Document Name	CONTROL LOGICS FOR DOUBLE EFFECT STEAM FIRED CHILLER		
Document No.	C5DS20CL01	Revision No.	02
Document Type	Control Logics	Department	Innovation
Product Series	TAC/TZC S2 Series	Prepared by	M Jayachandran

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TAC/TZC S2 SERIES (HORIZONTAL SPLIT DESIGN): CONTROL LOGICS

The operation of the Vapour Absorption Machine (VAM) is totally controlled by the PLC. The operational philosophy of VAM can be classified as:

A) Start up sequence
B) Control actions
C) Safety measures
D) Shut down sequences

A) START UP SEQUENCE:

- When VAM is powered on, the status of VAM as displayed on the HMI will be "VAM READY TO START", provided VAM has completed the 'DILUTION' cycle before control panel was powered off.
- This status indicates that VAM can be started now. Else VAM will first undergo 'DILUTION' as described in the Power Failure resumption described below.
- When VAM is started, PLC sends signal to start the Chilled Water Pump immediately.
- PLC then waits for activation of Flow switch, Flow healthy based on Chilled water inlet & outlet pressure transmitters and Chilled Water Pump Feedback Signal for 10 minutes time. VAM status will be "WAITING FOR FLOW" till the chilled water flow safeties become healthy.
- During this time, whenever these safeties become healthy, PLC will initiate start sequence & Steam Control Valve will start its slow opening simultaneously.
- Absorbent Pump switches ON based on HTG level.
- After a span of 15 seconds from start, Refrigerant Pump switches ON based on Evaporator level.
- After a span of 15 seconds from start, PLC sends signal to close the Cooling Water Bypass Shut-off Valve or open the Cooling Water In-line Shut-off Valve.
- After a span of 15 seconds from open/close command to Cooling Water In-line/Bypass Shut-off Valve, PLC sends signal to start the Cooling Water Pump.
- After a delay of 2 seconds, PLC sends signal to start Cooling Tower Fan.
- If after completion of 10 minutes, Flow switch, Flow healthy based on Chilled water inlet & outlet pressure transmitters and Chilled Water Pump feedback Signal safeties are not healthy, then chilled water pump will be stopped, VAM status will return to "VAM READY TO START", the start command would have to be given again on the panel/by remote for VAM to start again. Also, an alarm will generate with message content of "CHILLED WATER FLOW NOT ESTABLISHED".

B) CONTROL ACTIONS:

The control actions performed by the PLC are as given below.

1. Fixed ramp rate of loading for Thermal shock prevention
2. Capacity control
3. Chilled Water L-Cut control
4. Crystallization prevention
5. CT fan control on Cooling Water Inlet Temperature
6. Steam Control Valve control on HTG temperature
7. Cavitation protection of Refrigerant Pump
8. Absorbent pump AC Drive modulation (If Applicable)
9. HTG level control
10. Removal of condensate logging in HTG
11. Mixing solenoid valve control for Zero-degree application (If Applicable)

1. FIXED RAMP RATE OF LOADING FOR THERMAL SHOCK PREVENTION:

- This control is to prevent the sudden rush of steam to the high temperature generator (HTG) during cold start and to protect VAM from thermal shock.
- For this, the Steam Control Valve is opened gradually over a span of 7 minutes from VAM start up or whenever the HTG temperature is less than 120°C.
- After the slow opening duration is over, the control is switched over to Chilled Water temperature PID control loop automatically.
- In case the Chilled Water Outlet Temperature is already below the set point, then the slow opening is bypassed and the control is through the PID.

2. CAPACITY CONTROL:

- The cooling capacity of VAM is the total heat extracted from the Chilled Water. If the Chilled Water flow rate to VAM is kept constant, the cooling capacity is proportional to the difference in the temperatures of the inlet and outlet Chilled Water.
- Load changes are reflected in the rise or fall of the temperature of the inlet Chilled Water.
- As the inlet Chilled Water temperature rises or falls, the outlet Chilled Water temperature tends to follow the same pattern.
- A temperature sensor in the outlet Chilled Water senses this change in temperature. This signal is fed to the PLC.
- An inbuilt software PID control loop processes this signal with respect to the Chilled Water set point.
- A control output signal of 4 to 20 mA is sent to control valve. This signal controls the position of the Steam Control Valve [4 mA - 0% open, 20 mA - 100% open].
- As the load increases the Steam Control Valve opens and as the load reduces the Steam Control Valve closes, thus regulating the quantity of steam entering VAM.
- Note: The above operation is in conjunction with crystallization control (Refer the section on crystallization control).

3. CHILLED WATER L-CUT CONTROL:

- Sometimes the load may fall sharply due to which the Chilled Water Outlet Temperature will start dropping below its set point.

- When the Chilled Water Outlet Temperature drops below the Chilled Water Outlet Temperature set point minus L-Cut differential set point, the following actions will be taken place.
  - Refrigerant Pump is switched OFF.
  - Steam Control Valve shuts off fully.
  - Cooling Water Bypass Shut-off Valve will be opened (Applicable for TZC only).
  - Cooling Water In-line Shut-off Valve will be closed (Applicable for TZC only).
- This safety prevents further temperature drop of Chilled Water Outlet Temperature.
- The Refrigerant Pump, Steam Control Valve and Cooling Water Shut-off Valve (Bypass/In-line) will return to normal operation after the Chilled Water Outlet Temperature rises above the Chilled Water Outlet Temperature set point minus L-Cut differential set point plus the hysteresis.
- A slow opening timer of 2 minutes is provided during the reopening of steam control valve.

4. CRYSTALLIZATION PREVENTION:

- If the concentrated absorbent solution returning to the absorber from the low temperature generator is excessively cooled, it crystallizes in the low temperature heat exchanger and the operation of VAM may be affected.
- Crystallization occurs either when the concentration of the absorbent in relation to its temperature goes too high or the temperature of LiBr drops excessively.
- The following safety functions prevent LiBr in VAM from crystallizing.
  a) Steam Control Valve modulation on crystallization prevention
  b) Absorber level control
  c) Based on Cooling Water Inlet Temperature

a) STEAM CONTROL VALVE MODULATION ON CRYSTALLIZATION PREVENTION:

- The strong solution concentration is calculated in the PLC. The crystallization temperature for that concentration is also calculated by the PLC.
- The PLC always tries to keep the Preset safe distance between the crystallization temperature and strong solution temperature of LTHE outlet.
- If the distance is less than the preset safe distance (15°C), then the PLC modulates the Steam Control Valve so that the strong solution temperature will never reach crystallization temperature.
- When the distance is less than safe distance Steam Control Valve operates only on crystallization control signal and capacity control signal is overruled.
- In addition to the above, SCV opening shall also be based on strong concentration. SCV opening limit will be maximum set in HMI at 63.5% concentration and it will be 0% at 64.5% concentration. It will vary linearly in between 63.5% and 64.5% concentration. (Enable/disable option for this control has been given in the HMI (services screen). ***Default: Enable).***
- SCV will return to normal operation only after the strong concentration goes below the concentration very high setpoint (64.5%) minus the hysteresis (1.5%).
- A slow opening timer of 2 minutes is provided during the reopening of Steam Control Valve.

b) ABSORBER LEVEL CONTROL:

