LHCb Vertex Locator

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## Documentation

# TECHNICAL DESCRIPTION OF THE VELO THERMAL CONTROL SYSTEM

LHCb VELO group

**Abstract:** This document describes the design and construction of the VELO Thermal Control System.
**Keywords:** $CO_2$, Cooling, 2PACL, VTCS,

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# 1 Introduction

## 1.1 *Introduction to the VELO detector*

The Vertex Locator (LHCb-VELO) is the central detector of the LHCb experiment (1). LHCb is one of the four experiments of the newly constructed LHC proton collider at CERN in Geneva. The VELO detector is designed to make precise measurements of vertex positions from high energy particle decays like B-mesons. The B-mesons are made by the proton-proton collisions of the LHC collider. The requirements for precise detection of the B-meson vertices are the highest of all 4 LHC experiments. Therefore the silicon sensors have to be placed very close to the collision point. To achieve this the VELO detector is situated inside the LHC vacuum only 8 mm away from the proton beams.

The active detection surface is a disc shaped silicon strip sensor with an outer diameter of 80mm and an inner diameter of 16mm. The inner diameter hole is for the proton beam to pass through. The detector is split in two halves. Both halves can be moved 30mm away from the beam. The increased beam space is necessary as the beam trajectory can vary during beam injection.

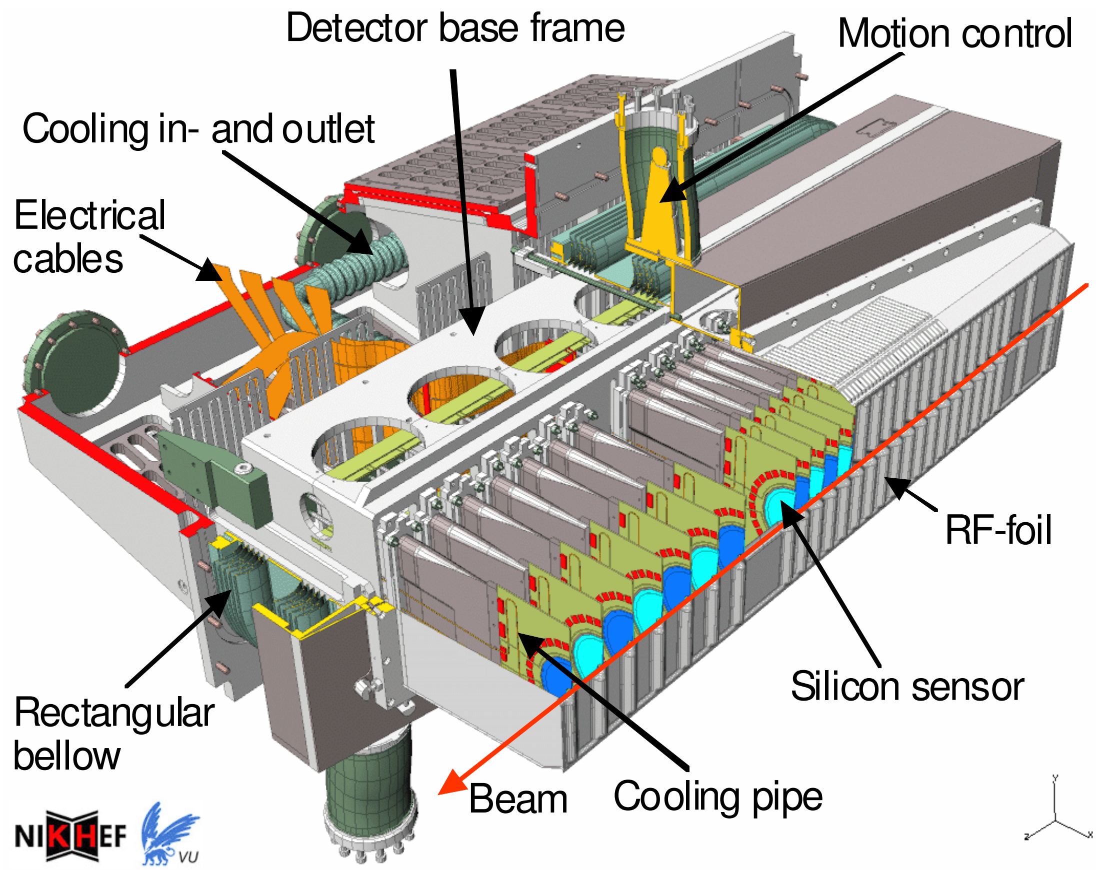


Figure 1.1-1: Inside look of 1 VELO detector half

Figure 1.1-1 shows an inside look of 1 detector half. The blue half circles are the detection silicon sensors. In total there are 21 VELO modules and 2 Pile-Up modules per half. The VELO modules are used to measure the particle tracks, the pile-up modules are used for triggering. All modules are assembled on an electronic substrate (green plate) housing the Beetle read-out chips (red dots around silicon periphery) (2). The modules are mounted via stand-off paddles on a precise machined aluminum base frame. Each detector half is situated inside a 300 micron thick aluminum foil box. The foil acts as a Faraday cage to protect the sensitive silicon from the beam interference. It is also a gas barrier to protect the ultra high accelerator vacuum from the out gassing of the silicon modules. A maximum pressure difference of 5 mbar may occur between the detector and the accelerator volumes. A complex vacuum system is designed to maintain a lower pressure difference at all times (3).

The silicon sensors are exposed to radiation. Cooling of the sensors to sub zero temperatures is needed to minimize the effect of radiation damage. The Beetle chips on the modules are also dissipating heat inside the vacuum, so an active cooling system is needed to remove the heat and keep the silicon sensors cold. The base frame is the positional reference of the modules, this frame must therefore stay at room temperature. The stand-off paddles have therefore a low thermal conductance. Additional heaters control the base frame to maintain at room temperature.

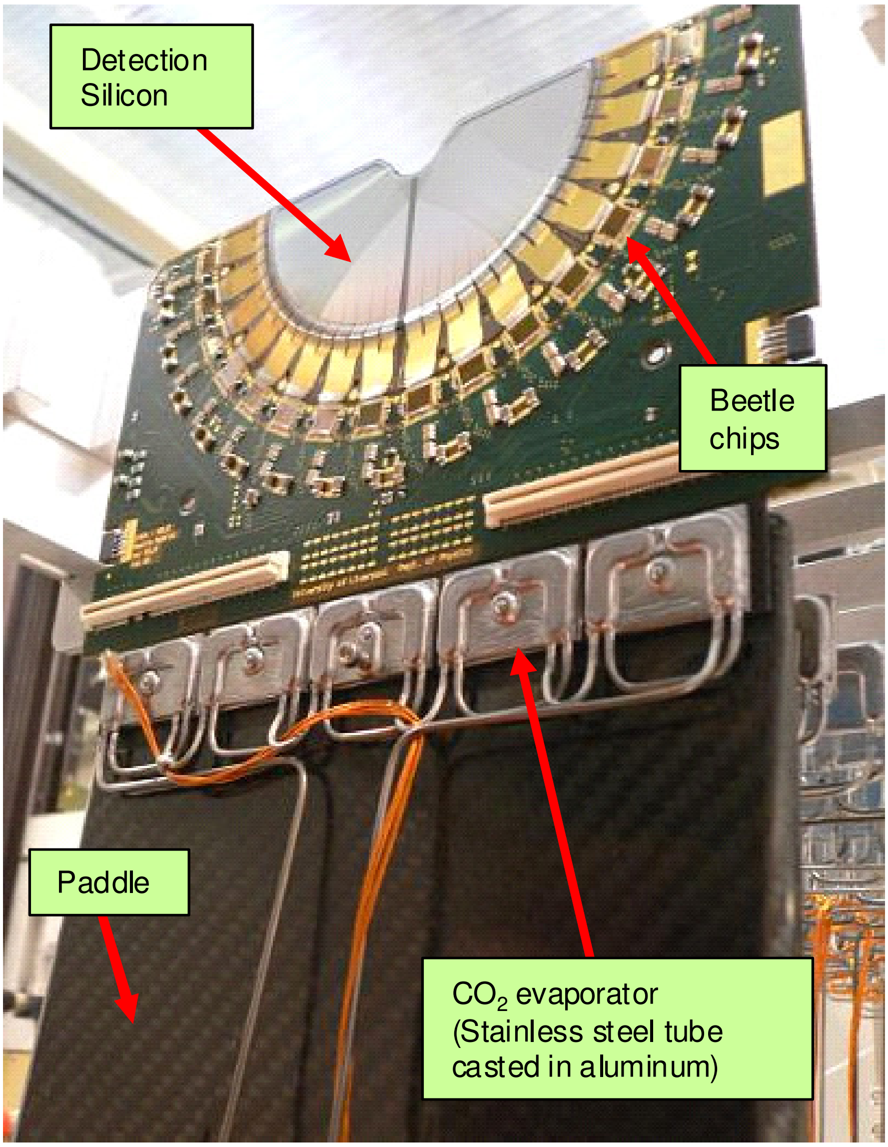


Figure 1.1-2: Velo module with $CO_2$ cooling connection

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# 3 VELO Thermal requirements and specifications.

## 3.1 *Temperature requirements*

Table 3.1-1 shows the main thermal requirements of the key-components, Table 3.2-1 shows the dissipated power in the detector which must be absorbed by the thermal control system. The thermal control system has been designed to meet these requirements. Interlocks have been integrated to prevent overheating or overcooling, if in extreme cases the thermal control system fails to do so.

Table 3.1-1: Operational and survival temperature limits of VELO key components.

| | Operational temperatures: | Survival temperatures: | |
|---|---|---|---|
| | | Before irradiation: | After irradiation: |
| Silicon Wafers | -12°C / -5°C<br>(Nominal tip = -7°C ) | -30°C / 100° | Long-term: -30°C / 0°C<br>Short term: 0°C / 24°C<br>(100 hours) |
| Hybrid | -20°C / 80°C | -30°C / 150°C | |
| Beetle chips | -20°C / 80°C | -30°C / 100°C | |
| Cables | -20°C / 100°C | -30°C / 200°C | |
| RF-Foil | <20°C | NA | |
| Module base frame | 18°C to 22°C (Stable) | NA | |

## 3.2 *Dissipation specifications*

Table 3.2-1: Power dissipation of VELO hardware inside the detector vacuum.

| | Per VELO module | Per PU module | RF-Foil | Total for VELO |
|---|---|---|---|---|
| Nominal power | 21.8 W | 13.3 W | 8 W | 978 W |
| Maximum power | 27.5 W | 16.2 W | 8 W | 1255 W |
| Absolute maximum power* | 30.2 W | 17.5 W | 8 W | 1617 W |
| *Absolute maximum power is the highest possible dissipated power when software settings are made accidentally wrong. A power limiter will prevent higher dissipation. | | | | |

After irradiation it is essential that the silicon sensor temperature stays below 0°C at all time. Exposure to higher temperatures causes the radiation damage to reveal. The revealed damaged is a function of temperature times the “warm” time. It was considered that a room temperature is reasonable to encounter in the silicon lifetime, so the amount of hours spent at room temperature is the driving requirement for integration or maintenance matter, when the cooling system cannot keep the sensors below 0°C.

# 4 VELO Thermal Control System (VTCS)

The full thermal control of the detector (module cooling and base frame heating) is done by the VTCS (VELO Thermal Control System). The cooling part inside the VELO is an evaporative system using $CO_2$ as coolant. The heating part is with normal electrical heating. The cooling system uses the 2PACL method (2-Phase Accumulator Controlled Loop) for circulating and conditioning the $CO_2$ (4). The 2PACL method condenses and sub cools the $CO_2$ with an external chiller.

## 4.1 *VTCS layout*

The VELO cooling system is a cascade of 3 hydraulic systems. Liquid $CO_2$ is pumped from the cooling plant on the service platform UXAC3 in the safe area to the detector in the experimental cavern. Figure 4.1-1 shows a schematic layout of the VTCS with the main components involved. The $CO_2$ system consists of 2 parallel systems each connected to one VELO detector half (Visible on both sides of the schematic layout). Both $CO_2$ systems are cooled by individual evaporator branches of the same hydrofluorocarbon (HFC) chiller. The heat in the detector is removed by evaporating part of the supplied $CO_2$. The $CO_2$ liquid-vapor mixture floats back to the cooling plant via the so called transfer lines. The returned $CO_2$ is condensed and sub-cooled by the HFC chiller which rejects its waste heat to the cold water system of CERN. In the VTCS the CERN cold water system is called the primary cooling system, the HFC-chiller the secondary and the $CO_2$ system the tertiary cooling system.

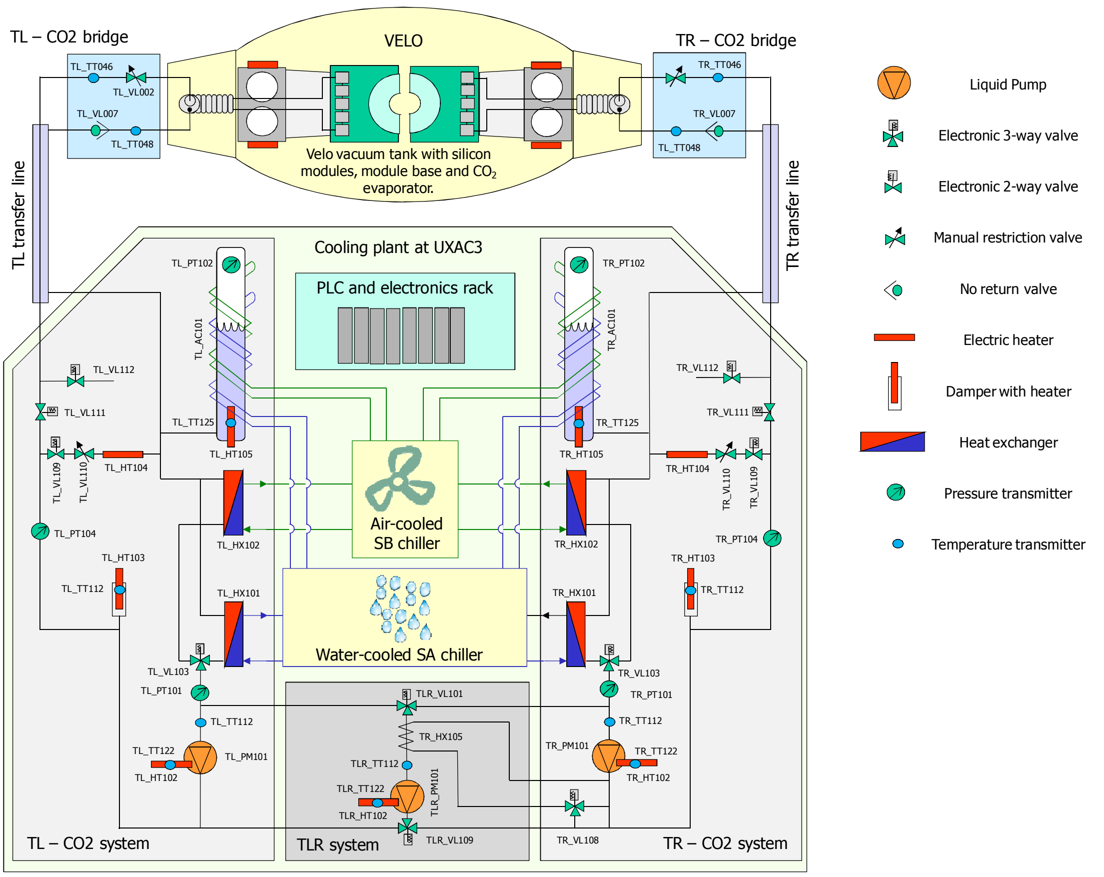



Figure 4.1-1: Overview of the VELO Thermal Control System

There are 2 HFC chillers in the VTCS. The main chiller is a large capacity water cooled chiller (2.5kW@-40ºC). A smaller capacity air cooled chiller (1.5kW@-25ºC) is available for back-up operations. The heat load of the VTCS exists of 2 main sources. The detector heat load due to the low voltage dissipation (~1kW) and the heat leak from the environment (~1kW), which is mainly picked up by the 55m $CO_2$ transfer line.

The air-cooled back-up chiller has a smaller capacity compared to the water cooled main chiller. It is designed for keeping the detector cold only. The back-up chiller is used only when there is a problem with the main chiller. The back-up system is air-cooled so problems with the CERN cooling water are also abolished. In case the back-up chiller is operational, it is not possible to power the VELO detector. It is designed only for maintaining the detectors cold enough to avoid the outcome of the radiation damage of the silicon sensors. Figure 4.1-2 shows a block diagram of the several cooling stages of the VTCS.

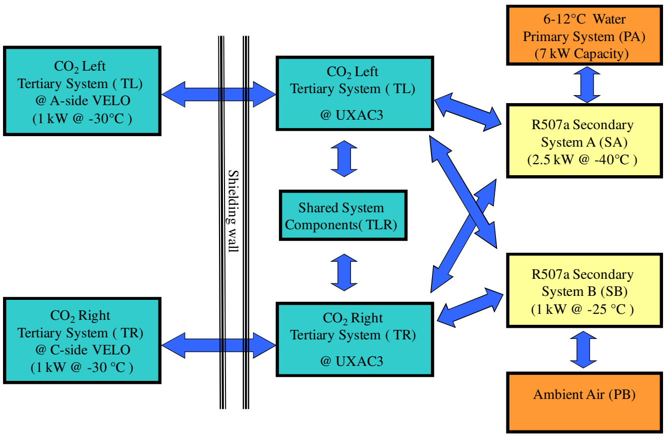



Figure 4.1-2: Schematic layout of the 3 VTCS stages

The tertiary $CO_2$ system is a concept which was originally designed for a satellite cooling application (5). It is a mechanically pumped loop system where the system pressure is controlled using an two-phase accumulator. The accumulator's pressure is kept constant by controlling its two-phase content. The principle is called 2-Phase Accumulator Controlled Loop (2PACL) (4). The pressure of the 2PACL directly controls the evaporative temperature in the detector. In this way it is possible to control the detector temperature accurately from a remote plant in the safe area. The evaporator and condenser of the tertiary 2PACL operate at the same pressure and hence at the same saturation temperature. For the liquid pumps it is needed to sub cool the $CO_2$ liquid. An external chiller which is colder than the $CO_2$ loop will take care of this and reject the waste heat to the cold water system of CERN. (6) Figure 4.1-3 shows the temperature profile and heat balance of the 3 VTCS stages. Seen from the detector the temperature is decreasing in the $CO_2$ loop from detector to the chiller. In the chiller the temperature is increased by the compression of the gas. The hot gas in the chiller is cooled and condensed by the coldwater system of LHCb. The final heat rejection Qp1 (primary heat load) to the water system is the sum of all the collected heat along the different systems shown.

The VTCS is not only a cooling system it is -as the name is indicating- a thermal control system. This means that it is designed to maintain the detector on the design temperature. In the requirement table (Table 3.1-1) it is stated that the module base must be kept at room temperature. Although the module base is not connected directly to the cooling system hardware a heating system on the module base is needed to prevent it from cooling down. The base plate heating is described together with the evaporator system in paragraph 7.2.

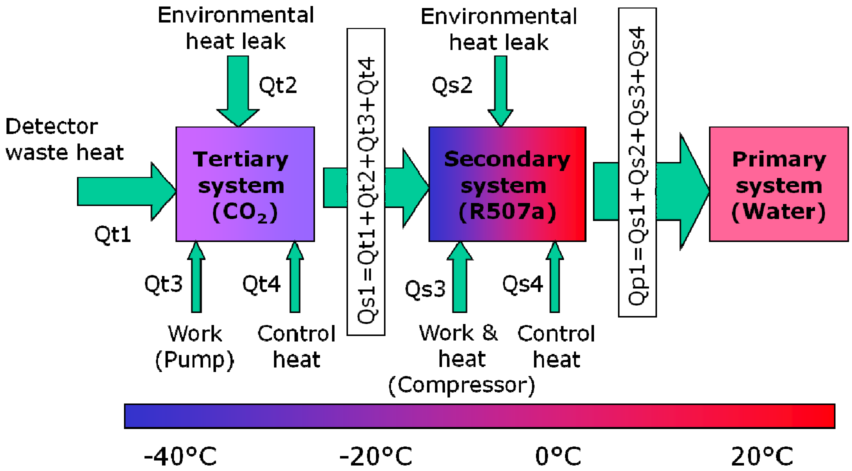


Figure 4.1-3: The thermal balance of the VTCS

All cooling stages and base plate heating are controlled by a Siemens S7-400 series Programmable Logic Controller (PLC). The PLC handles the PID controls, the alarm handling and the monitoring. A PVSS interface is used to monitor and archive all the system variables.

## 4.2 *VTCS hardware location.*

The majority of the cooling system hardware is located in the safe zone of the LHCb cavern. On the UXAC3 platform the cooling plants are located as well as the PLC control rack. This is all the hardware inside the light green field of Figure 4.1-1. Figure 4.2-1 shows a artistic interpretation of the cooling system hardware locations.

The $CO_2$ of both tertiary systems is transferred by two 50m long transfer lines to the two VELO detector halves. The transfer lines pass the thick concrete shielding wall via the piping and cable chicane. The transfer lines are connected to the $CO_2$ distribution box on top of the VELO (also called cooling bridge). From this box the 2 evaporators inside the VELO secondary vacuums are fed with saturated liquid. Figure 4.2-2 shows the cooling system hardware and its location in the LHCb cavern. Figure 4.2-3 shows detailed views of the platform and detector area.

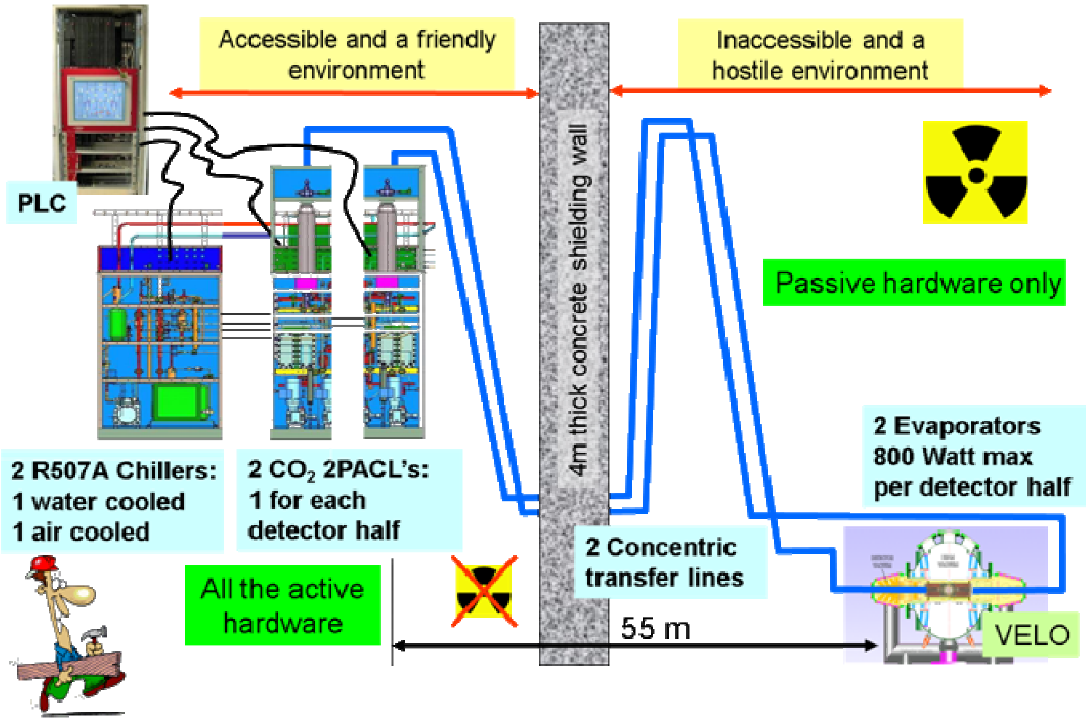



Figure 4.2-1: Interpretation of VTCS in LHCb

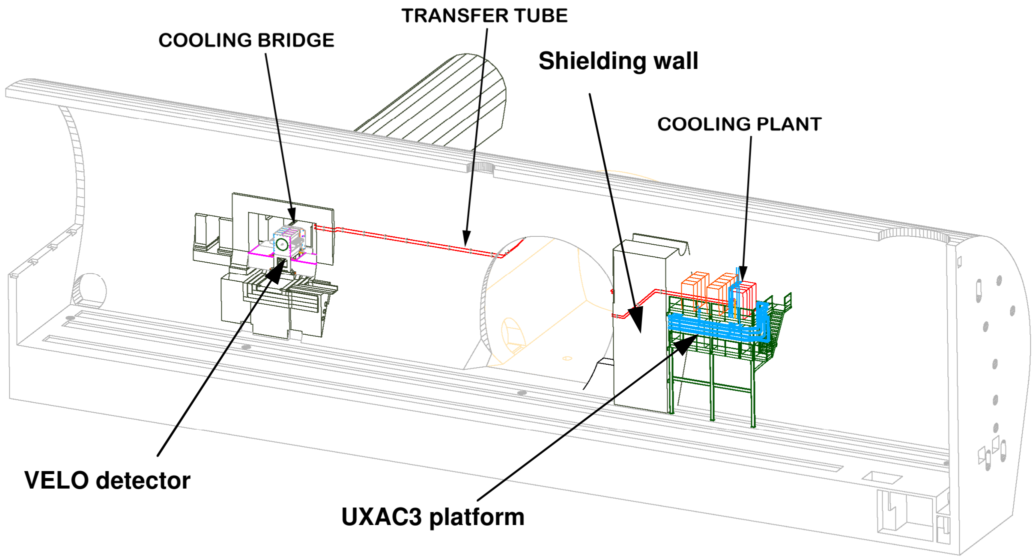



Figure 4.2-2: The VTCS cooling system hardware location in the LHCb cavern.

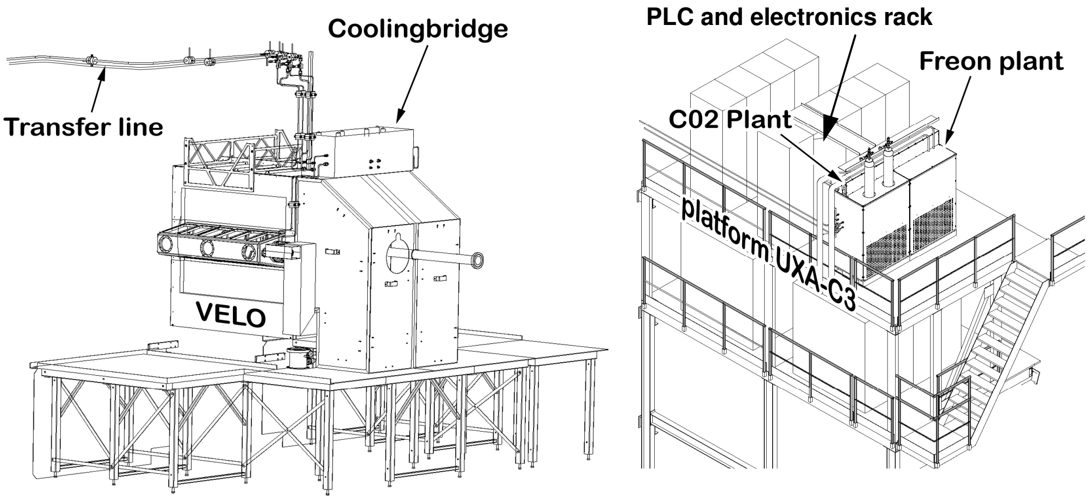



Figure 4.2-3: Detailed view of the VTCS cooling system locations

## 4.3 VTCS nomenclature

The various systems and components have a dedicated nomenclature to recognize the location and function of the labeled element. All labeling is of the format XY_ZZ999. Where X is the sub system (P=primary, S=secondary, T=tertiary), Y is the system identification (A for main, B for back-up or L and R for the left and right $CO_2$ system.

After the underscore the ZZ is the component identifier. For example PT stands for Pressure Transmitter, TT for Temperature Transmitter and VL for VaLve. A complete list of the nomenclature is shown in Table 4.3-1. After the component identifier a 3 digit number (shown as “999” in the example) is shown giving a unique label to the component. Numbers starting with a “1” are located in the plant zone of UXA-C3, all numbers starting with “0” are located in the VELO zone.

For the PVSS readout the same labeling sequence is used to label other non-hardware items like PLC variables or non-cooling system sensors like the temperature sensors on the modules. These sensors are of importance for the cooling system monitoring and are therefore relabeled to the same labeling concept. This is done to make the PVSS monitoring, data export and data analysis to be done in a homogeneous way. A list of these nomenclatures is shown in
Table 4.3-2.

In some circumstances the labeling may diverge from the above presented method. If a label shares more systems then the dedicated label is shown as an “x”.

Table 4.3-1: Nomenclature of cooling hardware

| | |
|---|---|
| PA_***** | Primary A system (Water cooling) |
| PB_***** | Primary B system (Air cooling) |
| SA_***** | Secondary A system (Main Freon chiller) |
| SB_***** | Secondary B system (Back-up Freon chiller) |
| TL_***** | Tertiary Left system (Left $CO_2$ system for the A-side VELO) |
| TR_***** | Tertiary Right system (Right $CO_2$ system for the C-side VELO) |
| TLR_***** | Tertiary Left and Right system (Labeling for combined used components for Left and Right) (Sometimes label TM_***** is used) |
| VL_***** | Left VELO detector (A-side) |
| VR_***** | Right VELO detector (C-side) |
| **_TT*** | Temperature transmitter |
| **_PT*** | Pressure transmitter |
| **_LT*** | Level transmitter |
| **_VL*** | Valve |
| **_HT*** | Heater |
| **_PM*** | Pump (or compressor) |
| **_AC*** | Accumulator |
| **_BD*** | Relieve device (Burst disc) |
| **_FL*** | Filter |
| **_HX*** | Heat exchanger |
| **_SG*** | Sight glass |

Table 4.3-2: Nomenclature of PLC and PVSS variables

| | |
|---|---|
| **_IL*** | Interlock signal |
| **_PV*** | PVSS FSM state |
| **_BA*** | Base plate alarm |
| **_BW*** | Base plate warning |
| **_HA*** | Heater alarm |
| **_HW*** | Heater warning |
| **_PA*** | Pressure alarm |
| **_PW*** | Pressure warning |
| **_MA*** | Miscellaneous alarm |
| **_MW*** | Miscellaneous warning |
| **_BL*** | Base plate limit |
| **_HL*** | Heater limit |
| **_PL*** | Pressure limit |
| **_ML*** | Miscellaneous limit |
| **_PC*** | Pressure clock timer |
| **_MC*** | Miscellaneous clock timer |
| **_VC*** | Valve clock timer |
| **_HC*** | Heater clock timer |
| **_SC*** | Clock timer setting |

Components have often more than 1 reference to for example an output variable. A pressure sensor gives out a pressure, but as well a saturation temperature and a status. In PVSS these variables are handled with an extra 4 digit code after a dot. For example the pressure variable from pressure transmitter TL_PT101 is labeled as

TL_PT101.pres, the saturation temperature TL_PT101.tsat. Table 4.3-3 shows an overview of the mostly used sub labels.

Table 4.3-3: Nomenclature of the PVSS sub labels

| | |
|---|---|
| .stat | Status |
| .temp | Temperature |
| .tsat | Saturation temperature |
| .powr | Power (in % of maximum heater power, actually the heater duty cycle) |
| .watt | Power in Watts |
| .curr | Current |
| .volt | Voltage |
| .PWon | Power switched on (in case of on-off heaters) |
| .levl | Calibrated level |
| .rawl | Raw level signal |
| .posi | Position |
| .SWon | Switched on |
| .TRon | Thermal relay on |
| .TRok | Thermal relay okay |
| .VLok | Valve okay |
| .FRac | Actual frequency |
| .FRtr | Target frequency |
| .MPok | Motor protection okay |
| .alrm | Alarm |
| .CLtm | Clock timer value |
| .CLsp | Clock timer set point |
| .SPac | Actual set-point |
| .SPtr | Target set-point |
| .Rthm | Thermal resistance |
| .lmit | Limit |

# 5 Primary cooling system

## 5.1 *Overview of the primary systems*

The primary cooling for the SA-chiller is the chilled water system of CERN, the primary cooling for the SB-back-up chiller is the air of the cavern. The primary systems are coded with PA (water) and PB (air).

## 5.2 *The PA-chilled water system of LHCb*

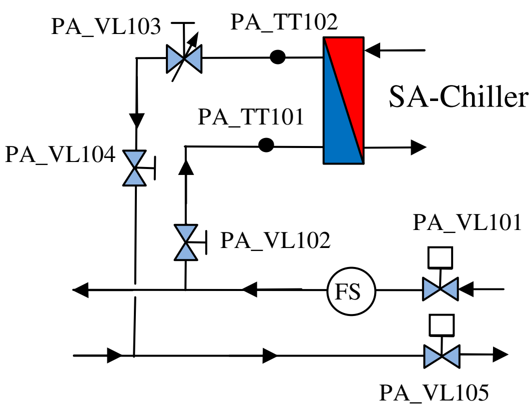



Figure 5.2-2: Simplified scheme of the primary chilled water system.

The chilled water system of LHCb (6) is for the VTCS the final location for the heat disposal. Although the cold water is cooled by a chilling system as well, from the VTCS point of view it remains to be called the primary system, as it was the final heat dump. The chilled water system is a general supply of chilled water with a temperature of about 6°C. It is provided from the main LHCb cooling station. The chilled water supply for the VTCS is in the same group of the TT and OT cooling stations on the lower platform UXAC2. This group is controlled and monitored by the DSS system of LHCb (7). Figure 5.2-2 shows a schematic of the cold water group of the UXAC platforms. The UXAC group can be shut-off from the main cold water supply using the electrical valves PA_VL101 and PA_VL105. The flow is monitored using a flow switch in the supply line. The branch to the VTCS can be shut-off manually for maintenance reasons. In Figure 5.2-1 a photo is shown of the VTCS cooling plant with the coldwater lines in front. The valves on top of the metal shielded part are the manual valves PA_VL102 and PA_VL104. These valves are the interface between the LHCb provided piping and the VTCS provided piping.

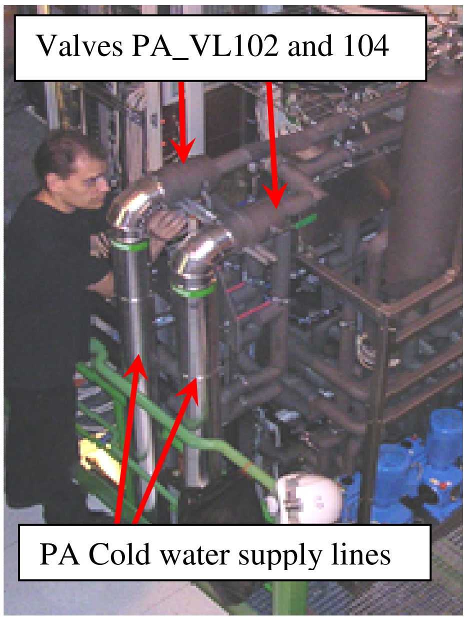



Figure 5.2-1: Cold water supply lines from the CERN cold water system

### 5.2.1 PA-construction

The inlet piping is a DN20 pipe with a maximum flow rate of 1.3 $m^3/h$. The flow must be reduced to a maximum water return temperature of 12°C at the maximum heat load. This reduction is necessary to supply enough cooling water to all the other connected systems. The maximum design heat load is 2.5

kW which means that the flow needs to be reduced to 0.36 $m^3/h$. Reduction valve PA_VL103 is set to achieve this flow setting. The in and outlet temperature can be monitored using PA_TT101 and PA_TT102.

### 5.2.2 PA- monitoring and control

The flow of the cold water is monitored with a flow switch. If the flow switch detects insufficient flow a DSS interlock signal will be send to the PLC and the main chiller will be stopped. The detector may not become warm, so the air-cooled back-up chiller is automatically switched on. An air cooled chiller is chosen as back-up to be independent of cooling water failures. Both VTCS plant units have floater switches in the capture bottom to detect a possible leak of the water system. A leak signal will automatically close the 2 in- and outlet valves (PA_VL101 and PA_VL105). During maintenance one has to be very careful with the flow switches or the corresponding connectors, a triggering of the VTCS floater switches also stops the OT and TT cooling and hence the OT and TT detectors. As these cooling station are on the same closed off group.

## 5.3 *PB air cooling*

The PB air cooling of the SB back-up chiller is not more than a ventilator which cools the condenser of the SB back-up chiller. The airflow inside the plant unit is provided by multiple holes in the unit covers. The ventilator is speed controlled depending on the heat load it must reject. See paragraph 6.2.1.2 for more details about the air cooling of the SB condenser.

# 6 Secondary cooling system

## 6.1 *Overview of the secondary systems*

The secondary systems are relative ordinary chillers using the HFC refrigerant R507a. The secondary stage cools the two $CO_2$ condensers of the tertiary $CO_2$ systems and controls the pressure in the two accumulators. The secondary stages consist of two independent operating chillers. One is a water cooled system for high power and low temperatures (~2.5kW@-40ºC) and is referred to as main chiller. The second one is a low power system for warmer temperatures (~1kW@-25ºC) and is cooled by ambient air. The air cooled system is a back-up system for the water cooled main chiller. Figure 6.1-1 shows the chiller hardware in the secondary system rack. This rack contains all of the chillers hardware except from the evaporators. The 4 evaporators are placed outside the rack in the tertiary $CO_2$ rack. The green blocks are the main HFC evaporators cooling the $CO_2$ condensers, the spirals on top are inside the $CO_2$ accumulators and control the pressure of the $CO_2$ in combination with a heater.

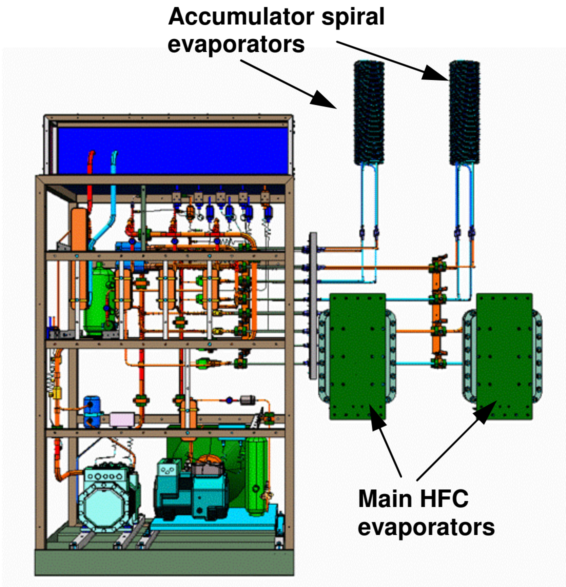



Figure 6.1-1: Both HFC chillers in the chiller rack with the external evaporators.

In Figure 6.1-2 a simplified scheme of the secondary chillers is shown. The low pressure gas is compressed by the compressor (A) to a pressure with a saturation temperature above the temperature of the primary cold source. In this case the discharge gas (1) will be condensed to liquid in the condenser (B). The condensed liquid is stored in the reservoir (C). The high pressure liquid from the reservoir (2) is sub-cooled in the sub-cooler (D) by exchanging heat with the evaporator exhaust. The cold liquid (3) is expanded by a restriction valve (E) and injected into the evaporator (F). The low pressure liquid starts to evaporate by extracting heat from the tertiary system. The cold gas (5) is fed through the sub cooler (D), where the residual cold is used for the sub-cooling of the inlet liquid. The warmer gas (6) is fed

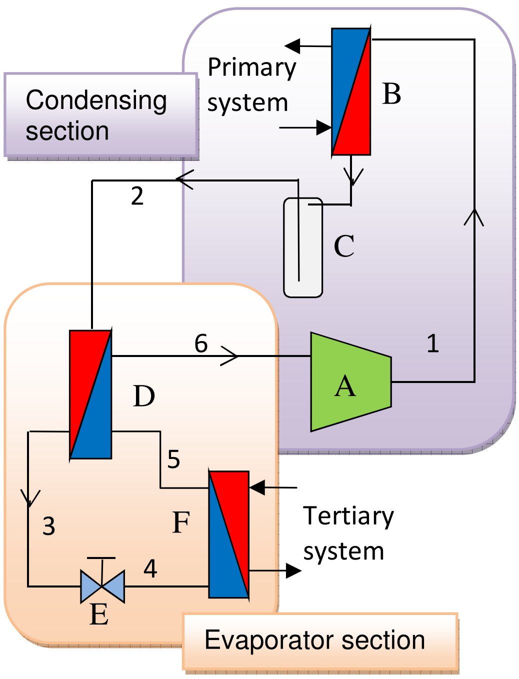



Figure 6.1-2: Simplified scheme of the secondary chillers.

back to the compressor (A) and the cycle starts over again. Figure 6.1-3 shows the fluid state points 1 to 6 in the Pressure–Enthalpy diagram of the refrigerant R507a. Two cycles are shown. The state points of the SA-main chiller are indicated with A, the state points of the SB-back-up chiller with B. The SA-main chiller is the lower cycle where the evaporator is operating around -40ºC and the condenser around 15ºC with the cold water source at 6-12ºC. The SB back-up chiller operates with an evaporator temperature around -20ºC and a condenser temperature of about 35ºC to condense against the ambient air temperature.

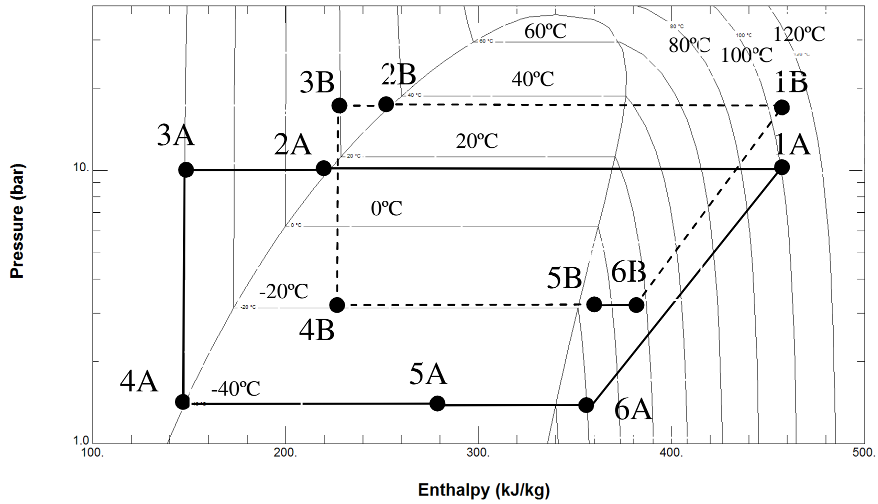



Figure 6.1-3: The SA main and SB back-up chiller in the PH diagram of R507a.

