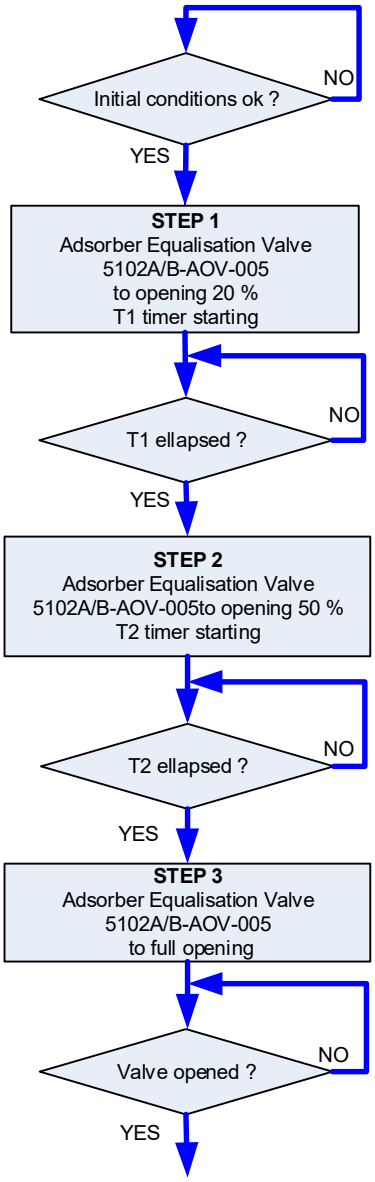
AND

- VACUUM STOPPING REQUEST FLAG

7.7 ADSORBER REGENERATION SEQUENCE



7.8 ADSORBER EQUALIZATION SEQUENCE (Timer based)



7.9 ADSORBER TO ADSORPTION SEQUENCE (Further adsorptions)