- In the event of LiBr getting crystallized in the spray solution line, the level of LiBr in the absorber sump starts reducing.
- To sense the level of LiBr in absorber, level transmitter is provided. There are three level (Normal/Medium/Low) setpoints provided in HMI service menu with respect to Absorber sight glass.
- When the level goes below ***Absorber Medium Level setpoint***, Steam Control Valve opening will be reduced by 20% of the current opening.
- Further if the level goes below ***Absorber Low Level setpoint***, Steam Control Valve opening will be reduced by 20% of the current opening and the Refrigerant solenoid valve will open to transfer refrigerant to the absorber to build the absorber level again. Also, Refrigerant solenoid valve will open only when the Refrigerant Pump is in 'ON' condition.
- If the level in absorber rises above ***Absorber Low Level setpoint***, Refrigerant solenoid valve will close.
- If the level in absorber rises above ***Absorber Normal Level setpoint***, Steam Control Valve modulation returns to Chilled Water Outlet Temperature PID control.
- A slow opening timer of 2 minutes is provided during the reopening of Steam Control Valve. This control action will come into action only when VAM is 'ON'.
- Note: Refrigerant solenoid valve should be operated in both Auto and Manual mode (Default: Auto)
- Note: SCV and Refrigerant solenoid valve control on ***Absorber Level Transmitter*** must have 'Enable/Disable' option in settings. ***Default: Enable.***

c) BASED ON COOLING WATER INLET TEMPERATURE:

- The maximum opening for steam control valve is to be limited based on cooling water inlet temperature to safeguard against excessive capacity extraction from VAM at lower cooling water inlet temperatures.
- If the incoming cooling water inlet temperature (T_{CW}) is less than Cooling water inlet temp low trip set-point (T_{CWL}), the control valve opening should be zero.
- If the incoming cooling water inlet temperature (T_{CW}) is equal to Cooling water inlet temp low trip set-point (T_{CWL}), the control valve opening should be 10% of the opening fixed @ rated capacity.
- If the incoming cooling water inlet temperature (T_{CW}) is equal to or greater than Cooling water inlet temp for Crystallization control set-point (T_{CZL}), the control valve opening should be 100% of the opening fixed @ rated capacity
- If $T_{CWL} < T_{CW} < T_{CZL}$, the maximum limit of opening will vary linearly as per the equation,

$$\text{if } (T_{CW} < T_{CWL}, 0, \text{if}(T_{CW} < T_{CZL}, (0.1+0.9*(T_{CW} - T_{CWL})/(T_{CZL} - T_{CWL}))*CV, CV))$$

Where, CV - Control Valve Opening %

- This control will come into action immediately after VAM is started. That is, like crystallization control, during the initial slow opening duration if the control becomes live, the slow opening will be bypassed.
- When crystallization control logic and the control based on cooling water inlet temperature are acting simultaneously, minimum of the two calculated control valve openings must be considered.
- This logic, like crystallization control, will always override the chilled water outlet PID.

5. COOLING TOWER FAN CONTROL ON COOLING WATER INLET TEMPERATURE:

- When the Cooling Water Inlet Temperature to VAM goes below the Cooling Tower Fan OFF Set point, after delay of 5 sec the start permissive for Cooling Tower Fan is made off by the PLC.
- The Cooling Tower Fan permissive is put ON only after the Cooling Water Inlet Temperature is more than Cooling Tower Fan OFF Set point plus Hysteresis.

6. STEAM CONTROL VALVE CONTROL ON HTG TEMPERATURE:

- This control is provided to prevent VAM to go to Dilution mode on HTG high temperature safety.
- Whenever the HTG temperature exceeds the HTG high temperature set point minus a differential set point for controlling Steam Control Valve, the Steam Control Valve closes immediately.
- This prevents further increase in HTG temperature and LiBr concentration.
- The valve control returns to the Chilled Water Outlet Temperature control PID loop, when HTG temperature goes below the HTG high temperature setpoint minus the differential setpoint for controlling Steam Control Valve minus its hysteresis.
- A slow opening timer of 2 minutes is provided during the reopening of Steam Control Valve.

7. CAVITATION PROTECTION OF REFRIGERANT PUMP:

- If the refrigerant level in the Evaporator pan falls below certain level, the pressure in the Refrigerant Pump suction drops below the saturation pressure of the refrigerant and the Refrigerant Pump starts to cavitate.
- To ensure minimum acceptable suction pressure, the refrigerant level is measured by level transmitter and Refrigerant pump start/stop operation will be controlled by PLC.
- There are three level (Very High/Normal/Low) setpoints provided in HMI service menu.
- When the level reaches ***Evaporator Normal Level setpoint***, Refrigerant pump starts and when the level goes below ***Evaporator Low Level setpoint***, the pump stops after a time delay of 10 seconds.
- If the refrigerant level goes above ***Evaporator Very High Level setpoint*** and remains for 60 seconds, it is an indication of tube failure or severe crystallization.
- VAM will go into 'Total Shutdown' mode. An alarm "EVAPORATOR LEVEL VERY HIGH, PLEASE ISOLATE ALL CIRCUITS. CONTACT THERMAX" will be displayed.
- After 2 minutes, the chilled water pump start permissive is also switched OFF. This alarm can be reset when the refrigerant level goes below ***Evaporator Very High Level setpoint***. This logic will be applicable for “VAM Run” condition.
- The control on ***Evaporator Very High Level setpoint*** must have ‘Enable/Disable’ option in settings. ***Default: Enable.***

8. ABSORBENT PUMP AC DRIVE MODULATION: (IF APPLICABLE)

- The flow of LiBr into the HTG can be regulated by modulating the speed of the Absorbent Pump which pumps the LiBr into the HTG.
- The speed control is achieved by means of an AC drive which is provided for the Absorbent Pump motor. The speed is controlled based on the HTG temperature.
- The minimum and maximum frequencies of the drive are settable in the Operator interface of the AC drive. The low and high limits of HTG temperature are settable in HMI.
- When the HTG temperature is below the low limit temperature, Absorbent Pump will run at the minimum frequency.
- When the HTG temperature is between the low limit and the high limit temperature, Absorbent Pump will be under modulation and will run at an intermittent frequency between the low and high limit frequencies.
- Once the HTG temperature goes above the high limit value, then the Absorbent Pump will run at the maximum frequency.
- AC drive Enable / Disable mode shall be there in settings menu. ***Default: Enable.***
- If AC drive is disabled, then Absorbent Pump will always run at maximum frequency.

9. HTG LEVEL CONTROL:

- LiBr solution level in HTG is controlled either based on Level relays or Level transmitter. It will be based on Level Relays by default. This option can be changed in HMI configuration menu.

a. BASED ON LEVEL RELAYS:

- If level of LiBr in HTG goes very high, it will go into the condenser and contaminate the refrigerant. Also, the level in absorber sump will drop. To avoid this, the level of LiBr in the HTG is sensed by three level electrodes provided in the HTG level box namely – GE1, GE2 and GE3.
- Of these, GE1 is the shortest electrode and GE3 is the longest. The level is to be maintained below GE1. GE3 acts as the reference electrode.
- When HTG level goes above GE1, the absorbent pump frequency will reduce settable frequency (range: 0-20 Hz, default: 5 Hz) from the current frequency for the settable time (range: 0-120 seconds, default: 40 seconds).
- If the level is still above GE1 after absorbent pump off delay time, the pump will be switched OFF. The pump will be restarted only after the level goes below GE2.