The section from 6 to 2 is called the condensing section (compressor and condenser); from 2 to 6 is the evaporator section (expansion valve, evaporator and sub cooler). The simplified scheme in Figure 6.1-2 shows only 1 evaporator branch, in reality each system has 4 parallel evaporator branches (2 main HFC evaporators and 2 accumulator spirals). Figure 6.1-3 shows a picture of the HFC chiller rack with most of the hardware visible. Picture was taken before the insulation was applied.

Figure 6.1-4: Secondary SA and SB chillers in the chiller rack

## 6.2 *Chiller descriptions.*

The next two figures show the full schematic of the SA-Main and SB-Back-up chillers. Larger prints can be found in the appendix at paragraph 11.1. On the left the 4 evaporator sections are shown, on the right the condensing section. In the schematics all parts have unique labeling. A full list of the components with a reference to the unique labeling is given in the parts lists in the appendix. Paragraph 11.2 shows a list of all the sensors, 11.3 shows a list of actuators and 11.4 shows all the passive line components.

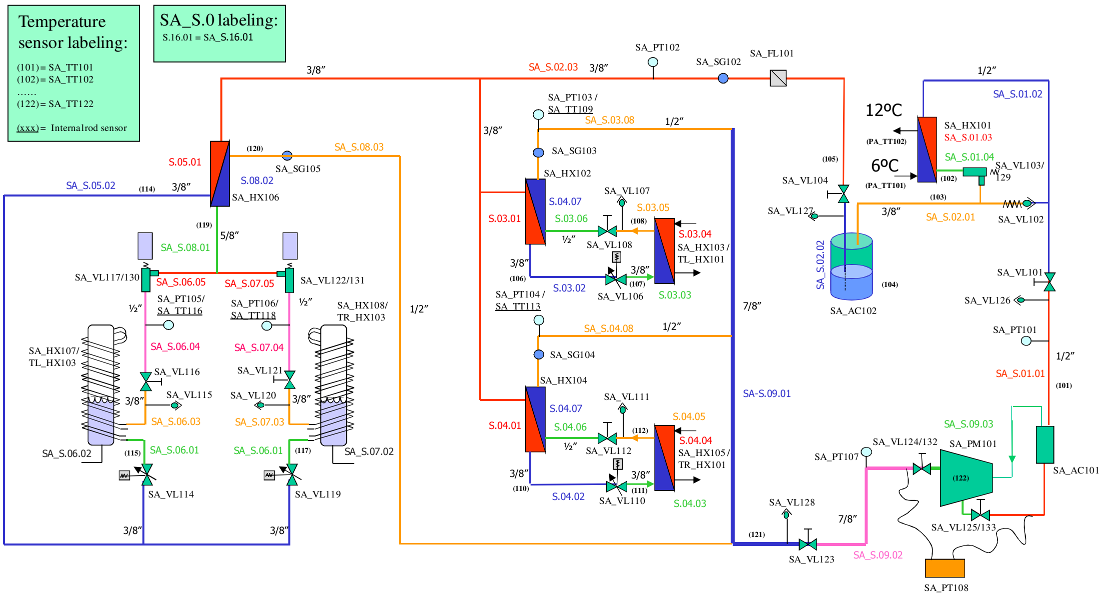



Figure 6.2-1: SA-Main schematic layout.

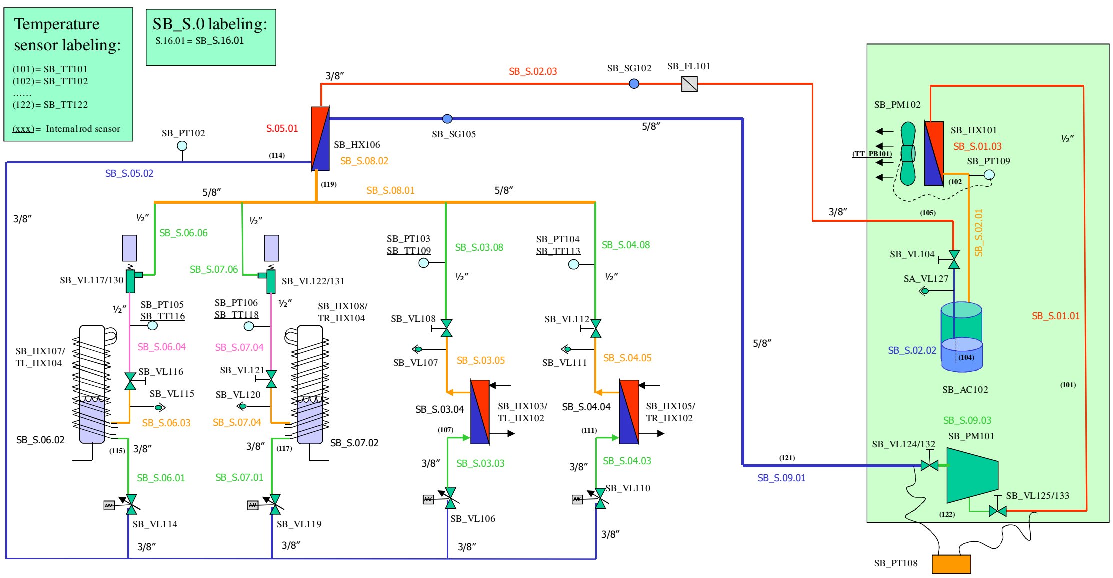



Figure 6.2-2: SB-Back-up chiller schematic layout.

The chillers are divided in several sub-volumes indicated with Sx_S.yy.yy (where yy.yy is the sub-volume number). The color of the section label corresponds to the near hardware volume with the same color (Blue code belongs to the volume of the blue line). The evaporators sections are sub-volume Sx_S.03, Sx_S.04, Sx_S.05, Sx_S.06, Sx_S.07 and Sx_S.08. The condensing section consists of the sub-volumes Sx_S.09, Sx_S.01 and Sx_S.02. The section volumes are used for charge calculation (paragraph 6.3) and system modeling (chapter 7.7.5).

## 6.2.1 HFC Condensing section

The condensing section of the secondary chillers compresses the low pressure gas and condenses it back to high pressure liquid. Both chillers use different condensing techniques.

### 6.2.1.1 SA Condensing section

Figure 6.2-3 shows the condensing section of the SA-main chiller. The low pressure gas in SA_S.09.02 is compressed by the compressor SA_PM101 into the discharge tubes (SA_S.01.01). The compressor is a frequency controlled Bitzer 2CC-3.2Y compressor with a capacity of about 2.5kW@-40ºC. Specifications can be found in the documentation directory on the same EDMS entry. The frequency can be adjusted between 40 and 70 Hz. The compressor is protected against over and under pressure by pressostat SA_PT108. The high pressure discharge gas is led through oil separator SA_AC101. This separates most of the oil from the refrigerant and feeds it back to the compressors carter. After the oil separator the discharge gas is cooled, condensed and sub-cooled by the condenser SA_HX101. The condenser pressure is controlled by pressure regulating valve SA_VL103. This valve assures that the condenser saturation temperature is above the temperature of the primary chilled water circuit. In this case the R507a can be condensed and sub cooled.

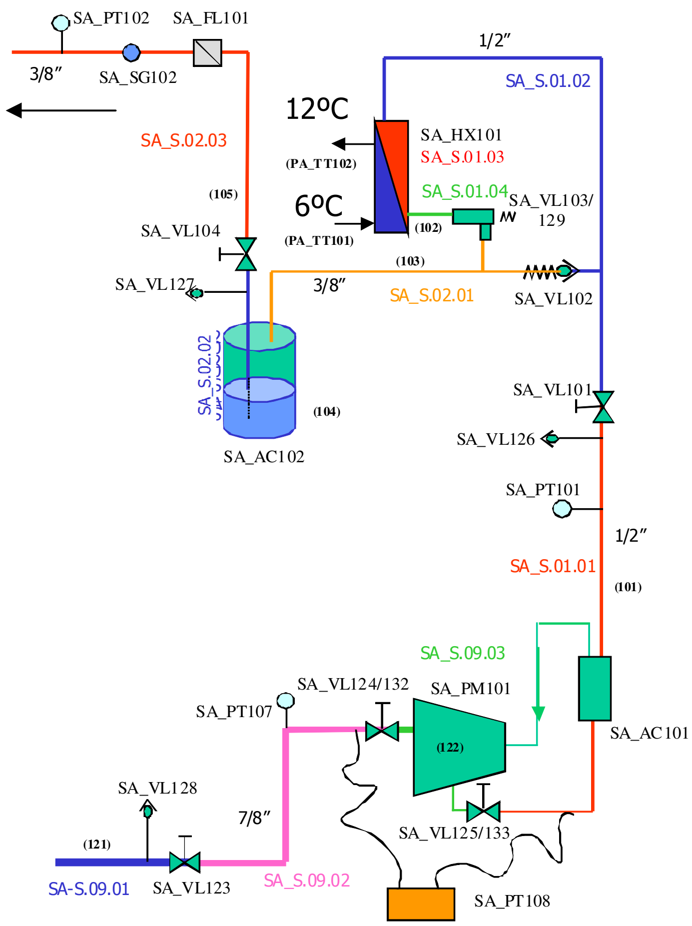



Figure 6.2-3: Detailed schematics of the SA-main condensing section

The liquid is now fed into the reservoir SA_AC102 which has a volume of 5.6 liter. This reservoir is compensating the varying content of liquid and vapor in the system and will always contain both phases in it. The condenser supplies the liquid to the reservoir; by-pass valve SA_VL102 supplies the necessary vapor content by directly inject the discharge gas.

The by-pass valve SA_VL102 is a Danfoss NRD differential pressure valve which starts to open at 1.4 bar and is fully open at 3 bar pressure difference. In this way the pressure of the reservoir is maintained between 1.4 to 3 bar below the condenser pressure setting. The condenser pressure setting of the SA-main chiller is around 10.5 bar, which correspond to a saturation temperature of about 18 ºC. The primary cold water supply is 6ºC the outlet varies between 8 and 10 ºC depending on the absorbed heat load.

The evaporators are fed with saturated liquid of about 12 ºC and 9 bar from the bottom of the reservoir. The liquid supply line contains components such as a filter/dryer (SA_FL101) and a sight glass (SA_SG102). The sight glass is used to check whether or not there is indeed liquid in the liquid lines. Passing vapor bubbles indicate an insufficient refrigerant charge.

In Figure 6.2-3 more components are shown than discussed. The system contains extra shut-off valves for maintenance (such as SA_VL123) and Schrader valves for filling, emptying or extra sensing (such as SA_VL128). Some line components come with an integrated Schrader valve, if the Schrader valve is not shown the label and existence is indicated by an additional valve number after the original component number like SA_VL103/129; here 103 is the label for the condenser pressure valve and 129 is the label for the integrated Schrader valve. A full list of the components in the condensing section is given in the parts lists in the appendix. Paragraph 11.2 shows a list of all the sensors, 11.3 shows a list of actuators and 11.4 shows all the passive line components.

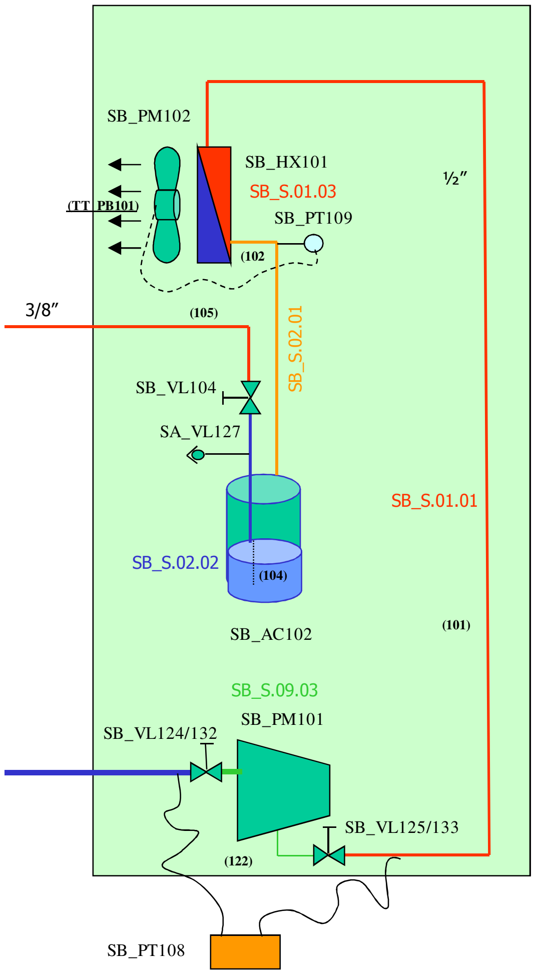



Figure 6.2-4: Detailed schematics of the SB-Back-up condensing section

### 6.2.1.2 **SB Condensing section.**

The SB condensing section is a standard air cooled condensing unit from Bitzer. The LH32/2KC-05.2y condensing unit contains all the hardware inside the green box of Figure 6.2-2 (Detailed view in Figure 6.2-4). It consist of an air cooled condenser with a variable speed fan, a 2KC-05.2y Bitzer compressor and a 3 liter reservoir. The capacity of the condensing unit is around 1kW @ -25ºC. The condensing pressure is regulated by the fan speed and is controlled around 15.5 bar which corresponds to a condensing temperature of about 32 ºC. The exit air temperature is around 28 ºC.

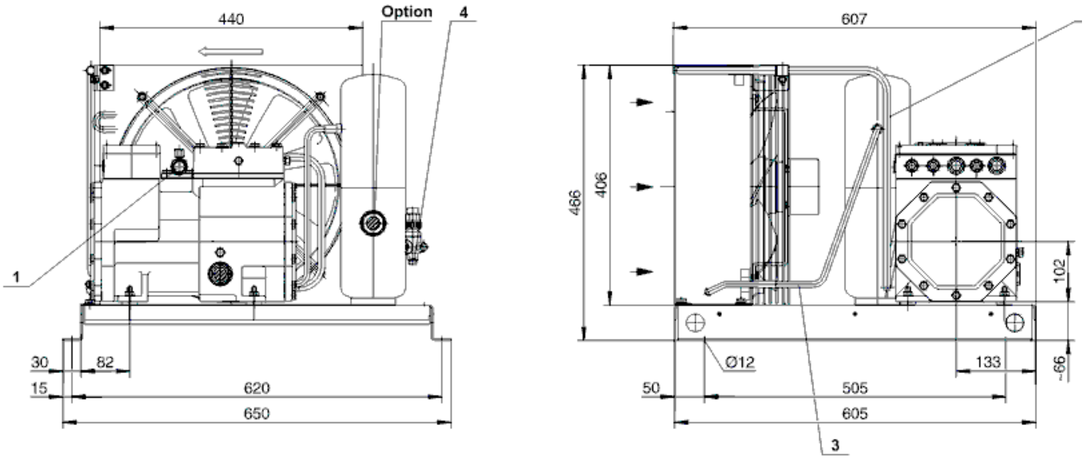



Figure 6.2-5: The Bitzer LH32/2KC-05.2y condensing unit

### 6.2.1.3 **Condensing section components**

Figure 6.2-6 and Figure 6.2-7 show pictures of severall condensing section components. A full list of these components is given in the parts lists in the appendix. Paragraph 11.2 shows a list of all the sensors, 11.3 shows a list of actuators and 11.4 shows all the passive line components.

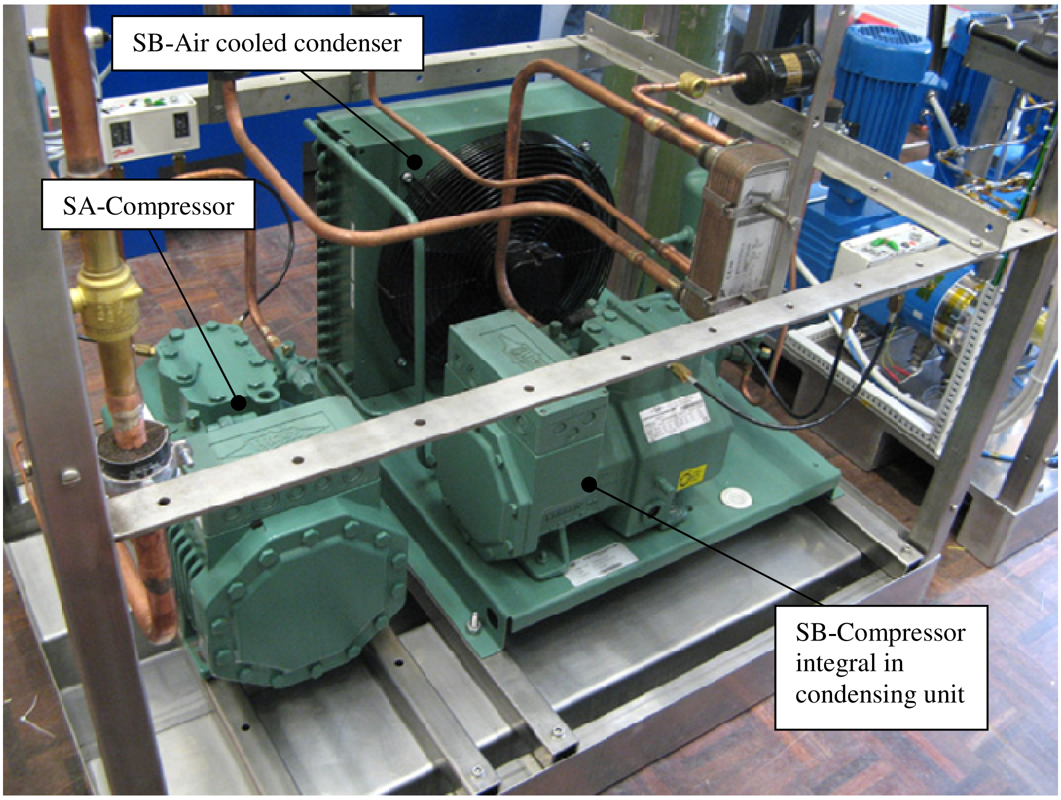



Figure 6.2-6: The SA compressor and SB condensing unit in the chiller rack.

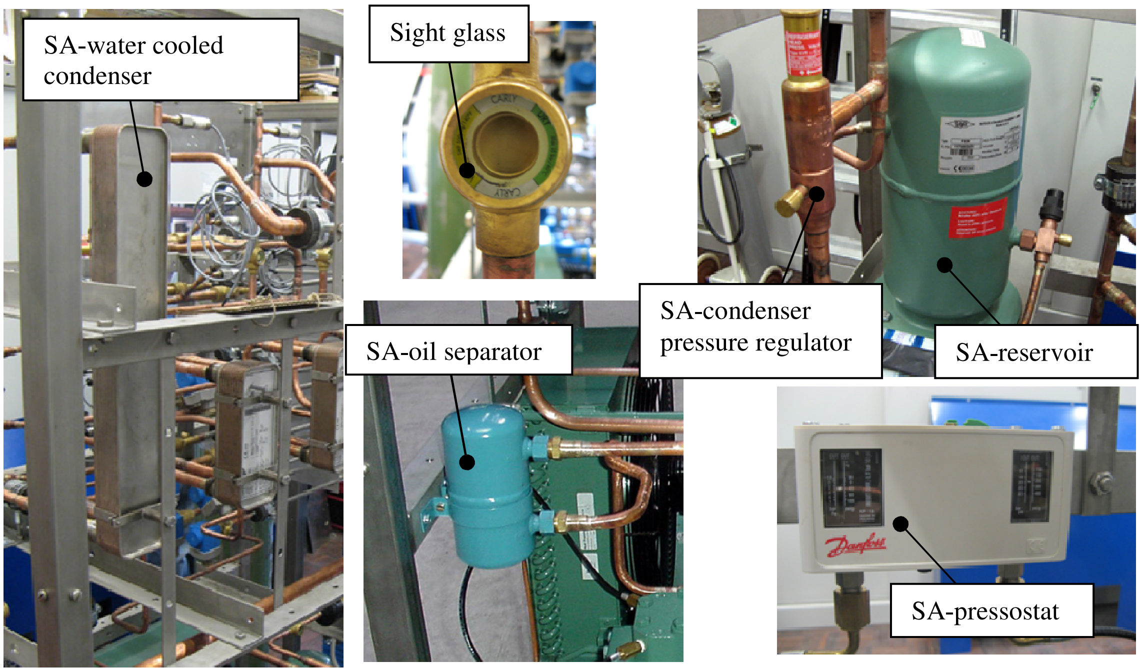



Figure 6.2-7: SA condensing section components

### 6.2.2 HFC Evaporator sections.

Both the SA-main and SB-back-up chillers have 4 parallel HFC evaporator branches. These branches are all fed with high pressure warm R507a liquid from the reservoir of the condensing section. After expansion in the controlled injection valve the low pressure cold liquid is evaporated and the low pressure gas is fed back to the compressor.

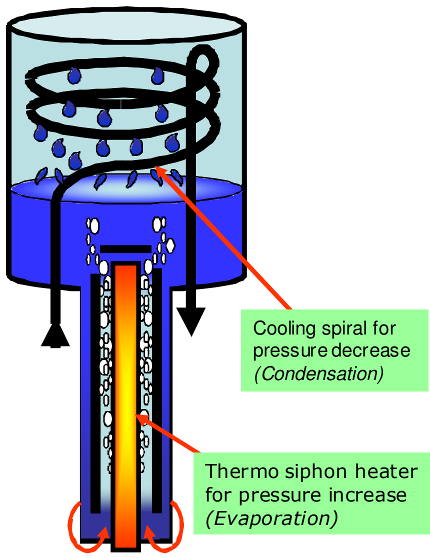



Figure 6.2-8: Principle of the $CO_2$ accumulator

There are 2 different type of HFC evaporators in the chillers. The 2 main HFC evaporators are cooling the $CO_2$ condensers, the other 2 HFC evaporators are the accumulator spirals evaporators, these are cooling the $CO_2$ accumulators. See Figure 6.1-1 for the evaporator locations. The main HFC evaporators are commercially brazed plate heat exchangers from SWEP. These plate heat exchangers are reinforced with steel plates for the high $CO_2$ pressure. The accumulator spiral evaporators are 3/8"x0.035" coiled tubes constructed inside the $CO_2$ accumulator. Figure 6.2-8 shows the principle of the evaporator spiral inside the accumulator vessel.

Both tertiary $CO_2$ systems are connected to the SA-main and SB-back-up chillers. Each tertiary $CO_2$ system is connected to four HFC evaporators. Two of these HFC evaporators are connected to the SA and two connected to the SB chiller. Figure 4.1-2 shows schematically the cross linked configuration.

All the evaporator branches are mass flow controlled using binary electronic restriction valves. The flow is controlled using the PWM (Pulse Width Modulation) method. Regulation of the refrigerant flow in the evaporator branches is achieved by controlling the outlet super heated gas temperature. The evaporator inlet liquid is sub cooled in sub-cooler (Sx_HX106) which uses the excess cold of evaporator cold gas from the outlet. In this way the vapor quality in the inlet of the evaporator is lower and the heat transfer is more efficient.

The inlet temperature of the $CO_2$ condensing side connected the HFC evaporator must be higher as the requested super heating temperature of the HFC refrigerant. In this way the $CO_2$ temperature is able to generate the requested super heating. In case of the $CO_2$ condensers of the SA main chiller this not always the case. At low $CO_2$ set-points the $CO_2$ inlet temperature can be too low not to generate sufficient superheating. Therefore the super heated vapor is controlled after the sub-cooler (SA_HX102 and SA_HX104). The main function of this heat exchanger is not any more to obtain sub-cooling of the inlet liquid, its main function has now become super heating of the outlet flow. Therefore these heat exchangers are called super heaters rather than sub-coolers. A consequence of this is that the two main evaporator branches have a dedicated heat exchanger in their evaporator branch. The other evaporator branches (2 accumulator branches in SA and all 4 evaporators in SB) share 1 sub-cooler. In both cases this is Sx_HX106. The effect on the evaporator of the displaced superheat control is clearly visible in the enthalpy-pressure cycles in Figure 6.1-3. State point 5 is the evaporator outlet; for the SA cycle this is in the 2-phase area, for the SB cycle this is in the superheated vapor area.

The AKV10 expansion valve is used for all 4 evaporator branches. The AKV10 is an electrically operated expansion valve using a solenoid operated armature for closing and opening a small orifice restriction. A drawing cut of the valve is shown in Figure 6.2-9. The restriction is #3 and the armature #6. The binary solenoid valve is made proportional using pulse width modulation with a modulation time of 6 seconds. The maximum capacity of the valve can be adjusted using a different orifice. The SA main evaporator branches have a 2kW orifice, the accumulator spiral evaporators and SB main evaporators branches a 1.2 kW orifice.

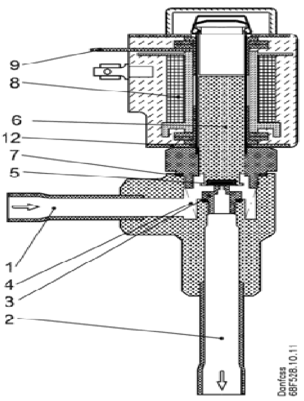



Figure 6.2-9: The AKV10 expansion valve

A full list of the other components in the evaporator section is given in the parts lists in the appendix. Paragraph 11.2 shows a list of all the sensors, 11.3 shows a list of actuators and 11.4 shows all the passive line components.

#### 6.2.2.1 **SA main HFC evaporator branches for cooling the $CO_2$ condensers.**

Figure 6.2-10 and Figure 6.2-11 show the schematic layout of the two main HFC evaporator branches that cool the two $CO_2$ condensers. They both have their own dedicated super heater as discussed in the previous chapter. The refrigerant flow is regulated using the overheating after the super heater. The evaporator itself stays completely two-phase which induces a better heat transfer in the evaporator itself.

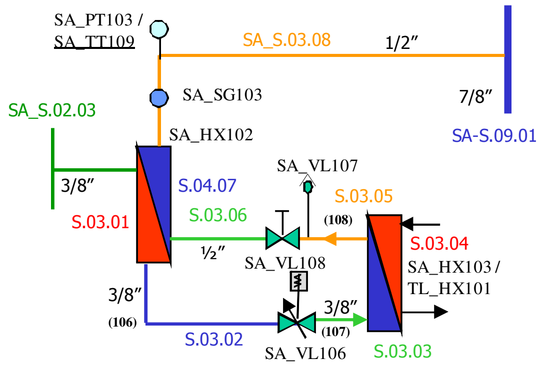



Figure 6.2-10: Main HFC Evaporator (branch 1) for the TL $CO_2$ condenser

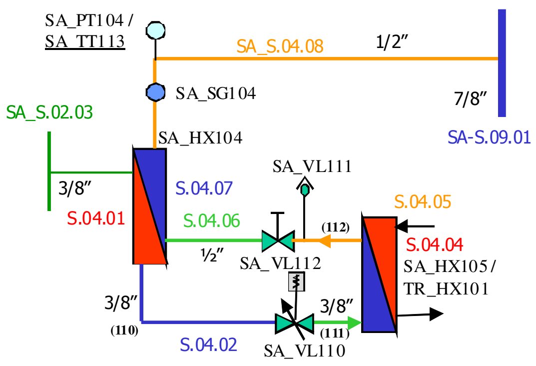



Figure 6.2-11: Main HFC Evaporator (branch 2) for the TR $CO_2$ condenser

The warm high pressure inlet liquid from the reservoir is cooled by the outlet super heater. (SA_HX102 & 104). The cold liquid approaches the same temperature of the evaporator (See Figure 6.1-3). The cold liquid is expanded from the high reservoir pressure to the low evaporator pressure by the electronic expansion valve (SA_VL106 & 110). The inlet liquid is saturated so evaporation is present in the main HFC evaporator (SA_HX103 & 105). The remaining liquid and vapor is fed through the super heater where the excess liquid is evaporated and superheated. The super heated vapor temperature (A combination of SA_PT103 with SA_TT109 and SA_PT104 with SA_TT113) is used to control the expansion valve (See paragraph 6.4.1. for details on the expansion valve control).

The main HFC evaporators are reinforced brazed plate heat exchangers from SWEP. They are reinforced because of the high pressures in the $CO_2$ side. The reinforcing metallic plates protect the heat exchangers from bursting. The $CO_2$ operates with pressures up to 100 bar (170 bar proof pressure), while R507a has low pressures. The internal structure of this heat exchanger must withstand this pressure difference as well. A special double wall heat-exchanger from SWEP was used. This B16DW series has double plates and a small wave pattern. This combination makes the plate heat exchanger suitable for withstanding these high pressure differences. The VTCS safety document (8) gives a detailed design and testing overview of this custom made heat exchanger.

#### 6.2.2.2 **SA accumulator spiral evaporators.**

Figure 6.2-12 shows the schematic layout of the SA accumulator spiral evaporators branches 3 and 4. The $CO_2$ pressure in the accumulator is controlled by heating and cooling of the two-phase content. A $CO_2$ pressure decrease is achieved by condensing of the vapor in the upper region using the HFC spiral evaporator. Pressure increase of the $CO_2$ is achieved by evaporating the liquid using an electrical heater in the bottom part of the accumulator (See Figure 6.2-8). The expansion valves (SA_VL114 & SA_VL119) are not controlled by the evaporator outlet superheating, but by the accumulators PID pressure control. The capacity of the cooling spiral is of the same order as the heating capacity of the liquid heater. The accumulator's PID control combines both actuators in 1 algorithm, where the cooling effect of the expansion valve control is treated as a negative heating element. More about this combined accumulator control can be found in paragraph 7.7.1.

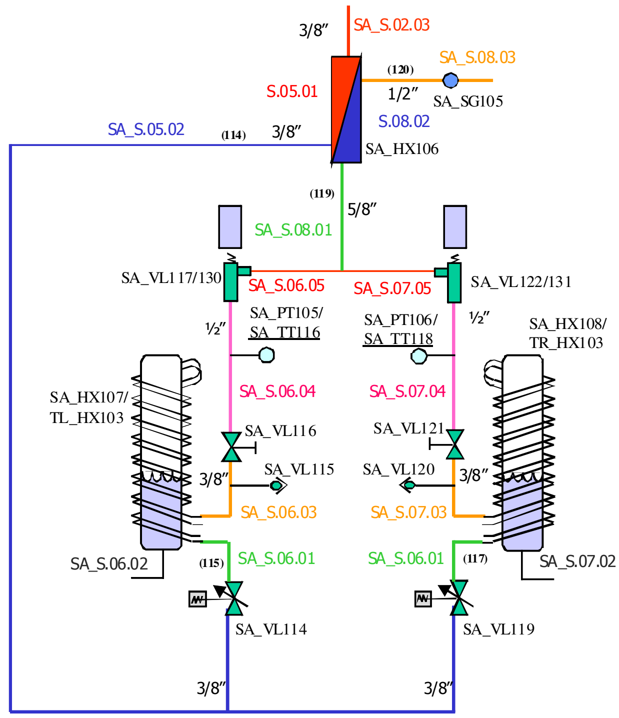



Figure 6.2-12: Evaporator section 6&7 cooling the $CO_2$ accumulators

Both SA evaporator branches for the accumulator control use one combined sub cooler (SA_HX106). Each evaporator branch has a manual back-pressure regulator which limits the evaporator pressure, so a minimum temperature of the $CO_2$ accumulators can be set. Both branches have super heating sensing by pressure and temperature sensors combinations SA_PT105/SA_TT116 and SA_PT106/SA_TT118. The superheating sensing is not used to control the refrigerant flow they are only present for monitoring.

Inside the accumulators two-coiled spirals are installed for condensing the $CO_2$ vapor in the vessel. The coils are located in the top of the vessel and have feed-throughs at the bottom flange. Figure 6.2-13 shows the accumulator during assembly. The evaporator spirals are clearly visible. The spirals are rolled up 3/8"x0.035" stainless steel tubes with a length of 10.1 m. There are 2 coils in the accumulator, one connected to the SA-Main chiller, the other connected to the SB-back-up chiller.

### 6.2.2.3 SB Evaporator branches.

Contrary to the SA evaporator branches, all SB evaporator branches use one common sub cooler. The main evaporator branches (SB_HX103 & 105) connected to the $CO_2$ condensers have the super heating control directly at the outlet of the evaporator. The superheating (a combination of SB_PT103 with SB_TT109) controls the refrigerant flow of the main evaporator SB_HX103 (cooling the TL condenser) by adjusting the injection valve SB_VL106. The SB_PT104 with SB_TT113 superheating controls the injection valve SB_VL110 for main evaporator SB_HX105 (cooling the TR condenser). The accumulator evaporator branches of SB are identical to the branches of the SA main chiller.

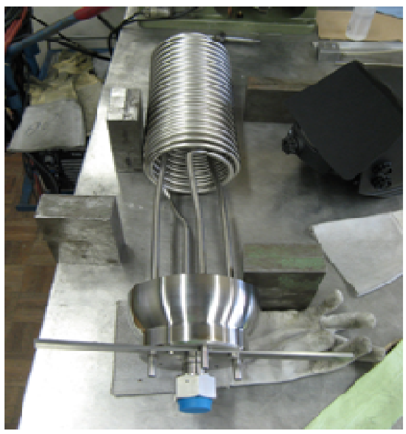


Figure 6.2-13: Cooling spirals in the accumulator

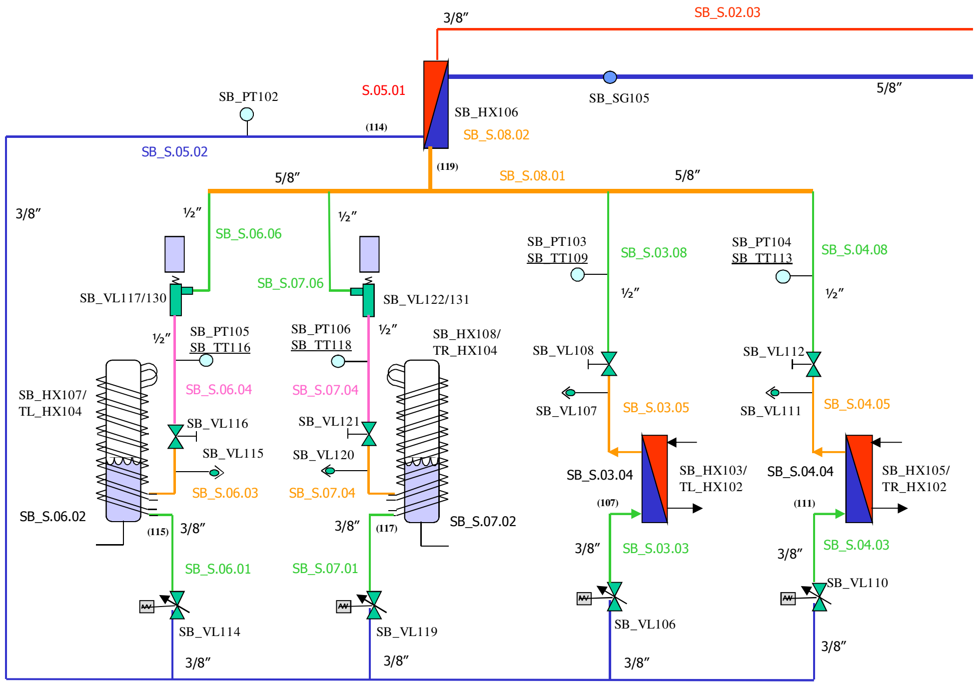


Figure 6.2-14: All four SB evaporator branches.

### 6.2.2.4 **Evaporator section components**

A full list of the components in the evaporator section is given in the parts lists in the appendix. Paragraph 11.2 shows a list of all the sensors, 11.3 shows a list of actuators and 11.4 shows all the passive line components.

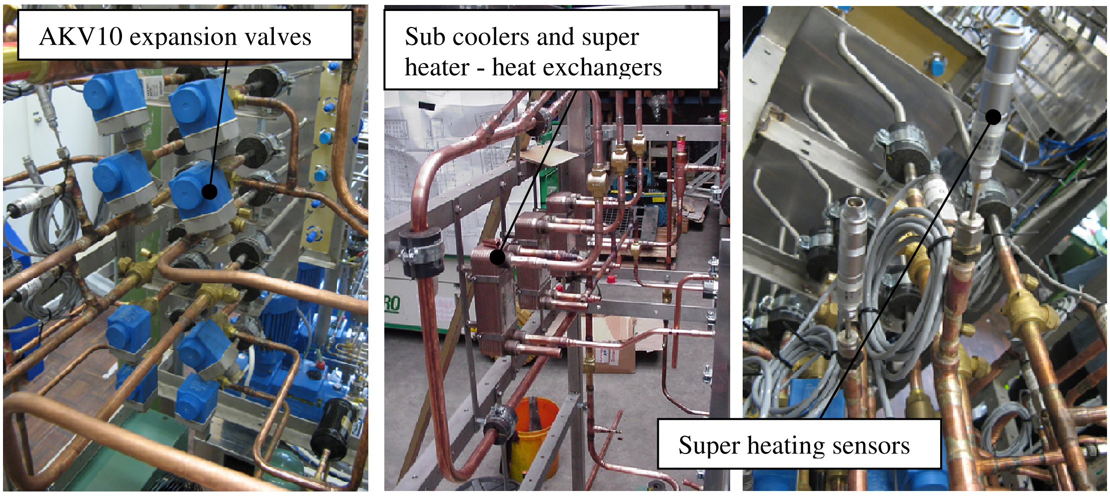


Figure 6.2-15: Evaporator section components

## 6.3 *Chiller volumes and charges*

A chiller must have sufficient refrigerant charge to have liquid in the supply lines, sufficient liquid in the evaporators and gas in the suction lines. The evaporators and condenser have a varying refrigerant content depending on the cooling temperature and absorbed heat load. This varying liquid/vapor content must be accumulated in the reservoir. This reservoir must have always liquid and vapor present.

The submerged suction tube in the reservoir must always be below the liquid level. In this case the evaporators are fed with liquid of the right enthalpy. At a too low charge, the submerged tube will suck vapor bubbles and the total inlet enthalpy of the evaporators will increase. With higher inlet enthalpy less cooling power for the evaporators is available. The first signs of a too low charge can be seen by vapor bubbles in the sight glass SA_SG102. The needed refrigerant charge is determined by calculating the fillings under nominal conditions and the two extremes. The extreme for the lowest reservoir level is a total flooding of all the evaporators and the condensers. This is a worst case situation for a too low heat input. A total flooding however will never appear, since a zero heat input is never taking place due to environmental heat loads, and alarms like the compressor low pressure will be triggered far before. The worst case for the highest level in the reservoir takes place during maintenance. In this case the liquid lines, the evaporators and cold gas lines are emptied by the compressor. The fluid is stored this way in the reservoir after being condensed in the condenser.

Table 11.5-1 and Table 11.5-3 show volumes of the several sections of the two chillers as indicated in the schematic of Figure 6.2-1 and Figure 6.2-2 . For each volume the refrigerant state is calculated for a nominal operation. When the state of the fluid in each section is known, the density per volume can be calculated and so the needed refrigerant mass.

Table 6.3-1 and
Table 6.3-2 show summaries of the combined volumes of the several sections. At the bottom off the table the corresponding reservoir levels are given for the nominal level, the minimum level (All external heat-exchangers flooded) and the maximum level (All the liquid stored in the reservoir). With a refrigerant charge of 4.5 kg in SA and 2.7 kg in SB there is in all cases sufficient liquid remaining in the reservoir.

A state point model of the chillers is made using the sections as marked in the schematic drawings (Figure 6.2-1 and Figure 6.2-2). In this state point model the pressure and enthalpy at each section is calculated in an iterative calculation process. A detailed description of the state point model is explained in chapter 9. From the enthalpy-pressure state points the temperature and density of the section volumes can be derived using the integrated Refprop database (9). The mass filling at each section is known this way. The state point results of the SA and SB chiller for a nominal situation including the derived mass filling is shown in the appendix in Table 11.5-1 and Table 11.5-3.

Table 6.3-1: Overview of the SA volumes, charge and reservoir levels

| | | |
|---|---|---|
| Discharge and condensing section | 1.25 | Liter |
| Liquid and buffer section | 5.78 | Liter |
| Evaporator section | 4.04 | Liter |
| Cold gas section | 1.28 | Liter |
| System volume w.o. reservoir | 6.74 | Liter |
| Total system volume | 12.34 | Liter |
| Max flooded volume | 2.85 | Liter |
| Reservoir volume | 5.60 | Liter |
| Filling | 4.5 | kg |
| Homogeneous filling | 0.36 | kg/L |
| Maximum buffer level | 74.10% | |
| Nominal buffer level | 48.98% | |
| Minimum buffer level | 14.25% | |

Table 6.3-2: Overview of the SB volumes, charge and reservoir levels

| | | |
|---|---|---|
| Discharge and condensing section | 0.82 | Liter |
| Liquid and buffer section | 3.32 | Liter |
| Evaporator section | 2.23 | Liter |
| Cold gas section | 0.52 | Liter |
| System volume w.o. buffer | 3.90 | Liter |
| Total system volume | 6.90 | Liter |
| Max flooded volume | 1.90 | Liter |
| Reservoir | 3.00 | Liter |
| Filling | 2.7 | kg |
| Homogeneous filling | 0.39 | kg/L |
| Maximum buffer level | 83.75% | |
| Nominal buffer level | 70.26% | |
| Minimum buffer level | 14.00% | |

## 6.4 *Chiller operation and control*

The SA-Main chiller is operated by 9 controlled actuators. 4 of these actuators are mechanically controlled with a onetime adjustment. These are the condenser control valves SA_VL102 and SA_VL103 (see paragraph 6.2.1.1) and the evaporator control valves SA_VL117 and SA_VL122 of the accumulator evaporators (see paragraph 6.2.2.2). The other 5 actuators are electrically controlled by the PLC. Four are electronic expansion valves SA_VL106, SA_VL110, SA_VL114 and SA_VL119 (see paragraph 6.2.2) the other one the frequency controlled compressor SA_PM101 (see paragraph 6.2.1.1). The SB Back-up chiller has a different condenser pressure control. No valves are present but a frequency control of the ventilator speed maintains the condensing pressure. A local electronic control (SB_PT109) controls independent from the PLC the fan speed. The SB evaporator branches are controlled in a similar way as the SA evaporator branches. The expansion valves SB_VL106, SB_VL110, SB_VL114 and SB_VL119 are controlled electronically by the PLC while the evaporator control valves SB_VL117 and SB_VL122 are set manually. The SB compressor has no frequency control. It is operated at 50 Hz at all time. Detailed explanation about the control algorithms is discussed in the PLC code documentation (10).