- If the level goes below GE2 within the absorbent pump off delay time, the AC Drive will operate based on HTG temperature logic. This logic is applicable above HTG temperature greater than HTG temperature set-point for HTG level [120°C].
- Below HTG temperature set-point for HTG level, the pump will start at GE2 & stop at GE1. This logic is also applicable when AC drive of Absorbent pump is disabled. There will be a delay of 2 seconds for pump off when level reaches GE1.

b. BASED ON LEVEL TRANSMITTER:

- Level transmitter is provided in HTG to measure LiBr level.
- There are two level (High/Normal) setpoints provided in HMI service menu.
- When HTG level goes above ***HTG High Level setpoint***, the absorbent pump frequency will reduce settable frequency (range: 0-20 Hz, default: 5 Hz) from the current frequency for the settable time (range: 0-120 seconds, default: 40 seconds).
- If the level is still above ***HTG High Level setpoint*** after absorbent pump off delay time, the pump will be switched OFF. The pump will be restarted only after the level goes below ***HTG Normal Level setpoint***.
- If the level goes below ***HTG Normal Level setpoint*** within the absorbent pump off delay time, the AC Drive will operate based on HTG temperature logic. This logic is applicable above HTG temperature greater than HTG temperature set-point for HTG level [120°C].
- Below HTG temperature set-point for HTG level, the pump will start at ***HTG Normal Level setpoint*** & stop at ***HTG High Level setpoint***. This logic is also applicable when AC drive of Absorbent pump is disabled. There will be a delay of 2 seconds for pump off when level reaches ***HTG High Level setpoint***.

10. REMOVAL OF CONDENSATE LOGGING IN HTG:

- If steam condensate is trapped in HTG, then the difference between surface temperature of top of condensate header and pipe leaving dish end bottom increases.
- When the absolute difference of the temperatures measured by HTG top and HTG bottom temperature sensors is greater than the set point, the condensate solenoid valve at heat reclaimer outlet will open.
- The condensate solenoid valve will close only after the absolute value of this temperature difference drops below set point minus its hysteresis.
- This control action will come into action only when VAM is 'ON'. The condensate solenoid valve can also be manually opened / closed from HMI.

11. MIXING SOLENOID VALVE CONTROL FOR ZERO-DEGREE APPLICATION: (APPLICABLE FOR TZC ONLY)

- The operation of the Mixing Solenoid Valve for Zero-degree application is based on the Density reading by the Refrigerant Differential Pressure Transmitter.
- There will be a high limit and low limit set point for the Density reading in the HMI.
- During the Refrigerant Pump operation, if the Density reading remains below the Low Limit Set point till Time Delay Setpoint for Mixing Solenoid Valve, then Mixing Solenoid Valve opens. When the Density reading goes above the High Limit Set point, the Mixing Solenoid Valve closes immediately.
- During the Refrigerant Pump operation, if the Density reading goes above the Upper Limit for Refrigerant Solenoid Valve, Refrigerant Solenoid Valve opens. Refrigerant Solenoid Valve closes only after Density reading goes below Low Limit Set point.
- Lower and Upper limits should be changed automatically based on CHW outlet temperature set point. Lookup table for range is provided below.

Chilled Water Outlet Temperature	Default Set point values [Refrigerant density] for Mixing solenoid valve control		Default Set point values [Refrigerant density] for Refrigerant Solenoid valve control	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
(°C)	kg/m3	kg/m3	kg/m3	kg/m3
2.5 < T < 3.5	Upper limit value minus (-) 20 kg/m3	1020	Mixing solenoid valve upper limit value	Upper limit value plus (+) 20 kg/m3
0.5 < T <= 2.5		1035		
-0.5 < T <=0.5		1055		
-2 < T <= -0.5		1075		
-3.5 < T <= 2		1090		
-5 < T <= -3.5		1100		

Note: DP Transmitter should be calibrated for 500-575 mmLC (1150 kg/m3) instead of 500-550 mmLC (1100 kg/m3). Part catalogue shall also be modified accordingly.

C) SAFETY MEASURES:

To ensure healthy operation of VAM certain safety measures taken by the PLC. These are divided into three categories:

1. Conditions that necessitate 'TOTAL SHUTDOWN'

a. Chilled Water Pump interlock trip
b. Chilled Water Flow Switch trip
c. Chilled Water Differential Pressure Low trip
d. Absorbent Pump overload relay / AC drive trip
e. Absorbent Pump / AC Drive not responding
f. Refrigerant temperature low safety
g. Temperature sensor error
h. Evaporator level very high *[Refer Cavitation protection of Ref pump]*

2. Conditions that necessitate 'DILUTION'

a. Cooling water low inlet temperature safety

b. Cooling water high inlet temperature safety
c. HTG high temperature safety
d. HTG Vapor temperature high safety
e. Refrigerant Pump overload relay trip
f. Refrigerant Pump not responding
g. Anti-freeze protection
h. Power failure resumption
i. HTG pressure high safety
j. Cooling water pump interlock trip
k. Cooling water shut-off valve (bypass/in-line) failed to open
l. Temperature sensor error

3. Warning messages

a. Purge Pump overload relay trip
b. Overflow temperature high
c. Scaling/Cooling water flow low
d. Temperature sensor errors
e. Pump bearing wear monitor
f. Cooling water shut-off valve (bypass/in-line) failed to close

Note: All alarms shall be initiated during VAM 'ON' condition only.

1. 'TOTAL SHUTDOWN' ALARM SEQUENCE:

- In case of a critical trip, VAM goes into 'TOTAL SHUTDOWN' alarm sequence. The status of VAM will read "VAM NOT READY TO START" and its condition will be "TRIP". Under the 'TOTAL SHUTDOWN' alarm sequence, the PLC performs the following actions.
  i. Steam Control Valve is closed immediately.
  ii. Cooling Water Pump will be switched OFF immediately.
  iii. Cooling Water Bypass Shut-Off Valve will be opened immediately.
  iv. Cooling Water In-line Shut-off valve will be closed immediately.
  v. Cooling Tower Fan start permissive will be switched OFF immediately.
  vi. Absorbent Pump is stopped immediately.
  vii. Refrigerant Pump is stopped immediately.
  viii. Chilled Water Pump permissive is kept ON (except Evaporator level very high safety).
- Once the fault condition has been rectified, the alarm can be reset. On resetting the alarm, VAM goes into 'DILUTION'.
- If the time taken to reset the alarm is less than or equal to 5 minutes, the 'DILUTION' is not compulsory. In this case, on resetting the alarm the status changes to "VAM READY TO START" and VAM condition will be 'DILUTION'. The operator can start VAM, if required.
- Also, if the time taken to reset the alarm is more than 5 minutes, the 'DILUTION' is compulsory. In this case, on resetting the alarm the status changes to "VAM NOT READY TO START" and VAM condition will be 'DILUTION'. VAM can be restarted only after completion of 'DILUTION'.
- If the alarm is not reset within 15 mins from trip, the absorber pump starts at the end of 15 mins. The pump continues to run based on HTG level for 15 mins to equalize the absorbent concentration across VAM and then absorbent pump will be put OFF, VAM will continue to be in trip mode.
- Further, whenever the alarm is reset, the status changes to "VAM NOT READY TO START" and VAM condition will be 'DILUTION'. VAM can be restarted only after completion of 'DILUTION'.

1A. CHILLED WATER PUMP INTERLOCK TRIP:

- If flow rate of the Chilled Water is very low or is completely stopped, freezing of Chilled Water in the Evaporator tubes can take place immediately.
- Chilled Water flow is very essential for VAM operation. Hence it is required that the Chilled Water Pump should be started or stopped through the Chilled Water Pump start/stop permissive contact of VAM control panel.
- Also, a potential free contact is to be wired from the Chilled Water Pump motor starter to VAM panel to sense Chilled Water Pump ON / OFF / TRIP status.
- If the pump trips during operation, VAM goes into 'TOTAL SHUTDOWN' alarm sequence.
- An alarm "CHILLED WATER PUMP TRIP / NOT RESPONDING" is flashed on the HMI. The alarm can be reset only after the Chilled Water Pump run feedback is received by the PLC.

Note: In case of VAM trip during running condition due to this safety, then VAM can be reset only, when this signal becomes healthy.

1B. CHILLED WATER FLOW SWITCH TRIP:

- In order to ensure that the minimum required Chilled Water circulation rate is maintained, a Flow Switch has been provided on the Chilled Water outlet nozzle.
- The Chilled Water Flow Switch trip value needs to be set at 50-60% of the rated value during commissioning of the equipment.
- If the Chilled Water flow rate drops below the Chilled Water Flow Switch set point, the 'TOTAL SHUTDOWN' alarm sequence is carried out. An alarm "CHILLED WATER FLOW SWITCH TRIP" is flashed on the HMI.
- The alarm can be reset only after the Chilled Water flow rate increases above the preset value.

Note: In case of VAM trip during running condition due to this safety, then VAM can be reset only, when this signal becomes healthy.

1C. CHILLED WATER DIFFERENTIAL PRESSURE LOW TRIP:

- In order to ensure that the minimum required Chilled Water flow rate, Pressure transmitters have been provided at Chilled Water inlet and outlet nozzles.
- The rated chilled water flow rate, friction loss and static head should be provided in HMI, with respect to the unit.
- The actual chilled water flow rate will be calculated based on the above setpoints and chilled water inlet & outlet pressure.
- When the actual flow rate value drops below ***Chilled Water Flow Low Trip setpoint***, 'TOTAL SHUTDOWN' alarm sequence is carried out.
- An alarm "CHILLED WATER DIFFERENCIAL PRESSURE LOW" is flashed on the HMI. The alarm can be reset only after the actual chilled Water flow rate increases above ***Chilled Water Flow Low Trip setpoint plus Hysteresis***.

Note: In case of VAM trip during running condition due to this safety, then VAM can be reset only, when this signal becomes healthy.

1D. ABSORBENT PUMP OVERLOAD RELAY / AC DRIVE TRIP:

- If the Absorbent Pump motor draws more than its rated current, the overload relay / AC Drive trips and the 'TOTAL SHUTDOWN' alarm sequence is carried out.
- An alarm "ABSORBENT PUMP / AC DRIVE TRIP" is flashed on the HMI. The alarm can be reset only after the overload relay has been reset.

1E. ABSORBENT PUMP / AC DRIVE NOT RESPONDING:

- If the Absorbent Pump contactor / AC Drive doesn't respond to the Absorbent Pump / AC Drive ON/OFF command, VAM trips and 'TOTAL SHUTDOWN' alarm sequence is carried out.
- An alarm "ABSORBENT PUMP / AC DRIVE NOT RESPONDING" is flashed on the HMI.

1F. REFRIGERANT TEMPERATURE LOW SAFETY:

- In case the Refrigerant Temperature goes very low, the water in the Chilled Water tubes may freeze. So, when the Refrigerant Temperature as measured by the Refrigerant Temperature sensor drops below the Refrigerant temperature Low set point, 'Total Shutdown' sequence is carried out. An alarm "REFRIGERANT TEMPERATURE LOW TRIP" is flashed on the HMI.
- The alarm can be reset only after the Refrigerant Temperature rises above the Refrigerant temperature low set point plus the hysteresis set point.

1G. TEMPERATURE SENSOR ERROR:

- In case of temperature sensor errors (for the sensors listed below), VAM trips and the 'TOTAL SHUTDOWN' alarm sequence is carried out.
- An alarm "*** TEMP. SENSOR ERROR" is flashed on the HMI. The alarm can be reset only after the problem has been rectified.
- Sensor list:
    i. CHILLED WATER OUTLET TEMPERATURE

*** Name of the temperature sensor that has failed.

2. 'DILUTION' ALARM SEQUENCE:

- When VAM trips on any of the below safeties and goes into 'DILUTION' alarm sequence, the status of VAM will read "VAM NOT READY TO START" and its condition will be 'DILUTION'.
- Once the alarm has been reset the status will read as "VAM READY TO START" while VAM condition remains the same. The operator can start VAM, if required.
- Under the 'DILUTION' alarm sequence, the PLC performs the following actions.

i. Steam Control Valve is closed immediately.
ii. Cooling Tower Fan start permissive will be switched OFF immediately.
iii. Cooling Water Pump start permissive will be switched OFF after 4 minutes.
iv. Cooling Water Bypass Shut-Off Valve will be opened after 4 minutes.
v. Cooling Water In-line Shut-off valve will be closed after 4 minutes.
vi. Refrigerant pump runs based on Evaporator level and stopped after 4 minutes.
vii. Absorbent pump runs based on HTG level and stopped at the end of "Dilution time".

The dilution time is variable based on strong concentration measured at VAM stoppage,

- If Xconc >= 62, dilution time = " 15 " mins
- If Xconc <= 58, dilution time = " 7 " mins
- If 58 < Xconc < 62 , dilution time = " 7 + (Xconc - 58)*2 " mins

i.e. Dilution time = "if (Xconc <58,7, if (Xconc >62,15,7+(Xconc -58)*2)) " mins

- Residual duration of Dilution time shall be displayed on the HMI.

viii. The speed of absorbent pump will be based on HTG temperature logic.
ix. Chilled Water Pump start permissive is put OFF at the end of "Dilution time".

- If the alarm is reset during Dilution mode, the status of VAM will become “VAM READY TO START” and its condition will be still in “Dilution” mode only. But VAM can be started in Cooling mode from HMI.
- If the alarm is not reset, then after completion of ‘DILUTION’, the status will be “VAM NOT READY TO START” and condition will be “OFF”.

2A. COOLING WATER INLET TEMPERATURE LOW SAFETY:

- If the temperature of the cooling water entering VAM drops, the LiBr solution coming to the absorber may crystallize.
- To prevent this, whenever the Cooling Water Inlet Temperature goes below the cooling water low temperature set point, the ‘DILUTION’ alarm sequence is carried out.
- An alarm “COOLING WATER INLET TEMP. LOW” is flashed on the HMI.
- VAM can be restarted only after the Cooling Water Inlet Temperature rises above the cooling water low temperature set point plus the hysteresis set value.
- During initial startup, till the time HTG temperature goes above 120^{o}C this safety is bypassed. However, 30 minutes after VAM startup this safety will be in operation irrespective of HTG temperature.

2B. COOLING WATER INLET TMPERATURE HIGH SAFETY:

- If Cooling Water Inlet Temperature goes above Cooling Water Inlet Temperature High Set point, VAM will go into Dilution.
- An alarm "COOLING WATER INLET TEMPERATURE HIGH" is flashed in the HMI.
- This alarm can be reset only after the Cooling Water Inlet Temperature goes below Cooling Water Inlet Temperature set point minus hysteresis.
- This safety will be in operation from 5 minutes after VAM startup.

2C. HTG TEMPERATURE HIGH SAFETY:

- If the HTG temperature goes very high, the concentration of the LiBr solution can go up leading to crystallisation.
- Hence, if the HTG temperature exceeds the HTG high temperature set point, the ‘DILUTION’ alarm sequence is carried out.
- An alarm “HTG TEMPERATURE HIGH” is flashed on the HMI. VAM can be restarted only after the HTG temperature drops below the HTG high temperature set point minus the hysteresis set value.

2D. HTG VAPOR TEMPERATURE HIGH SAFETY:

- The HTG Vapour Temperature is a clear indicator of the pressure inside the HTG.
- If the HTG Vapour Temperature goes above the HTG vapor temperature High Set point, the ‘DILUTION’ alarm sequence is carried out.
- An alarm “HTG VAPOUR TEMPERATURE HIGH” is flashed on the HMI. VAM can be restarted only after the HTG vapor temperature goes below the HTG vapor temperature High Set point minus the hysteresis set value.

2E. REFRIGERANT PUMP OVERLOAD RELAY TRIP:

- If the Refrigerant Pump motor draws more than its rated current, the overload relay trips and the ‘DILUTION’ alarm sequence is carried out.
- An alarm “REFRIGERANT PUMP TRIP” is flashed on the HMI. Resetting the overload relay resets the alarm.