### 6.4.1 Control of the SA evaporator branches cooling the $CO_2$ condensers

The expansion valves SA_VL106 and SA_VL110 regulate the amount of needed refrigerant to condense and sub cool the $CO_2$ in the heat exchangers SA_HX103 and SA_HX105. The flow is regulated by measuring the overheating of the exhaust of heat exchanger SA_HX102 and SA_HX104. The overheating is the measured temperature of SA_TT109 minus the translated saturation temperature of pressure sensor SA_PT103 for the branch 1 evaporator and SA_TT113 and SA_PT104 for branch 2 evaporator. Figure 6.4-1 shows the control relation between the measured overheating and the expansion valve set-

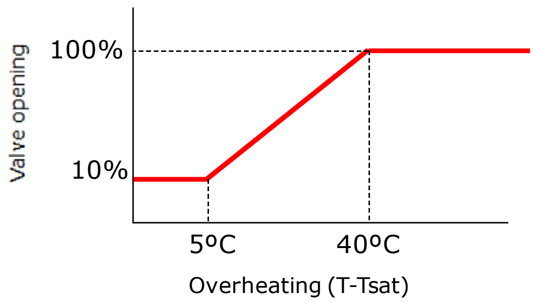



Figure 6.4-1: Expansion valve control

point. A direct control was applied as a PID control was too hard to implement due to the difficult dynamics of the sub cooling cycle. The super heater has a direct influence of the inlet condition, which together with the delay between inlet and outlet condition makes it hard to regulate. The present control makes the evaporator flow to vary a lot but is never exceeding the alarm limits as a previous PID control did. The variations however are not a problem for the system behavior. The $CO_2$ temperature in the detector is very stable as the 2PACL principle is damping out any variations at the condenser side. This is exactly where it was designed for in the AMS-TTCS; damping out the orbital variations. This good feature of the 2PACL behavior did make further tuning of the chiller unnecessary. An example of the measured dynamic behavior of the SA evaporators is shown in Figure 6.4-2.

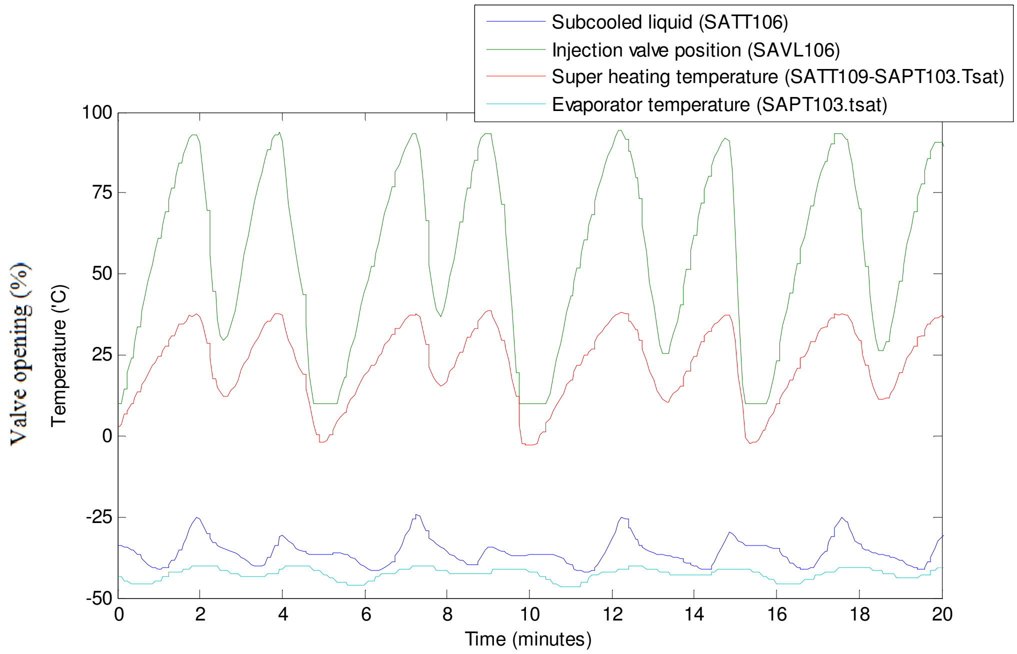



Figure 6.4-2: Dynamic behavior of the SA main HFC evaporator control.

### 6.4.2 Control of the SB evaporator branches cooling the $CO_2$ condensers

The expansion valves SB_VL106 and SB_VL110 regulate the amount of needed refrigerant to condense and sub cool the $CO_2$ in the heat exchangers SB_HX103 and SB_HX105. The flow is regulated by measuring the super heating of the exhaust of the evaporators. The super heating is the measured temperature of SB_TT109 minus the translated saturation temperature of pressure sensor SB_PT103 for the evaporator branch 1 and SB_TT113 and SB_PT104 for evaporator branch 2. A PID algorithm in the PLC maintains the super heating around 10ºC.

### 6.4.3 Control of the SA and SB accumulator spirals evaporators.

The control of the expansion valves for the accumulator spirals is integrated in the PID control of the accumulator pressure control. The capacity of the cooling spiral is of the same order as the heating capacity of the liquid heater. The accumulator's PID control combines both actuators in 1 algorithm, where the expansion valve control is treated as a negative heating element. More about this combined accumulator control can be found in paragraph 7.1.1. The control of SA and SB is identical.

### 6.4.4 Control of the SA compressor suction pressure.

The varying refrigerant flow caused by the 4 different expansion valve settings causes a varying suction pressure in the compressor. The compressor is a fixed volume flow pump, meaning a smaller mass flow needs a smaller density. The smaller density results in a lower pressure in front of the compressor. The suction pressure has a direct influence on the evaporation pressure in the two $CO_2$ condensers. The pressure of these two branches are not controlled by an additional pressure regulator as it is the case for the accumulator branches. The varying suction pressure therefore causes a varying evaporation temperature and hence a varying $CO_2$ liquid temperature.

For the VTCS it is not important to have stable chiller temperatures as the 2PACL principle in the $CO_2$ system will dampen all the temperature fluctuations of the cold $CO_2$ liquid. The fluctuations in the $CO_2$ liquid flow are not influencing the $CO_2$ evaporator temperatures in the VELO detector. The fluctuations in the chiller temperatures are directly caused by the fluctuations in the suction pressure of the compressor. The suction pressure of the compressor need to stay within reasonable limits for several reasons. A too low suction pressure has a low massflow as a result. This will give insufficient cooling of the compressor itself. The low suction pressure in the chiller will give a low evaporation pressure and hence a low evaporation temperature, this low temperature may cause the $CO_2$ too freeze which freezes around -56ºC . A too high suction pressure will limit the ability of the VTCS to run cold as the evaporation temperature increases.

To stay within a good range a frequency control of the compressor was implemented. For high heat loads a large speed is needed to maintain the pressure low enough, for low heat loads a low speed is required not to go too low in suction pressure. A too low suction pressure will trigger the low pressure alarm of pressure switch SA_PT108, which needs to be avoided at any time. Figure 6.4-3 shows the relation between the frequency set point as a function of the measured suction pressure.

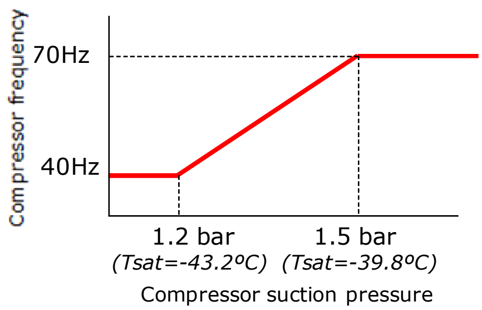


Figure 6.4-3: Compressor speed control

### 6.4.5 Chiller alarm handling.

A proper operation of the chillers is monitored by the PLC. If the system is out of its design working range alarms are generated and proper actions are taken. The alarm handling procedure is in detail described in the user manual (11). A table with the alarms properties can be found in the appendix at paragraph 11.6.

# 7 Tertiary cooling system

## 7.1 *Overview of the Tertiary $CO_2$ 2PACL systems*

Each detector half is cooled by an individual $CO_2$ circulation loop. The 2 $CO_2$ loops are cooled by a common HFC chiller (see Figure 4.1-2). The two $CO_2$ loops are running independently from each other, but have some interconnects and share the same back-up pump. The interconnections are only used in emergency cases and can connect both detector halves or transfer lines to a single loop. The tertiary $CO_2$ loops connect the detector in the experimental cavern via the so-called transfer lines to the cooling plant in the safe zone on the UXAC3 platform. (See Figure 4.2-2). Figure 7.1-1 shows a schematic interpretation of the $CO_2$ loops as they are implemented in the LHCb cavern. The $CO_2$ plant with all the control hardware is located in the safe zone next to the secondary chillers and are shielded from radiation by the thick concrete shielding wall. The plant part is always accessible for maintenance or troubleshooting. The evaporators in the detector and large part of the transfer lines located in the experimental zone are hard to access. This hardware is only passive so the risk of an unreachable failure is limited.

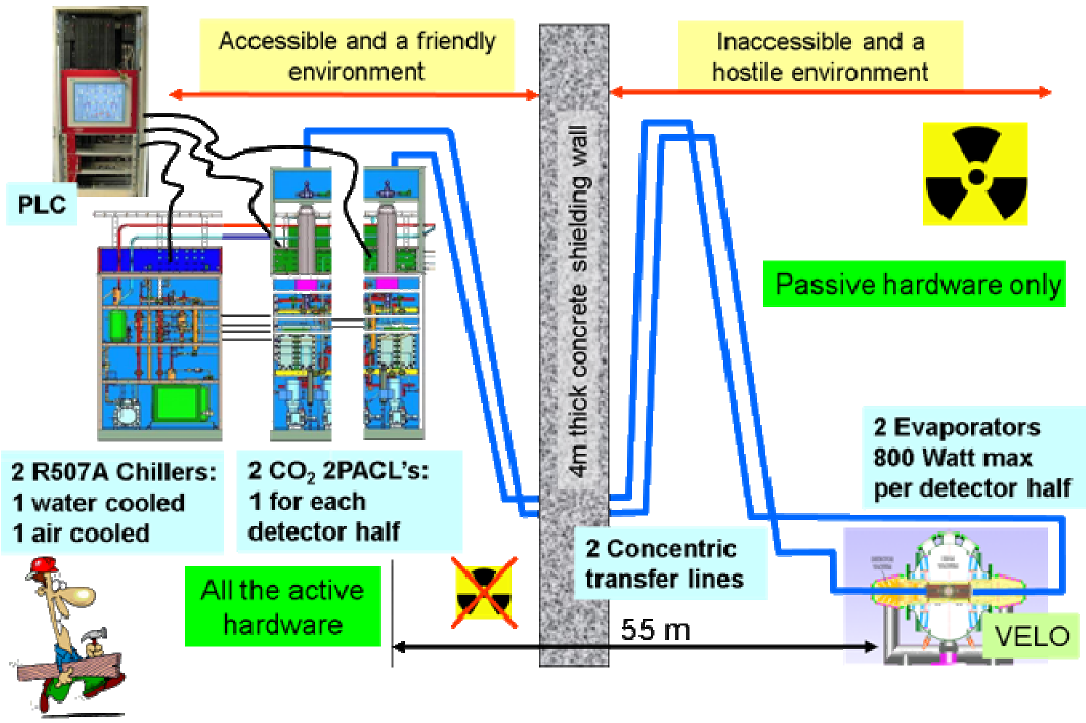



Figure 7.1-1: Artistic view of the tertiary $CO_2$ loops in LHCb

### 7.1.1 2PACL principle

The tertiary $CO_2$ loops use a novel technology of controlling the evaporator pressure and enthalpy. The principle is called 2-Phase Accumulator Controlled Loop (2PACL) (4) and is originating from satellite cooling systems. It was developed for the AMS-TTCS (5) by Nikhef and NLR. The 2PACL principle controls the evaporator pressure and inlet enthalpy remotely and is therefore ideal for cooling and temperature control of an inaccessible detector. In the case of the VTCS, all the control is located in the plant in the safe area, the evaporator and transfer lines are only passive tubing. Figure

7.1-2 shows a simplified scheme of the 2PACL as it is implemented for the VELO in LHCb.

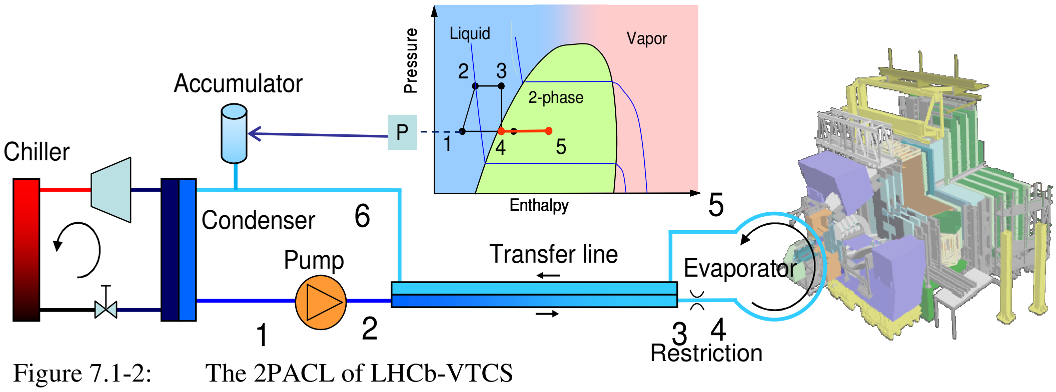



Figure 7.1-2: The 2PACL of LHCb-VTCS

A 2PACL is a liquid circulation loop where the sub cooled liquid is heated to saturation by an internal heat exchanger. The evaporator, the return tube and the condenser are connected without a significant pressure drop and thus work at the same pressure. An accumulator vessel is side mounted in front of the condenser, controlling this pressure. The accumulator is designed to have always a liquid and vapor content. Evaporating the accumulator's liquid or condensing the accumulators vapor directly influences the pressure of the accumulator, condenser, return tube and the evaporator.

The regulation of the system work as follows (see Figure 7.1-2 for node locations); the accumulator vessel needs to be maintained at a fixed temperature and hence pressure set-point. This is achieved with a cooling and heating combination. The pressure drop between the outlet of the evaporator (5) and the accumulator connection (6) is low, therefore the accumulator directly controls the pressure of the evaporator. The transfer line / internal heat exchanger (2-3) heats up the pumped sub-cooled liquid to saturation, causing the inlet of the evaporator always to be saturated (point 4 within green 2-phase zone of the pressure-enthalpy diagram). The system works with an overflow of liquid. The fluid state in the evaporator is per definition 2-phase, and independent from the absorbed heat. The independence of heat absorption is ideal for detector cooling as they need to be kept cold all the time, even if there is no dissipated power in the detector. The returning vapor is condensed in the condenser (6-1) which is cooled by a standard chiller. The sub cooled liquid (1) is pumped back into the system by a liquid pump (1-2). The chiller of the VTCS remains always cold (around -40ºC, depending on heat load) and the accumulator can be set between -5ºC and −35ºC.

The key items in the system are the accumulator and the transfer line. They are responsible for the condition of the evaporator. More details about the working of the accumulator and transfer line are given in paragraph 7.4.1 and 7.3.

### 7.1.2 Tertiary schematics

Figure 7.1-3 shows a simplified scheme of the $CO_2$ systems. The A side of the VELO detector is cooled by the TL (Tertiary Left) system, the C-side is cooled by the TR (Tertiary Right) system. A shared back-up pump is available. Related system hardware is referred to as TLR (Tertiary Left-Right) system. Both TL and TR are connected to the SA-Main chiller and the SB-Back-up chiller. The TL and TR are identical, except from the TLR pump cooling. This extra heat exchanger is only in the TR system and is used to maintain the “not-used” TLR pump cold, so a cold start-up is possible.

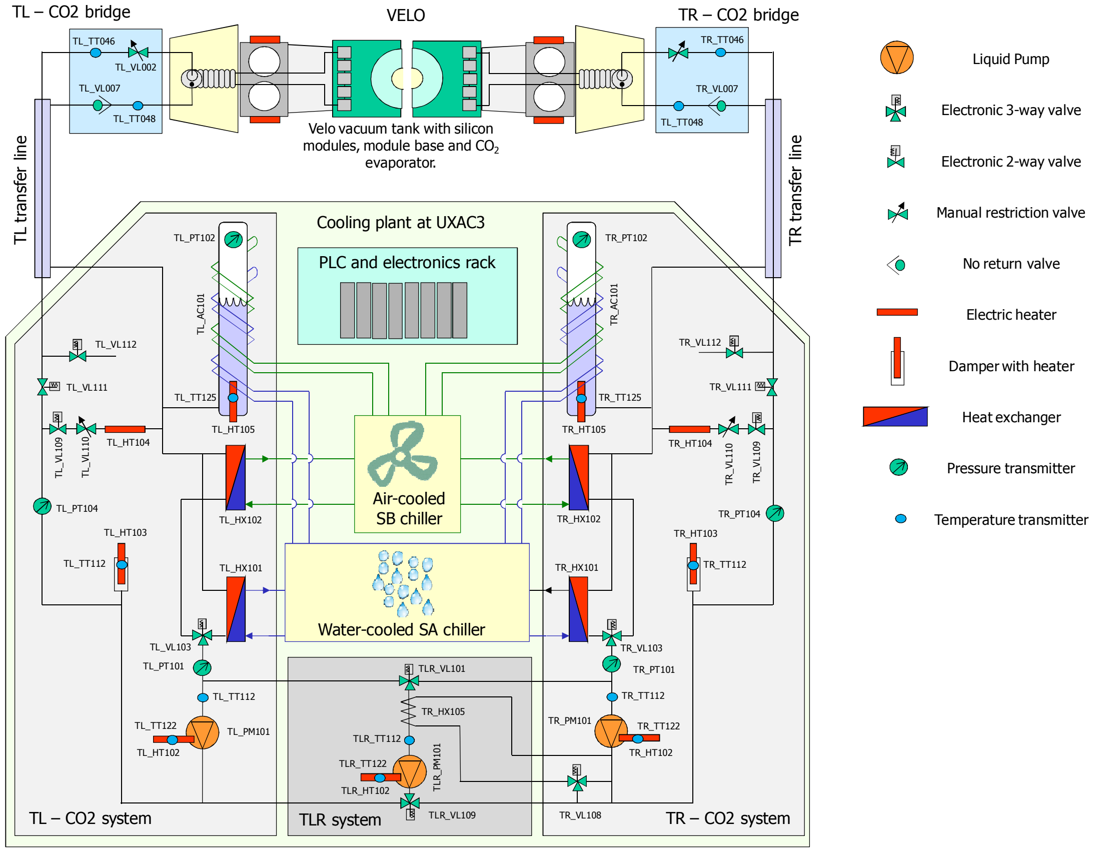



Figure 7.1-3: Simplified schematics of the tertiary $CO_2$ systems

In the above scheme only the important hardware is shown and labeled. Detailed schematics can be found in the appendix in paragraph 11.1. A full list of the components in the tertiary systems is given in the parts lists in the appendix. Paragraph 11.2 shows a list of all the sensors, 11.3 shows a list of actuators and 11.4 shows all the passive line components.

## 7.2 *VTCS hardware at VELO*

The hardware of the VTCS located inside the VELO cave is the evaporator, the base-plate heating and the cooling distribution bridge. Figure 7.2-1 shows the labeling of all the VTCS hardware near the VELO. The evaporator has a fluid connection on the outside of the vacuum. The cooling bridge is mounted on top of the VELO tank. The electrical signals from within the VELO vacuum vessel (temperature sensors and base plate heaters) are fed to the outside via 2 extra VELO kapton cables and vacuum feed-through. A dummy electronic board on the outside is used to group these electrical signals from the VELO and the cooling bridge for a connection to the distant cooling PLC. Figure 7.2-2 shows the VELO internal hardware and the interconnects.

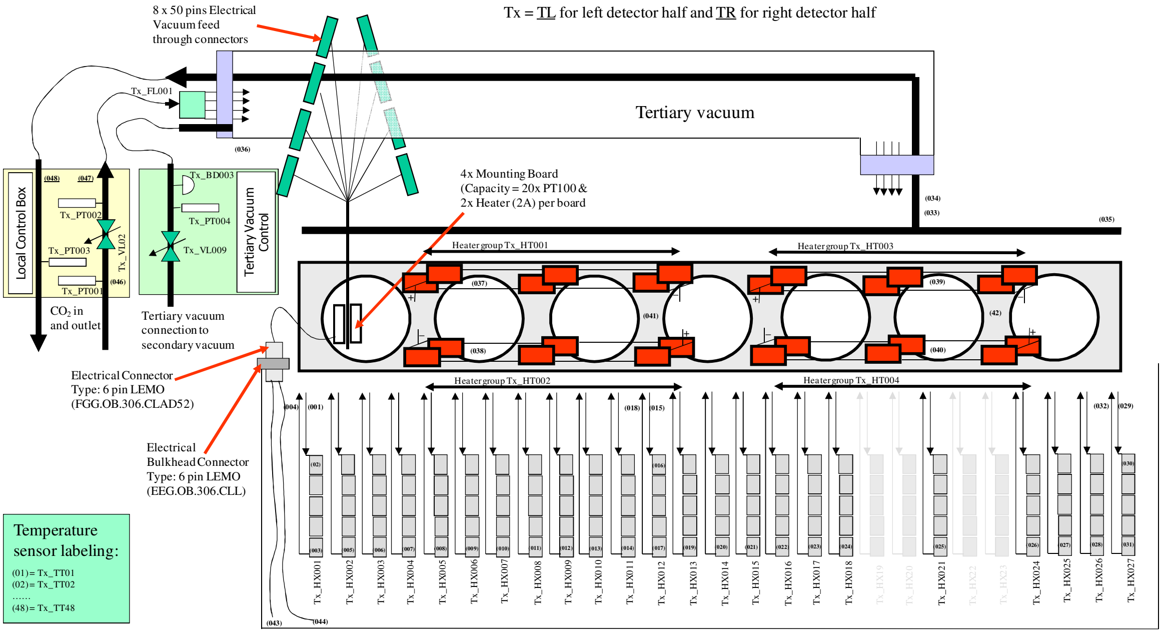



Figure 7.2-1: VTCS hardware labeling inside the VELO detector

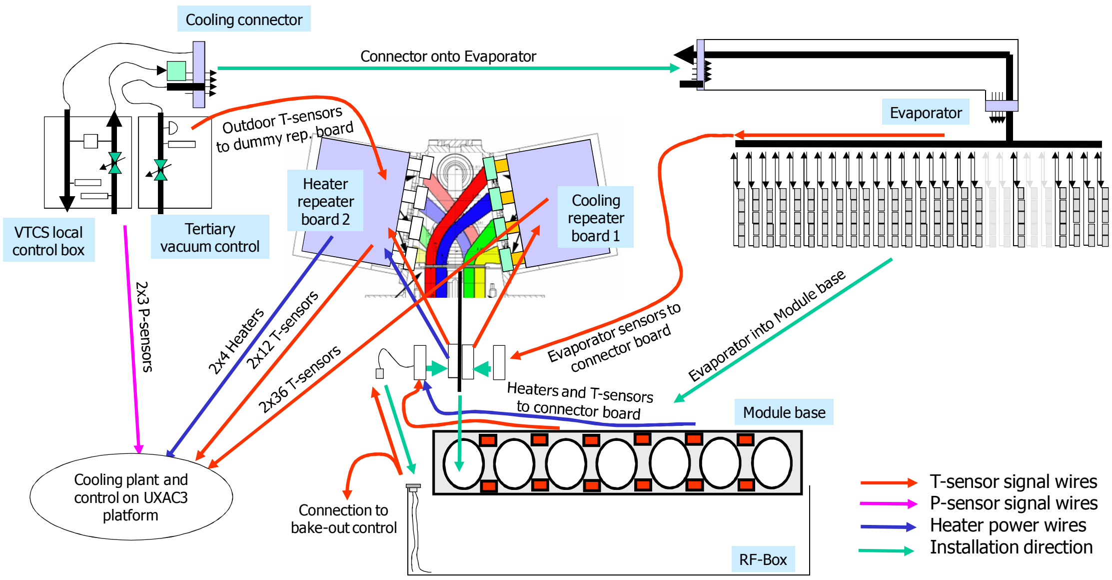



Figure 7.2-2: VELO internal hardware and interconnects

## 7.2.1 Module base plate heating

The module base plate is the positional reference of the modules. The precision interfaces are machined at room temperature. The base plate must therefore stay around 20ºC all time (see requirements in chapter 3). The base plate is indirectly connected to the cooling system via some supports and via the module support paddles which causes the base plate to be cooled down eventually. The base plate is maintained at room temperature by kapton foil heaters glued on the inside of the frame. Figure

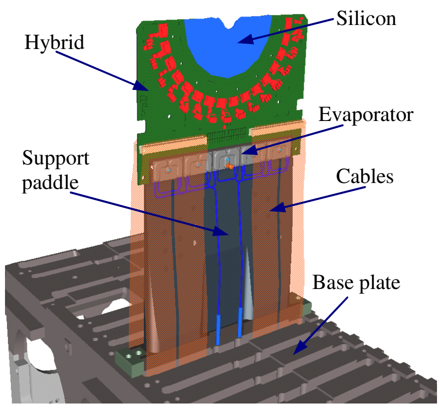



Figure 7.2-3: Overview of a VELO module on the base plate

7.2-4 shows an inside view with the heaters. In total 24 heater pads are present per detector half. 6 heaters are combined in a group and are controlled together by 1 temperature sensor. The group layout is shown in Figure 7.2-1. Additional information about the base plate heating can be found in the appendix in paragraph 11.8.

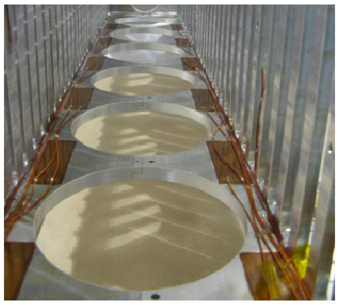


Figure 7.2-4: Base plate heaters

### 7.2.2 Evaporator

The evaporator absorbs the heat from the modules by evaporating the injected liquid $CO_2$. The $CO_2$ evaporation pressure is controlled by the 2PACL principle, resulting in a stable evaporation temperature of the evaporator. The evaporator temperature indirectly controls the temperature of the silicon which according to the requirements (Chapter 3) must stay below -7ºC. At full power the gradients in the modules are in the order of 20-25ºC resulting in a required evaporator temperature of about -25 to -30ºC (12).

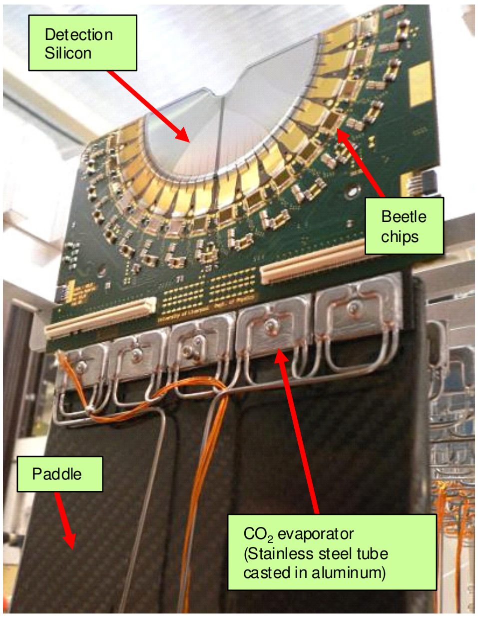



Figure 7.2-5: Velo module with $CO_2$ cooling connection evaporator

The $CO_2$ evaporator consist of 23 parallel branches of 1.5x0.25mm 1115mm long CRES321 stainless steel tubes. Each tube is coiled to prevent thermal expansion. A 457mm long section of the tube is embedded in casted aluminum cooling blocks for heat exchange. The cooling blocks are nick-named cooling cookies as the production method of casting showed similarities with baking cookies in an oven. The thermal interface of the cookies to the modules is achieved with THERMFLOW® T710 phase-change Thermal Interface Material (TIM). This TIM was chosen because of its low melting temperature and low clamping force. Figure 7.2-5 shows a picture of a cooling cookie assembly mounted to a module. Each VELO module consists of a double sided hybrid (printed circuit board) with two silicon sensors. The core of the hybrid is a thermally conductive Carbon fiber-TPG laminate supporting the module and conducting the heat to the cooling cookies. The cooling cookies are mounted with M2.5 screws to the module using the stiff paddle structure on the opposite side as contra clamp. Each evaporator branch has one PT100 sensor glued to the last cookie in the flow direction to monitor possible dry-out phenomena of the tube.

Figure 7.2-6 shows the layout of the evaporator assembly. The whole assembly is situated inside the VELO vacuum vessel. The requirements for leak tightness are extremely high. All the wetted parts are made of stainless steel and only reliable joining techniques as orbital welding and vacuum brazing (Nicrobraz EL-36) are applied. The 1.5x0.25mm cooling tubes from the aluminum cooling cookies are connected via 4x0.7mm tubes to the support manifold. The support manifold connects

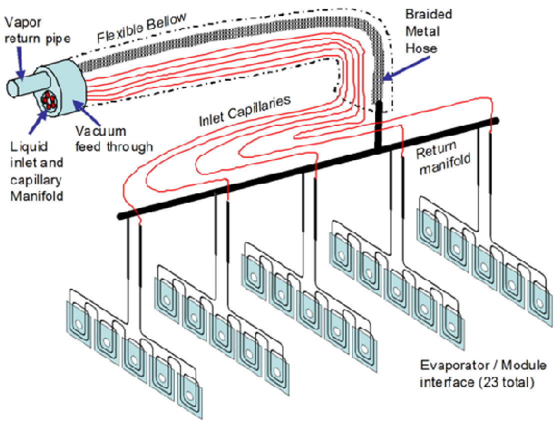



Figure 7.2-6: Concept of the VTCS evaporator

the outlets of all the branches together. A flexible braided metal hose connects the manifold to the vacuum feed through.

The inlet of the branches are connected via 2038mm long 1x0.25mm capillaries directly to the vacuum feed through flange. The capillaries all have the same length so the flow impedance is the same for all. This ensures a good flow distribution for all the parallel channels. The capillaries are accessible from the outside, a feature which was used during the installation and commissioning of the VELO modules, where individual modules needed to be cooled. The capillaries are routed into a small channel on the outside of the support manifold. This channel also houses the PT100 cables. Detailed pictures about cabling of this are shown in Figure 7.2-9.

For LHC proton beam injection the detector halves need to be retracted away from the beam by 30mm. The evaporator connection to the outside needs to be flexible to allow for this movement. The flexible return hose together with the inlet capillaries are inside a sealed vacuum bellow. The bellow is indicated as dotted line in Figure 7.2-6. Figure 7.2-8 shows a photo of the evaporator assembly, and Figure 7.2-7 shows the CAD design with cut-out views to show internal structures.

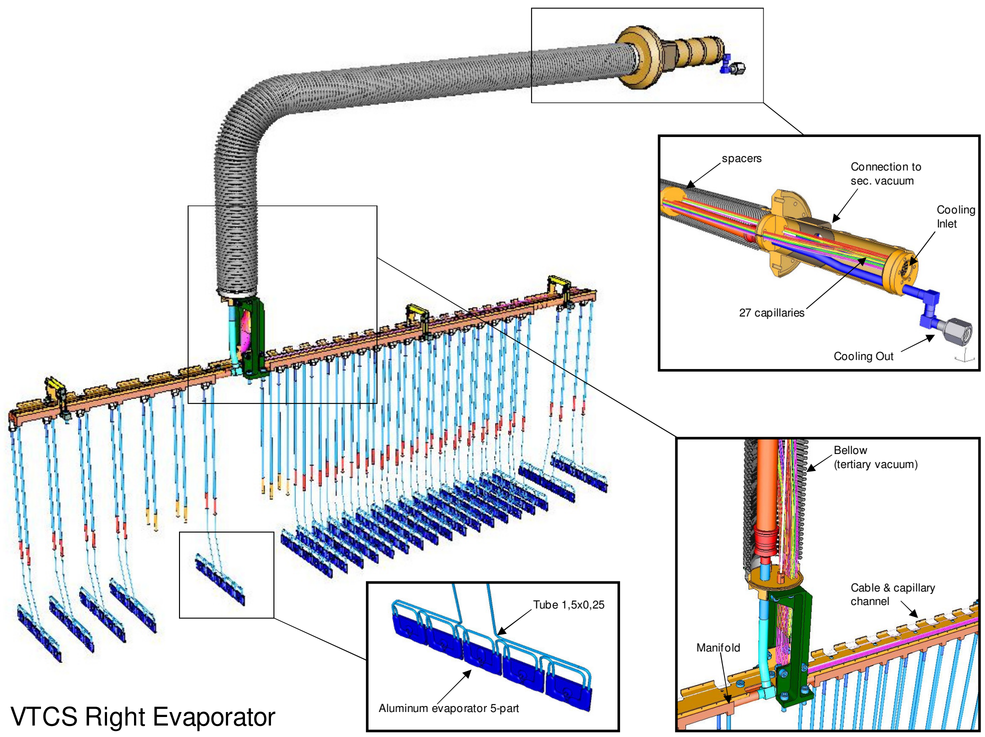



Figure 7.2-7: The VTCS evaporator design

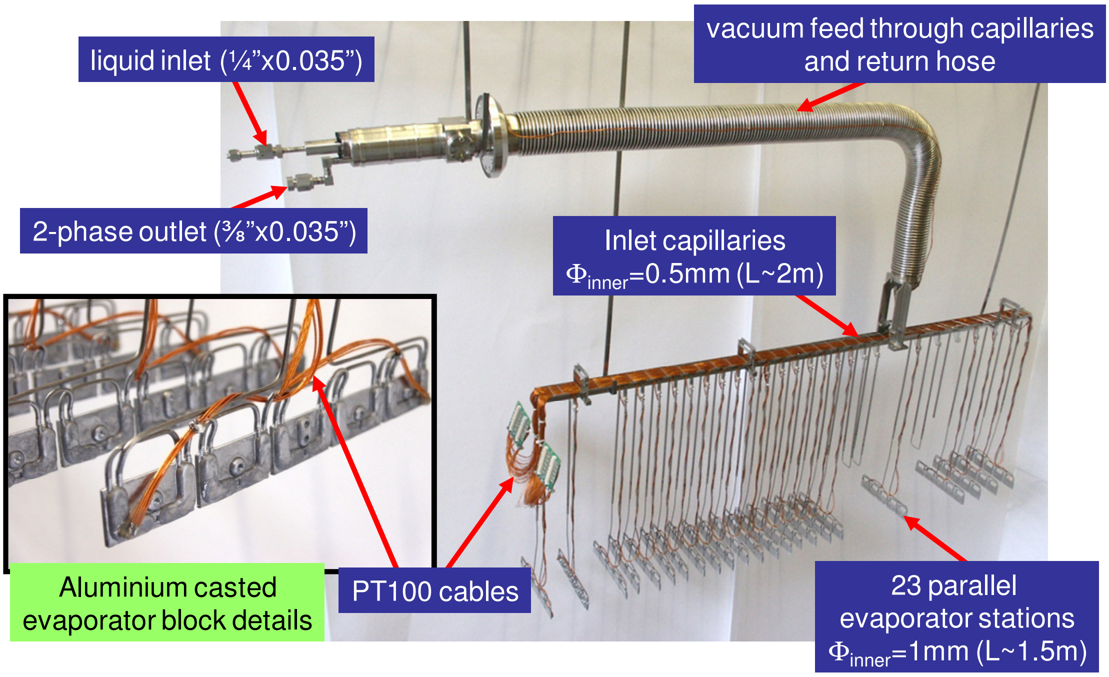



Figure 7.2-8: The VTCS evaporator construction

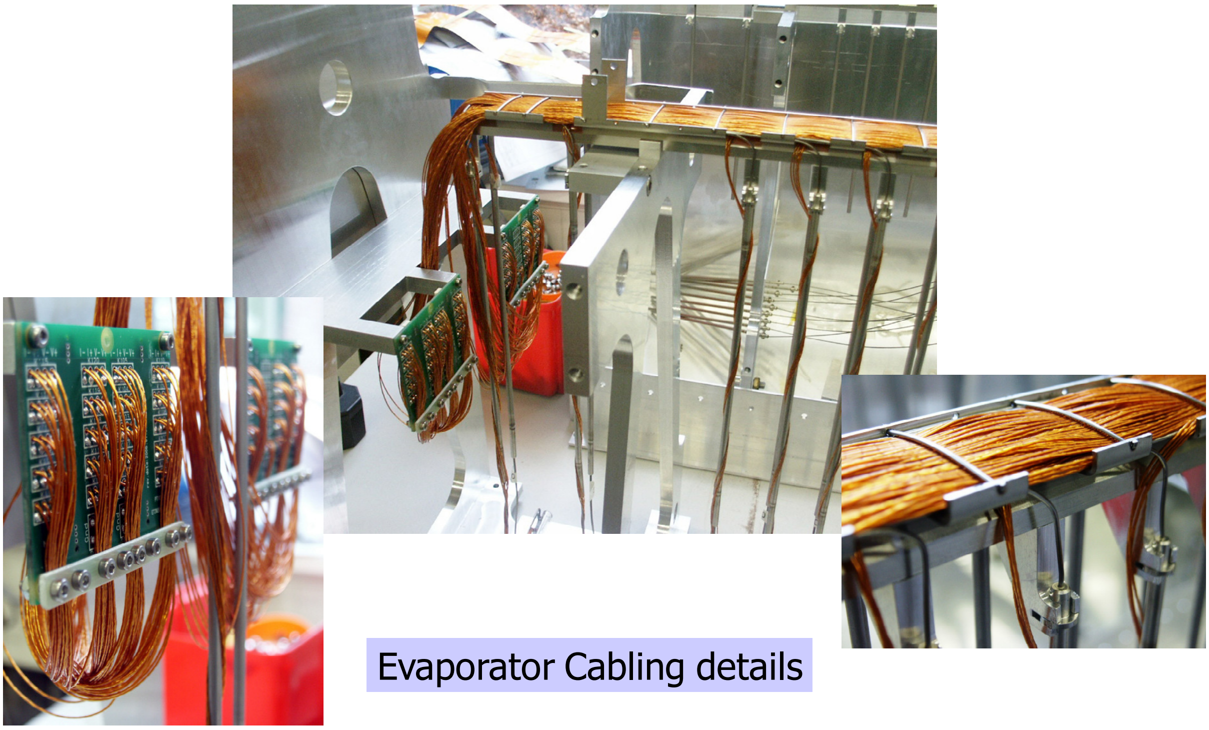



Figure 7.2-9: Evaporator PT100 cabling

### 7.2.2.1 **Evaporator cooling cookies**

The aluminum cooling blocks are casted around the cooling tube with a specially developed procedure (13), (12). The evaporator must have a low mass near the modules, to minimize distortion of the particle tracks. Aluminum has a low density and good conductive properties. Casting gives the freedom of applying material only at the place where it is needed. The thermal connection to the cooling pipe is achieved by the crimping of aluminum around it. The CTE differences between steel and aluminum clamps the aluminum around the pipe during cooling down. The shape of the cooling cookies is achieved by the stainless steel mould. The flat interface to the module is made by milling.

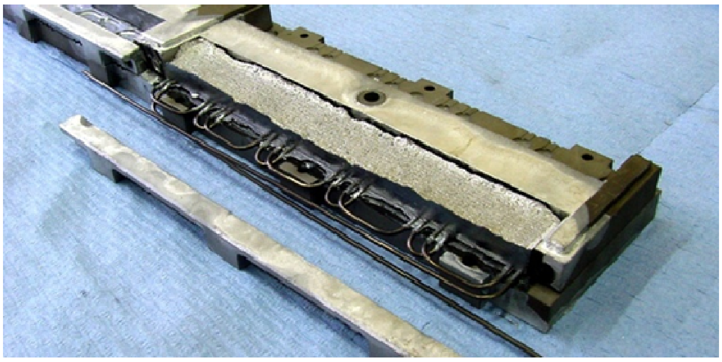


Figure 7.2-10: Aluminum cookie still in the casting mould

The melting of the aluminum is done in a vacuum oven. The aluminum flows perfectly in the mould under vacuum conditions ($<10^{-3}$ mbar) creating a smooth finish. The view of the cookies in Figure 7.2-5 is the result of the mould print. The best results were obtained with ACP 5080 (AlMg4,5Mn). The vacuum however causes the magnesium content to vaporize during the melting, which creates bubbles in the liquid aluminum. Solidification of the aluminum is done under a 1 bar argon atmosphere to suppress the created magnesium vapor. The vacuum oven was heated in1½ hour to 700°C, 10 minutes later the argon was applied, and another ten minutes later the oven was switched off. Figure 7.2-10 shows the fresh backed cooling cookie prior to machining.

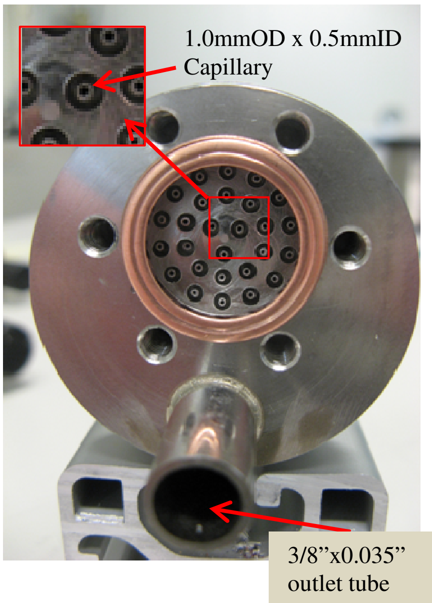



Figure 7.2-11: Evaporator inlet manifold and outlet connection.

#### 7.2.2.2 Evaporator capillaries

The VTCS evaporator has 23 parallel branches. The flow resistance of each branch depends on the amount of created vapor. The more vapor, the more flow resistance, the less fluid is floating through the branch. This is an instable situation since an increased heat load causes a decreased flow while an increased flow is needed.

In the VELO all the modules can be individually powered up. This means that the evaporator branches can be loaded as well on an individual basis. The vapor increase only has effect on the outlet of the evaporator branches. The fluid condition at the inlet is for all the branches the same and not dependent on the heat load of the specific branch. The flow resistance of the inlet must therefore be dominant over the outlet flow resistance.

In the VTCS this is achieved by an inlet capillary of 2038mm x 0.5mmID at each evaporator branch. The capillaries are routed inside the vacuum bellow to an interface on the outside of the VELO vacuum vessel. In this way all the branches can be reached from the outside for individual cooling or additional flow tuning (See Figure 7.2-11). The individual tuning is not done in the

VELO but one has the opportunity to do so when needed. All the capillaries have the same length. The extra length is stored in the U-channel on top of the manifold underneath the PT-100 cables. The branch stand-offs are mounted to the support bar underneath the cable channel (See Figure 7.2-12).