2F. REFRIGERANT PUMP NOT RESPONDING:

- If the Refrigerant Pump contactor doesn’t respond to the Refrigerant Pump ON/OFF command, VAM trips and the ‘DILUTION’ alarm sequence is carried out.
- An alarm “REFRIGERANT PUMP NOT RESPONDING” is flashed on the HMI.

2G. ANTI-FREEZE PROTECTION:

- In case the Chilled Water Outlet Temperature goes below freezing point of water, the water in the Chilled Water header will freeze.
- So, when the Chilled Water Outlet Temperature as measured by the Chilled Water Outlet Temperature sensor drops below the Anti-freeze set point, dilution sequence is carried out.
- An alarm “ANTI-FREEZE TRIP” is flashed on the HMI. The alarm can be reset only after the Chilled Water Outlet Temperature rises above the anti-freeze set point plus the hysteresis set point.

2H. POWER FAILURE RESUMPTION:

- In case of Power Failure during VAM operation, there is chance of LiBr crystallizing in the heat exchangers.
- To avoid this, when VAM resumes after Power Failure, it goes into ‘DILUTION’ immediately. An alarm “POWER FAILURE” is flashed on the HMI.
- In case the duration of Power Failure is less than 5 minutes, VAM status will show “VAM READY TO START”. In such case, ‘DILUTION’ can be bypassed and VAM can be put back to normal operation after resetting the alarm.
- But if the duration of Power Failure is more than 5 minutes, VAM status will be “VAM NOT READY TO START”. In this case, ‘DILUTION’ is compulsory and VAM can be started only after completion of ‘DILUTION’.

2I. HTG PRESSURE HIGH SAFETY:

- If the pressure inside the HTG goes above the HTG pressure high set-point, 'DILUTION' alarm sequence is carried out.
- An alarm "HTG PRESSURE HIGH" is flashed on the HMI.
- VAM can be restarted only after the pressure goes below HTG pressure high set-point minus hysteresis.

2J. COOLING WATER PUMP INTERLOCK TRIP:

- Cooling water flow is very essential for VAM operation. Hence it is required that the Cooling Water Pump should be started or stopped through the Cooling Water Pump start/stop permissive contact of VAM control panel.
- Also, a potential free contact is to be wired from the Cooling Water Pump motor starter to VAM panel to sense cooling water pump ON / OFF / TRIP status.
- VAM after giving the permissive to start the Cooling Water Pump waits for 7 seconds for feedback.
- In case the feedback is not received, 'DILUTION' alarm sequence is carried out. An alarm "COOLING WATER PUMP TRIP" is flashed on the HMI. The alarm can be reset only after the Cooling Water Pump run feedback is received by the PLC.

2K. COOLING WATER SHUT-OFF VALVE (BYPASS/IN-LINE) FAILED TO OPEN:

- In case, PLC does not receive open feedback from Cooling water shut-off valve (bypass/in-line), VAM trips and the 'Dilution' alarm sequence is carried out.
- An alarm "COOLING WATER SHUT-OFF VALVE FAILED TO OPEN" is flashed on the HMI. The alarm can be reset only after the feedback is received.
- During start-up, PLC will wait for the shut-off valve feedback for the settable time (Default: 2mins, Range: 1-10mins). However, during operation, PLC shall wait only 15 seconds, after which 'Dilution sequence' will be initiated.
- All the controls on shut-off valve will have enable/disable option. ***Default: Enable.***

2L. TEMPERATURE SENSOR ERROR:

- In case of temperature sensor errors (for the sensors listed below), VAM trips and the 'DILUTION' alarm sequence is carried out.
- An alarm "*** TEMP. SENSOR ERROR" is flashed on the HMI. The alarm can be reset only after the problem has been rectified.
- Sensor list:
  i. COOLING WATER INLET TEMPERATURE
  ii. LTG TEMPERATURE
  iii. CONDENSING TEMPERATURE
  iv. SPRAY TEMPERATURE
  v. HTG TEMPERATURE
  vi. HTG VAPOUR TEMPERATURE
  vii. REFRIGERANT TEMPERATURE

*** Name of the temperature sensor that has failed.

3. WARNING MESSAGES:

3A. PURGE PUMP OVERLOAD RELAY TRIP:

If the Purge Pump motor draws more than its rated current, the overload relay trips and an alarm "PURGE PUMP TRIP" is flashed on the HMI. Resetting the overload relay resets the alarm.

3B. OVERFLOW TEMPERATURE HIGH SAFETY:

- When the Overflow temperature goes above the overflow temperature high setpoint (Dilute temperature + 15°C) and remains there for more than 5 minutes, an alarm "OVERFLOW TEMPERATURE HIGH" will be flashed.
- VAM will keep running normally, this alarm will be reset only when the Overflow temperature drops below Overflow temperature high setpoint minus hysteresis.

3C. SCALING/COOLING WATER FLOW LOW:

- When the difference between condensing temperature and cooling water outlet temperature is more than Scaling setpoint entered in service menu and remains for more than 60 seconds, an alarm "COOLING WATER FLOW LOW / SCALING IN COOLING WATER CIRCUIT" will be flashed.
- VAM will keep running normally, this alarm will be reset on acknowledgement.
- The alarm will reappear after 10 AM every day, if the condition persists.
- This logic will be applicable only above HTG temperature of 110°C.
- The first instance of the alarm appearing will be logged with date and time in the utility screen.

3D. TEMPERATURE SENSOR ERROR:

- In case of temperature sensor errors (for the sensors listed below), an alarm "*** TEMP. SENSOR ERROR" is flashed on the HMI. VAM keeps running normally. The alarm can be reset only after the problem has been rectified.
- Sensor list:
  i. CHILLED WATER INLET TEMPERATURE
  ii. HTG TOP TEMPERTAURE
  iii. HTG BOTTOM TEMPERATURE
  iv. COOLING WATER OUTLET TEMPERATURE
  v. DILUTE SOLUTION TEMPERATURE
  vi. STEAM CONDENSATE TEMPERATURE
  vii. OVERFLOW TEMPERATURE
  viii. HTHE INTERMEDIATE TEMPERATURE

*** Name of the temperature sensor that has failed.

3E. PUMP BEARING WEAR MONITOR:

- The signal from TRG meters mounted on both, absorber and refrigerant pumps will read by the PLC once every 24 hours.
- For abnormal readings, an alarm will be flashed.
- When the TRG Meter enters the yellow range i.e. (5 - 7.5 V), an alarm "increased wear of Abso/Ref pump bearings. Please replace the bearings to avoid pump damage" will be flashed.
- When the TRG Meter enters the red range i.e. (7.5 – 10.0 V), an alarm "Faulty bearings Abso/Ref pump. Immediately replace bearings to avoid severe damage to the pump" will be flashed.
- VAM will keep running normally, this alarm will be reset on acknowledgement. The alarm will reappear after 1 day, if the condition persists.
- The first instance of each of the alarm appearing will be logged with date and time in the utility screen.

3F. COOLING WATER SHUT-OFF VALVE (BYPASS/IN-LINE) FAILED TO CLOSE:

- In case, PLC does not receive close feedback from Cooling water shut-off valve (bypass/in-line), an alarm "COOLING WATER SHUT-OFF VALVE FAILED TO CLOSE" is flashed on the HMI. The alarm can be reset only after the feedback is received.
- During start-up, PLC will wait for the shut-off valve feedback for the settable time (Default: 2 mins, Range: 1-10mins). However, during operation, PLC shall wait only 15 seconds, after which an alarm will be generated.
- All the controls on shut-off valve will have enable/disable option. ***Default: Enable.***

D) SHUT DOWN SEQUENCE:

- After the completion of operation, when VAM is switched off from the HMI it goes into 'DILUTION'. This is done to avoid any chances of crystallisation.
- While VAM is in operation, different parts of VAM are at different concentration and temperature. 'DILUTION' helps in making them even.
- After completion of 'DILUTION' VAM status reads as "VAM READY TO START" and VAM condition will be "OFF".

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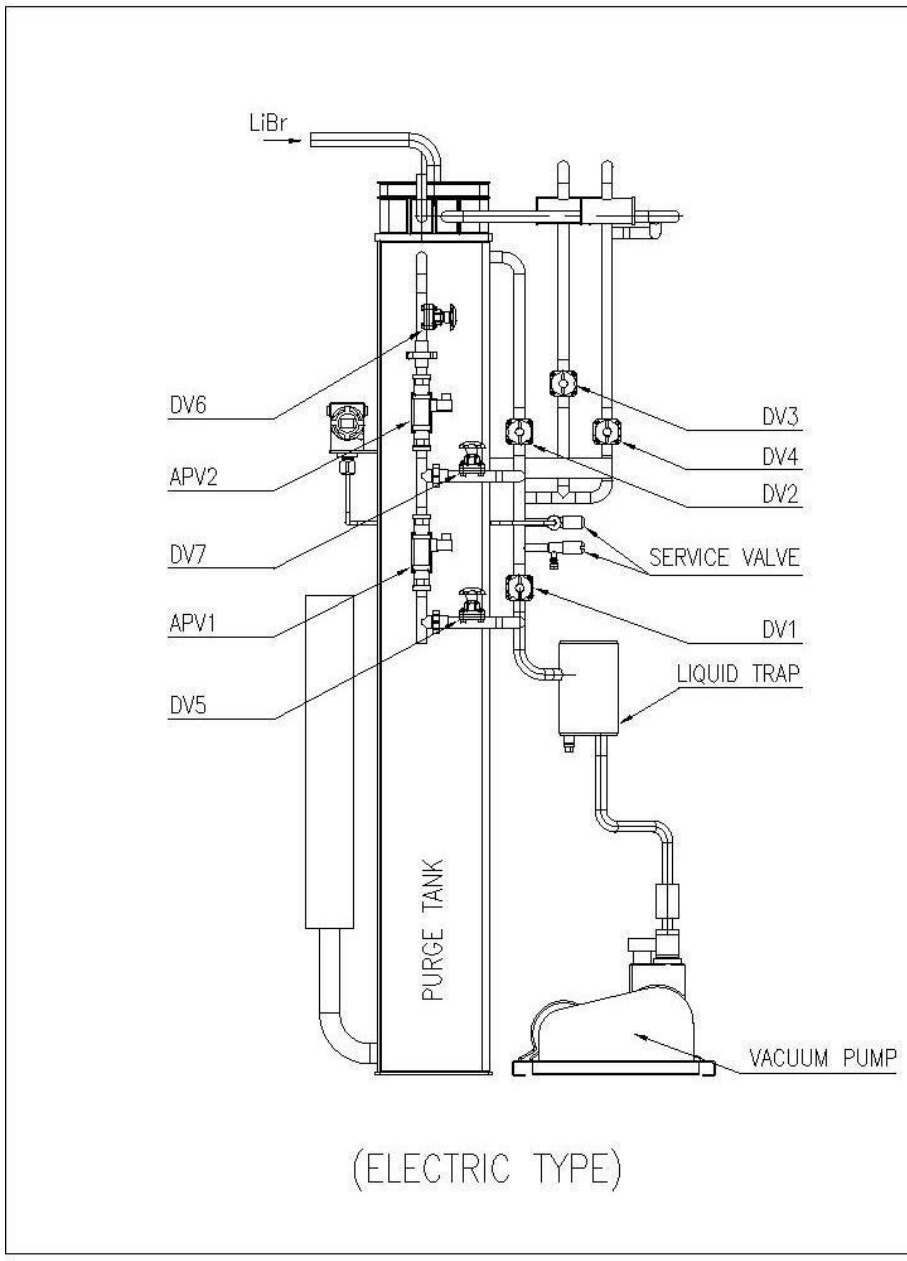
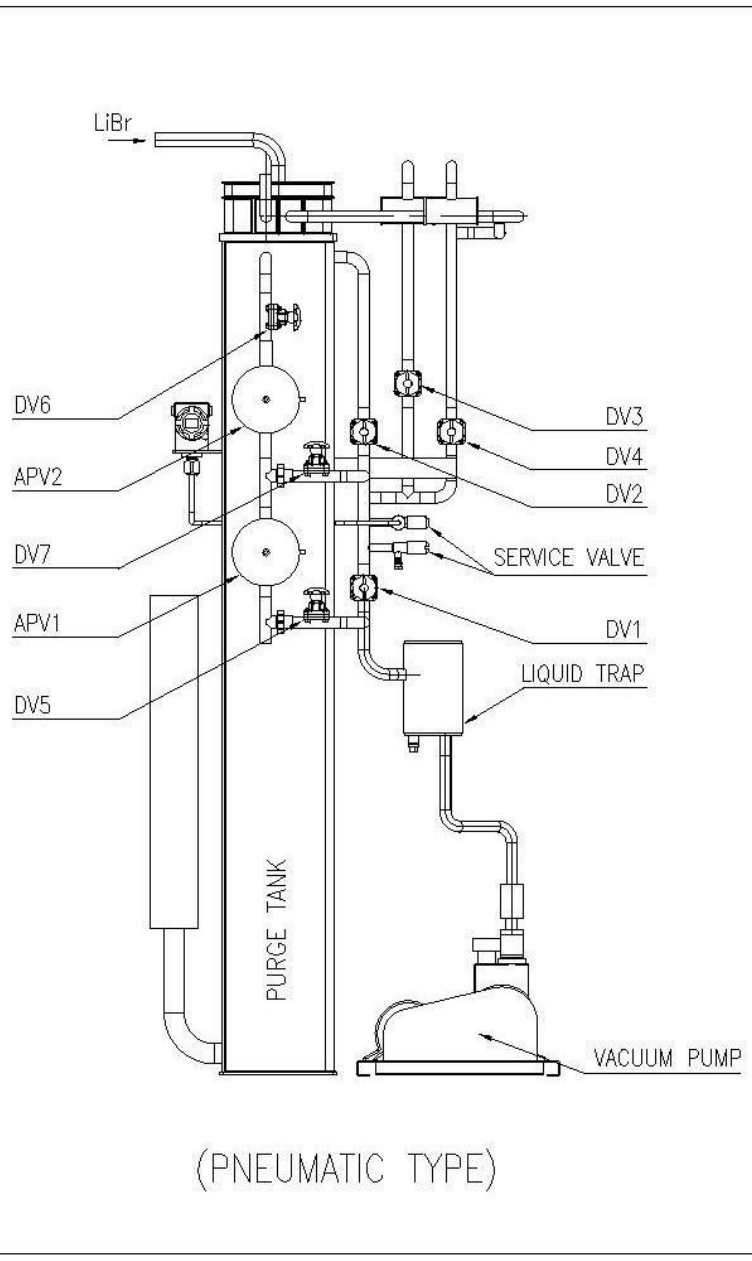
AUTO PURGING PROCESS: (IF APPLIABLE)

General Description	Auto Purging Valve assembly consists of 2 nos. Auto Purging Valves (APV1 & APV2) (Electric/Pneumatic type) & one Vacuum Transmitter. The whole operation of Auto Purging is PLC controlled. The mode of Purging in HMI should be put in 'AUTO' to enable Auto Purging.
Automatic Tank Side Purging	This operation is based on the Pressure inside the tank side of the Purge Tank. Vacuum Transmitter will sense the purge tank pressure. When this pressure increases above the ***Tank Side Purge Start Set-point***, Auto Purging operation will start. The sequence of operation is described in the table given below. Once the pressure goes below ***Tank Side Purge Stop Set-point***, the tank side purge operation stops. Auto Purging operation will be carried out only when the Machine is in 'ON' condition.