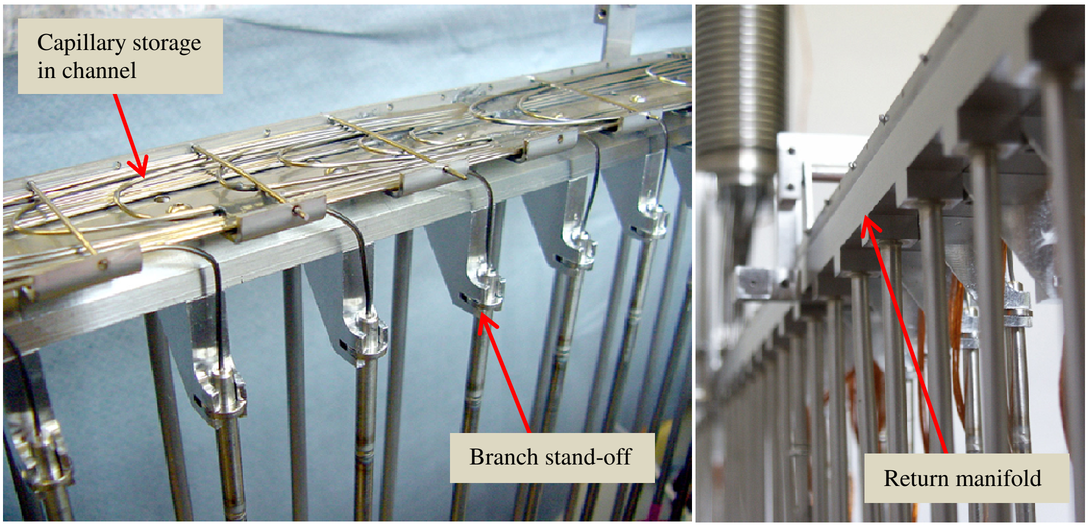



Figure 7.2-12: Capillary routing (Left) and return manifold (Right)

### 7.2.2.3 **Evaporator Manifold.**

The resistance of the outlet of the evaporator branches must be as small as possible not to disturb the flow distribution. Therefore the branches must be manifolded as close to the outlet as possible. The return manifold of the VTCS evaporator is the main support bar supporting all the parallel branches and is located underneath the cable channel. The manifold is a machined tube where the branch connections (4mmODx2.6IDmm) are brazed into (See Figure 7.2-12 right picture). The manifold sections are orbital welded to each other and to the outlet return hose.

### 7.2.2.4 **Evaporator terminal and evaporator vacuum bellow**

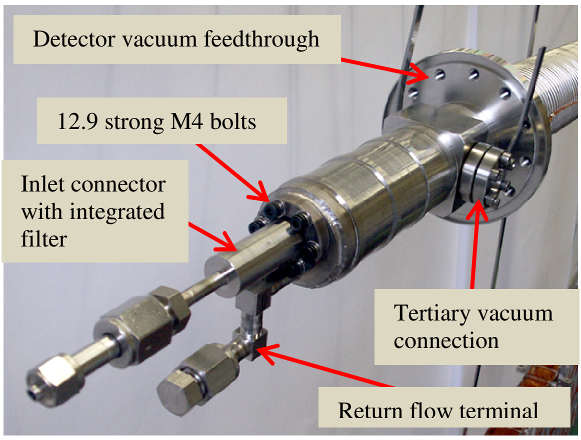


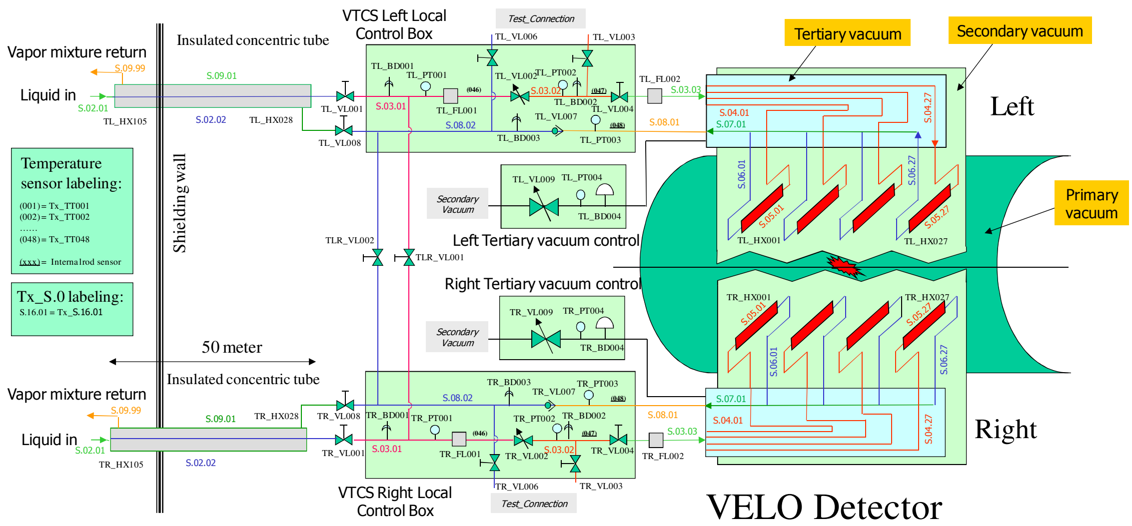

Figure 7.2-13: Evaporator terminal and vacuum connection.

The evaporator is flexible to allow the detector to move inside the vacuum. This movement is necessary if the particle beam is injected and tuned. The inlet capillaries and the return hose are the flexible parts of the evaporator. These flexing parts were considered to be a possible leak risk of the pressurized volumes. To minimize the risk of a $CO_2$ leak into the vacuum system an extra vacuum volume was created around the flexible hose and capillaries. The evaporator terminal (See Figure 7.2-13) is sticking out of the vacuum volume and consists of the connection to the $CO_2$ in- and outlet and the connection to the evaporator vacuum. The evaporator vacuum is a volume that is evacuated once. It has a vacuum pressure sensor

(Tx_PT004) and a burst disc in case of a pressure increase due to a $CO_2$ leak. The schematic of the vacuum lines is shown in the schematic of Figure 7.2-14.

The inlet of the evaporator is a conflate-16 connector with an integrated filter and is mounted with 6 M4 screws to the inlet capillary manifold using a copper gasket (See Figure 7.2-11) . The conflate is from origin a vacuum connector. It must be installed with strong grade 12.9 bolts and torgued to 4.5Nm. The calculation  is given in Figure 11.9-1 in the appendix.

## 7.2.3 Cooling bridge




*Tx* = *TL* for left detector half, *TR* for right detector half, *TLR* for combined hardware

Figure 7.2-14: VTCS schematics and hardware labeling in the VELO cavern.

The cooling bridge is the link between the transfer lines and the evaporator. All the components are housed in a box located above the VELO. The schematics of the bridge is shown in Figure 7.2-14. The transfer lines are fed into the alcove on the ceiling and enter the box from the left side. The TL and TR system have interconnects so both detectors can be connected to 1 tertiary system in case of problems with 1 system. The valves can only be operated manually.

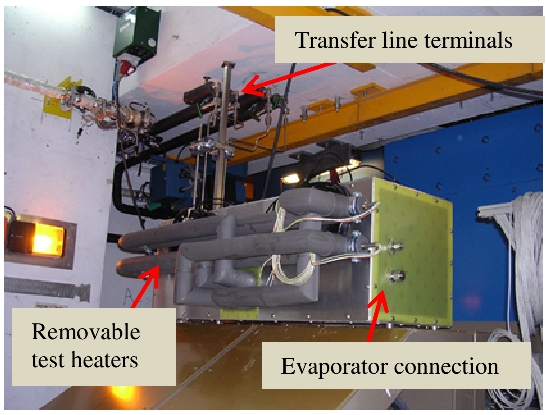



Figure 7.2-15: Cooling bridge above VELO

On the cooling bridge test heaters can be mounted to simulate a heat load. This is used for testing the VTCS without cooling the detector. The heaters are visible in the picture of Figure 7.2-15. During LHC operations, the heaters and their control are removed from the system as they are not radiation tolerant.

## 7.3 $CO_2$ system Transfer lines

The transfer lines are concentric tubes where the liquid feed line is located inside the vapor return line. Figure 7.3-1 shows a cross section of a transfer line with the insulation layer. The inner tube is laying lose inside the return tube and is not centered by spacers or so. It is bend a bit so it is jammed inside the return tube. The purpose of the transfer line is multiple. Besides from transferring the cooling fluid from the cooling plant to the evaporator and back, it has also an integrated functionality of conditioning the right liquid enthalpy of the evaporator inlet.

The transfer tube is a simple device, however its working is rather important and complicated. It serves a few purposes at the same time which also all rely on each other. An important feature is the heating of the inlet liquid line. The concentric layout functions as an internal heat exchanger where the cold liquid in the central feed line is heated to the right temperature by exchanging heat with the return flow in the outer annulus.

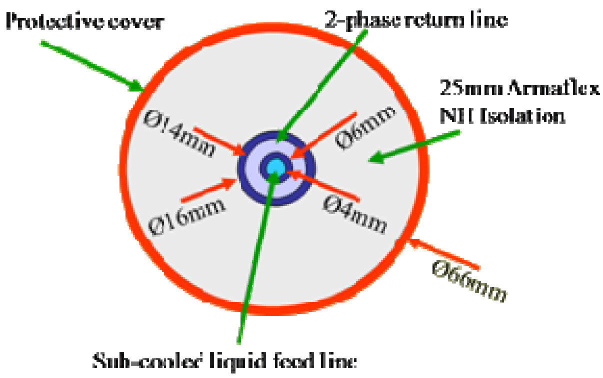



Figure 7.3-1: Transfer line crossection

The energy which is exchanged between the two lines can be more than there is absorbed by the system (detector heat load and environmental losses). One can say that the efficiency of heating is very high, but in fact the large temperature difference involved makes the system a very inefficient system from the point of heat transfer. The heat sink of the 2PACL is the chiller temperature. This is always around -40 ºC to -50ºC. The evaporator temperature can be set to higher temperatures. The transfer line has to cope with the difference between them. The limit of the highest possible evaporation temperature is determined by the conduction of the heat exchange surface of the concentric tube. The transfer tube can only exchange heat if there is some heat absorbed by either evaporator heat load or by transfer line environmental losses. This absorbed heat creates the necessary temperature gradient needed to exchange heat between the feed and return line. The temperature of the evaporator can never be higher than the environment in case of no evaporator power, as there is no heat absorbed to create a temperature gradient for a heat exchange. The environmental heat leak on the transfer tube is the driving factor for the permanent heat exchange, the detector power can be off while the detector still needs to be temperature controlled by the evaporator. This is why the heat exchanger is included in the full return line rather than a local heat exchanger in the detectors vicinity.

The maximum range of the 2PACL is the temperature of the evaporator under full liquid condition. From this point onwards the accumulator can let the evaporator boil until the sub cooled liquid temperature of the pump is approached. In practice the lowest accumulator temperature is a few degrees above the liquid temperature of the pump inlet. The working of the transfer line can be explained by Figure 7.3-2. Here one sees the temperature distribution over the tube length of the feed and return tube under 3 different accumulator set-point temperatures. Plot A shows the temperature distribution of the transfer line at a high set point of about 22ºC. The evaporator (at the right) is full with liquid of about 18ºC. The set point temperature is the dotted horizontal line. Lowering the set point will not change much in the temperatures until it passes the evaporator temperature. From this point on it starts to evaporate in the evaporator and the beginning of the return transfer line. Heat is removed from the

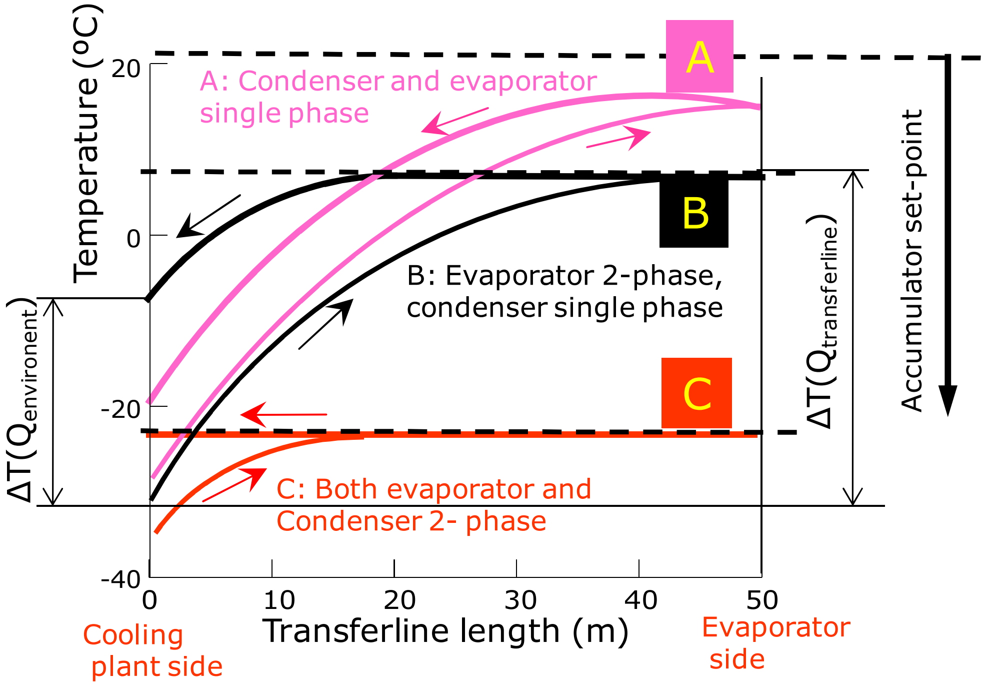



Figure 7.3-2: Transfer line temperatures at different operational states

return line to heat up the inlet flow so at a certain moment the return tube will become single phase again. This is illustrated in the plot B lines. Here the evaporator is 2-phase while the condenser is single phase and is in fact not a condenser but a liquid cooler. Lowering the set point even more will decrease the amount of internally exchanged heat, so the outlet of the transfer tube becomes 2-phase as well. This is illustrated by the lines of plot C. The transfer tube picks up a relatively large amount of heat from the environment. This is needed for a good transfer line operation. The amount of pick-up heat increases with a lower set point. As long as the outlet of the return tube is single phase the difference between the inlet of the feed line and the outlet of the return line temperature is a measure of the amount of picked up heat from the environment.($Q = \dot{m} * C * \Delta T$). This ΔT is shown as an example for the plot B situation. This environmental heat is less than what is exchanged in the transfer line. The ΔT of the exchanged heat in the transfer line is illustrated on the right of the plot B example. The transferred heat increases with setpoint, the environemental heat decreases due to a higher average transferline temperature. The above example shows the independence of the sub cooled liquid heating and the amount of absorbed environmental heat.

The plots in Figure 7.3-2 show just an example of principle. The temperatures do not match with the VTCS. In paragraph 9.4 a detailed simulation of this behavior is shown. Simulations show that the maximum possible set point temperature is at $-10$ºC. Measurements have shown that for the VTCS it is around -5ºC.

# 7.4 *$CO_2$ system circulation plant*

## 7.4.1 $CO_2$ plant schematics

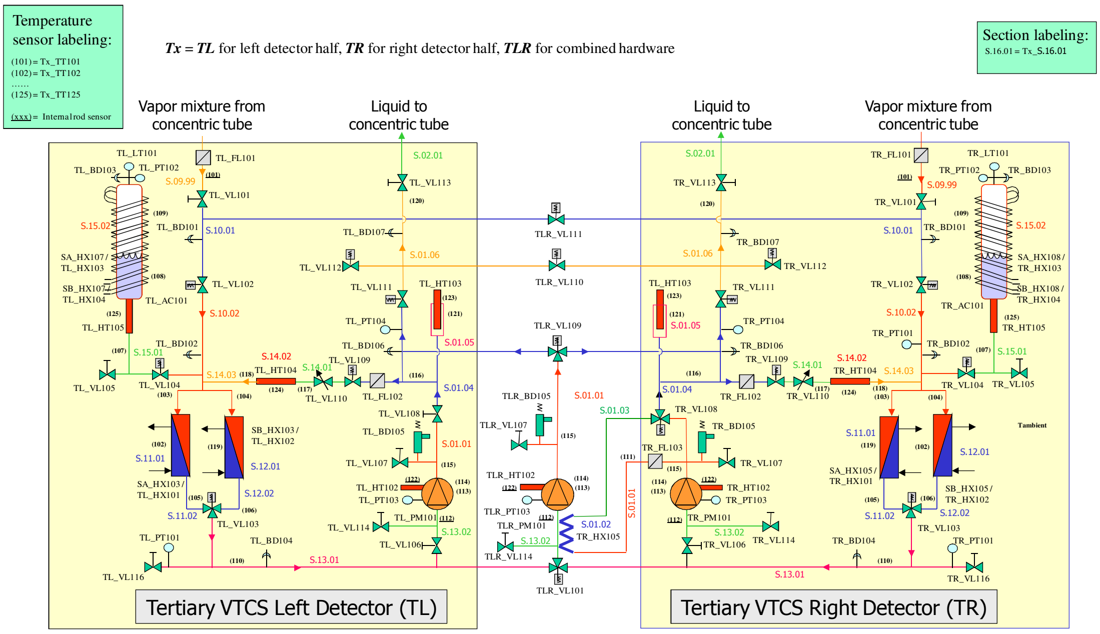



Figure 7.4-1: $CO_2$ plant schematics.

Figure 7.4.1 shows the schematics of the $CO_2$ plants. A large scale copy of the layout can be found in the appendix at paragraph 11.1. A full list of the components in the tertiary systems is given in the parts lists in the appendix. Paragraph 11.2 shows a list of all the sensors, 11.3 shows a list of actuators and 11.4 shows all the passive line components. The TL and TR are identical except from the TLR pump cooling heat exchanger. This TLR cooling is only present in the TR system. For the rest the 2 systems are identical and are more or less mirror oriented to each other.

Each system has 1 pump with oil bath heating and a pulse damper. Each pump can be shut-off from the system in case of pump maintenance. These are the valves Tx_VL106 and Tx_VL108. Valves Tx_VL114 and Tx_VL107 are used to flush the pump with $CO_2$ after the maintenance. The pump may never be evacuated as it damages the Teflon membrane. A by-pass is present to circulate the fluid internally via a liquid heater. The liquid heater can be used to supply heat for testing. The by-pass has a restriction valve (Tx_VL110) which is set to the same pressure drop as the transfer line and evaporator resistance.

Two condensers are present. One is connected to the SA chiller one to the SB chiller. The condenser flow can be selected by 3-way valve Tx_VL103. The accumulator is connected above the condensers and can be shut-off from the system with valve Tx_VL104. An external valve Tx_VL105 is connected to the accumulator and is used for filling. A second external valve (Tx_VL116) is present on the outlet of the condensers.

Both systems are interconnected with valves TLR_VL110 and TLR_VL111. These can be used in case of a serious problem with one of the systems. They are not used in the current back-up procedures. The valves can be used to evacuate both systems together prior to filling. Opening the valves during normal operation mixes up the fluid content resulting in unknown fillings of both system.

The plant can be shut-off from the transfer line with the manual valves Tx_VL101 and Tx_VL113 . Manual valves must always be in the original position as the PLC cannot identify the status.

Each section which can be closed off from the rest of the system has a burst disc to minimize the damage of a cold liquid trap expansion. Only the pump discharge has a spring relieve as the fast pulses can break the burst disc at lower pressures. Both relieve types open at around 130 bar.

### 7.4.2 Accumulator

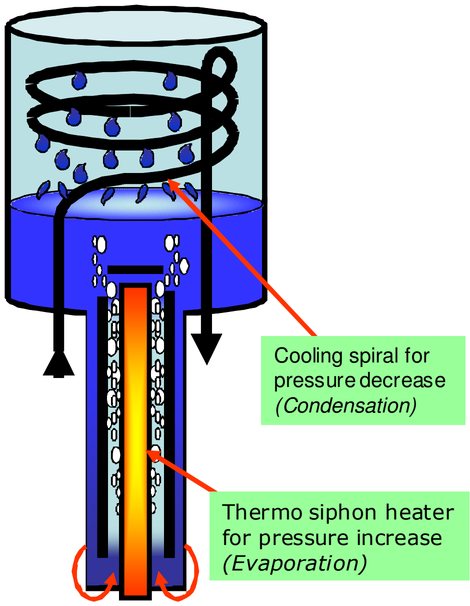



Figure 7.4-2: Principle of the $CO_2$ accumulator

The main control of the system is the accumulator. It regulates the pressure in the system and hence the temperature in the evaporator. The accumulator size, together with the fluid filling of the system is designed such that there is in all cases a liquid and vapor mixture present. With the 2-phases present the pressure can be increased by evaporating part of the liquid, the pressure can be decreased by condensing part of the vapor. The heater must always be submerged to prevent dry-out of the heating surface. The cooling spiral must have a significant portion in the vapor volume. A partly submerged cooling spiral is not a problem. The heater is located in a thermosyphon underneath the accumulator, the thermosyphon allows the heater to remain in full contact with a small remaining volume of liquid. Figure 7.4-2 shows the principle of the accumulator with the thermosyphon heater and the cooling spiral. Figure 7.4-3 and Figure 7.4-4 show pictures of the accumulator hardware.

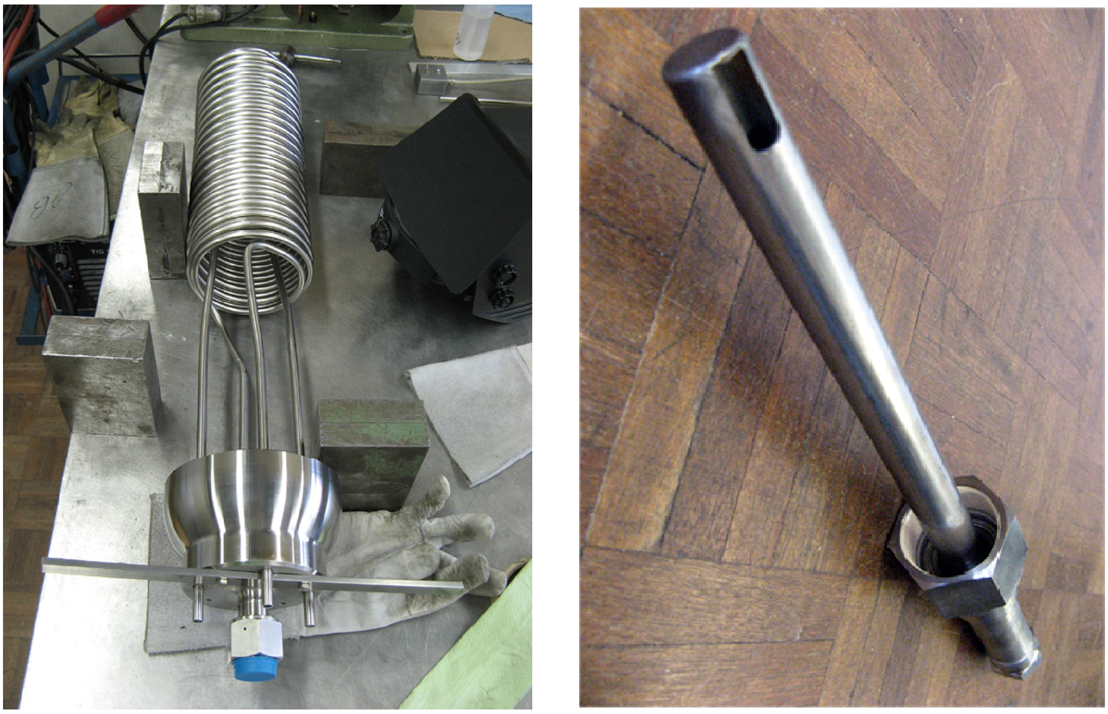


Figure 7.4-3: Accumulator cooling spiral (left) and thermosyphon heater (right)

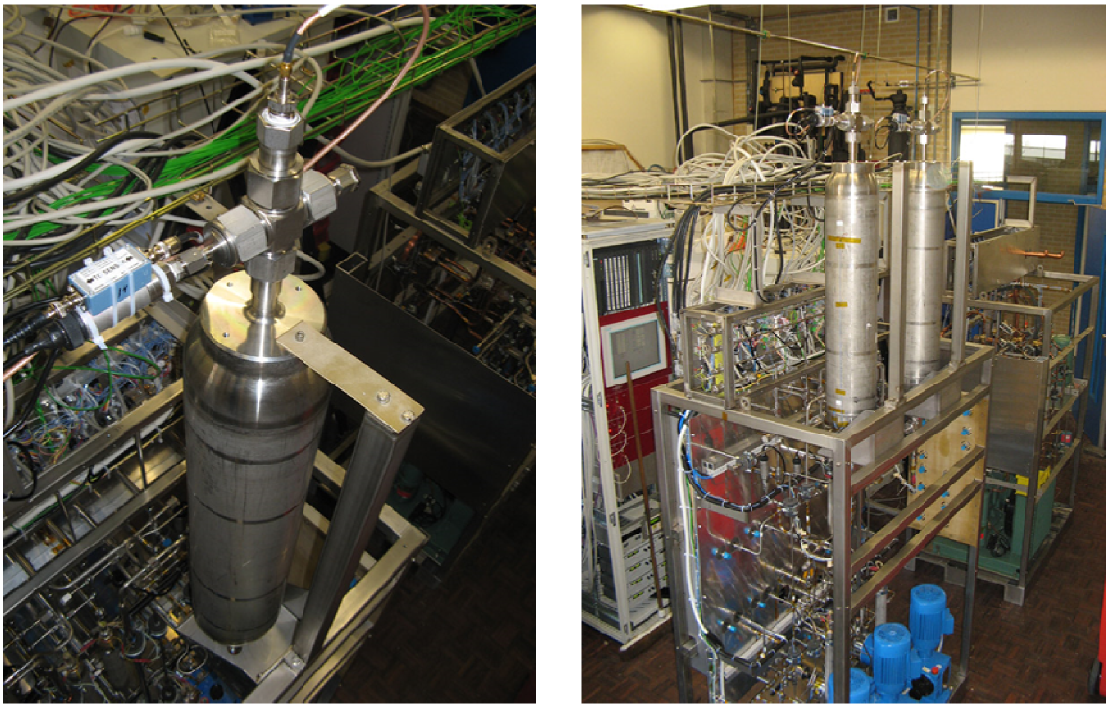


Figure 7.4-4: Accumulator in the cooling plant.

The thermosyphon heater is a 1kW heater. The convective cooling flow around the heater is a function of the density difference between the liquid and the vapor. $CO_2$ has its critical point at 31ºC. Near the critical point the liquid/vapor density ratio is decreasing resulting in a reduced convective flow around the heater. Around 50 bar (14ºC) the convective flow is insufficient for the 1kW of the heater, so the maximum heater power must be reduced with increasing accumulator temperature. Figure 7.4-5 shows the measured dependence of the maximum heater power as a function of the accumulator saturation temperature.

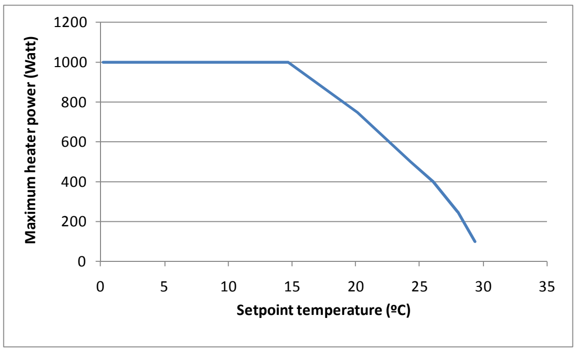



Figure 7.4-5: Maximum accumulator heater power

The densities of the liquid and vapor near the critical point change rapidly. The liquid level is not only a function of the fluid mass it also depend a lot on the density ratio of the liquid and vapor. Figure 7.4-6 shows a plot of the liquid level of a $CO_2$ filled accumulator as function of saturation temperature for several fill grades. The dashed line is the level when filled with 468 g/l, which is the density in the critical point. The liquid level of lower fill grades decreases with increasing saturation temperature, while at higher fill grades it increases with saturation temperature. The dependence of the level to the saturation temperature is important to realize, as the level decreases without exchanging fluid with the system.

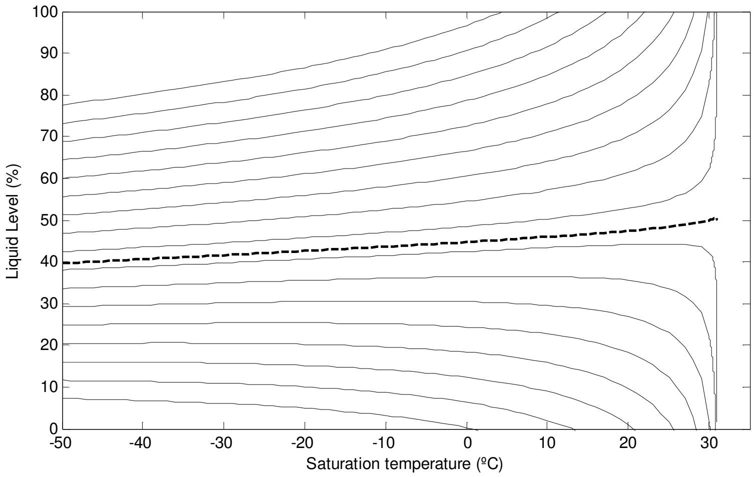



Figure 7.4-6: Accumulator liquid level as function of temperature and filling

At low fill grades the level decreases with increasing temperature, this phenomena must be taken into account when sizing an accumulator. It shows that the minimum level occurs at start-up. At start-up the loop is fully filled with liquid and the accumulator saturation temperature is high. These conditions determine the minimum filling of the system.

The accumulator is an in-house fabricated vessel. It has a volume of 14.2 liter and is the most important component with respect to pressure safety. The VTCS safety document (8) gives a detailed design and testing overview of this custom made pressure vessel.

### 7.4.3 LEWA LDC-1 liquid pump

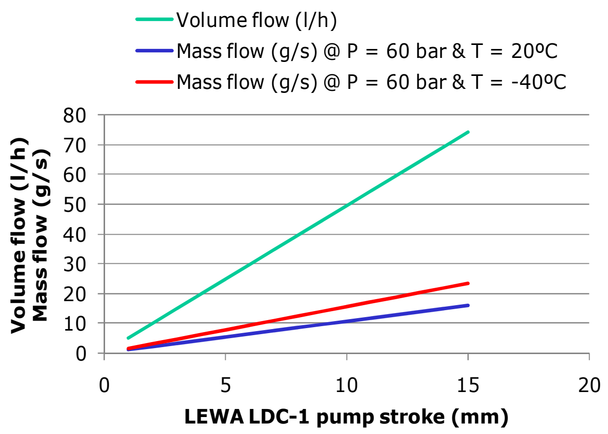



Figure 7.4-8: Pump flow as a function of the stroke setting

Figure 7.4-7: The LEWA LDC-1 metering pump

Each $CO_2$ system has one liquid pump (TL_PM101 and TR_PM101). One spare pump (TLR_PM101) is available for both halves and can be connected to any of the 2 systems by the 3 way valves TLR_VL101 and TLR_VL109. The two 3-way valves always operate together in a procedure so that the fluid content of TL cannot be mixed up with the content of TR. The pumps are LEWA LDC-1 membrane metering pumps and provide a constant volume flow. The pump head can be as high as 100 bar. The volume flow of the pump is constant and can be set manually with the black-knob on the side of the crankshaft (see black knob in picture of Figure 7.4-8). The adjustment is achieved by changing the stroke of the membrane. Figure 7.4-9 shows the obtained volume flow as a function of the stroke setting. The resulting mass flow is also a function of the pumped density. The green and red lines are the pumped mass flow at two temperature extremes of 20ºC and -40ºC. The default stroke setting is 7mm, resulting in a 10 g/s mass flow under cold operation.

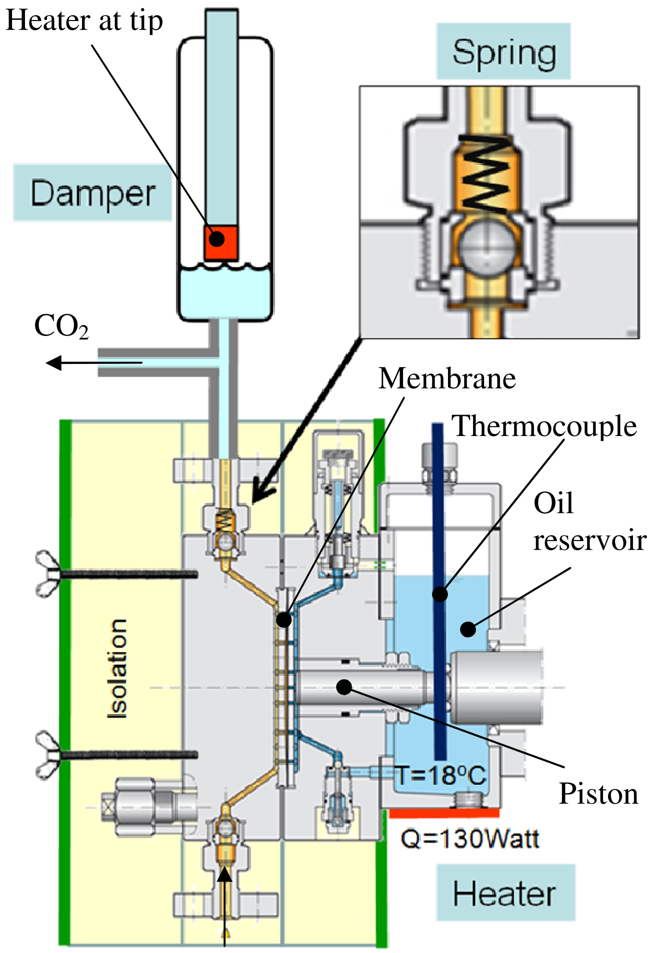



Figure 7.4-9: Cross section of the LEWA metering pump

The Teflon membrane is displaced hydraulically with oil. In this way the membrane is homogeneously stressed by the constant back-pressure. Figure 7.4-7 shows a cross section of the hydraulic part of the LEWA pump. The oil is displaced by a piston which is connected to the crankshaft and electric motor. The membrane has two Teflon layers so that a leak in one membrane is not polluting the $CO_2$ with oil. A pressure switch is connected to the volume in between the membrane layers, which is filled with alcohol of 1 bar. A pressure increase of the alcohol volume is a direct consequence of a leak to the high pressure volumes of either the oil or $CO_2$ side. The pressure switches act at a measured pressure of 10 bar, resulting in an immediate pump shut-down. The TLR pump will be automatically switched on as a replacement.

The LEWA pump is used to pump cold liquid, therefore the pump head is insulated. The oil in the pump head is becoming cold too. There is a small flow of oil from the pump head to the reservoir. The oil in the reservoir may not become cold as moisture will get in the open oil bath. A heater (Tx_HT102) is placed underneath the oil reservoir to maintain the oil at 18ºC. The oil temperature is measured using Tx_TT122 and is a rod thermocouple dipped in the oil bath. The heater control is done by the PLC PID control. Figure 7.4-7 shows the heater and thermocouple location with respect to the oil bath.

The pump flow is directed by 2 no-return valves. A ball is laying on a seat at the in- and outlet of the pump head. The balls are put in their seats by gravity. The pump is modified with an extra spring loading on the exhaust to prevent bouncing. The pump provides a pulsed flow. A damper is placed in the discharge liquid line to dampen the pressure pulses by creating a compressible gas volume in the damper. Figure 7.4-7 shows the damper and ball valves. Details about the dampers are given in Paragraph 7.4.5.

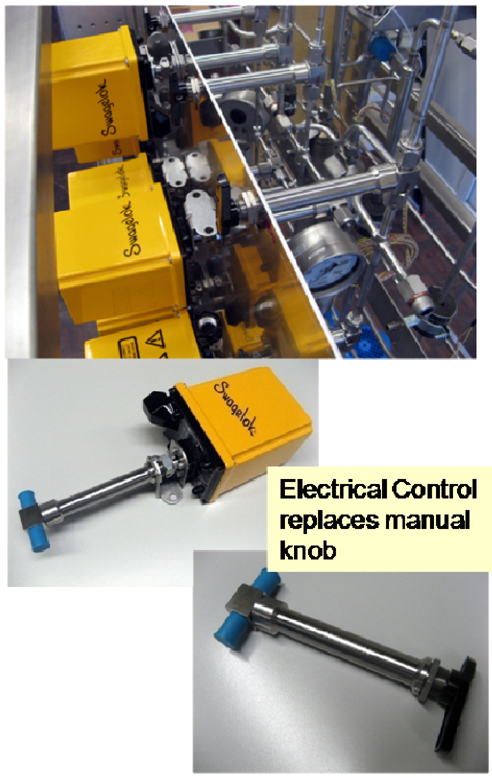



Figure 7.4-10: Swalok 43G 2-way valves with extensions.

### 7.4.4 Valves

6 valve types are used in the $CO_2$ systems. Below the valve types are discussed. A detailed list of all the valves used is given in the appendix in paragraph 11.3.1.

#### 7.4.4.1 2-Way valves

In the cooling plant all the 2-way valves are Swagelok 43G series valves. (SS-43GHLVCR4). The valves have been modified with an extension so they can be mounted to a warm panel. All the valves are mounted on the front panel of the $CO_2$ plant unit. The valves can be equipped with a manual knob or an electrical motor. The flow path of the ball valves is a T-shape. With a T-shape the valve can be closed but liquid can never be trapped. Trapped cold liquid can give very high pressures when warmed up and so the valve will be damaged.

The ball valve seats are made of Teflon. Teflon is not radiation resistant. Therefore other 2-way valves are used in the cooling bridge on top of the VELO these are SS-4UW-TW and are full metal shut-off valves. All of them are manual.

#### 7.4.4.2 **3-Way valves**

The 3-way valves have the same handle interface as the 2-way ones (SS-43GXVCR4). The same extension concept is used. All the 3-way valves are panel mounted and equipped with an electrical motor.

Figure 7.4-11: Valve mounting panel of the $CO_2$ plant.

#### 7.4.4.3 **Restrictor valves**

Restrictor valves are present in the cooling bridge (Tx_VL002) and the by-pass in the plant itself (Tx_VL110). They throttle the flow such that the pumps have a pressure head of about 10 to 20 bar. Low pressure heads cause the pump to malfunction. A high pressure in the supply lines also suppresses the risk of vapor in the supply lines. The used valves are SS31RS4 valves and have a onetime adjustment. The Teflon shaft seal of the valve in the cooling bridge (Tx_VL002) is replaced by Viton O-rings.

#### 7.4.4.4 **No return valves.**

A no return valve is present in the cooling bridge in the return line. The valve must prevent back flow in case of a leak of the evaporator in the vacuum tank. See details about this in paragraph 7.7.5. The valve is a modified Swagelok Swagelok SS-58SW8T. The full metal poppet is replaced by an o-ring sealed poppet.

#### 7.4.4.5 **Relieve valves.**

Relieve valves are present in the pump discharge lines. The relieve valves are Swagelok SS-4R3A-EP and have the label Tx_BD105. Originally these were burst discs as present in each closed section. The pump pulses caused the burst discs to burst sometimes when pumping against a closed valve due to the short time pressure peaks. A relieve valve acts more as a slow fuse and is therefore not delicate for short time pressure peaks. The relieve valves have the same pressure setting as the burst discs which is 130 bar.

### 7.4.5 Vibration dampers

The damper is a 500cc reservoir with a heater inside to generate vapor. The heater is a rod heater with a heating element only at the tip. The liquid from the liquid line is vaporized and rises into the reservoir. The gas damps the pulsed flow which is directly fed into the damper. The ongoing flow is perpendicular to the damper and not floating through the damper. The heat generation does not reach the flowing liquid.

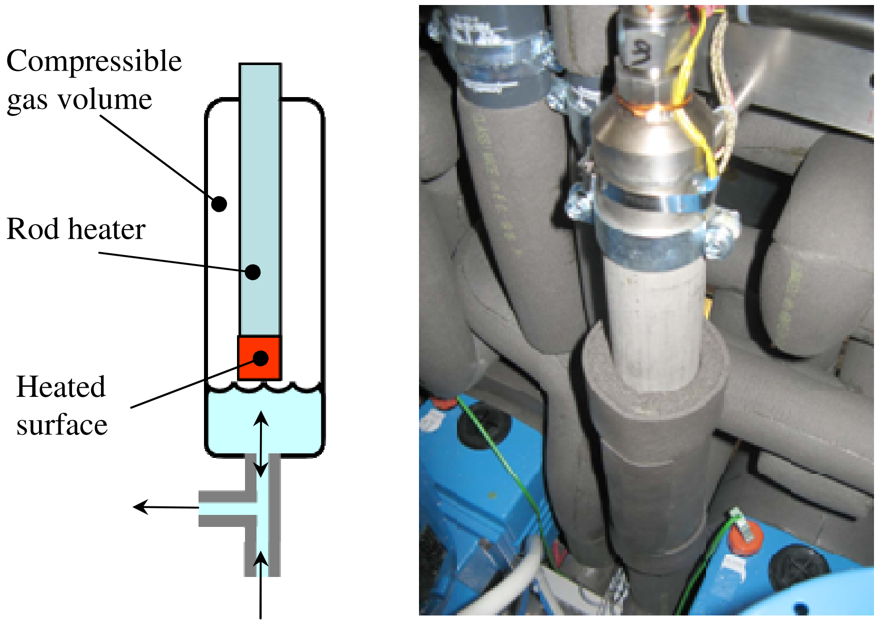



Figure 7.4-12: VTCS Pulse damper

## 7.5 *$CO_2$ condensers*

The condensers are reinforced brazed plate heat exchangers from SWEP. They are reinforced because of the high pressure of the $CO_2$. The reinforcing metallic plates protect the heat exchangers from bursting. The $CO_2$ operates with pressures up to 100 bar (170 bar proof pressure), while R507a on the other side has low pressures. The internal structure of this heat exchanger must withstand this pressure difference as well. A special double wall heat-exchanger from SWEP was used. This B16DW series has double plates and a small wave pattern. This combination makes the plate heat exchanger suitable for withstanding these high differential pressure. The VTCS safety document (8) gives a detailed design and testing overview of this custom made heat exchanger. Figure 7.5-1 shows the reinforced condesnsers installed in the $CO_2$ rack.