(ELECTRIC TYPE)



(PNEUMATIC TYPE)

S. No.	Automatic Tank Side Purging	Tank purging will now be time based for starting the Auto purging time.
1	Machine Power OFF	All Auto Purging Valves will be in closed condition.
2	Machine power ON	After Settable Time, APV-2 opens; APV-1 remains closed. APV-2 will remain open for 120 sec. The tank side pressure is read by Vacuum Transmitter and is displayed on HMI.
3	Tank Side Purge Start	APV-2 is open & When the tank pressure exceeds the ***Tank Side Purge Start Set-point*** and remains for 1 minute, APV-2 closes immediately. Purge pump starts and runs dry for 10 minutes. After this duration, APV-1 opens if the purge pump is running. After 1 minute, based on The Vacuum Transmitter reading PLC checks if the purge pump is developing ultimate vacuum. In case of purge pump OFF/TRIP, APV-1 will not open; in case it is already open, it will close immediately.

4	If Purge Pump does not develop Ultimate Vacuum	If the measured Tank Pressure is greater than the ***Ultimate Vacuum Set-point***, PLC will give an alarm that "PURGE PUMP NOT DEVELOPING VACUUM, PLEASE PERFORM MAINTENANCE". This alarm will stop the Auto Purging operation and goes into Manual Purging Mode (Both Auto Purging Valves (APV-1&2) will be in closed condition, the purge pump stops immediately), but will not trip VAM. After completing the maintenance, check whether the purge pump is developing ultimate vacuum, using the diaphragm valves. If yes, the mode of purging should be changed to 'AUTO' by operator.
5	If the purge pump develops Ultimate Vacuum	If the measured tank pressure is lesser than the Ultimate Vacuum Set-point, APV-1 will continue to remain open and APV-2 opens. Now the tank side purging is performed.
6	If the tank side purging doesn't complete within 15 minutes	In case the purge pump malfunctions, then the auto purging operation stops and the purging shifts to 'MANUAL' mode. An alarm "PLEASE CHECK THE PURGE PUMP; PURGING SHIFTED TO MANUAL MODE" is flashed on HMI. Once the problem has been rectified, the operator can put the purging back to 'AUTO' mode.
7	Tank Side Purge Stop	After a time delay of 10 seconds from the opening of APV-2, if the measured pressure goes below the ***Tank Side Purge Stop Set-point***, Both Auto Purging Valves (APV-1&2) close immediately. The purge pump keeps running dry for 5 minutes. The details of last purge done, gets updated in the PLC.
8	Tank side purging frequency high	If the tank side purging is performed more than 2 times in a calendar day, it indicates possibility of leakage in the Machine. So, when the tank side purging starts for the third time in a day, an alarm "TANK PURGING FREQUENCY HIGH" is flashed on HMI. This logic is valid for the purging done in 'AUTO' mode only.

Notes:

1. Auto Purging Valves can be opened in AUTO/MANUAL mode, only when the purge pump is running.
2. In case of purge pump TRIP/OFF, Both Auto Purging Valves (APV-1&2) close immediately.
3. In case of purge pump TRIP, purging shifted to Manual Mode if is in Auto Mode.
3. For Manual Purging using diaphragm valves, please refer 'Operating Instructions' section.
4. Do not open the service valves, other than those connected to Vacuum Transmitter.

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PASSIVATION PROCESS:

- Passivation mode is available in the service menu.
- Once the Passivation mode is selected, following note will be displayed on the PLC:

> **BEFORE STARTING PASSIVATION PROCESS**
>
> - CONNECT A HOSE PIPE BETWEEN THE SERVICE VALVES ON REFRIGERANT PUMP OUTLET AND ABSORBENT PUMP OUTLET AND THEN OPEN THE SERVICE VALVES.
> - DRAIN THE WATER FROM CHILLED WATER AND COOLING WATER HEADERS AND KEEP THE VENTS OPEN.

- There will be a settable timer for Passivation duration. Range: 4 - 12 hours | Default: 8 hours
- On selecting the Passivation mode, Chilled water Flow switch, Flow healthy based on Pressure Transmitters, CHW pump permissive, COW shut off valve permissive, CT fan permissive shall not be given by PLC & CHW pump feedback shall not be checked.

Passivation Mode:

- Upon start of VAM in Passivation mode, Absorbent pump will run based on absorber level (HTG level based absorbent pump ON/OFF will be bypassed).
- The refrigerant pump will run based on Evaporator level only.
- If Absorber level is above ***Absorber Normal Level setpoint***, Absorbent pump will be switched ON.
- Once the level goes below ***Absorber Low Level setpoint***, Absorbent pump will stop.
- The Absorbent pump will run always at maximum frequency (if AC drive mode is enable).
- The SCV opening limit will be settable as required. There will be a slow opening timer of 7 minutes.
- There will be a setpoint for Spray solution temperature high. Range: 60 - 90ºC | Default: 80ºC.
- If the spray solution temperature goes above this setpoint, the heat input will stop.
- The heat source will reopen once the spray temperature goes below high setpoint minus Hysteresis. Range: 3 - 15ºC, default: 10ºC.
- All chilled water & cooling water temperature related safeties will not come into picture.
- Purge pump ON/OFF will be disabled.
- Refrigerant solenoid valve will remain closed during this mode.
- Cooling water inline shut-off valve will be in close condition in this mode.
- Cooling water bypass shut-off valve will be in open condition in this mode.
- In case of power failure, once the power resumes, VAM will start back in Passivation mode.
- Once the Passivation duration is completed, the heat source will stop, both Absorbent pump and Refrigerant pump will stop.
- VAM operation will automatically shift to normal mode.
- While shifting from Passivation mode to normal mode, following message would appear

> **BEFORE STARTING VAM**
>
> - ALLOW VAM TO COOL DOWN BEFORE CHARGING WATER INTO THE CHILLED WATER AND COOLING WATER CIRCUIT.
> - The activity will be logged with date & time.

CONDITIONS THAT WOULD NECESSITATE ALARM:

- In this mode, for any of the below conditions, the Heat source, Absorbent pump and Refrigerant pump will stop immediately and corresponding anomaly alarm will be flashed. Once the alarm is reset, the Passivation process will restart from where it was left.
- HTG temperature high
- HTG vapour temperature high
- Spray solution temperature sensor error
- HTG temperature sensor error
- HTG vapour temperature sensor error
- Absorbent pump trip
- Refrigerant pump trip

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SET POINTS:

The field instruments and the components in the control panel are to be set as follows:

Sl. No.	Description	Set points
1.	Chilled Water Flow Switch	50-60% of rated flow
2.	Chilled Water Flow Low Trip Setpoint	50% of rated flow
	Hysteresis	10% of rated flow
3.	Absorbent Pump over current relay	As per pump rating +10%
4.	Refrigerant Pump over current relay	As per pump rating +10%
5.	Vacuum Pump over current relay	As per pump rating +10%

HMI SET POINTS:

The operator terminal settings are as follows:

S. No.	Description	Setpoints			Remarks	Control
		Default	Low Limit	High Limit		
1	Chilled Water Temperature Low Limit Setpoint	As per Specs	-5	60	Adjustable	Capacity Control
2	Temperature Setpoint for PID control	CHW Temp Low Limit	CHW Temp Low Limit – 1°C	60	Adjustable	
3	L-cut differential setpoint	1°C	0.5	5	Adjustable	L-cut control
	Hysteresis	0.5°C	0.5	2	Adjustable	
4	Anti-Freeze setpoint	3.5°C	Refer attachment		Adjustable	Anti-Freeze protection
	Hysteresis	2.0°C	0.3	5	Adjustable	
5	Refrigerant temperature low setpoint	3°C	Refer attachment		Adjustable	Anti-Freeze protection
	Hysteresis	1°C	0.5	5	Adjustable	
6	SCV Opening Limit	100%	0	100	Adjustable	SCV control
7	Chilled Water temperature modulation control settings (SCV):					
	a) Proportional Band	35	-32000	32000	Adjustable	Capacity Control
	b) Integral Band	800	0	32000	Adjustable	
	c) Derivative Band	0	0	32000	Adjustable	
8	HTG Temperature High setpoint	160°C	50	165	Adjustable	HTG Temp. High safety
	Hysteresis	5.0°C	3	50	Adjustable	
9	HTG differential setpoint for controlling SCV	3°C	1	5	Adjustable	SCV control on HTG Temp
	Hysteresis	2°C	1	10	Adjustable	
10	HTG temperature setpoint for AC drive minimum frequency	110°C	50	150	Adjustable	AC Drive modulation
11	HTG temperature setpoint for AC drive maximum frequency	150°C	50	165	Adjustable	AC Drive modulation
12	HTG Temperature setpoint for HTG Level control	120°C	-	-	Not accessible	HTG Level control
13	Absorbent pump frequency reduction	5 Hz	0	20	Adjustable	
	Absorber pump off delay setpoint	40 sec	0	120	Adjustable	
14	HTG Vapour Temperature High setpoint	105°C	50	110	Adjustable	HTG Vapour Temp high safety
	Hysteresis	3°C	0.5	10	Adjustable	
15	HTG Top-Bottom temperature difference	10°C	3	15	Adjustable	Removal of condensate logging
	Hysteresis	2°C	1	5	Adjustable	
16	Conc. Very High setpoint	64.5%	-	-	Not accessible	Crystallization prevention
	Hysteresis	1.5%	-	-		
	Preset safe distance	15°C	-	-		
17	Cooling Water Inlet Temperature setpoint for crystallization control (T_{CZL})	25°C	10	60	Adjustable	Crystallization prevention
18	Cooling Water Inlet Temperature low setpoint (T_{CWL})	10°C	10	40	Adjustable	Cooling water In temp. low safety
	Hysteresis	3°C	0.5	10	Adjustable	
19	Cooling Water Inlet Temperature High Setpoint	36°C	25	50	Adjustable	Cooling water In temp. high safety
	Hysteresis	2°C	1	5	Adjustable	
20	CT Fan OFF setpoint	25°C	15	35	Adjustable	CT Fan control CW In temp.
	Hysteresis	3°C	0.5	10	Adjustable	
21	Scaling differential setpoint for Cooling water flow	2°C	0	5	Adjustable	Scaling control
22	Overflow temperature high setpoint	Dilute + 15°C	5	40	Adjustable	
	Hysteresis	5	5	40	Adjustable	
23	Data log sampling time	60 min	1	60	Adjustable	
24	Anti-chattering timer for FS, PT, DPS, DPT & INTERLOCK of Chilled Water	2 sec	-	-	Not accessible	
25	Anti-chattering timer for temperature sensors and dependent alarms / safeties	2 sec	-	-	Not accessible	
26	Anti-chattering timer for instruments	1 sec	-	-	Not accessible	

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S. No.	Description	Setpoints			Remarks	Control
		Default	Low Limit	High Limit		
27	Dilution cycle timer	Variable	7	15	Not accessible	
28	OFF delay timer for Absorbent Pump	2 sec	-	-	Not accessible	
29	OFF delay timer for Refrigerant Pump	10 sec	-	-	Not accessible	
30	Waiting time for chilled water flow healthy feedback	10 min	-	-	Not accessible	
31	Refrigerant solenoid valve scheduler interval	168 hours	4	168	Adjustable	
	Refrigerant solenoid valve opening duration	15 mins	15	60	Adjustable	
32	HTG Pressure High setpoint	0.1	-1	1	Adjustable	
	Hysteresis	0.2	-0.5	0.5	Adjustable	
33	Evaporator Very High Level setpoint	300 mm	0	500	Adjustable	
	Evaporator Normal Level setpoint	100 mm	0	500	Adjustable	
	Evaporator Low Level setpoint	70 mm	0	500	Adjustable	
34	Absorber Normal Level setpoint	100 mm	0	500	Adjustable	
	Absorber Medium Level setpoint	80 mm	0	500	Adjustable	
	Absorber Low Level setpoint	60 mm	0	500	Adjustable	
35	HTG High Level setpoint	200 mm	0	350	Adjustable	
	HTG Normal Level setpoint	170 mm	0	350	Adjustable	
36	Tank Purging Start setpoint	75mmHg	20	90	Adjustable	Auto Purging Process (If Applicable)
	Tank Purging Stop setpoint	10mmHg	5	15	Adjustable	
	Ultimate Vacuum setpoint	3mmHg	2	5	Adjustable	
	Tank Pressure Check Interval	120 mins	30	600	Adjustable	
INSTRUMENTS CALIBRATION:						
1	Chilled Water Inlet Temperature	°C	-10	10	Adjustable	
2	Chilled Water Outlet Temperature	°C	-10	10	Adjustable	
3	Cooling Water Inlet Temperature	°C	-10	10	Adjustable	
4	Cooling Water Outlet Temperature	°C	-10	10	Adjustable	
5	HTG Temperature	°C	-10	10	Adjustable	
6	HTG Vapour Temperature	°C	-10	10	Adjustable	
7	HTHE Intermediate Temperature	°C	-10	10	Adjustable	
8	LTG Temperature	°C	-10	10	Adjustable	
9	Spray Temperature	°C	-10	10	Adjustable	
10	Dilute Temperature	°C	-10	10	Adjustable	
11	Overflow Temperature	°C	-10	10	Adjustable	
12	Condensing Temperature	°C	-10	10	Adjustable	
13	Refrigerant Temperature	°C	-10	10	Adjustable	
14	HTG Top Temperature	°C	-10	10	Adjustable	
15	HTG Bottom Temperature	°C	-10	10	Adjustable	
16	Steam Condensate Temperature	°C	-10	10	Adjustable	
17	Vacuum	mmHg	NA	NA	Adjustable	
18	Dilute Concentration	%	-2	2	Adjustable	
19	Strong Concentration	%	-2	2	Adjustable	

Note:

- Toggle switch needs to be there in HMI for selection of ***TAC/TZC*** in Machine configuration page. It should be ***TAC by default***. The necessary actions should be taken care in Program. It should display/hide the variables/cycle diagram, etc., accordingly.

- When changing it to TZC, message box should be popped up like below:
  "Are Zero-degree controls provided in this chiller?"
  If 'Yes', then it will check Refrigerant DP Transmitter input (4-20 mA) to PLC. If Refrigerant DP Transmitter is not provided, then it will not give any signal (0 mA) to PLC. Then it will not allow to shift to **TZC** configuration and alarm will be pop up like below:
  "Refrigerant DPT signal unavailable. Please check".

- We have to consider 8 channel Analog Input module instead of 4 channel Analog module. It should be configured as like below:

  1st Channel: Vacuum Transmitter

  2nd Channel: Chilled Water Inlet Pressure Transmitter

  3rd Channel: Chilled Water Outlet Pressure Transmitter

  4th Channel: Refrigerant DP Transmitter

  5th Channel: Evaporator Level Transmitter

  6th Channel: Absorber Level Transmitter

  7th Channel: HTG Level Transmitter

  8th Channel: HTG Pressure Transmitter