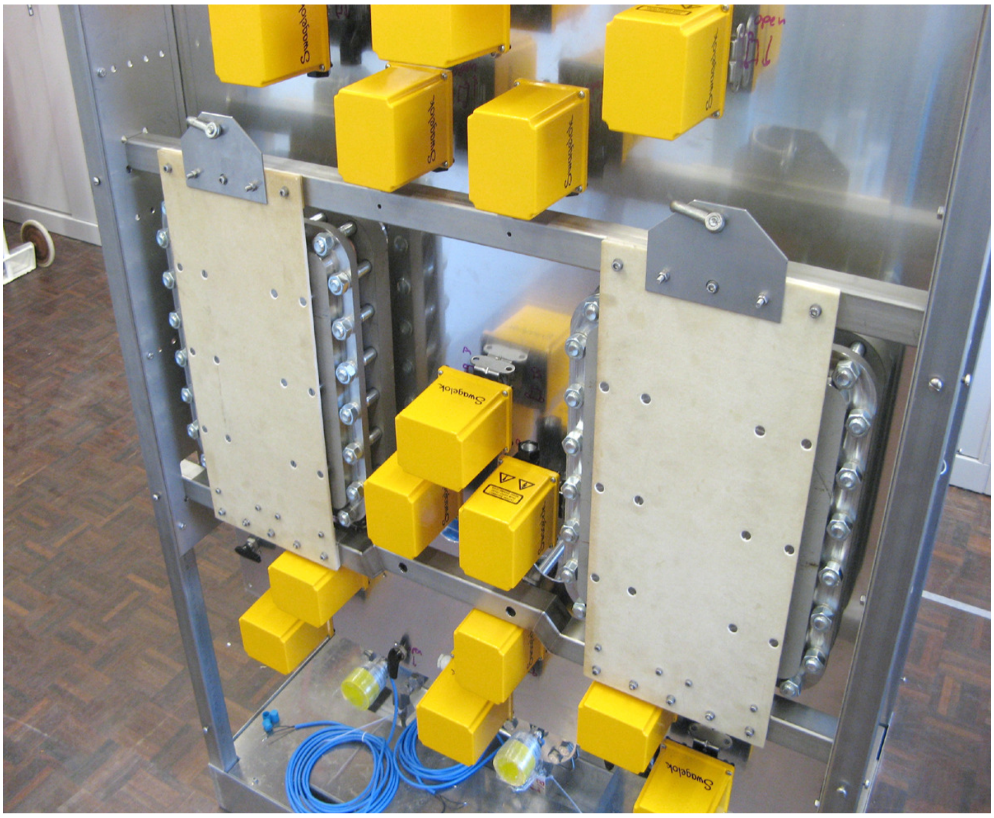


Figure 7.5-1: Reinforced $CO_2$ condensers.

## 7.6 *$CO_2$ system volume and charge*

The accumulators must always have a liquid/vapor mixture to maintain the set-point pressure in the loop. The heater must stay submerged which determines the minimum level, while the cooling spiral must have a significant fraction in the vapor volume. The accumulator volume can be determined by analyzing the total loop mass and verify at a certain filling or a 2-phase mixture is still present in the accumulators. Table 7.6-1 shows the volumes of the main sections of the $CO_2$ systems.

Table 7.6-1 Summary of the Tertiary volume.

| Subsystem | TL volume (ml) | TR Volume (ml) |
|---|---|---|
| Evaporator | 220.0 | 220.0 |
| Liquid feed | 944.4 | 957.8 |
| Vapor return | 6213.7 | 6062.4 |
| SA-Condenser | 311.4 | 310.8 |
| SB-Condenser | 128.4 | 127.8 |
| Liquid suction | 59.1 | 59.1 |
| By-pass | 260.7 | 260.7 |
| Dampers | 605.0 | 605.0 |
| Accumulator | 14203.0 | 14203.0 |
| Total system volume | 22969.0 | 22822.6 |
| Loop volume | 8766.0 | 8619.6 |
| Plant volume | 15728.6 | 15748.5 |
| Transfer volume | 7240.4 | 7074.2 |

The loop filling is calculated in the state point model. See chapter 9 for details of the state point model. A detailed overview of the results is given in the appendix in Table 11.5-5 for the TL system and Table 11.5-6 for the TR system. The tables show the nominal powered case.

The liquid level in the accumulator changes as a function of the set-point temperature and the applied load. Figure 7.6-1 shows the simulation results of the TL liquid level as a function of set point. The worst case low level occurs at high set point and an unpowered loop. The worst case high level at low set points and maximum heat load. Both systems need to be filled with 12kg $CO_2$ in order to have a liquid level in range at any time during any operation.

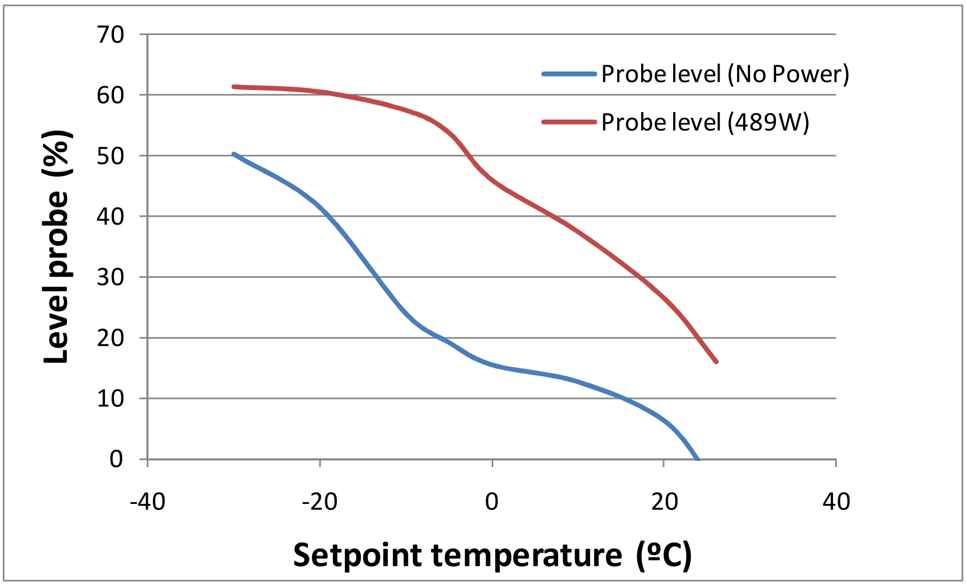


Figure 7.6-1: TL accumulator liquid levels

## 7.7 *$CO_2$ system operation and control*

### 7.7.1 Accumulator control

The main control of the VTCS is the accumulator pressure control. The accumulator pressure is a direct measure of the evaporator temperature. By heating and cooling the liquid content in the accumulator is varying by evaporation or condensation. As the accumulator is able to variate the fluid content in the system, it can also empty it or fill it with liquid. The filling option is used at start-up, the emptying procedure is used for maintenance. Figure 7.7-1 shows the principle of the accumulator control.

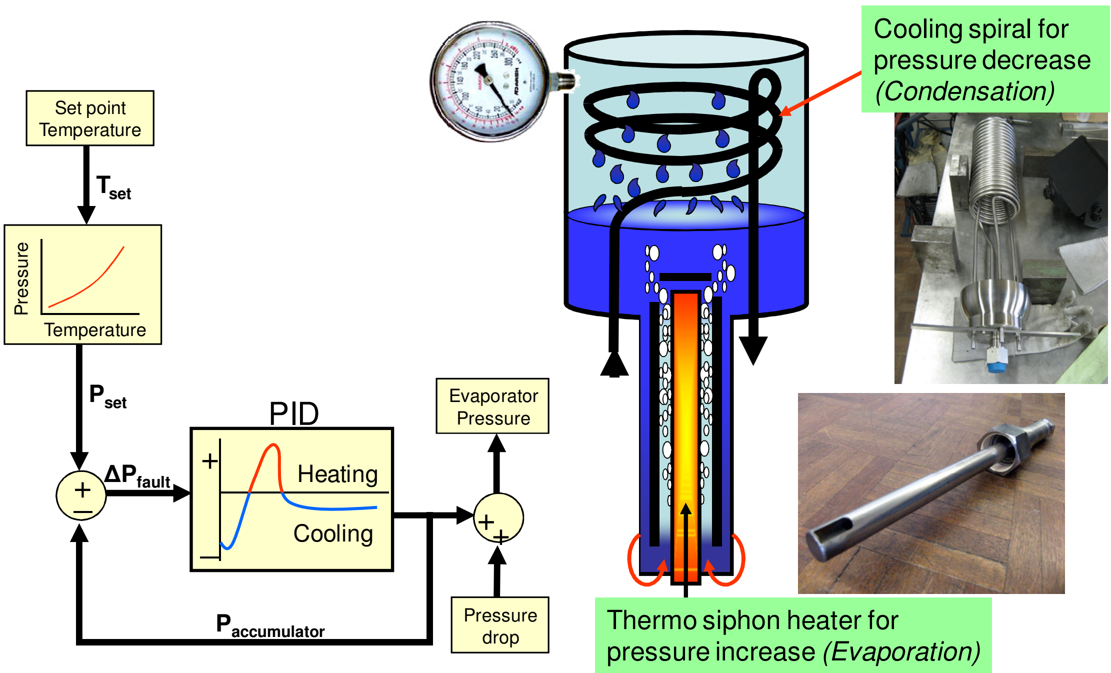



Figure 7.7-1: Accumulator control principle

The LHCb-VTCS accumulator pressure control is a bipolar PID-process, it regulates both the heater element (Tx_HT105) and the expansion valve to the cooling spiral (Sx_VL114/Sx_VL119). Which of the two expansion valves is controlled depends on whether the main (SA) or backup chiller (SB) is used. The cycle time of the PID process is 100 ms. A detailed description of the accumulator control is written in the PLC technical description (10).

Input to the PID-controller are the actual pressure in the accumulator (Tx_PT102) and the saturation pressure of the set-point temperature (see Figure 7.7-2). The PID controller only uses the P-action with a gain-factor of 100. The PID process has upper and lower limiters which limit the output to guarentee a good system operation. The upper limiter limits the heater in case of a dry-out of the heater, the lower limiter limits the cooling in case the accumulator saturation temperature is approaching the pumped liquid temperature, as a too low sub cooling causes cavitation in the pumps.

#### 7.7.1.1 Accumulator control at start-up

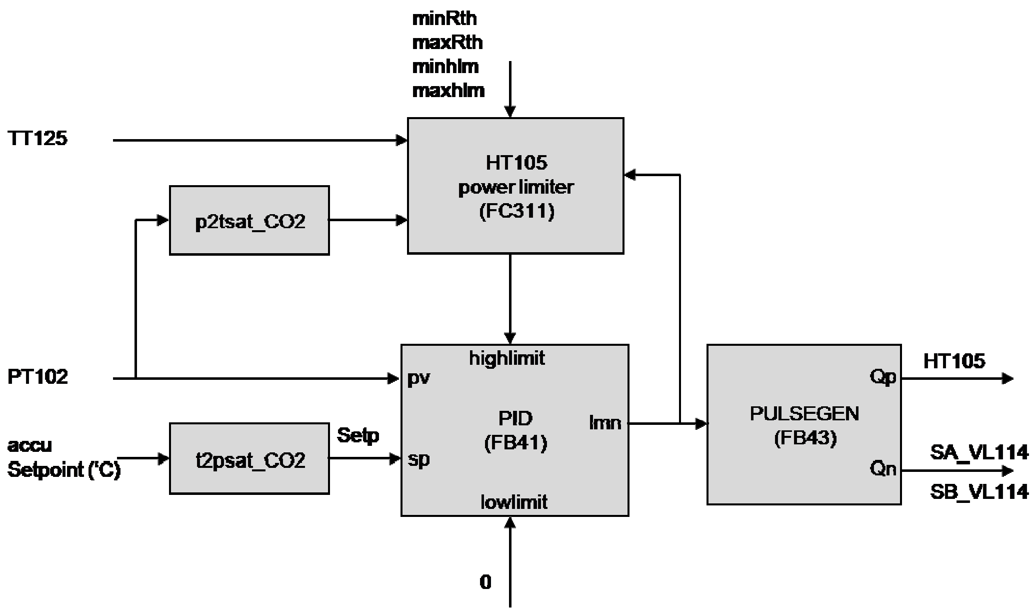



Figure 7.7-2: Start-up accumulator control of the VTCS

During startup the accumulator is heated for a long time. The heater is evaporating liquid and generates vapor in the accumulator. The increasing pressure pushes liquid from the accumulator into the loop. The existing vapor in the loop is condensing to liquid when the saturation temperature is getting above the ambient temperature. At start-up a set-point temperature of 6ºC above the temperature of the pump inlet (Tx_TT112 ) is taken. The maximum start-up set-point is cut-off at 26ºC. A start-up of a cold system can go fast without heating. If the sub cooled temperature of Tx_TT112 is already lower than the required ΔT of 6ºC, the threshold is reached immediately and the system starts directly without an accumulator heating action.

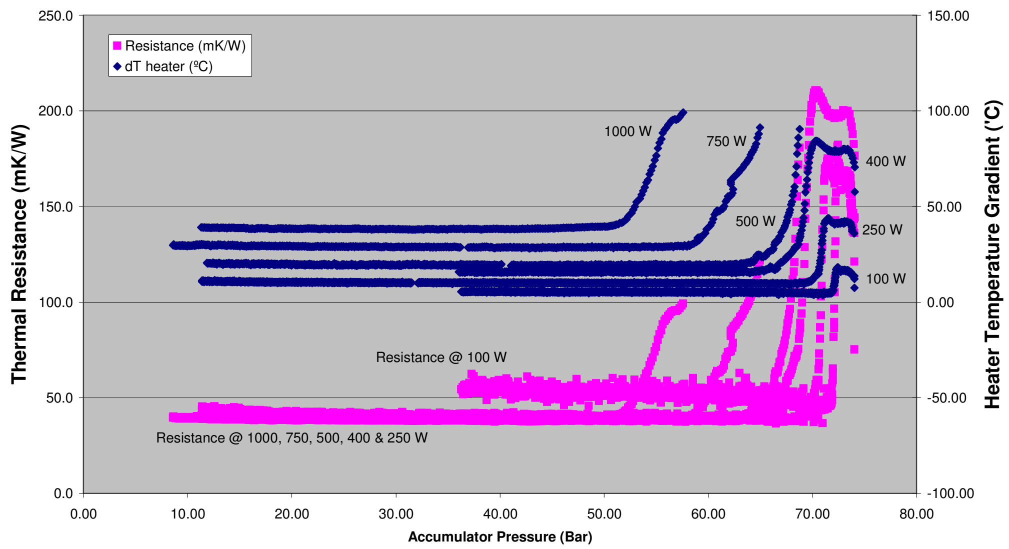



Figure 7.7-3: Accumulator heater performance

At higher pressures (temperatures) not all power of the heater can be transferred to the liquid $CO_2$ and the risk of overheating exists. The $CO_2$ is supplied to the heater by a thermosyphon configuration. At increasing pressures the density ratio between the liquid and vapor is decreasing resulting in a less convective fluid flow. To compensate for the reduced flow the upper power limiter in the PID control limits the heater power to avoid dry-out. Figure 7.7-3 shows the measured temperature difference of the heater with respect to the saturation temperature (blue lines). For each applied power it is constant until dry-out occurs. The pink lines show the calculated heater resistance which is denoted as:

$$R_{th} = \frac{T_{heater} - T_{saturation\_accu}}{Power}, \quad \text{Equation 7.1}$$

Where $T_{heater}$ and $T_{saturation\_accu}$ in °C and Power in Watts which is derived from the output (lmn) of the PID-controller.

The resistance of the heater is not depending on the heater power, only at low powers (100 Watt) it shows a dependency. The heater limiter is limiting the output power with the relation as shown in Figure 7.7-4.

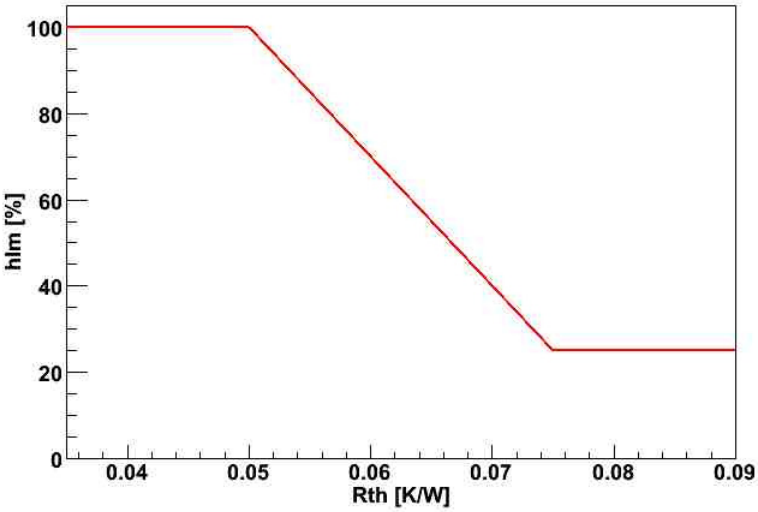



Figure 7.7-4: High limit as function heater resistance

In order to avoid jumps in the PID process, the high-limit used by the PID process is the moving average of the last 10 calculations. During the accumulator heating stage and subsequent stages up to the cooling of the accumulator, the low-limit of the PID process is kept a 0.

#### 7.7.1.2 **Accumulator control during operation**

When the cooling system reaches the stage where the cooling of the accumulator starts, the above mentioned control of the high-limit based on thermal resistance is replaced by a joint high- and low-limit control based on the sub cooling conditions of the pump as shown in Figure 7.7-5. Sub cooling is defined as the difference of the saturation temperature of the accumulator (from pressure) minus the temperature at the inlet of the pump (Tx_TT112).

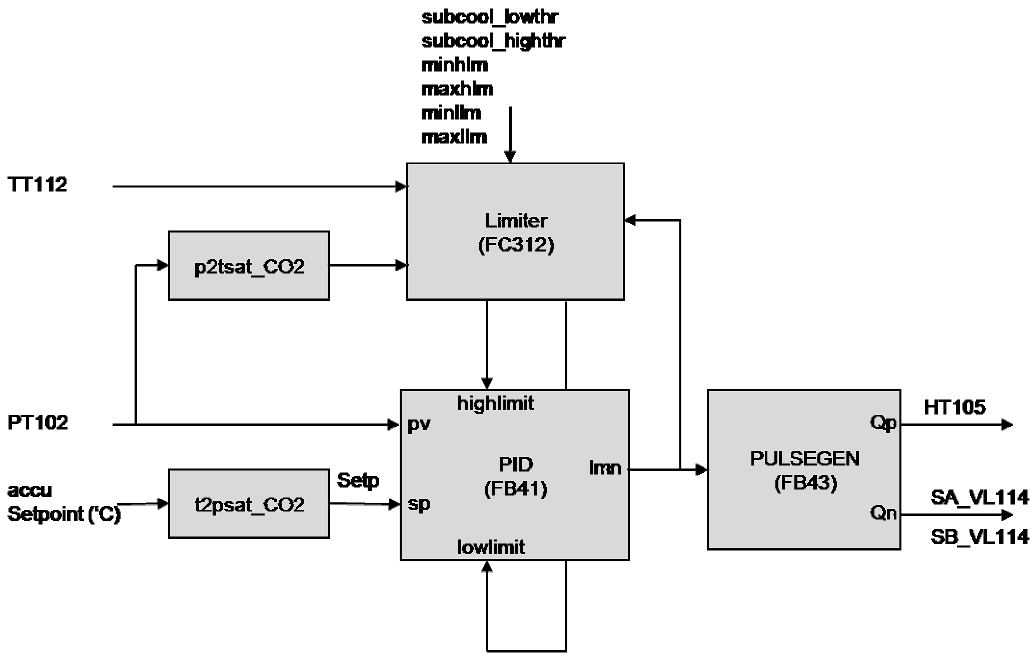



Figure 7.7-5: Operational control of the VTCS accumulator

During normal operations the accumulator saturation temperature must be maintained at least a few degrees above the pump sub cooled temperature (Tx_TT112). If the sub cooling is insufficient the pump can cavitate resulting in a stop of the liquid flow. If the accumulator saturation temperature is getting to close to the sub-cooled temperature, the accumulator cooling power must be reduced. The lower limiter of the PID process is limiting this cooling output with the relation as shown in Figure 7.7-6.

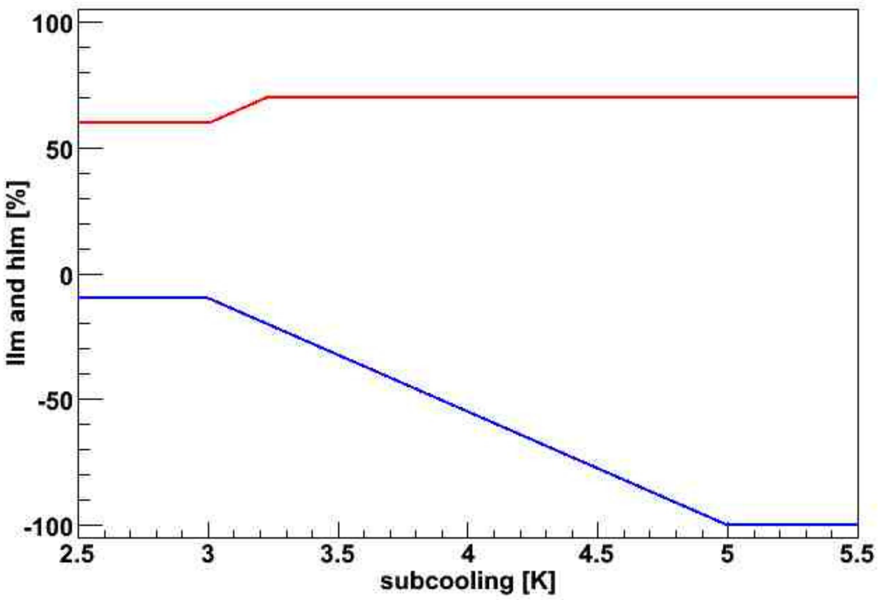



Figure 7.7-6: VTCS low and high limit settings as a function of the sub cooling

The upper limiter based on heater thermal resistance used at start-up is replaced by limiter based on sub cooling too. A heating action in the accumulator pushes saturated liquid into the system which can have a sub cooling increase as a result. Here the heating power is also limited based on sub cooling conditions.

### 7.7.2 Heater control and safety.

The $CO_2$ system has 4 heaters per system. One heater to maintain the pump oil at room temperature (see paragraph 7.4.3). One heater in the vibration damper (see paragraph 7.4.5) one heater in the bypass circuit to test the system under load conditions and the accumulator heater (See paragraph 7.4.1).

Heaters are the most dangerous elements in a cooling system. Liquid heaters have in general a very high heat density. If a liquid heater is switched on without a provided coolant flow it can dry-out with high temperatures as a result. The heaters are within the insulation and have therefore no convective cooling as emergency. Often a heater failure will result in a fire of the insulation material, which is a very serious issue.

In the VTCS a triple redundant fail safe approach is used concerning heaters. The first level is a warning threshold of the heater internal temperature sensor. The PLC will turn-off the heater involved. The second protection is a higher threshold of the same sensors. The PLC will shut-off all heaters. This is done to avoid the possible mistake of a temperature sensor swap. The third level of protection is an independent thermal switch (clixon) on the outside of the tubing. All clixons are mounted in series and are normally closed. Opening up 1 clixon will break the circuit and will directly open the main heater relay independent of the PLC.

Table 7.7-1 Heater alarms and warnings

| Heater label | Function | Temperature sensor label | Warning level (ºC) | Alarm level (ºC) | Clixon level (ºC) |
|---|---|---|---|---|---|
| TL_HT102 | TL pump oil heater | TL_TT122 | 40 | 50 | 70 |
| TL_HT103 | TL press damper heater | TL_TT123 | 120 | 160 | 90 |
| TL_HT104 | TL by-pass heater | TL_TT124 | 80 | 120 | 90 |
| TL_HT105 | TL accumulator heater | TL_TT125 | 120 | 160 | 90 |
| TR_HT102 | TR pump oil heater | TR_TT122 | 40 | 50 | 70 |
| TR_HT103 | TR press damper heater | TR_TT123 | 120 | 160 | 90 |
| TR_HT104 | TR by-pass heater | TR_TT124 | 80 | 120 | 90 |
| TR_HT105 | TR accumulator heater | TR_TT125 | 120 | 160 | 90 |
| TLR_HT102 | TLR pump oil heater | TLR_TT122 | 40 | 50 | 70 |

### 7.7.3 Tertiary system alarm handling.

The PLC controls and monitors the $CO_2$ systems. If the system is out of its design working range alarms are generated and proper actions are taken by the PLC. The alarm handling procedure is in detail described in the user manual (11). A table with the alarms properties can be found in the appendix in section 11.6. In some cases an alarm requires an automatic switch over to a back-up component. In this case the system is automatically restarted with a changed configuration. See paragraph 8.3 for details on the restart procedure and the selection of default components.

## 7.7.4 VTCS 2PACL operation

### 7.7.4.1 Start-up

The system is started-up under full liquid condition. First the system is filled with liquid by heating the accumulator to a saturation temperature above ambient. See paragraph 7.7.1 for details on the accumulator start-up heating. Figure 7.7-7 shows the start-up from the system from an ambient condition. Around 13:30 the system is started with a heating of the accumulator. The red line is the accumulator heater power. As a consequence the accumulator pressure increases (light green line). The liquid level in the accumulator is decreasing as the loop is filled with liquid from the accumulator (dark blue line). The heater power is limited by the accumulator control as the heater is subject to dry-out. This is visible by a the decreasing trend of the varying heater power. The variation is an oscillation of the limiter control. Around 13:40 the start-up set point of the accumulator is reached. The liquid pump starts pumping liquid which is visible by the occurring pressure increase of the pump outlet (dark green line). When a liquid flow is present the chiller is started and the liquid in the condenser is cooled down (purple line). The system is now pumping around cold liquid for a while and cools down the system in full liquid mode.

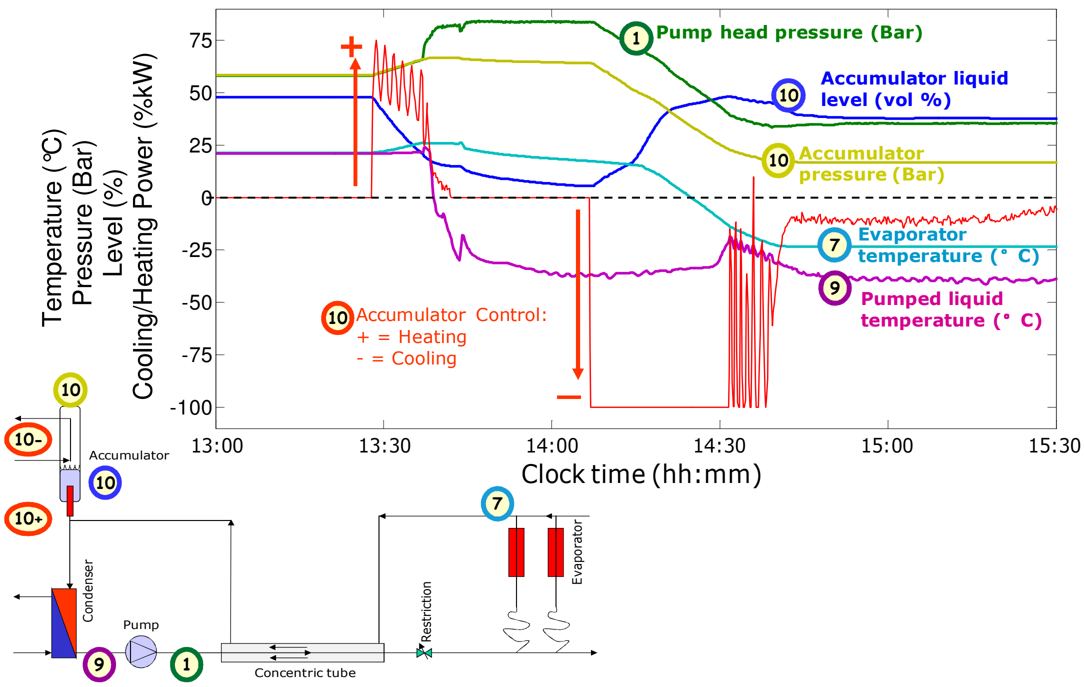



Figure 7.7-7: 2PACL start-up

The evaporator (also in liquid mode) is cooling down in a much slower rate. The heat exchange in the transfer line is heating up the liquid before it enters the evaporator (Details about the working of the transfer line is explained in paragraph 7.3). If the evaporator is around 18ºC the accumulator set-point is changed to the requested temperature, which is in this example -25ºC. This occurs around 14:06. The temperature sensor which triggers the set-point change is Tx_TT046. The -25ºC set-point request causes the accumulator control to cool the accumulator with 100%. This is visible by the red line which shows a -100% heating. As a consequence to the cooling, the pressures (dark and light green lines) are decreasing and the liquid level in the accumulator (dark blue line) is increasing, due to the condensation of the vapor in the accumulator.

At first the temperature of the evaporator is not affected by the pressure decrease. Evaporation in the evaporator starts when the saturation temperature is equal to the liquid (~14:15). The evaporator temperature is now following the accumulator saturation temperature and full temperature control of the evaporator by the accumulator is present. Due to the evaporation in the system the liquid level in the accumulator is rising more rapidly than before.

Around 14:30 the sub cooling is getting too small as the pump liquid temperature is approaching the saturation temperature (purple line is approaching light blue line). To avoid pump cavitation the accumulator PID control is limiting the accumulator cooling power (See paragraph 7.7.1 for details about the limiter). The limiting action is visible by oscillations in the red line.

Around 14:45 the -25ºC set-point is reached and the cooling of the accumulator is decreased to a steady level of about -10%, This continuous cooling is due to the environmental heat leak on the accumulator itself. The VTCS system is now ready, the detector can be powered-up.

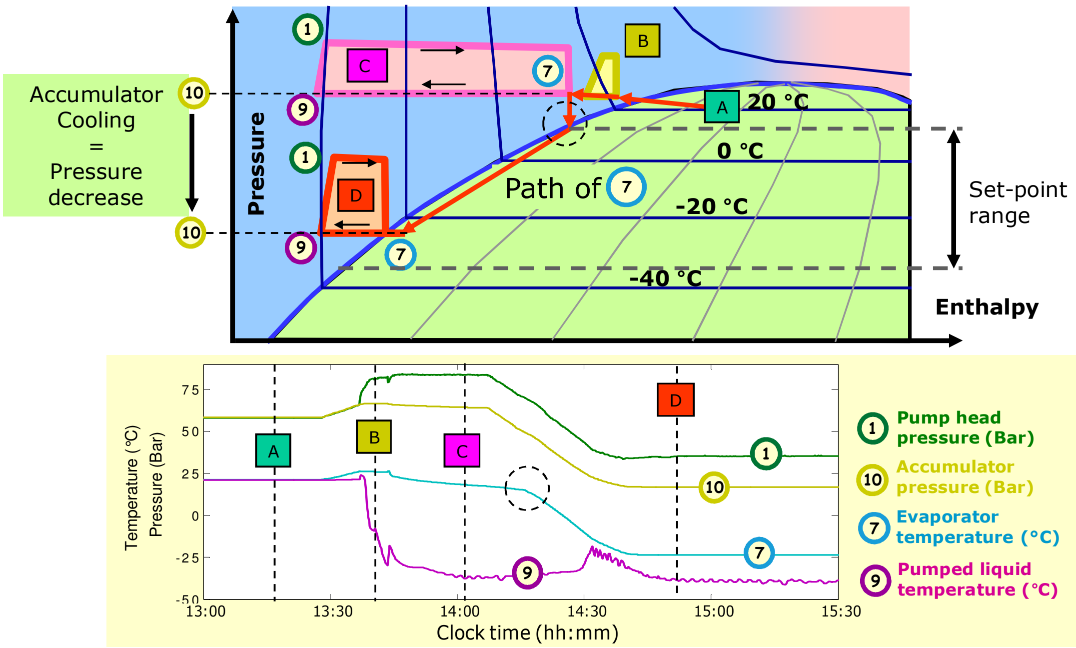



Figure 7.7-8: 2PACL start-up in the PH-diagram

Figure 7.7-8 shows the same start-up but now with the state-points plotted in the PH-diagram. In the PH-diagram it is better visible which part is operating in single- or two- phase. Prior to start-up the condition of the system is unknown. Liquid and vapor are present anywhere (Situation A). Heating the accumulator brings the system to situation B where everything is liquid. Cooling down brings the loop in situation C, where the pumped liquid temperature is cold, while the evaporator remains relatively warm. The stretched horizontal line length is mainly due the heat exchanged internally by the transfer line. After C the accumulator is cooled and the pressure is decreased which is visible by a lowering of the cycle along the vertical axis. At the moment that state point 7 of the cycle hits the saturation line (dashed circle), the evaporator starts boiling and the accumulator has the full control over the evaporator temperature. Lowering the pressure brings state point 7 closer to the sub cooling which is state point 9. When they become too close the accumulator control limits the accumulator cooling power and the lowest possible set-point is reached. The full operational range is the range shown by the diagonal red arrow.

The situation above shows a start-up from an ambient condition. A start-up from a cold condition can be much different. If the system is shut-down and immediately restarted, it goes rather fast as most of the state requests are already fulfilled.

### 7.7.4.2 Detector powering.

If the accumulator saturation temperature is within 0.5°C of the required set-point, the cooling ready state is released by the PLC. The interlock to the detector low-voltage is cleared. The detector can now be powered-up. There is no specific power-up sequence, any module can be powered-up individually or together with the rest. A power-up will create more vapor in the system which must be compensated for by the accumulator. Figure 7.7-9 shows a full power-up of a VELO half at a set-point of -25°C. The power-up around 0:18 causes the pressure in the loop to increase, which causes a cooling action of the accumulators PID control. The PID cooling action is visible by the decreasing trend of PID output which is the light blue line.

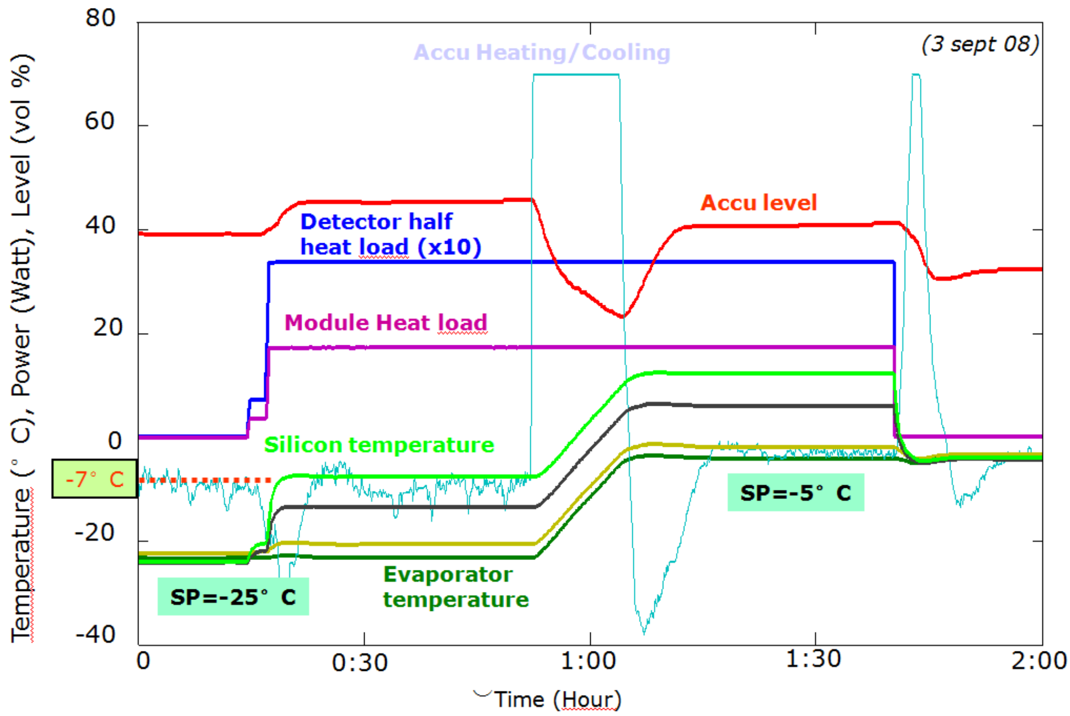



Figure 7.7-9: Set-point change and powering

The extra vapor generation in the loop causes the liquid level in the accumulator to rise. The red line shows the accumulator liquid level. After a power-up the system is behaving as before, with the accumulator cooling power being the same as before.

A power down of the detector works similar but reversed to a power-up. In Figure 7.7-9 a set-point change to -5°C is shown. A set point change explanation is given in paragraph 7.7.4.3. After the set point change the detector is powered down around 1:40. The loss of heat causes the vapor volume in the loop to decrease which has a pressure decrease as a result. The accumulator PID control reacts with heating the accumulator to restore the pressure. The liquid level in the accumulator is lowered as more liquid is present in the loop now.

#### 7.7.4.3 **Change of accumulator set-point**

Figure 7.7-9 shows as well the response of the system to a set-point change. Around 0:50 the set point is changed from -25ºC to -5ºC. The accumulator PID control reacts by heating the accumulator to bring the pressure to the requested saturation pressure of -5ºC. The evaporator and the detector temperatures are following the changing accumulator saturation temperature. During the heating the accumulator liquid level is decreasing. Around 1:10 the -5ºC is reached and the accumulator heating is lowered and finally cooled to compensate for the environmental heat leak. The heat leak compensation is lower than at -25ºC as the heat loss is less due to the smaller temperature difference to ambient. The accumulator is stable again around 1:20.

### 7.7.5 Evaporator venting

The VTCS has an automatic venting procedure of the volumes which are connected to the pressurized parts of the VTCS inside the VELO vacuum tank. In case of a leak of the $CO_2$ system into the tank volume a maximum of 12kg of $CO_2$ can float into the vessel which will make severe damage to the VELO detector. A pressure switch is mounted on the VELO vacuum system which switches around 1150 mbar. A pressure in the tank above atmospheric pressure is most likely caused by a $CO_2$ leak. When the PLC gets the 1150 mbar switch signal it stops the VTCS and closes valve Tx_VL111 and opens valve Tx_VL112 to vent the content of the feed line and evaporator to the atmosphere. The no-return valve in the cooling bridge must make sure that the rest of the system is not floating back to the leaking evaporator. The rest of the $CO_2$ remains in the system, only the content of the evaporator and feed line is vented. In this way the pressure can be relieved quickly from the pressurized part inside the vacuum.

# 8 VTCS Control System

## 8.1 *PLC*

The VTCS is controlled by a Siemens S7-400 series Programmable Logic Controller (PLC). The PLC contains the individual control loops, the sensor read-outs, the alarm handling and the procedural steps. The PLC is mounted with the electronics in a 19-inch rack next to the cooling plant on the UXAC3 platform. The PLC controls all of the VTCS, no user interference is needed other than switching it on and setting the desired evaporation temperature in the detector. The PLC also switches automatically to back-up configurations if a malfunction of a part is occurring. A detailed description of the PLC control is written in the PLC technical description (10).

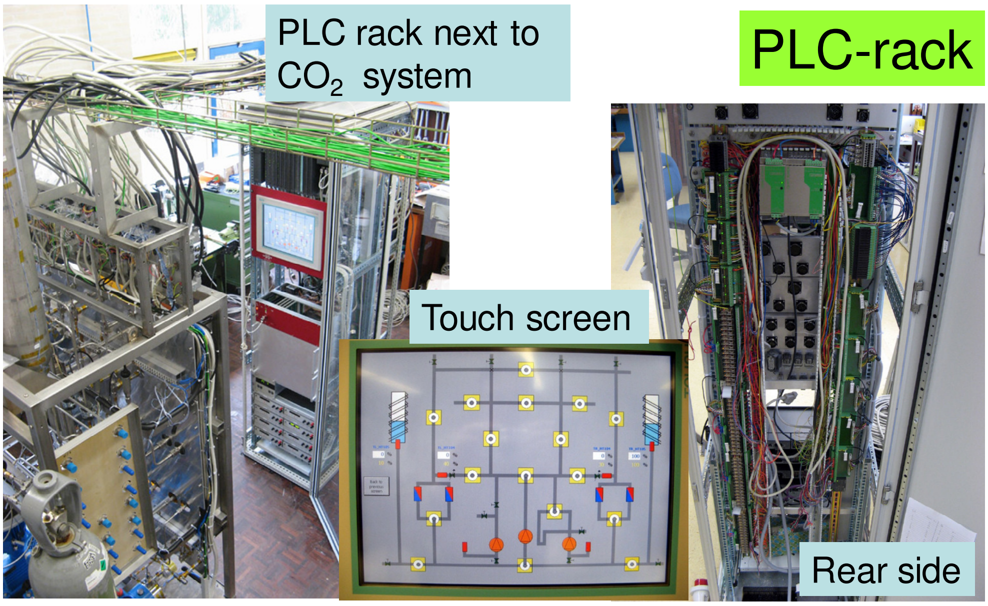



Figure 8.1-1: VTCS PLC and electronics rack and user interface.

The PLC can be operated via the touch-screen. The touch screen has several panels from where a user can control things. It also displays all the variables for system monitoring. A detailed description of all the user screens is given in the user manual (11).

## 8.2 *VTCS electronics.*

The electronics are all mounted in the same rack as the PLC. Detailed descriptions of the electronics can be found in EDMS (14).

## 8.3 *VTCS configuration and start-up*

The VTCS can be configured to operate in several ways. The configuration is in detail described in the user manual (11). In short the system can run with the following configurations:

1. TR on/auto / manual
2. TL on/ auto/manual
3. TLR auto/forced left/forced right/manual
4. SA auto/manual
5. SB auto/manual

The configurations can be set on the touch screen of the PLC. See Figure 8.3-1 for a screen shot of the configuration panel.

Both TL and TR can be switched on individually. If the TL or TR configuration is automatic it will start the corresponding $CO_2$ system with the default pump. If the configuration is on manual it will claim the TLR pump on a "who is first" bases. If the TLR pump is unavailable the corresponding system will stop. When the procedure is starting the chiller it will first look to the SA chiller configuration. If the SA is configured on auto it will start on SA. If the SA is set to manual it will automatically start SB. If SB is also on manual the system will stop.

The configurations can be set manually or by the PLC itself. In case of an alarm in the pump group or chiller group it will put the corresponding group on manual. A restart of the system automatically switches to the back-up solution.

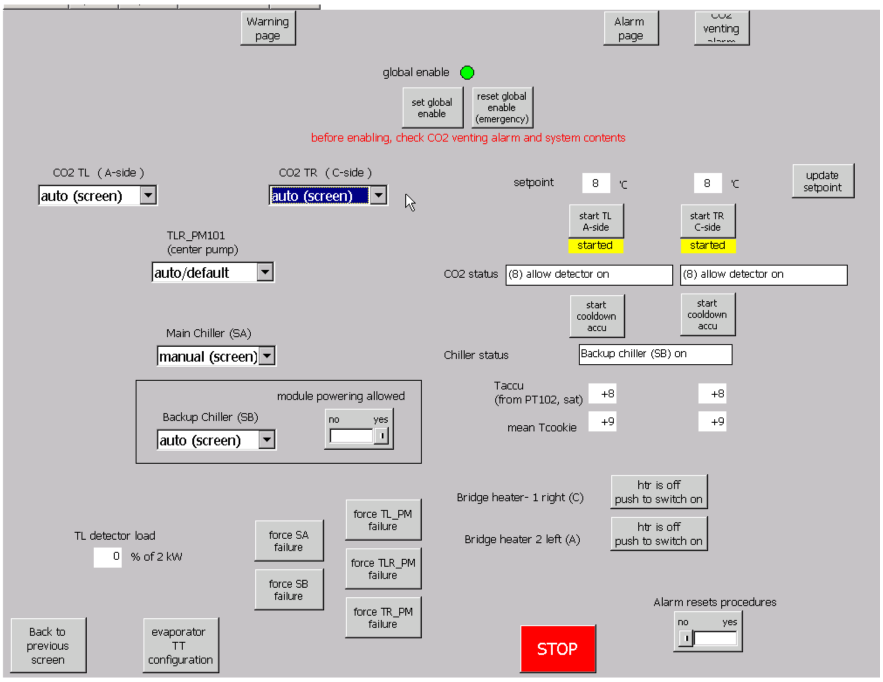



Figure 8.3-1: PLC configuration touch screen

At start-up first the accumulator will be heated up to prime the loop with liquid. Secondly the pump will start pumping over the by-pass (see paragraph 7.4.1) and later the chiller will be switched on. When the pump is sufficiently cooled the flow is diverted from the by-pass to the transfer line. After pumping liquid for a while the accumulator pressure is lowered to the desired set-point. When the set point in the accumulator is reached the cooling is ready for the detector to be powered. If one system is switched on the other system will also be switched on and follows the steps towards cold liquid pumping over the by-pass. This partially switched on mode has no effect for the temperature of the evaporator. A later start of the second system is much faster this way as part of the time consuming start-up has already passed. A start-up of only 1 half has the consequence that the heat load for the chiller is less. In case that the SA main chiller this low heat load can be a problem. Therefore the test heater in the by-pass line is switched on to 500W when one tertiary system is running in the stand-by mode

## 8.4 *PVSS interface*

The PLC user interfaces have a copy in the overall LHCb PVSS monitoring and control software. In this way the cooling system can be monitored by the experimental control team in the LHCb control room. Operation from PVSS is for the VTCS not possible as the system may never be switched off. Operation can only be done at the cooling station itself via the PLC touch screen. All of the VTCS variables (sensors values and PLC variables) are visible in PVSS and logged to an oracle database. A detailed list of all the PVSS variables can be found in the appendix at paragraph 11.7.

# 9 System simulation.

For the static analyses a state point model was generated of the SA, SB and TL and TR system. In a state point model the pressure and enthalpy is calculated iteratively at defined points starting from known boundaries. The state point model has an integrated physical property database of Refprop (9). With this Refprop database the right properties are used at any iteration round. The pressure drop and applied power between each points is calculated and added to the pressure and enthalpy of the next state point. In this way a complete overview is generated for each location in one of the VTCS systems.

For the VTCS models a state point is in a section as indicated on the schematic layouts of paragraph 11.1. The pressure drop is calculated by mass flow through the local pipe length and diameter or restrictor. The applied heat is calculated by the environmental heat leak on the same pipe configuration with the present insulation applied. An extra applied load like the detector heat is added in the same way between the state points if present. Knowing all the states of the sections (pressure and enthalpy), the density and temperatures can be derived. Together with the section volume and the derived density the fillings at each section can be calculated. The fluid charge in the R507a reservoirs and $CO_2$ accumulators can be calculated when knowing the fluid content in each section and the total charge applied.

## 9.1 *SA system simulation*

Figure 9.1-2 shows the simulation result of the SA state–point model in the pressure enthalpy diagram. The plotted state-point locations can be found in the drawing of Figure 9.1-1. The calculation is done with each section being a state-point, but only the important points are plotted. The different operation of the main evaporators and the accumulator spirals is visible. The superheating control after the internal heat exchangers makes the entire evaporators to be in the 2-phase region (Point 6ab). The accumulator evaporator operates at a higher pressure due to the manual back pressure valve. The shown simulation is a nominal heat load situation of 900 Watt (detector power + environment heat) on each main evaporator and 400 Watt on each accumulator evaporator. The state point values can be found in the table below. All the section state values can be found in Table 11.5-1 in the appendix.

Table 9.1-1: SA simulation state-points

| | Enthalpy (kJ/kg) | Pressure (bar) | Enthalpy (kJ/kg) | Pressure (bar) | Enthalpy (kJ/kg) | Pressure (bar) |
|---|---|---|---|---|---|---|
| State point | | | ab | ab | cd | cd |
| 1 | 428.0 | 10.5 | | | | |
| 2 | 206.7 | 10.5 | | | | |
| 3 | 216.0 | 9.1 | 216.0 | 9.1 | 216.0 | 9.1 |
| 4 | | | 134.7 | 9.1 | 184.4 | 9.1 |
| 5 | | | 134.7 | 0.9 | 184.4 | 1.2 |
| 6 | | | 275.1 | 0.9 | 351.0 | 1.2 |
| 7 | | | | | 351.0 | 0.9 |
| 8 | | | 356.5 | 0.9 | 382.6 | 0.9 |
| 9 | 363.6 | 0.9 | | | | |

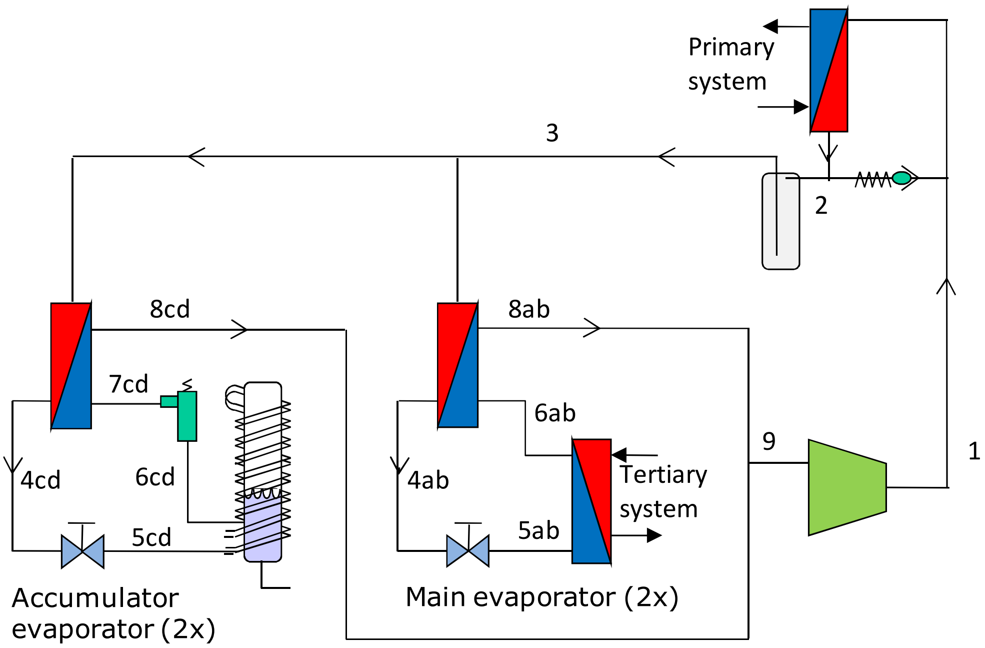



Figure 9.1-1: State-points of the SA main chiller.

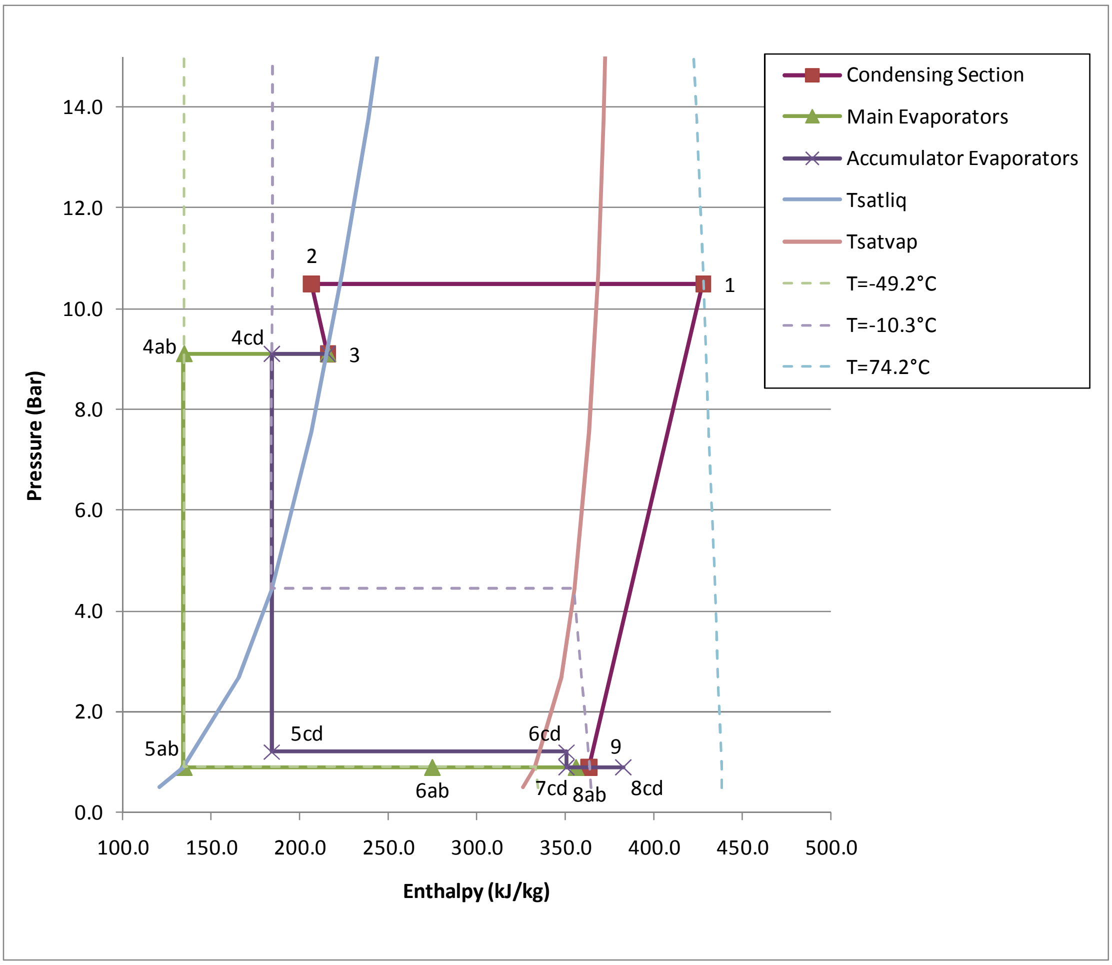



Figure 9.1-2: State point model result of the SA-chiller in the pressure enthalpy diagram of R507a.

## 9.2 *SB system simulation*

The SB chiller simulation is similar to the SA chiller simulation. The SB chiller has 1 common internal heat exchanger and therefore all the evaporator branches (accumulator and main) start with the same fluid condition. The only difference is the higher evaporator pressure in the accumulator evaporator. This is due to the manual back-pressure valve. Figure 9.2-1 shows the state-point locations and Figure 9.2-2 shows the results in the pressure-enthalpy diagram. The shown simulation is a nominal heat load situation of 300 Watt (detector power + environment heat) on each main evaporator and 400 Watt on each accumulator evaporator. The state point values can be found in the table below. All the section state values can be found in Table 11.5-3 and Table 11.5-1 in the appendix.

Table 9.2-1: SB simulation state-points

| | Enthalpy (kJ/kg) | Pressure (bar) | Enthalpy (kJ/kg) | Pressure (bar) | Enthalpy (kJ/kg) | Pressure (bar) |
|---|---|---|---|---|---|---|
| State point | | | ab | ab | cd | cd |
| 1 | 447.6 | 15.0 | | | | |
| 2 | 242.2 | 15.0 | | | | |
| 3 | 243.9 | 15.0 | | | | |
| 4 | 204.5 | 15.0 | 204.5 | 15.0 | 204.5 | 15.0 |
| 5 | | | 204.5 | 2.5 | 204.5 | 3.0 |
| 6 | | | 355.1 | 2.5 | 359.1 | 3.0 |
| 7 | | | | | 359.1 | 2.5 |
| 8 | 357.0 | 2.5 | | | | |
| 9 | 396.4 | 2.5 | | | | |

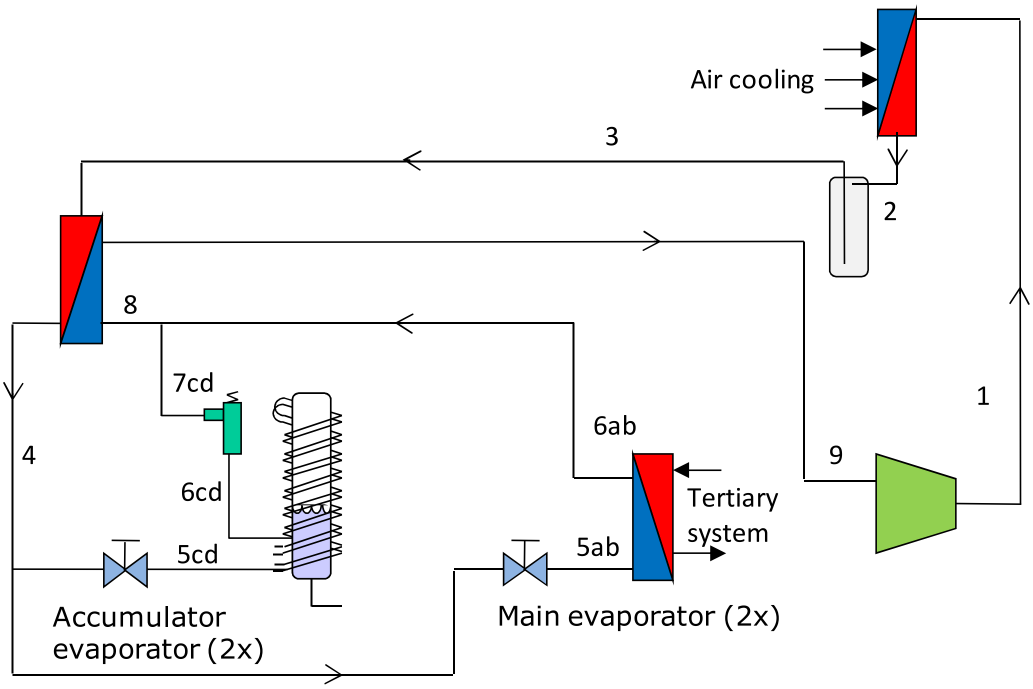



Figure 9.2-1: State-points of the SB main chiller.

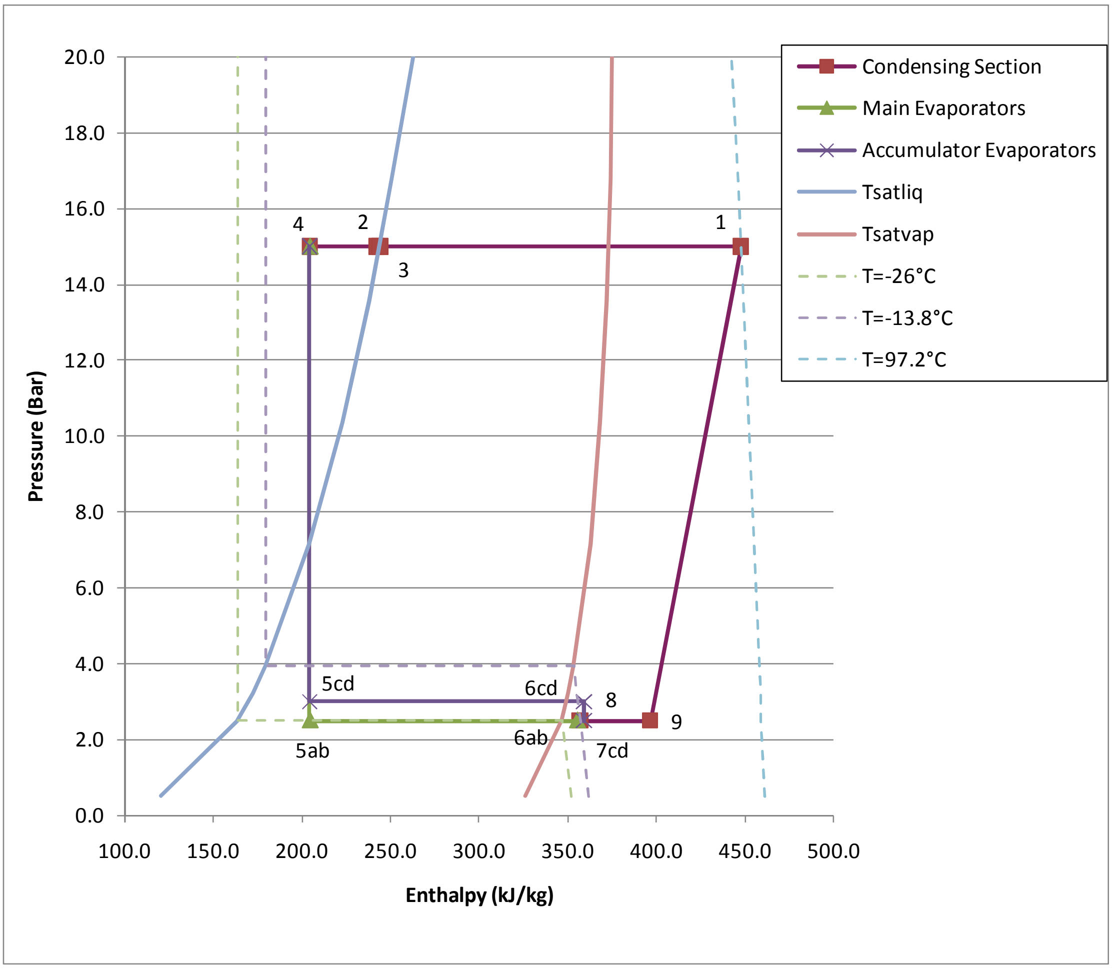



Figure 9.2-2: State point model result of the SB-chiller in the pressure enthalpy diagram of R507a.

## 9.3 *Tertiary system simulation*

A state point model has been build to simulate the tertiary $CO_2$ 2PACL systems. Figure 9.3-1 shows a schematic diagram of the cycle with the main state points numbered. The model is calculated with each section being a state-point.

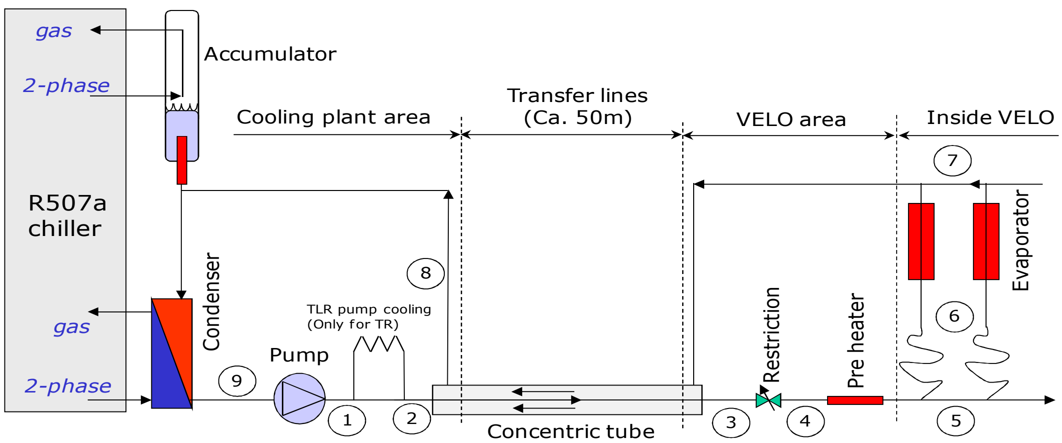



Figure 9.3-1: State point locations of the TL- and TR-$CO_2$ systems.

The 2PACL state models are much more detailed than the chiller models. The 2PACL state models are used to investigate the behavior of the $CO_2$ systems under the various conditions in which it is used. The 2PACL's are started with a pressurization to turn the system into a single phase liquid loop. The model shows in detail what happens if the single phase operation turns into a 2-phase operation, so the start-up and the application range can be explained.

The models of the TL and TR are a bit different from each other. The main difference is that TR has an extra heat exchanger after the pump to maintain the TLR pump cold for start-up. This is shown in the schematic between state-point 1 and 2. For the rest there are no big differences, other than some small volume differences. The real volumes are used for both the TL and TR models. In the model a pre-heater between state point 4 and 5 is present. In the current VTCS this heater does not exist. It is in the model to study a possible modification in the system. This is not discussed in this document. This power is set to zero.

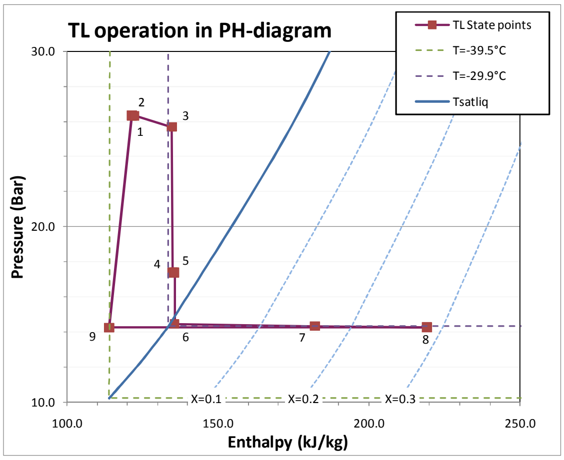



Table 9.3-1: TL state-points

| TL State points | Enthalpy (kJ/kg) | Pressure (Bar) | Temperature (ºC) | Vapor Quality |
|---|---|---|---|---|
| 1 | 121.6 | 26.3 | -35.8 | Sub cooled |
| 2 | 122.4 | 26.3 | -35.4 | Sub cooled |
| 3 | 134.7 | 25.7 | -29.3 | Sub cooled |
| 4 | 135.0 | 17.4 | -29.2 | Sub cooled |
| 5 | 135.6 | 17.4 | -28.9 | Sub cooled |
| 6 | 135.6 | 14.5 | -29.6 | 0.00 |
| 7 | 182.1 | 14.3 | -29.9 | 0.16 |
| 8 | 219.2 | 14.3 | -30.0 | 0.28 |
| 9 | 114.0 | 14.3 | -39.5 | Sub cooled |

Figure 9.3-2: TL state-points in the PH diagram (Tsat =-30, Q=489W)

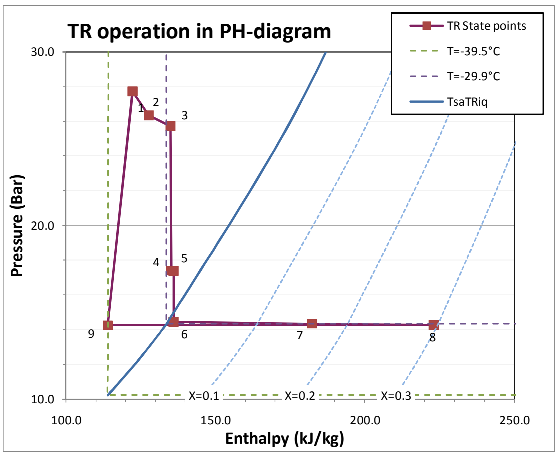



Table 9.3-2: TR state-points

| TR State points | Enthalpy (kJ/kg) | Pressure (Bar) | Temperature (ºC) | Vapor Quality |
|---|---|---|---|---|
| 1 | 122.3 | 27.7 | -35.4 | Sub cooled |
| 2 | 127.7 | 26.3 | -32.8 | Sub cooled |
| 3 | 135.1 | 25.7 | -29.2 | Sub cooled |
| 4 | 135.3 | 17.4 | -29.0 | Sub cooled |
| 5 | 135.9 | 17.4 | -28.7 | Sub cooled |
| 6 | 135.9 | 14.5 | -29.6 | 0.01 |
| 7 | 182.4 | 14.3 | -29.9 | 0.16 |
| 8 | 223.1 | 14.3 | -30.0 | 0.30 |
| 9 | 114.0 | 14.3 | -39.5 | Sub cooled |

Figure 9.3-3: TR state-points in the PH diagram (Tsat =-30, Q=489W)

The influence of the TLR pump cooling is clearly visible, at the TR results node 2 is below node 1, at TL they are overlapping. The detector load which is applied is 489 Watt, this is the section between node 6 and 7.

## 9.4 *Transfer line simulation*

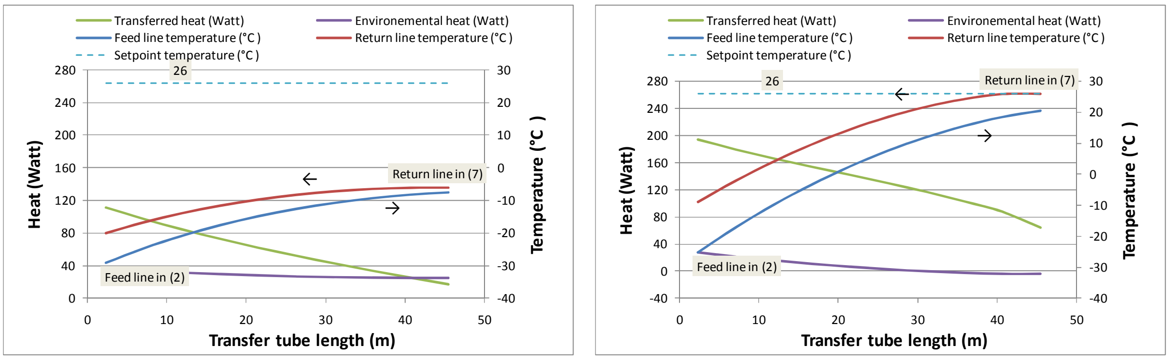



Figure 9.4-1: Set point 26ºC (left Unpowered, right powered with 489W)

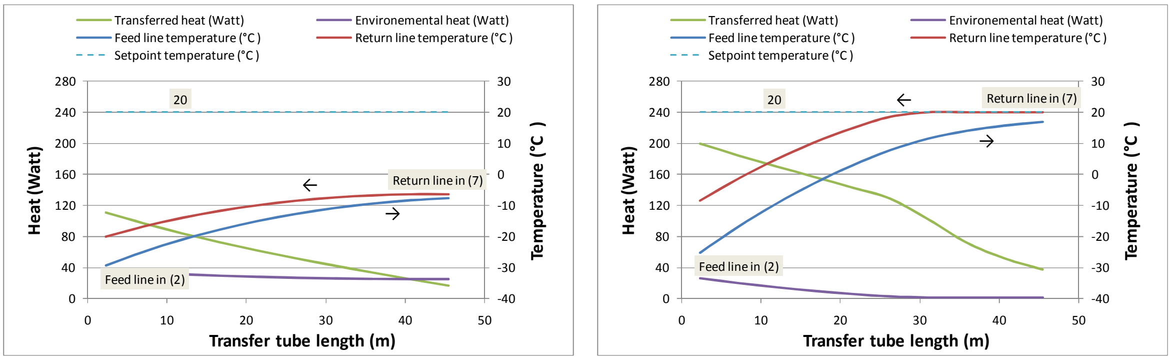



Figure 9.4-2: Set point 20ºC (left Unpowered, right powered with 489W)

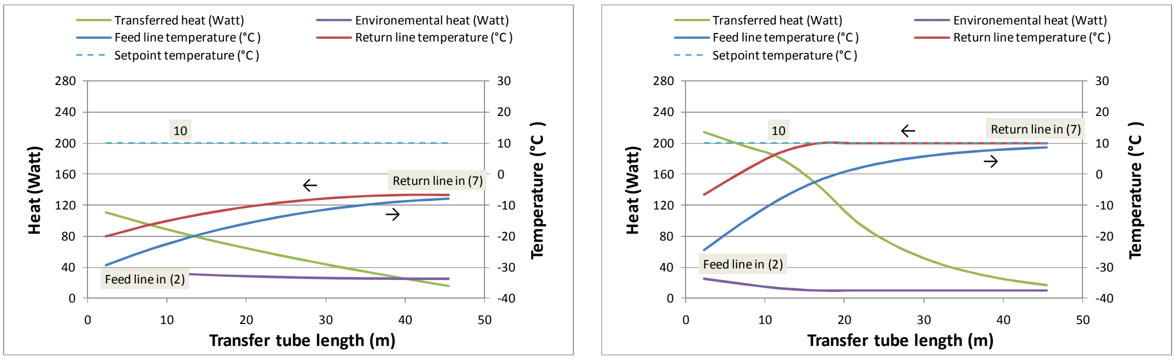



Figure 9.4-3: Set point 10ºC (left Unpowered, right powered with 489W)

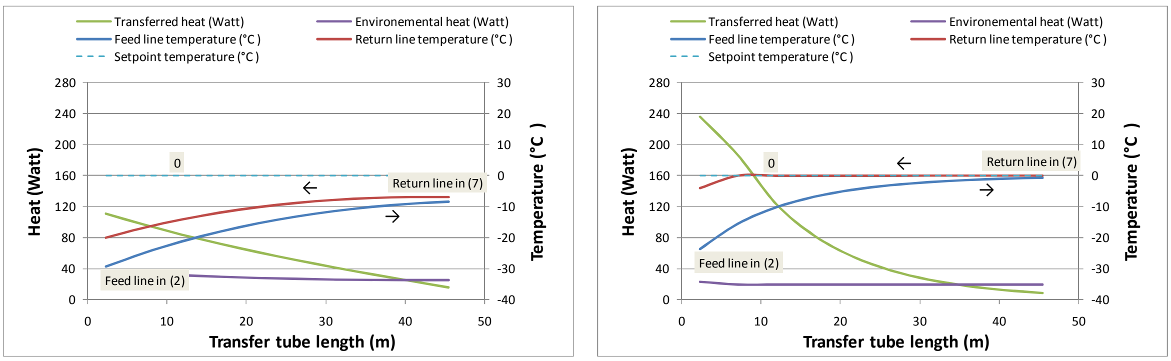



Figure 9.4-4: Set point 0ºC (left Unpowered, right powered with 489W)

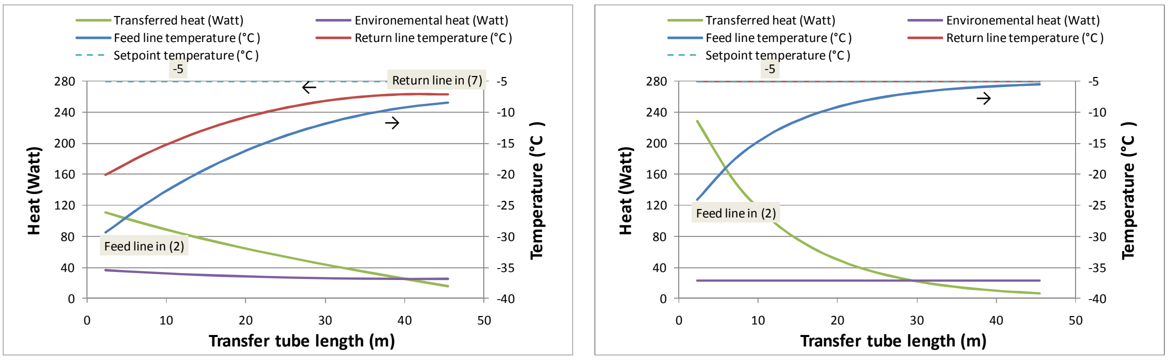


Figure 9.4-5: Set point -5° C (left Unpowered, right powered with 489W)

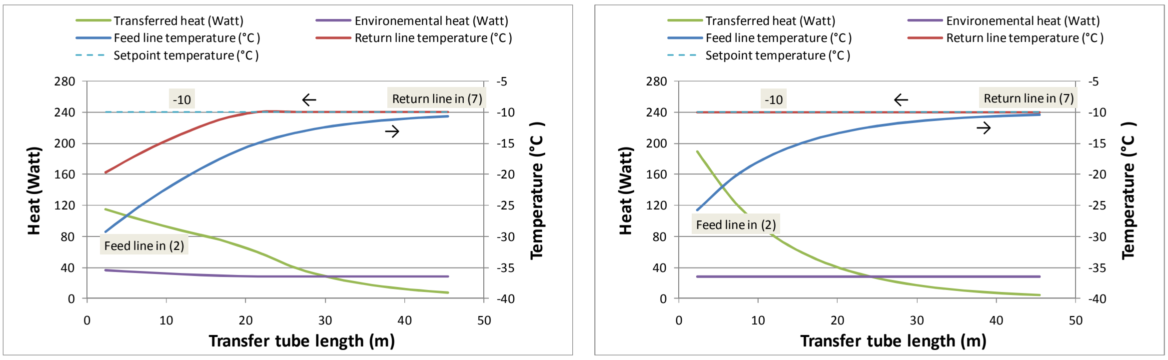


Figure 9.4-6: Set point -10ºC (left Unpowered, right powered with 489W)

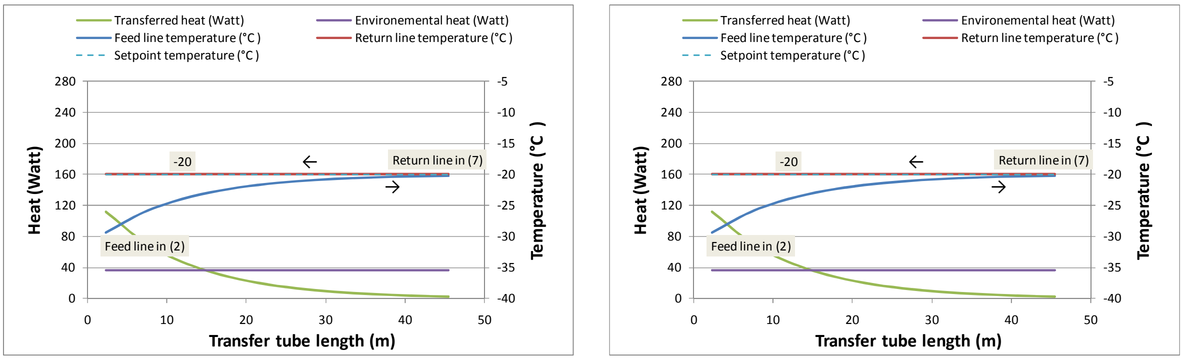


Figure 9.4-7: Set point -20ºC (left Unpowered, right powered with 489W)

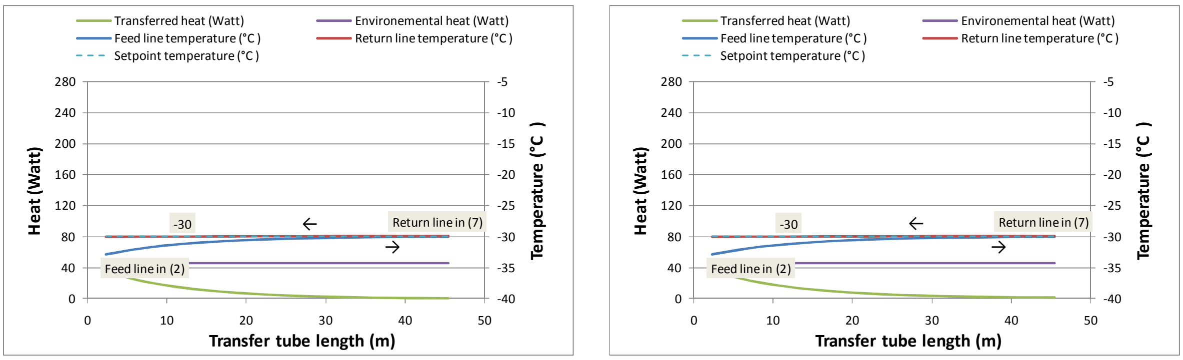


Figure 9.4-8: Set point -30ºC (left Unpowered, right powered with 489W)

The transfer line has a special role in the 2PACL principle. Besides from transferring the liquid from and to the evaporator, it must heat-up the inlet liquid of the evaporator towards saturation. The transfer line does this with virtual energy as it does not cost any additional applied heat. It is often believed that the maximum exchanged heat is the heat which is absorbed in the system and will so be reused. This is not the case, it is really virtual and as the simulations show, more heat can be exchanged than there is applied by heat loads or the environment. Figure 9.4-1 to Figure 9.4-8 show the results of the transfer line for simulations under different set point temperatures. The left figure indicates the unpowered situation, the right figure the powered situation. The nominal applied power is in all cases 489 Watt. The environmental load changes as the temperature changes.

## 9.5 *$CO_2$ 2PACL start-up simulation*

The 2PACL is started up by priming the complete loop with liquid. In the VTCS the loop is “pumped-up” to a saturation temperature 6 degrees above the measured temperature on Tx_TT112. The start-up set point is limited to 26ºC, otherwise the accumulator will have no liquid anymore. The simulations show that the loop is completely operated in single phase at this time. The figures starting from Figure 9.5-1 show the steady state results of the different start-up stages. The left row of plots showthe unpowered situation of the start-up stage the right row of plots show the powered situation.

The trapezium sized cycles in the PH diagram are lowered by lowering the accumulator set-point. At the moment that point 6 (the evaporator inlet) hits the saturation line it starts to evaporate in the evaporator. From that moment on a further lowering of this point follows the saturation line. It shows that the accumulator has full control over the evaporator temperature in the range between -10ºC to -30ºC. In this range the VTCS is operated. The shown simulation results are from the same simulation as shown for the transfer line (paragraph 9.4). State point temperatures 2,3,7 and 8 in the PH diagram can be compared to the temperatures in the transfer line in and outlets.

The simulation results will be compared with measurements of the VTCS in future publications. First measurements show a good comparison of the simulation with real measurement data.

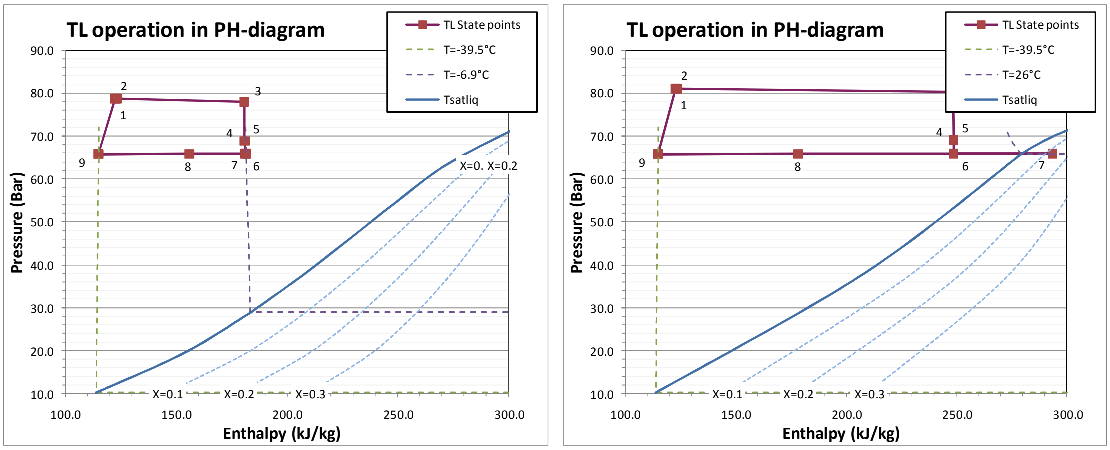



Figure 9.5-1: Set point 26ºC (left Unpowered, right powered with 489W

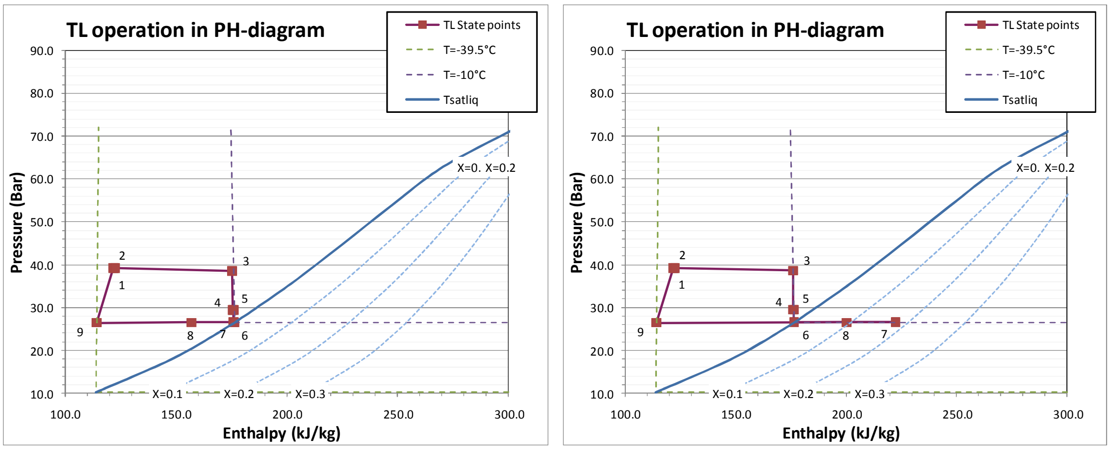



Figure 9.5-2: Set point -10ºC (left Unpowered, right powered with 489W

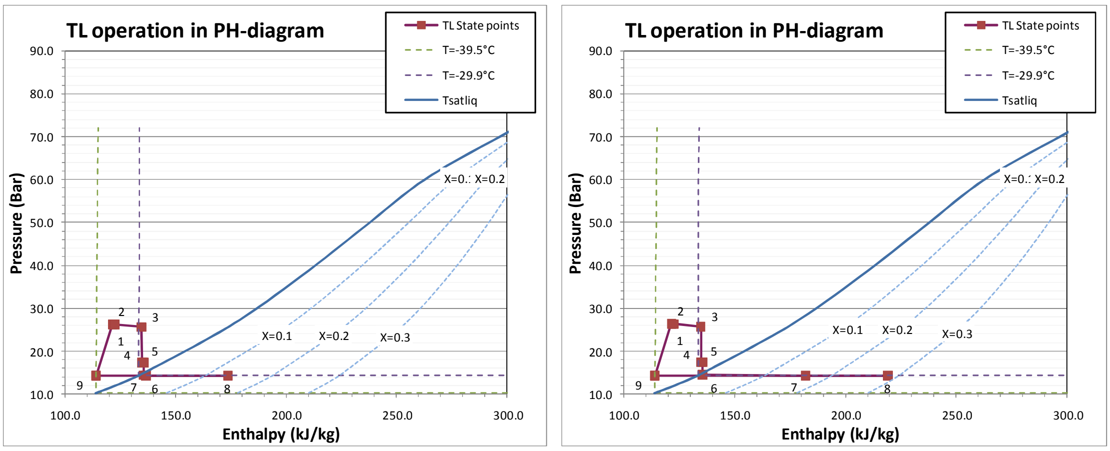



Figure 9.5-3: Set point -30ºC (left Unpowered, right powered with 489W

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24. *Evaporative CO2 Heat Transfer Measurements for Cooling Systems of Particle Physics Detectors.* **Colijn, A.P and Verlaat, B.** Antalya, Turkey : HEFAT-2010, 7th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics, 2010. 1238.
25. *CO2 Cooling for Particle Physics Experiments.* **Colijn, A.P and Verlaat, B.** Sydney, Australia : 9th IIF/IIR Gustav Lorentzen Conference on Natural Working Fluids, 2010. 38.

# 11 Appendix

## 11.1 *Schematics*

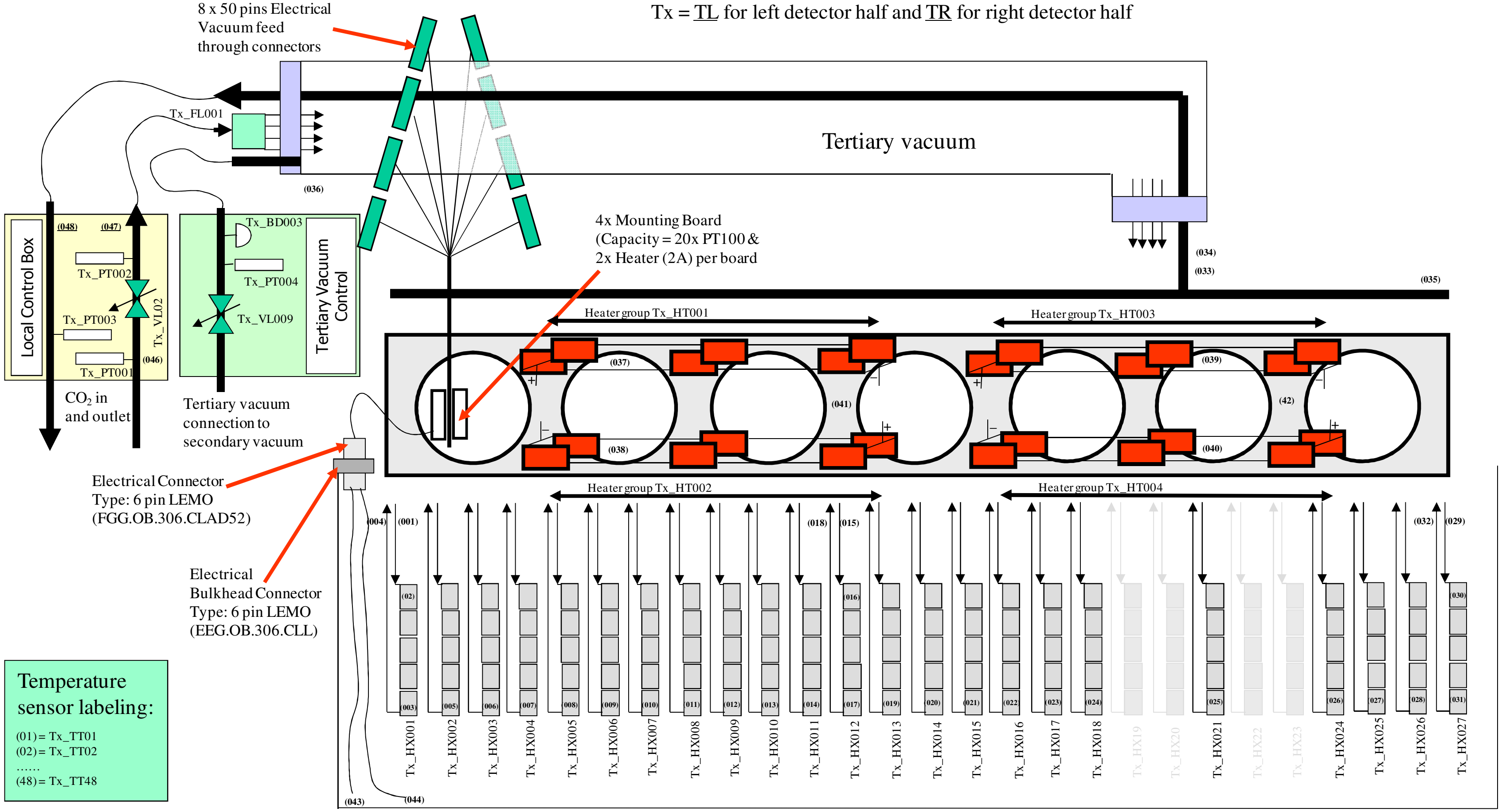


Figure 11.1-1: VTCS hardware labeling inside the VELO detector

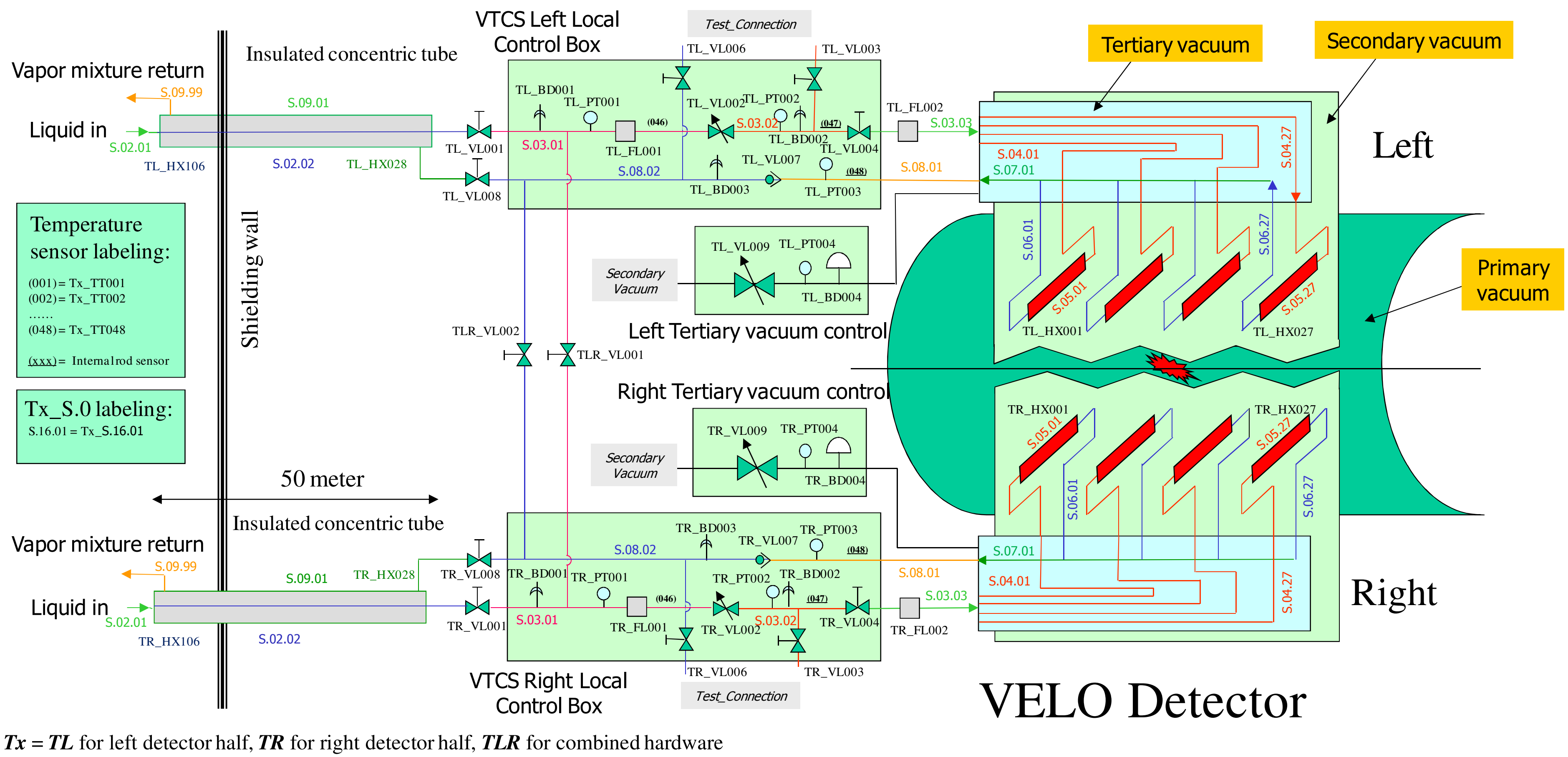


Figure 11.1-2: VTCS schematics and hardware labeling outside the VELO detector in the VELO cavern

Temperature sensor labeling:
(101) = Tx_TT101
(102) = Tx_TT102
……
(125) = Tx_TT125
(xxx) = Internal rod sensor

***Tx*** = ***TL*** for left detector half, ***TR*** for right detector half, ***TLR*** for combined hardware

Section labeling:
S.16.01 = Tx_S.16.01

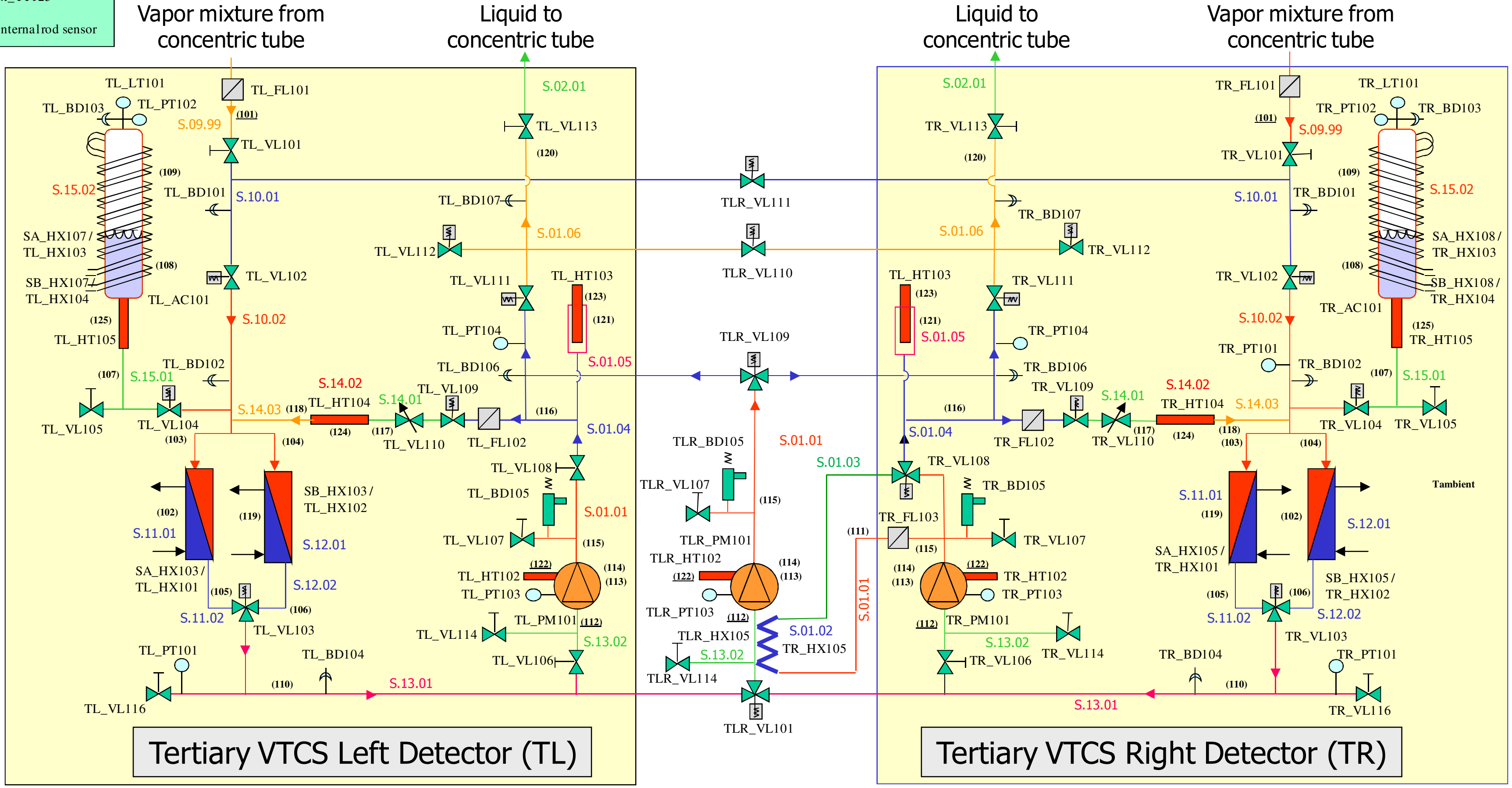


Figure 11.1-3: VTCS Tertiary $CO_2$ plant schematics and labeling

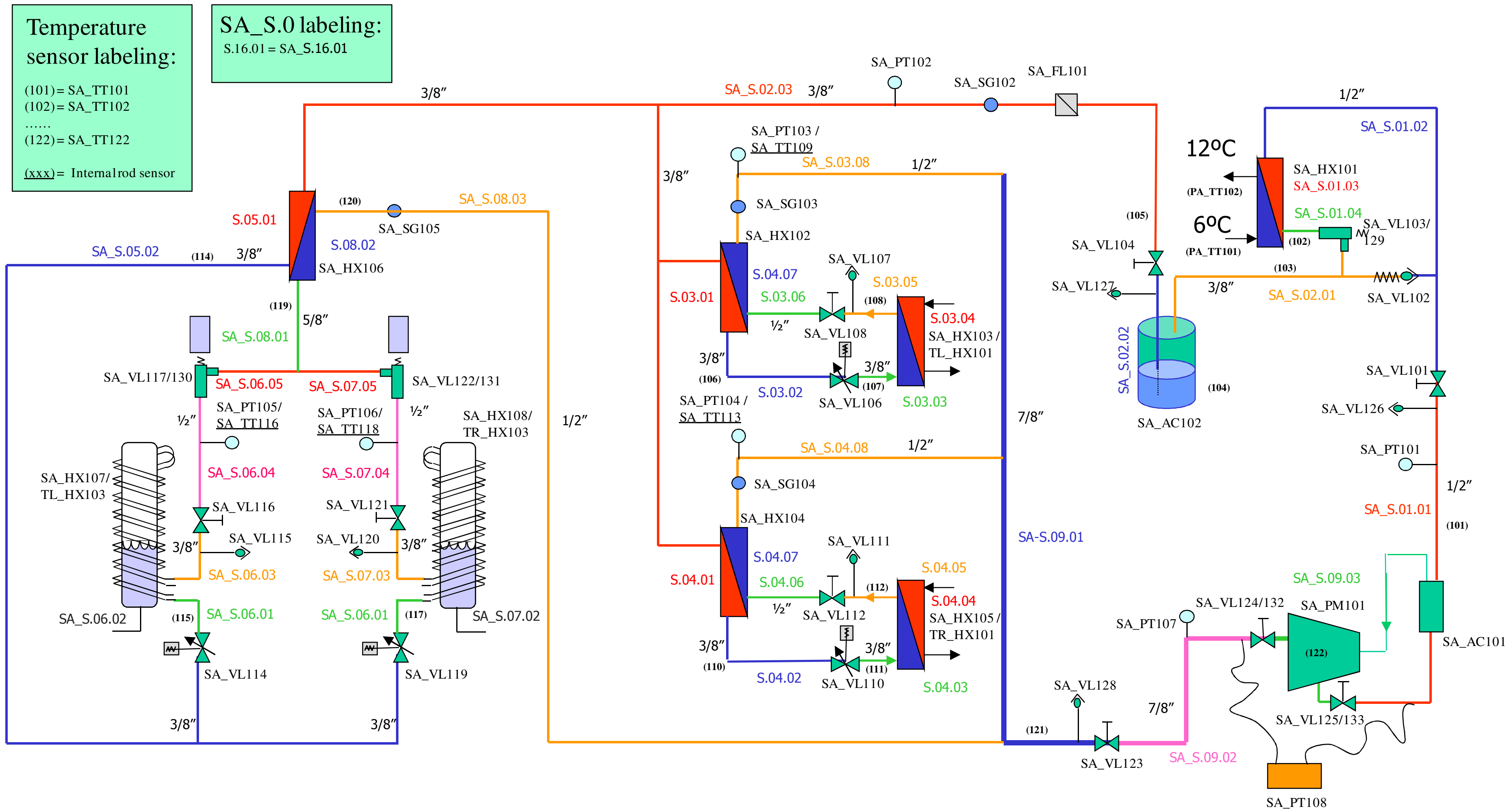


Figure 11.1-4: Secondary main chiller schematics and labeling

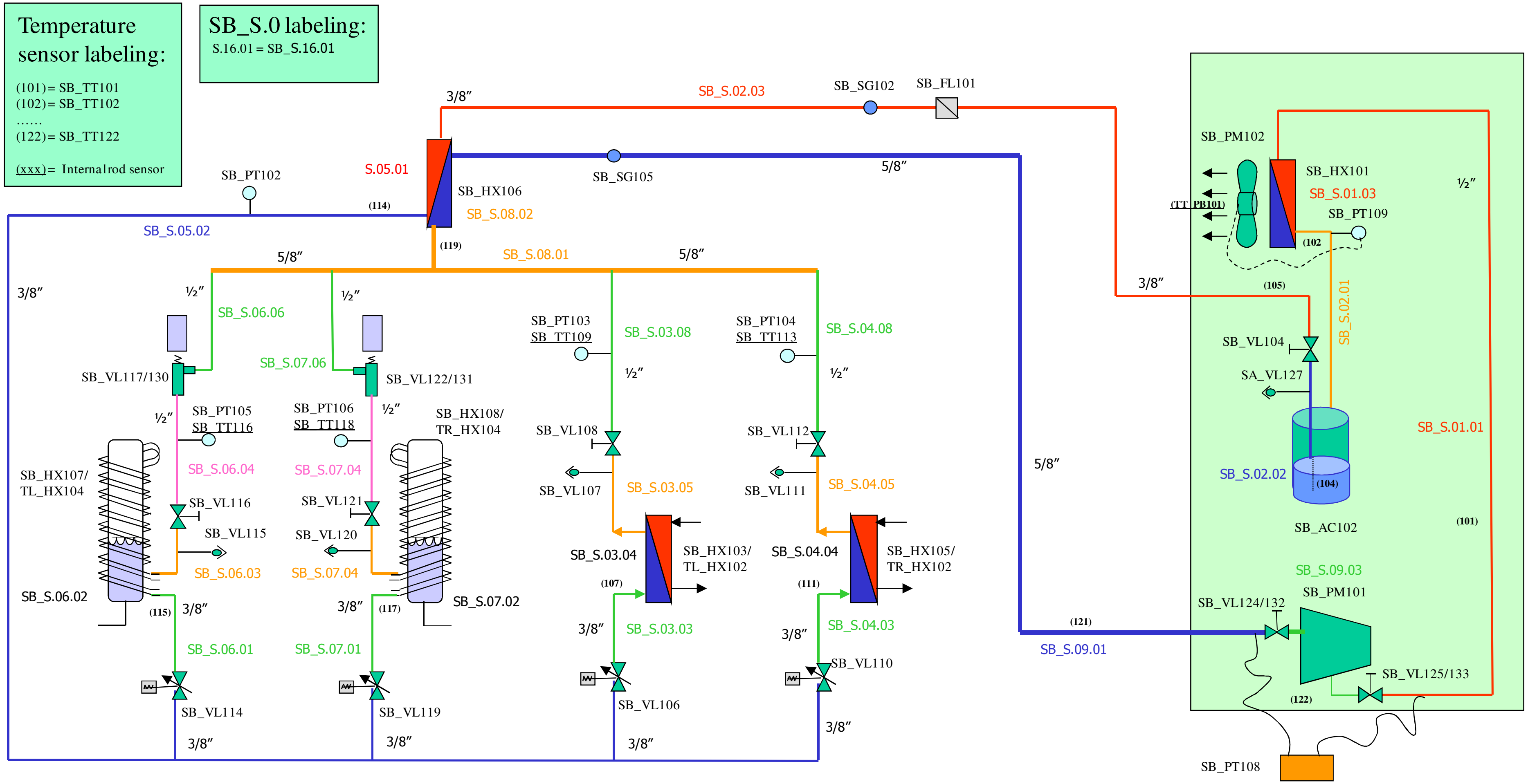


Figure 11.1-5: Secondary Back-up chiller schematics and labeling

## 11.2 *Sensors*

### 11.2.1 Temperature Transmitters

| Code | low | high | Part number | Function |
|---|---|---|---|---|
| TL_TT001 | -35 | 10 | PT100 | TL_HX001 Liquid inlet |
| TL_TT002 | -35 | 10 | PT100 | TL_HX001 block 1 |
| TL_TT003 | -35 | 10 | PT100 | TL_HX001Dry-out monitoring |
| TL_TT004 | -35 | 10 | PT100 | TL_HX001 Vapor outlet |
| TL_TT005 | -35 | 10 | PT100 | TL_HX002 Dry-out monitoring |
| TL_TT006 | -35 | 10 | PT100 | TL_HX003 Dry-out monitoring |
| TL_TT007 | -35 | 10 | PT100 | TL_HX004 Dry-out monitoring |
| TL_TT008 | -35 | 10 | PT100 | TL_HX005 Dry-out monitoring |
| TL_TT009 | -35 | 10 | PT100 | TL_HX006 Dry-out monitoring |
| TL_TT010 | -35 | 10 | PT100 | TL_HX007 Dry-out monitoring |
| TL_TT011 | -35 | 10 | PT100 | TL_HX008 Dry-out monitoring |
| TL_TT012 | -35 | 10 | PT100 | TL_HX009 Dry-out monitoring |
| TL_TT013 | -35 | 10 | PT100 | TL_HX010 Dry-out monitoring |
| TL_TT014 | -35 | 10 | PT100 | TL_HX011 Dry-out monitoring |
| TL_TT015 | -35 | 10 | PT100 | TL_HX012 Liquid inlet |
| TL_TT016 | -35 | 10 | PT100 | TL_HX012 block 1 |
| TL_TT017 | -35 | 10 | PT100 | TL_HX012 Dry-out monitoring |
| TL_TT018 | -35 | 10 | PT100 | TL_HX012 Vapor outlet |
| TL_TT019 | -35 | 10 | PT100 | TL_HX013 Dry-out monitoring |
| TL_TT020 | -35 | 10 | PT100 | TL_HX014 Dry-out monitoring |
| TL_TT021 | -35 | 10 | PT100 | TL_HX015 Dry-out monitoring |
| TL_TT022 | -35 | 10 | PT100 | TL_HX016 Dry-out monitoring |
| TL_TT023 | -35 | 10 | PT100 | TL_HX017 Dry-out monitoring |
| TL_TT024 | -35 | 10 | PT100 | TL_HX018 Dry-out monitoring |
| TL_TT025 | -35 | 10 | PT100 | TL_HX021Dry-out monitoring |

| | | | | |
|---|---|---|---|---|
| TL_TT026 | -35 | 10 | PT100 | TL_HX024 Dry-out monitoring |
| TL_TT027 | -35 | 10 | PT100 | TL_HX025 Dry-out monitoring |
| TL_TT028 | -35 | 10 | PT100 | TL_HX026 Dry-out monitoring |
| TL_TT029 | -35 | 10 | PT100 | TL_HX027 Liquid inlet |
| TL_TT030 | -35 | 10 | PT100 | TL_HX027 block 1 |
| TL_TT031 | -35 | 10 | PT100 | TL_HX027 Dry-out monitoring |
| TL_TT032 | -35 | 10 | PT100 | TL_HX027 Vapor outlet |
| TL_TT033 | -35 | 10 | PT100 | Vapor return |
| TL_TT034 | -35 | 10 | PT100 | Vapor return |
| TL_TT035 | -35 | 20 | PT100 | Manifold |
| TL_TT036 | 12 | 30 | PT100 | Bellow flange |
| TL_TT037 | 15 | 27 | PT100 | TL_HT001 Heater Control |
| TL_TT038 | 15 | 27 | PT100 | TL_HT002 Heater Control |
| TL_TT039 | 15 | 27 | PT100 | TL_HT003 Heater Control |
| TL_TT040 | 15 | 27 | PT100 | TL_HT004 Heater Control |
| TL_TT041 | 15 | 27 | PT100 | Module base |
| TL_TT042 | 15 | 27 | PT100 | Module base |
| TL_TT043 | 15 | 27 | PT100 | RF-Foil |
| TL_TT044 | 15 | 27 | PT100 | RF-Foil |
| TL_TT045 | -35 | 30 | PT100 | Transfer tube liquid outlet |
| TL_TT046 | -35 | 10 | PT100 | Local control box liquid inlet |
| TL_TT047 | -35 | 10 | PT100 | Capillaries inlet |
| TL_TT048 | -35 | 10 | PT100 | Local control box vapor outlet |
| TL_TT101 | -45 | 5 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | Transfer tube vapor outlet |
| TL_TT102 | -48 | 30 | PT100 | Main condenser Front plate |
| TL_TT103 | -48 | 5 | PT100 | Main condenser inlet |
| TL_TT104 | -48 | 5 | PT100 | Back-up condeser inlet |
| TL_TT105 | -48 | 5 | PT100 | Main condenser outlet |
| TL_TT106 | -48 | 5 | PT100 | Back-up condeser outlet |
| TL_TT107 | -45 | 5 | PT100 | Accumulator line |

| | | | | |
|---|---|---|---|---|
| TL_TT108 | -20 | 5 | PT100 | Accumulator Liquid |
| TL_TT109 | -5 | 20 | PT100 | Accumulator Vapor |
| TL_TT110 | -48 | -2 | PT100 | Condenser outlet |
| xx_TTamb | 15 | 25 | | |
| TL_TT112 | -48 | -2 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | TL-PM101 pump.state inlet |
| TL_TT113 | -40 | 30 | PT100 | TL-PM101 pump.state head oil side |
| TL_TT114 | -40 | 30 | PT100 | TL-PM101 pump.state head $CO_2$ side |
| TL_TT115 | -45 | -2 | PT100 | TL-PM101 pump.state outlet |
| TL_TT116 | -45 | -2 | PT100 | liquid line |
| TL_TT117 | -45 | 30 | PT100 | By-pass liquid |
| TL_TT118 | -45 | 30 | PT100 | By-pass vapor |
| TL_TT119 | -48 | 30 | PT100 | Condenser Back plate |
| TL_TT120 | -48 | 30 | PT100 | Transfer tube liquid inlet |
| TL_TT121 | 0 | 100 | Thermocouple K | Press damper temperature |
| TL_TT122 | 12 | 25 | Thermocouple K | TL-HT102 Control (pump.state oil heater) |
| TL_TT123 | 0 | 100 | Thermocouple K | TL-HT103 Control |
| TL_TT124 | -45 | 50 | Thermocouple K | TL-HT104 Control |
| TL_TT125 | -45 | 100 | Thermocouple K | TL-HT105 Control (Accu heater) |
| TR_TT001 | -35 | 10 | PT100 | TR_HX001 Liquid inlet |
| TR_TT002 | -35 | 10 | PT100 | TR_HX001 block 1 |
| TR_TT003 | -35 | 10 | PT100 | TR_HX001Dry-out monitoring |
| TR_TT004 | -35 | 10 | PT100 | TR_HX001 Vapor outlet |
| TR_TT005 | -35 | 10 | PT100 | TR_HX002 Dry-out monitoring |
| TR_TT006 | -35 | 10 | PT100 | TR_HX003 Dry-out monitoring |
| TR_TT007 | -35 | 10 | PT100 | TR_HX004 Dry-out monitoring |
| TR_TT008 | -35 | 10 | PT100 | TR_HX005 Dry-out monitoring |
| TR_TT009 | -35 | 10 | PT100 | TR_HX006 Dry-out monitoring |
| TR_TT010 | -35 | 10 | PT100 | TR_HX007 Dry-out monitoring |
| TR_TT011 | -35 | 10 | PT100 | TR_HX008 Dry-out monitoring |
| TR_TT012 | -35 | 10 | PT100 | TR_HX009 Dry-out monitoring |

| | | | | |
|---|---|---|---|---|
| TR_TT013 | -35 | 10 | PT100 | TR_HX010 Dry-out monitoring |
| TR_TT014 | -35 | 10 | PT100 | TR_HX011 Dry-out monitoring |
| TR_TT015 | -35 | 10 | PT100 | TR_HX012 Liquid inlet |
| TR_TT016 | -35 | 10 | PT100 | TR_HX012 block 1 |
| TR_TT017 | -35 | 10 | PT100 | TR_HX012 Dry-out monitoring |
| TR_TT018 | -35 | 10 | PT100 | TR_HX012 Vapor ouTRet |
| TR_TT019 | -35 | 10 | PT100 | TR_HX013 Dry-out monitoring |
| TR_TT020 | -35 | 10 | PT100 | TR_HX014 Dry-out monitoring |
| TR_TT021 | -35 | 10 | PT100 | TR_HX015 Dry-out monitoring |
| TR_TT022 | -35 | 10 | PT100 | TR_HX016 Dry-out monitoring |
| TR_TT023 | -35 | 10 | PT100 | TR_HX017 Dry-out monitoring |
| TR_TT024 | -35 | 10 | PT100 | TR_HX018 Dry-out monitoring |
| TR_TT025 | -35 | 10 | PT100 | TR_HX021Dry-out monitoring |
| TR_TT026 | -35 | 10 | PT100 | TR_HX024 Dry-out monitoring |
| TR_TT027 | -35 | 10 | PT100 | TR_HX025 Dry-out monitoring |
| TR_TT028 | -35 | 10 | PT100 | TR_HX026 Dry-out monitoring |
| TR_TT029 | -35 | 10 | PT100 | TR_HX027 Liquid inlet |
| TR_TT030 | -35 | 10 | PT100 | TR_HX027 block 1 |
| TR_TT031 | -35 | 10 | PT100 | TR_HX027 Dry-out monitoring |
| TR_TT032 | -35 | 10 | PT100 | TR_HX027 Vapor ouTRet |
| TR_TT033 | -35 | 10 | PT100 | Vapor return |
| TR_TT034 | -35 | 10 | PT100 | Vapor return |
| TR_TT035 | -35 | 20 | PT100 | Manifold |
| TR_TT036 | 12 | 30 | PT100 | Bellow flange |
| TR_TT037 | 15 | 27 | PT100 | TR_HT001 Heater Control |
| TR_TT038 | 15 | 27 | PT100 | TR_HT002 Heater Control |
| TR_TT039 | 15 | 27 | PT100 | TR_HT003 Heater Control |
| TR_TT040 | 15 | 27 | PT100 | TR_HT004 Heater Control |
| TR_TT041 | 15 | 27 | PT100 | Module base |
| TR_TT042 | 15 | 27 | PT100 | Module base |
| TR_TT043 | 15 | 27 | PT100 | RF-Foil |
| TR_TT044 | 15 | 27 | PT100 | RF-Foil |

| | | | | |
|---|---|---|---|---|
| TR_TT045 | -35 | 30 | PT100 | Transfer tube liquid outlet |
| TR_TT046 | -35 | 10 | PT100 | Local control box liquid inlet |
| TR_TT047 | -35 | 10 | PT100 | Capillaries inlet |
| TR_TT048 | -35 | 10 | PT100 | Local control box vapor outlet |
| TR_TT101 | -45 | 5 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | Transfer tube vapor outlet |
| TR_TT102 | -48 | 30 | PT100 | Main condenser Front plate |
| TR_TT103 | -48 | 5 | PT100 | Main condenser inlet |
| TR_TT104 | -48 | 5 | PT100 | Back-up condeser inlet |
| TR_TT105 | -48 | 5 | PT100 | Main condenser outlet |
| TR_TT106 | -48 | 5 | PT100 | Back-up condeser outlet |
| TR_TT107 | -45 | 5 | PT100 | Accumulator line |
| TR_TT108 | -20 | 5 | PT100 | Accumulator Liquid |
| TR_TT109 | -5 | 20 | PT100 | Accumulator Vapor |
| TR_TT110 | -48 | -2 | PT100 | Condenser outlet |
| TR_TT111 | -5 | 10 | PT100 | TLR-PM101 pump.state head cooling |
| TR_TT112 | -48 | -2 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | TR-PM101 pump.state inlet |
| TR_TT113 | -40 | 30 | PT100 | TR-PM101 pump.state head oil side |
| TR_TT114 | -40 | 30 | PT100 | TR-PM101 pump.state head $CO_2$ side |
| TR_TT115 | -45 | -2 | PT100 | TR-PM101 pump.state outlet |
| TR_TT116 | -45 | -2 | PT100 | liquid line |
| TR_TT117 | -45 | 30 | PT100 | By-pass liquid |
| TR_TT118 | -45 | 30 | PT100 | By-pass vapor |
| TR_TT119 | -48 | 30 | PT100 | Condenser Back plate |
| TR_TT120 | -48 | 30 | PT100 | Transfer tube liquid inlet |
| TR_TT121 | 0 | 100 | Thermocouple K | Press damper temperature |
| TR_TT122 | 12 | 25 | Thermocouple K | TR-HT102 Control (pump.state oil heater) |
| TR_TT123 | 0 | 100 | Thermocouple K | TR-HT103 Control |
| TR_TT124 | -45 | 50 | Thermocouple K | TR-HT104 Control |
| TR_TT125 | -45 | 100 | Thermocouple K | TR-HT105 Control (Accu heater) |

| | | | | |
|---|---|---|---|---|
| TLR_TT112 | -35 | 10 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | TLR-PM101 pump.state inlet |
| TLR_TT113 | -35 | 10 | PT100 | TLR-PM101 pump.state head oil side |
| TLR_TT114 | -35 | 10 | PT100 | TLR-PM101 pump.state head $CO_2$ side |
| TLR_TT115 | -35 | 10 | PT100 | TLR-PM101 pump.state outlet |
| TLR_TT122 | -45 | 80 | Thermocouple K | TLR-HT102 Control (pump.state oil heater) |
| SA_TT101 | 15 | 25 | PT100 | Discharge |
| SA_TT102 | 4 | 25 | PT100 | Condensor outlet |
| SA_TT103 | 12 | 25 | PT100 | Liquid vessel inlet |
| SA_TT104 | 12 | 25 | PT100 | Liquid vessel |
| SA_TT105 | 12 | 25 | PT100 | Liquid |
| SA_TT106 | -45 | 25 | PT100 | SA-HX103 subcooled liquid |
| SA_TT107 | -45 | 25 | PT100 | SA-HX103 evaporator inlet |
| SA_TT108 | -45 | 25 | PT100 | SA-HX103 evaporator outlet |
| SA_TT109 | -45 | 25 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | SA-HX103 superheat |
| SA_TT110 | -45 | 25 | PT100 | SA-HX105 subcooled liquid |
| SA_TT111 | -45 | 25 | PT100 | SA-HX105 evaporator inlet |
| SA_TT112 | -45 | 25 | PT100 | SA-HX105 evaporator outlet |
| SA_TT113 | -45 | 25 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | SA-HX105 superheat |
| SA_TT114 | -35 | 25 | PT100 | SA-HX107/108 subcooled liquid |
| SA_TT115 | -35 | 25 | PT100 | SA-HX107 evaporator inlet |
| SA_TT116 | -35 | 25 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | SA-HX107 superheat |
| SA_TT117 | -35 | 25 | PT100 | SA-HX108 evaporator inlet |
| SA_TT118 | -35 | 25 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | SA-HX108 superheat |
| SA_TT119 | -35 | 25 | PT100 | SA-HX107/108 cold gas |
| SA_TT120 | -35 | 25 | PT100 | SA-HX107/108 Suction |
| SA_TT121 | -35 | 25 | PT100 | Suction |

| | | | | |
|---|---|---|---|---|
| SA_TT122 | 12 | 60 | PT100 | Compressor |
| SB_TT101 | 15 | 100 | PT100 | Discharge |
| SB_TT102 | 4 | 35 | PT100 | Condensor outlet |
| SB_TT104 | 12 | 35 | PT100 | Liquid vessel |
| SB_TT105 | 12 | 35 | PT100 | Liquid |
| SB_TT107 | -35 | 25 | PT100 | SB-HX103 evaporator inlet |
| SB_TT109 | -35 | 25 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | SB-HX103 superheat |
| SB_TT111 | -35 | 25 | PT100 | SB-HX105 evaporator inlet |
| SB_TT113 | -35 | 25 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | SB-HX105 superheat |
| SB_TT114 | -25 | 25 | PT100 | subcooled liquid |
| SB_TT115 | -25 | 25 | PT100 | SB-HX107 evaporator inlet |
| SB_TT116 | -25 | 25 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | SB-HX107 superheat |
| SB_TT117 | -25 | 25 | PT100 | SB-HX108 evaporator inlet |
| SB_TT118 | -25 | 25 | Internal PT100 Rodax: PPA_PT100_SO_S_A1_D3_W4_130_6D | SB-HX108 superheat |
| SB_TT119 | -25 | 25 | PT100 | Cold gas |
| SB_TT121 | -25 | 25 | PT100 | Suction |
| SB_TT122 | 12 | 25 | PT100 | Compressor |
| PA_TT101 | 4 | 15 | PT100 | Cooling water inlet |
| PA_TT102 | 4 | 15 | PT100 | Cooling water outlet |
| PB_TT101 | 12 | 35 | PT100 | Air inlet |

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|---|---|---|---|

**To : NIKHEF**

**Attn : Dhr. P.J.M. de Groen**

**From : Tom Smets**

**Page :** 1

E-mail address: tsmets@rodax.be

In case you did not receive all pages, please contact +32 3 360 90 00

Geachte heer de Groen,

Betreft : Uw prijsaanvraag d.d. 18/11/2004

Hiermede hebben wij het genoegen U volgende aanbieding te maken :

PZA Pt100 NW S A1 D3 W4 750

| | |
|---|---|
| PZA | : RTD model |
| Pt100 NW | : RTD type |
| S | : Single element |
| A1 | : Nauwkeurigheidsklasse |
| D3 | : Diameter 3 mm |
| W4 | : 4-draads uitvoering |
| 750 | : Lengte element 750 mm |

Prijs voor 1-9 stuks : 55,70 Euro/stuk
Prijs vanaf 10 stuks : 45,50 Euro/stuk
Levertermijn : 4-6 weken (eventueel nader te bespreken)

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Onze algemene verkoopsvoorwaarden zijn van toepassing.
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Ze staan ook beschikbaar op onze website : www.rodax-europe.com
De hiernavolgende bijzondere voorwaarden zijn eveneens geldig:

| | |
|---|---|
| Prijzen | : excl. BTW |
| Betaling | : 30 net |
| Levering | : - DDP Benelux > 125 €<br>- Voor een orderbedrag minder dan 125.00 €, zal 17.00 € vrachtkosten aangerekend worden<br>- minimum orderbedrag: 75.00 €<br>- voor een orderbedrag minder dan 75.00 €, zal 17.00 € administratiekosten aangerekend worden |
| Levertijd | : Zie hierboven |
| Waarborg | : 1 jaar bij juist gebruik met goed vakmanschap, onder normale werkingsomstandigheden en binnen de limieten van het product. |
| Geldigheidsduur van de offerte | : 30 dagen |

Als u nog eventuele vragen heeft hoor ik het graag.

Met vriendelijke groeten,

Tom Smets
Inside Sales Engineer

RODAX NV

Figure 11.2-1: Submerged PT100's

### 11.2.2 Pressure Transmitters

Table 11.2-1: VTCS Pressure sensors

| Code | Part number | Function | Connection | Operating Pressure (Bar) | Maximum Design Pressure (Bar) | Minimum design temperature (°C) | Maximum design temperature (°C) | Minimum measuring range (Bar) | Maximum measuring range(Bar) | Supply (V) | Output signal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TL_PT001 | Kulite HKM-375M-100BAR-A | Transfer tune outlet pressure | M10x1 Male | 100 | 200 | | | 0 | 100 | 10Vdc | 100mV |
| TL_PT002 | Kulite HKM-375M-100BAR-A | Evaporator inlet pressure | M10x1 Male | 100 | 200 | | | 0 | 100 | 10Vdc | 100mV |
| TL_PT003 | Kulite HKM-375M-100BAR-A | Evaporator (outlet) pressure | M10x1 Male | 100 | 200 | | | 0 | 100 | 10Vdc | 100mV |
| TL_PT004 | Balzers Pirani TPR0118 (DN 16 CF-F) BGG15011 | Tertiary vacuum monitoring | CF16 | 2 | | | | 1.00E-06 | 1 | | |
| TL_PT101 | Druck PTX7511-100bar | Condenser pressure | G1/4"Female | 100 | 200 | -40 | 80 | 0 | 100 | 9-30Vdc | 4-20mA |
| TL_PT102 | Druck PTX7511-100bar | Accumulator pressure | G1/4"Female | 100 | 200 | -40 | 80 | 0 | 100 | 9-30Vdc | 4-20mA |
| TL_PT103 | Lewa pump integral | TL-PM101 Membrane Pressure | | 100 | | | | | | | Open/close |
| TL_PT104 | Druck PTX7511-100bar | Pump outlet | G1/4"Female | 100 | 200 | -40 | 80 | 0 | 100 | 9-30Vdc | 4-20mA |
| TR_PT001 | Kulite HKM-375M-100BAR-A | Transfer tune outlet pressure | M10x1 Male | 100 | 200 | | | 0 | 100 | 10Vdc | 100mV |
| TR_PT002 | Kulite HKM-375M-100BAR-A | Evaporator inlet pressure | M10x1 Male | 100 | 200 | | | 0 | 100 | 10Vdc | 100mV |
| TR_PT003 | Kulite HKM-375M-100BAR-A | Evaporator (outlet) pressure | M10x1 Male | 100 | 200 | | | 0 | 100 | 10Vdc | 100mV |
| TR_PT004 | Balzers Pirani TPR0118 (DN 16 CF-F) BGG15011 | Tertiary vacuum monitoring | CF16 | 2 | | | | 1.00E-06 | 1 | | |
| TR_PT101 | Druck PTX7511-100bar | Accumulator pressure | G1/4"Female | 100 | 200 | -40 | 80 | 0 | 100 | 9-30Vdc | 4-20mA |
| TR_PT102 | Druck PTX7511-100bar | Accumulator pressure | G1/4"Female | 100 | 200 | -40 | 80 | 0 | 100 | 9-30Vdc | 4-20mA |
| TR_PT103 | Lewa pump integral | TR-PM101 Membrane Pressure | | 100 | | | | | | | Open/close |
| TR_PT104 | Druck PTX7511-100bar | Pump outlet | G1/4"Female | 100 | 200 | -40 | 80 | 0 | 100 | 9-30Vdc | 4-20mA |
| TLR_PT103 | Lewa pump integral | TLR-PM101 Membrane Pressure | | 100 | | | | | | | Open/close |
| SA_PT101 | Danfoss AKS 33 60G2051 | Discharge pressure | 1/4" Male Flare | 33 | 55 | 0 | 80 | 0 | 35 | | 4-20mA |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SA_PT102 | Danfoss AKS 33 60G2051 | Liquid pressure | 1/4" Male Flare | 33 | 55 | 0 | 80 | 0 | 35 | | 4-20mA |
| SA_PT103 | Danfoss AKS 33 60G2048 | Left evaporator pressure | 1/4" Male Flare | 33 | 33 | -30 | 40 | 0 | 7 | | 4-20mA |
| SA_PT104 | Danfoss AKS 33 60G2048 | Rigth evaporator pressure | 1/4" Male Flare | 33 | 33 | -30 | 40 | 0 | 7 | | 4-20mA |
| SA_PT105 | Danfoss AKS 33 60G2048 | Left accumulator pressure | 1/4" Male Flare | 33 | 33 | -30 | 40 | 0 | 7 | | 4-20mA |
| SA_PT106 | Danfoss AKS 33 60G2048 | Right accumulator pressure | 1/4" Male Flare | 33 | 33 | -30 | 40 | 0 | 7 | | 4-20mA |
| SA_PT107 | Danfoss AKS 33 60G2048 | Suction gas pressure | 1/4" Male Flare | 33 | 33 | -30 | 40 | 0 | 7 | | 4-20mA |
| SA_PT108 | Danfoss KP15 060-1261 | Compressor protection | 1/4" Male Flare | | | | | | | | Open/close |
| SB_PT102 | Danfoss AKS 33 60G2051 | Liquid pressure | 1/4" Male Flare | 33 | 55 | 0 | 80 | 0 | 35 | | 4-20mA |
| SB_PT103 | Danfoss AKS 33 60G2048 | Left evaporator pressure | 1/4" Male Flare | 33 | 33 | -30 | 40 | 0 | 7 | | 4-20mA |
| SB_PT104 | Danfoss AKS 33 60G2048 | Right evaporator pressure | 1/4" Male Flare | 33 | 33 | -30 | 40 | 0 | 7 | | 4-20mA |
| SB_PT105 | Danfoss AKS 33 60G2048 | Left accumulator pressure | 1/4" Male Flare | 33 | 33 | -30 | 40 | 0 | 7 | | 4-20mA |
| SB_PT106 | Danfoss AKS 33 60G2048 | Right accumulator pressure | 1/4" Male Flare | 33 | 33 | -30 | 40 | 0 | 7 | | 4-20mA |
| SB_PT108 | Danfoss KP15 060-1261 | Compressor protection | 1/4" Male Flare | | | | | | | | Open/close |
| SB_PT109 | | Condenser fan speed control | | | | | | | | | |

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# PTX 7500 Specifications

## Pressure Measurement

**Operating Pressure Ranges**
Any zero based full scale (FS) from 1.5 to 1000 psi (100 mbar to 70 bar) gauge or absolute
Any zero based FS above 1000 psi (70 bar) up to 10000 psi (700 bar) sealed gauge or absolute
Barometric 11.5 to 17.4 psi (800 to 1200 mbar) absolute

For other barometric, elevated zero (e.g. 15 to 60 psi (1 to 4bar)) and compound ranges (e.g. -15 to +15 psi (-1 to +1 bar)) Refer to GE Druck for further information

**Pressure Units**
psi, mbar, bar, hPa, kPa, MPa, $mmH_2O$, torr, $kgf/cm^2$ $cmH_2O$, $mH_2O$, $inH_2O$, $ftH_2O$, mmHg, inHg, $kg/cm^2$

**Over Pressure**
The operating FS pressure range can be exceeded by the following multiples with negligible effect on calibration:
- 8 x for ranges up to 2.5 psi (160 mbar)
- 6 x for ranges above 2.5 to 7.5 psi (160 up to 500 mbar)
- 4 x for ranges above 7.5 to 30 psi (500 mbar up to 2 bar)
- 3 x for ranges above 30 up to 2030 psi (2 up to 140 bar) (2900 psi (200 bar) max)
- 2 x for ranges above 2030 up to 10000 psi (140 up to 700 bar) (14500 psi (1000 bar) max)

**Pressure Containment**
The operating FS pressure range may be exceeded by the following multiples without a loss of mechanical containment:-

Gauge ranges:
- 12 x for ranges up to 2.5 psi (160 mbar)
- 8 x for ranges above 2.5 to 7.5 psi (160 up to 500 mbar)
- 6 x for ranges above 7.5 to 30 psi (500 mbar up to 2 bar)
- 4 x for ranges above 30 to 1015 psi (2 up to 70 bar) (2900 psi (200 bar) max)

Sealed gauge and absolute ranges:
- 3625 psi (250 bar) for ranges 1.5 to 2030 psi (100 mbar to 140 bar)
- 14500 psi (1000 bar) for ranges above 2030 up to 10155 psi (140 up to 700 bar)

Pressure Equipment Directive (PED) 97/23/EC approved (Category 1 - Pressure Accessory)

**Pressure Media**
Fluids compatible with 316L stainless steel and Hastelloy C276 (NACE compatible grades)

**Supply Voltage**
9 to 30 V at PTX terminals (28 V maximum for Intrinsically Safe option)

**Start -Up Time**
Recommended minimum power on time before output sample is taken is 500 msec

**Output Signal**
4 to 20 mA (2 wire) proportional to the zero to FS pressure range

## Performance

**Accuracy**
Combined effects of non-linearity, hysteresis and repeatability
±0.1% FS Best Straight Line (BSL) typical (±0.2% FS BSL max)
0.15% Terminal Straight Line (TSL) typical (0.3% TSL max)

**Zero Offset and Span Setting**
Supplied with ±5% zero and span noninteractive site adjustable potentiometers (excludes 7533 model)

**Long Term Stability**
±0.1% FS per year

**Operating Temperature Range**
-40 to 212°F (-40 to 100°C) ambient (176°F (80°C) max for 7511/7533/7534 models)
-40 to 248°F (-40 to 120°C) process media

**Temperature Effects**
Output will not deviate from room temperature (RTE) by more than:
- 0.7% FS typical (1% FS max) over 14 to 122°F (-10 to 50°C)
- 1.5% FS typical (2% FS max) over -4 to 176°F (-20 to 80°C)

For ranges below 500 bar, these values will multiply on a pro rata basis.

**Shock**
- 1000g, half sine pulse, duration 1 msec
- 100g, peak half sine wave duration 11 msec
- 2000g, half sine pulse, duration 0.5 msec

All in each of 3 mutually respendicular axis will not effect calibration.

**Vibration**
Conforms to MIL-STD 810C method 514.2 figure 514.2-2 curve L

**Pressure Response**
1kHz band width (63% response to step change in pressure).

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**Certification**
Certificate of Calibration supplied as standard.

**CE marking**
Marked for use in potentially explosive atmosphere, electromagnetic compatibility and the pressure equipment directive.

**Hazardous Area Approval**
EEx ia IIC T4 (-40 < T amb < 80°C)
Certificate BAS01 ATEX1254
300 metres max integral cable (models PTX 7511/7533)

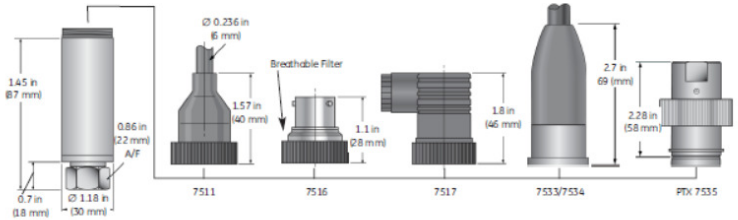
## Physical

**Pressure Connection**
G1/4 female with Option B screw-in adaptors

**Electrical Connection**
- IP65 Integral 5.7mm polyurethane cable
- IP65 6-pin bayonet plug
- IP65 DIN 43650A plug/socket
- IP68 Integral 8mm polyurethane or hytrel cable
- IP65 M20 female conduit (PTX 7500)

## Options

(A) ATEX Intrinsically Safe Approval
(B) Screw in adaptors with bonded seals
(C) Separate vented cable (7517)
5.7mm vented cable provided as a separate line item (supplied unfitted)
(D) Pressure snubber adaptor
Refer to GE for further information




*Installation drawing*

## Ordering Information

**Please state the following:**
**(1) Select model number**

| Code | Output | |
|---|---|---|
| PTX75 | mA output | |
| | **Code** | **Electrical Connections** |
| | 11 | 5.7 MM INTEGRAL CABLE Core (IP65) |
| | 16 | 6-pin bayonet plug (IP65) |
| | 17 | DIN 43650 plug/socket (IP 65) |
| | 33 | 8 mm integral cable (IP 68) |
| | 34 | 8 mm integral Hytrel cable (IP68) |
| | 35 | M20 female conduit (IP65) |
| PTX 75 | 11 | **Typical model number** |

*(2) Pressure range*
*(3) Pressure units e.g. psi, bar, etc..*
*(4) Specify gauge or absolute*
*(5) Cable lengths (7511, 7533, 7534)*
*(6) Required options*

## Wiring Details

| | + supply | - supply |
|---|---|---|
| PTX 7511 | Red | Blue |
| PTX 7516 | A | B |
| PTX 7517 | 1 | 2 |
| PTX 7533/7534 | Red | Blue |
| PTX 7535 | A | B |



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Figure 11.2-2: $CO_2$ pressure sensors in the cooling plant

**kulite**

## MINIATURE HIGH PRESSURE IS® PRESSURE TRANSDUCER

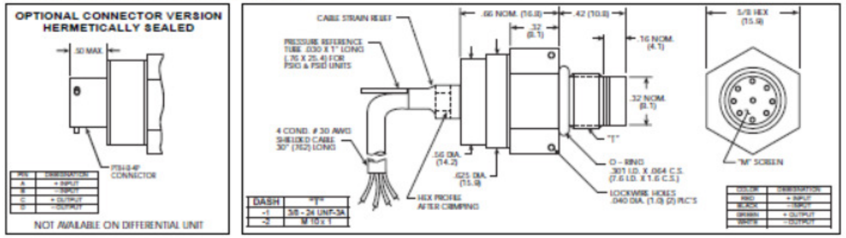
**HKM-375 (M) SERIES HKL-375 (M) SERIES**

- Excellent Stability
- All Welded Construction
- Robust Construction
- High Natural Frequencies
- 3/8-24 UNJF or M10 X 1 Thread
- Patented Leadless Technology (HKL Series)

The HKM-375 is a miniature threaded pressure transducer. The hexagonal head and o-ring seal make it easy to mount and simple to apply.

The HKM-375 utilizes a flush metal diaphragm as a force collector. A solid state piezoresistive sensing element is located immediately behind this metal diaphragm which is protected by a metal screen. Force transfer is accomplished via an intervening film of non-compressible silicone oil. This sensing sub assembly is welded to a stainless steel body. The HKL-375 Series utilizes Kulite's Patented Leadless Technology.

This advanced construction results in a highly stable, reliable and rugged instrument with all the advantages of microcircuitry: significant miniaturization, excellent repeatability, low power consumption, etc. The miniaturization process also yields a marked increase in the natural frequencies of the transducers, making them suitable for use even in shock pressure measurements.




| | HKL/HKM | | | | | | | HKM | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **INPUT** Pressure Range | 1.7<br>25 | 3.5<br>50 | 7<br>100 | 17<br>250 | 35<br>500 | 70<br>1000 | 170<br>2500 | 350<br>5000 | 700<br>10000 | 1400 BAR<br>20000 PSI |
| Operational Mode | Absolute, Gage, Sealed Gage, Differential | | | | | | | | | |
| Over Pressure | 2 Times Rated Pressure to a Max. of 30000 PSI (2100 BAR) | | | | | | | | | |
| Burst Pressure | 3 Times Rated Pressure to a Max. of 35000 PSI (2400 BAR) | | | | | | | | | |
| Pressure Media | Any Liquid or Gas Compatible With 15-5PH or 316 SS (HKM) 15-5 PH SS and $SiO_2$ (HKL) | | | | | | | | | |
| Rated Electrical Excitation | 10 VDC | | | | | | | | | |
| Maximum Electrical Excitation | 15 VDC | | | | | | | | | |
| Input Impedance | 1000 Ohms (Min.) | | | | | | | | | |
| **OUTPUT** Output Impedance | 1000 Ohms (Nom.) | | | | | | | | | |
| Full Scale Output (FSO) | 100 mV (75 mV For 25 PSI Range) (Nom.) | | | | | | | | | |
| Residual Unbalance | ± 5 mV (Typ.) | | | | | | | | | |
| Combined Non-Linearity, Hysteresis and Repeatability | ± 0.1% FS BFSL (Typ.) | | | | | | | | | |
| Resolution | Infinitesimal | | | | | | | | | |
| Natural Frequency (KHz) (Typ.) | 400 | 500 | 600 | 750 | 1000 | 1200 | 1500 | 1120 | 1350 | 1600 |
| Acceleration Sensitivity % FS/g Perpendicular Transverse | $3.0x10^{-4}$<br>$6.0x10^{-5}$ | $1.5x10^{-4}$<br>$3.0x10^{-5}$ | $1.0x10^{-4}$<br>$2.0x10^{-5}$ | $5.0x10^{-5}$<br>$1.0x10^{-5}$ | $3.0x10^{-5}$<br>$6.0x10^{-6}$ | $2.0x10^{-5}$<br>$4.0x10^{-6}$ | $1.1x10^{-5}$<br>$2.2x10^{-6}$ | $2.0x10^{-5}$<br>$2.4x10^{-6}$ | $1.3x10^{-5}$<br>$1.5x10^{-6}$ | $8.0x10^{-6}$<br>$1.0x10^{-6}$ |
| Insulation Resistance | 100 Megohm Min. at 50 VDC | | | | | | | | | |
| **ENVIRONMENTAL** Operating Temperature Range | –65° F to +350° F (–55° C to +175° C) | | | | | | | | | |
| Compensated Temperature Range | +80° F to +180° F (+25° C to 80° C) Any 100° F Range Within The Operating Range on Request | | | | | | | | | |
| Thermal Zero Shift | ± 1% FS/100° F (55° C) (Typ.) (± 2% FS/100° F For 25 PSI Range) | | | | | | | | | |
| Thermal Sensitivity Shift | ± 1% FS/100° F (55° C) (Typ.) (± 2% FS/100° F For 25 PSI Range) | | | | | | | | | |
| Linear Vibration | 100g Peak, Sine up to 5000 Hz | | | | | | | | | |
| Humidity | 100% Relative Humidity | | | | | | | | | |
| Mechanical Shock | 20,000g, 100µ sec. | | | | | | | | | |
| **PHYSICAL** Electrical Connection | 4 Conductor 30 AWG Shielded Cable 30" (762) Long | | | | | | | | | |
| Weight | 17 Grams (Max.) Excluding Cable | | | | | | | | | |
| Sensing Principle | Fully Active Four Arm Wheatstone Bridge Dielectrically Isolated Silicon on Silicon (Patented Leadless Technology - HKL) | | | | | | | | | |
| Mounting Torque | 80 Inch-Pounds (Max.) | | | | | | | | | |

*Note: Custom pressure ranges, accuracies and mechanical configurations available.*
*Continuous development and refinement of our products may result in specification changes without notice - all dimensions nominal. (B)*

*KULITE SEMICONDUCTOR PRODUCTS, INC. • One Willow Tree Road • Leonia, New Jersey 07605 • Tel: 201 461-0900 • Fax: 201 461-0990 • http://www.kulite.com*

**STEKON**

*load cells / pressure sensors / electronics*

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Datum/Date : 13 april 2007
Aan/To : Nikhef
T.a.v./Attn. : Dhr. B. Verlaat
Betr./Re. : offerte Kulite druksensoren / AW980 versterkers
Onze/Our ref. : S-K-02587-EL
Email : bverlaat@nikhef.nl

Aantal pagina's/Number of pages: 1 (incl. voorpagina/frontpage)

Geachte heer Verlaat,

Naar aanleiding van ons telefonisch onderhoud van hedenmiddag bieden wij u hierbij als volgt aan:

**6 x Kulite druksensor, model HKM-375M-100BAR-A.**
Drukbereik: 100 BAR (Absoluut): $ 777,00
De sensor wordt voorzien van een connector en 'mating'-connector: $ 138,00
Gecompenseerde temperatuur range: -30°C tot +20°C: $ 57,00
Overige technische gegevens volgens bijlage.
Prijs per stuk: $ 972,00

Totaalprijs 6 stuks: $ 5.832,00

**3 x Meetversterker, 2-kanaals, model AW980-2K.**
Output 4-20mA / 0-10V
De Kulite sensoren worden afgeregeld op deze meetversterkers.
Technische gegevens reeds in uw bezit.
Prijs per stuk: € 525,00

Totaalprijs 3 stuks: € 1.575,00

Wij wijzen u erop dat de prijzen voor de Kulite sensoren zijn vermeld in US-dollars.
Uiteraard is betaling in Euro's mogelijk tegen de ten tijde van facturatie geldende koers.

Figure 11.2-3: $CO_2$ pressure sensors in cooling bridge

## Introduction

AKS 32 and AKS 33 are pressure transmitters that measure a pressure and convert the measured value to a standard signal:

- 1 → 5 V d.c. or 0 → 10 V d.c. for AKS 32
- 4 → 20 mA for AKS 33

A robust design makes the AKS very suitable for application within a number of fields e.g.

- Air conditioning systems
- Refrigeration plant
- Process control
- Laboratories

## Features

Highly developed sensor technology means high pressure regulation accuracy, a very important factor in the precise and energy-economic capacity regulation of refrigeration plant.

- Temperature compensation for LP and HP pressure transmitters, developed specially for refrigeration plant:
  LP: −30 → +40°C (≦16 bar)
  HP: 0 → +80°C (>16 bar)
- Compatibility with all refrigerants incl. ammonia means less stock and greater application flexibility.
- Built-in voltage stabiliser, i.e. the AKS pressure transmitters can be powered from an unregulated voltage supply of any output within given limits.
- Effective protection against moisture means that the sensor can be mounted in very harsh environments, e.g. in the suction line encapsulated in an ice block.
- Robust construction gives protection against mechanical influences such as shock, vibration and pressure surge. AKS sensors can be mounted direct on to the plant.
- No adjustment necessary. With the highly developed sensor technology and sealed gauge principle, the accuracy of the factory
- setting is maintained independent of variations in ambient temperature and atmospheric pressure. This is very important when ensuring evaporating pressure control in air conditioning and refrigeration applications.
- EMC protection according to EU EMC-directive (CE-marked)
- UL approved
- Polarity protected inputs.

*AKS 33, version 4 → 20 mA*

| Operating range bar | | Max. working pressure PB bar | Compensated temperature range °C | Code no. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | DIN 43650 plug | | | Cable | | |
| | | | | 1/4 NPT 1) | G 1/4 A 2) | 1/4 flare 3) | 1/4 NPT 1) | G 1/4 A 2) | 1/4 flare 3) |
| LP | −1 → 5 | 33 | −30 → +40 | 060G2112 | 060G2108 | 060G2047 | | | |
| | −1 → 6 | 33 | −30 → +40 | 060G2100 | 060G2104 | 060G2048 | 060G2116 | 060G2120 | |
| | −1 → 9 | 33 | −30 → +40 | 060G2113 | 060G2111 | 060G2044 | | | 060G2062 |
| | −1 → 12 | 33 | −30 → +40 | 060G2101 | 060G2105 | 060G2049 | 060G2117 | | |
| | −1 → 20 | 40 | 0 → +80 | 060G2102 | 060G2106 | 060G2050 | 060G2118 | | |
| HP | −1 → 34 | 55 | 0 → +80 | 060G2103 | 060G2107 | 060G2051 | 060G2119 | | 060G2065 |
| | 0 → 16 | 40 | 0 → +80 | 060G2114 | 060G2109 | | | | |
| | 0 → 25 | 40 | 0 → +80 | 060G2115 | 060G2110 | | | 060G2127 | 060G2067 |

1) 1/4-18 NPT
2) Thread ISO 228/1 - G 1/4 A (BSP)
3) 7/16-20 UNF

Figure 11.2-4: HFC pressure sensors

Technical leaflet | Pressure transmitters, type AKS 32 and AKS 33

## Technical data

*Performance*

| | |
|---|---|
| Accuracy (3 σ) | ±0.3% FS (typ.)/±0.8% FS (max.) |
| Non-linearity (Best fit straight line) | < ±0.2% FS |
| Hysteresis and repeatability | ≦ ±0.1% FS |
| Thermal zero point shift | ≦ ±0.1% FS/10K (typ.)<br>≦ ±0.2 %FS/10K (max.) |
| Thermal sensitivity (span) shift | ≦ ±0.1% FS/10K (typ.)<br>≦ ±0.2 %FS/10K (max) |
| Response time | < 4 ms |
| Max. operating pressure | See ordering, overleaf |
| Burst pressure | min. 300 bar |

*Electrical specifications for AKS 33, 4 - 20 mA output signal*

| | |
|---|---|
| Rated output signal | 4 to 20 mA |
| Supply voltage, $V_{supply}$ (polarity protected) | 10 to 30 V d.c. |
| Voltage dependency | < 0.05% FS/10 V |
| Current limitation (linear output signal up to 1.5 × rated range) | 28 mA |
| Max. load, $R_L$ | $R_L \leq \frac{V_{supply} - 10\ V}{0.02\ A}$ [Ω] |

*Electrical specifications for AKS 32, 0 - 10 V d.c. output signal*

| | |
|---|---|
| Rated output signal (short-circuit protected) | 0 to 10 V d.c. |
| Supply voltage, $V_{supply}$ (polarity protected) | 15 to 30 V d.c. |
| Supply current consumption | < 8 mA |
| Supply voltage dependency | < 0.05% FS/10 V |
| Output impedance | < 25 Ω |
| Load resistance, $R_L$ | $R_L \geq 10$ kΩ |

*Electrical specifications for AKS 32, 1-5 V d.c. output signal*

| | |
|---|---|
| Rated output signal (short-circuit protected) | 1 to 5 V d.c. |
| Supply voltage, $V_{supply}$ (polarity protected) | 9 to 30 V d.c. |
| Supply current consumption | < 5 mA |
| Supply voltage dependency | < 0.05% FS/10 V |
| Output impedance | < 25 Ω |
| Load resistance, $R_L$ | $R_L \geq 10$ kΩ |

*Environmental conditions*

| | | | | | |
|---|---|---|---|---|---|
| Operating temperature range | | | | | −40 to 85°C |
| Compensated temperature range | | | | | LP:−30 to +40°C / HP:0 to +80°C |
| Transport temperature range | | | | | −50 to 85°C |
| EMC - Emission | | | | | EN 50081-1 |
| EMC - Immunity | Electrostatic discharge | | Air | 8 kV | EN 50082-2 (IEC 801-2) |
| | | | Contact | 4 kV | EN 50082-2 (IEC 801-2) |
| | RF | field | 10 V/m, 26 MHz - 1 GHz | | EN 50082-2 (IEC 801-3) |
| | | conducted | 3 $V_{rms}$, 150 kHz - 30 MHz | | EN 50082-2 (IEC 801-6) |
| | Transient | | burst | 4 kV (CM) | EN 50082-2 (IEC 801-4) |
| | | | surge | 1 kV (CM,DM) | EN 50082-2 (IEC 801-5) |
| Insulation resistance | | | | | > 100 MΩ at 500 V d.c. |
| Mains frequency test | | | 500 V, 50 Hz | | SEN 361503 |
| Vibration stability | Sinusoidal | | 20 g, 25 Hz - 2 kHz | | IEC 68-2-6 |
| | Random | | 7,5 $g_{rms}$, 5 Hz - 1 kHz | | IEC 68-2-34, IEC 68-2-36 |
| Shock resistance | Shock | | 500 g / 1 ms | | IEC 68-2-27 |
| | Free fall | | | | IEC 68-2-32 |
| Enclosure | Plug version | | | | IP 65 - IEC 529 |
| | Cable version | | | | IP 67 - IEC 529 |

### 11.2.3 Level Transmitters

Table 11.2-2: VTCS level transmitters

| Code | Part number | Function | Connection | Operating Pressure (Bar) |
|---|---|---|---|---|
| TL_LT101 | American Magnetics Model 175 RF | TL Accumulator liquid level | 1/2" male NPT | 100 |
| TR_LT101 | American Magnetics Model 175 RF | TR Accumulator liquid level | 1/2" male NPT | 100 |

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1009 DB Amsterdam
The Netherlands

VAT-UST-ID-Nr.: DE 188120763

Berlin, December 4, 2006

**Quotation 011801/BLN**
AMI-Ref.: QV15244B

| ITEM | QTY. | DESCRIPTION | PRICE/Euro |
|---|---|---|---|
| 1 | 1 | **Model 286 Liquid Level Controller with 4-20 mA Output** | **€ 1.681** |

The Model 286 Liquid Level Controller is an advanced, microprocessor-based solution designed to provide reliable level monitoring and control of virtually any cryogenic or non-conductive, low viscosity liquid. The unit operates by measuring sensor capacitance which is directly related to the liquid level in the sensor. The Model 286 features include up to 4 independent level sensor inputs, 2 independent controller outputs, mode selected operation, built-in approximate calibrations for liquids other than nitrogen, fill/drain rate, multiple calibration values for each channel, etc.

The system consists of the Model 286 controller, sensors, and connecting coaxial cables. Cryogenic solenoid valves operated by the Model 286 are an available option needed to fully utilize the capabilities of this instrument. All calibration data is password protected to prevent unauthorized modification and is stored in non-volatile memory. In most cases factory calibration is included, but for highest accuracy the system can be field calibrated after installation is complete.

**Operation Modes**
Normal Mode utilizes two (2) capacitance sensor inputs and allows these to operate independent control valve outputs to perform two (2) basic auto-fill functions at the same time.

**System Description**
The Model 286 is keypad or remotely controlled. Hi - Low alarm and control band setpoints are user configurable on all four channels. Hi - Low alarms and corresponding rear panel dry contact relays are provided for both of the two control channels. Fill and drain rate is displayed in %, centimeters, or inches per minute. A fill and drain rate alarm is also provided for each of the two control channels.

The Model 286 control and alarm functions are keypad programmable from 0 to 100 percent of the active sensing length. Two independent control band setpoints, "A" and "B", activate selected power receptacles on the rear panel. When the liquid level drops below the "B" setpoint, the power receptacle is energized and remains energized until the liquid level rises to the "A" setpoint. The Model 286 also provides a fail-safe timer feature that automatically de-energizes

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Amtsgericht Darmstadt HRB 6538 Geschäftsführer: Ralph Köhler

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the power receptacle once a programmed maximum time interval is reached. In addition, the Model 286 provides "High" and "Low" alarm setpoints to activate rear panel relay outputs in the event of an overfill or liquid loss condition. Both level alarms also energize an audible warning which can be silenced from the front panel. The Model 286 is ideal for unattended systems where automated refill is required for 1 or 2 vessels.

The Model 286 provides universal bench-top calibration which allows the user to quickly and easily calibrate between various liquids with differing dielectrics. Once the Model 286 is calibrated using a common cryogenic liquid such as nitrogen, the dielectric constant ratio of other liquids can be programmed into the instrument. Several common liquid dielectric values are provided in memory for saturated conditions at 1 atm. pressure. Approximate values can be entered and used without invalidating the base calibration. The Model 286 also has the capability to transform partial length sensor calibration into complete sensor length calibration. This is extremely useful for long sensor applications or where normal calibration is otherwise impractical.

The Model 286 is equipped with a 2 line x 16 character LCD digital display which provides liquid level indication in inches, centimeters or percent as selected by a front panel push button. Microprocessor-based electronics provide 0.1% readout accuracy. Nonvolatile, read only memory maintains instrument calibration without battery backup. Watchdog timer circuitry and low line voltage (brownout) detector prevent microprocessor lock-up and provide fail-safe operation.

The Model 286 has the following specifications:
1. Input power ........ 100-120 or 200-240 VAC, 50-60 Hz; 4.2 amps max.
2. Linearity ........ 0.1%
3. Accuracy ........ 0.1% or 1 mm (whichever is greater)
4. Analog output resolution ........ 16 bits
5. Display ........ Backlit LCD
6. Local interface ........ 4 x 4 keypad
7. Dimensions ........ 3.5"H x 8.4"W x 11.4"D
8. Operating environment ........ 0-40 °C non-condensing
9. Approximate weight ........ 4.9 Lbs.
10. Regulatory ........ CE approved (please specify)

Additional Features:
1. Operation Modes ........ Normal, Pre-Cool, Auto-Changeover
2. Control bands ........ Inputs A and B - user set
3. Controller output ........ Line voltage @ 2A max. current
4. Alarms ........ Audible HI and Low - user set
5. Rear panel alarm relays ........ Normally open, 10 VA @ 0.5 A max. current
6. Rear panel analog outputs ........ Optional
7. Rate alarms ........ User set
8. Precool and fail safe timer ........ User set from 0 to 9999.9 minutes
9. Fill inhibit feature ........ User interrupt with contact inputs
10. Multiple stored calibrations ........ 4 calibrations stored per channel
11. Pre-defined approximate calibration factors ........ LH2, LOX, Ar and LNG

**Liquid CO2 Level Sensor with High Pressure Construction** **€ 2.260**
The liquid level sensor is manufactured of 1/2 inch OD 304 stainless steel tubing and will operate with virtually all cryogenic liquids including nitrogen, hydrogen, oxygen, carbon dioxide, liquefied natural gas, argon, neon, etc. Suitable materials of construction are used for each application. Threaded and flanged fittings are available. The standard sensor is provided with a 1/2 NPT brass swagelok mounting fitting. Twenty feet (6m) of connecting coaxial cable and in-line oscillator/transmitter are included. With additional cable the sensor can be remotely mounted over 500 feet from the instrument without affecting performance.

Liquid level sensor specifications:

1. Outside diameter ........ 0.5 inches
2. Active length ........ 31.5inches (800 mm)
3. Overall length ........ 46 inches (1170 mm)
4. Mounting fitting ........ ½"male NPT brass Swagelock fitting

| | | | |
|---|---|---|---|
| 3 | 1 | **Customization Charge** | **€ 659** |

| | |
|---|---|
| Ship Date: | The earliest ship date is January 31, 2007 due to the holidays and AMI inventory count. Normal delivery is 2-4 weeks after receipt of order |
| Shipping terms: | ex works, duty paid |
| payment: | 30 days, net<br>plus German VAT if you don't supply a valid EU-VAT number with the order; prices do not include VAT; |
| warranty: | 1 year |
| quote valid for: | 60 days |

**Order Cancellation Policy**
In the event that a customer desires to cancel an order after it has been accepted by American Magnetics there may be a cancellation charge for services provided prior to the cancellation. This charge may be for work/engineering performed and/or for material commitments already made by AMI for the purposes of fulfilling the order. The amount of the charge may vary and will be at the discretion of AMI. AMI reserves the right not to ship or sell merchandise that has not been completed, due to order cancellation, and reserves the right to retain ownership of all such materials upon order cancellation. In the unlikely event that AMI must cancel an order all money previously received will be refunded unless other arrangements have been agreed to. This will be the extent of AMI's liability and obligation.

Export or Re-Export of these goods must be made in compliance with all U.S., European and national export laws and regulations. Diversion contrary to U.S., European or national law is prohibited!

***Provision Clause:***
This offer / acceptance of order keeps it's availability only provided that our company will receive an export license for the offered goods from the corresponding authorities ***where required***. Our company is not bound to meet any deliveries and other obligations which arise from an offer, a contract or an acceptance order, if it is detained at it by effective export control regulations of the Federal Republic of Germany, the European Union, the USA or another country respectively, if there exists a common prohibition.

**WEEE/ROHS:** According to the German Electricity Act (ElektroG), the above mentioned electronic products are listed in category 9: „Monitoring and Control Instruments" for commercial users only. Pursuant to § 10.2 of the act, we hereby state that any costs for the disposal of the products are not included in the price and that the sole responsibility for the disposal lies with you as the buyer.
Should you not be able to take care of the disposal yourself, we will be happy to dispose of them on your behalf or provide you with addresses of qualified disposal companies.
LOT-Oriel is registered as a trademark with the German foundation for old electric products (EAR Stiftung) under registration no. DE 76652923.

You can contact: Rainer Weissflog: phone +49/(0)30/49914-775 or weissflog@lot-oriel.com.

With best regards,

Rainer Weißflog

Figure 11.2-5: $CO_2$ level sensor

# 11.3 *Actuators*

## 11.3.1 Valves

Table 11.3-1: VTCS Valves

| Code | Part number | Function | Connection | Operating Pressure (Bar) | Maximum Design Pressure (Bar) | Minimum design temperature (°C) | Maximum design temperature (°C) | Pressure setting range (Bar) | Cv (-) | Orifice (mm) | Supply (V) | Power (W) | Electrical Control | Manual Control | Output signal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL_VL102 | Swagelok SS-43GHLVCR4-42dc | Left VTCS shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TL_VL103 | Swagelok SS-43GXVCR4-42dcx | 3-way Condenser selection | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 0.9 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TL_VL104 | Swagelok SS-43GHLVCR4-42dc | Accumulator shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TL_VL109 | Swagelok SS-43GHLVCR4-42dc | By-pass | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TL_VL111 | Swagelok SS-43GHLVCR4-42dc | Left VTCS shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TL_VL112 | Swagelok SS-43GHLVCR4-42dc | Liquid vent | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TR_VL102 | Swagelok SS-43GHLVCR4-42dc | Left VTCS shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TR_VL103 | Swagelok SS-43GXVCR4-42dcx | 3-way Condenser selection | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 0.9 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TR_VL104 | Swagelok SS-43GHLVCR4-42dc | Accumulator shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TR_VL108 | Swagelok SS-43GXVCR4-42dcx | Pump shut-off/TLR pump cooling | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 0.9 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TR_VL109 | Swagelok SS-43GHLVCR4-42dc | By-pass | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TR_VL111 | Swagelok SS-43GHLVCR4-42dc | Left VTCS shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TR_VL112 | Swagelok SS-43GHLVCR4-42dc | Liquid vent | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TLR_VL101 | Swagelok SS-43GXVCR4-42dcx | Spare pump | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 0.9 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TLR_VL109 | Swagelok SS-43GXVCR4-42dcx | 3-way Condenser selection | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TLR_VL110 | Swagelok SS-43GHLVCR4-42dc | Left-right liquid inter connect | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| TLR_VL111 | Swagelok SS-43GHLVCR4-42dc | Left-right vapor inter connect | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | 24Vdc | 22 | motor/end switch | | Position switch |
| SA_VL106 | Danfoss AKV 10-2/068F1164+018F6701 | Evaporator expansion valve and shut-off valve | 3/8"x1/2" solder | 20 | 42 | -60 | 60 | NA | | 0.65 | | | | | |
| SA_VL110 | Danfoss AKV 10-2/068F1164+018F6701 | Expansion valve | 3/8"x1/2" solder | 20 | 42 | -60 | 60 | NA | | 0.65 | | | | | |
| SA_VL114 | Danfoss AKV 10-1/068F1161+018F6701 | Evaporator expansion valve and shut-off valve | 3/8"x1/2" solder | 20 | 42 | -60 | 60 | NA | | 0.5 | | | | | |
| SA_VL119 | Danfoss AKV 10-1/068F1161+018F6701 | Expansion valve | 3/8"x1/2" solder | 20 | 42 | -60 | 60 | NA | | 0.5 | | | | | |
| SB_VL106 | Danfoss AKV 10-2/068F1164+018F6701 | Evaporator expansion valve and shut-off valve | 3/8"x1/2" solder | 20 | 42 | -60 | 60 | NA | | 0.65 | | | | | |
| SB_VL110 | Danfoss AKV 10-2/068F1164+018F6701 | Expansion valve | 3/8"x1/2" solder | 20 | 42 | -60 | 60 | NA | | 0.65 | | | | | |
| SB_VL114 | Danfoss AKV 10-1/068F1161+018F6701 | Evaporator expansion valve and shut-off valve | 3/8"x1/2" solder | 20 | 42 | -60 | 60 | NA | | 0.5 | | | | | |
| SB_VL119 | Danfoss AKV 10-1/068F1161+018F6701 | Expansion valve | 3/8"x1/2" solder | 20 | 42 | -60 | 60 | NA | | 0.5 | | | | | |
| TL_VL001 | Swagelok SS-4UW-TW | Transfer tube shut-off | 1/4" socket weld | 100 | 172 | -29 | 343 | NA | 0.36 | 4.4 | NA | NA | NA | Proportional | NA |
| TL_VL002 | Swagelok SS31RS4 (Modified) | Liquid expansion | 1/4" Swagelok | 100 | 212 | -65 | 343 | NA | 0.012 Nom / 0.04 max | 1.6 | NA | NA | NA | Proportional | NA |
| TL_VL003 | Swagelok SS-4UW-TW | Test evaporator inlet | 1/4" socket weld | 100 | 172 | -29 | 343 | NA | 0.36 | 4.4 | NA | NA | NA | Proportional | NA |
| TL_VL004 | Swagelok SS-4UW-TW | Evaporator inlet | 1/4" | 100 | 172 | -29 | 343 | NA | 0.36 | 4.4 | NA | NA | NA | Proportiona | NA |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | socket weld | | | | | | | | | | | l | |
| TL_VL006 | Swagelok SS-6UW-TW | Test evaporator outlet | 3/8" socket weld | 100 | 172 | -29 | 343 | NA | 1 | 7.1 | NA | NA | NA | Proportional | NA |
| TL_VL007 | Swagelok SS-58SW8T | Check valve with modified poppet | 1/2" socket weld | 100 | 307 | -53 | 176 | NA | 2.2 | 11.1 | NA | NA | NA | NA | NA |
| TL_VL008 | Swagelok SS-6UW-TW | Transfer tube shut-off | 3/8" socket weld | 100 | 172 | -29 | 343 | NA | 1 | 4.4 | NA | NA | NA | Proportional | NA |
| TL_VL009 | TBV | Tert. vacuum evacuation | CF16 | 2 | NA | NA | NA | NA | NA | NA | NA | NA | NA | Proportional | NA |
| TL_VL101 | Swagelok SS-43GHLVCR4 | Transfer tube shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TL_VL105 | Swagelok SS-43GHLVCR4 | Filling port | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TL_VL106 | Swagelok SS-43GHLVCR4 | Pump shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TL_VL107 | Swagelok SS-43GHLVCR4 | Filling port | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TL_VL108 | Swagelok SS-43GHLVCR4 | Pump shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TL_VL110 | Swagelok SS31RS4 | Liquid expansion | 1/4" Swagelok | 100 | 212 | -65 | 343 | NA | 0.012 Nom / 0.04 max | 1.6 | NA | NA | NA | Proportional | NA |
| TL_VL113 | Swagelok SS-43GHLVCR4 | Transfer tube shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TR_VL001 | Swagelok SS-4UW-TW | Transfer tube shut-off | 1/4" socket weld | 100 | 172 | -29 | 343 | NA | 0.36 | 4.4 | NA | NA | NA | Proportional | NA |
| TR_VL002 | Swagelok SS31RS4 (Modified) | Liquid expansion | 1/4" Swagelok | 100 | 212 | -65 | 343 | NA | 0.012 Nom / 0.04 max | 1.6 | NA | NA | NA | Proportional | NA |
| TR_VL003 | Swagelok SS-4UW-TW | Test evaporator inlet | 1/4" socket weld | 100 | 172 | -29 | 343 | NA | 0.36 | 4.4 | NA | NA | NA | Proportional | NA |
| TR_VL004 | Swagelok SS-4UW-TW | Evaporator inlet | 1/4" socket weld | 100 | 172 | -29 | 343 | NA | 0.36 | 4.4 | NA | NA | NA | Proportional | NA |
| TR_VL006 | Swagelok SS-6UW-TW | Test evaporator outlet | 3/8" socket weld | 100 | 172 | -29 | 343 | NA | 1 | 7.1 | NA | NA | NA | Proportional | NA |
| TR_VL007 | Swagelok SS-58SW8T | Check valve with modified poppet | 1/2" socket weld | 100 | 307 | -53 | 176 | NA | 2.2 | 11.1 | NA | NA | NA | NA | NA |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TR_VL008 | Swagelok SS-6UW-TW | Transfer tube shut-off | 1/4" socket weld | 100 | 172 | -29 | 343 | NA | 1 | 4.4 | NA | NA | NA | Proportional | NA |
| TR_VL009 | TBV | Tert. vacuum evacuation | CF16 | 2 | NA | NA | NA | NA | NA | NA | NA | NA | NA | Proportional | NA |
| TR_VL101 | Swagelok SS-43GHLVCR4 | Transfer tube shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TR_VL105 | Swagelok SS-43GHLVCR4 | Filling port | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TR_VL106 | Swagelok SS-43GHLVCR4 | Pump shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TR_VL107 | Swagelok SS-43GHLVCR4 | Filling port | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TR_VL110 | Swagelok SS31RS4 | Liquid expansion | 1/4" Swagelok | 100 | 212 | -65 | 343 | NA | 0.012 Nom / 0.04 max | 1.6 | NA | NA | NA | Proportional | NA |
| TR_VL113 | Swagelok SS-43GHLVCR4 | Transfer tube shut-off | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | NA | NA | NA | Open/Close | NA |
| TLR_VL001 | Swagelok SS-4UW-TW | Left right inter connect | 1/4" socket weld | 100 | 172 | -29 | 343 | NA | 0.36 | 4.4 | NA | NA | NA | Proportional | NA |
| TLR_VL002 | Swagelok SS-6UW-TW | Left right inter connect | 3/8" socket weld | 100 | 172 | -29 | 343 | NA | 1 | 7.1 | NA | NA | NA | Proportional | NA |
| TLR_VL107 | Swagelok SS-43GHLVCR4 | Filling port | 1/4"VCR male | 100 | 172 | -53 | 37 | NA | 2.4 | 4.8 | | | | | |
| SA_VL101 | Danfoss GBC10S/009G7051 | Compressor section shut-off | 3/8" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SA_VL102 | Danfoss NRD/020-1132 | Condenser control | 1/2" solder | 20 | 28 | -45 | 130 | 1.4 - 3 | | | | | | | |
| SA_VL103 | Danfoss/KVR-12/034L0093 | Condenser pressure control | 1/2" solder | 20 | 28 | -45 | 130 | 5 - 17.5 | | | | | | | |
| SA_VL104 | Integral in SA-AC102 | Liquid line shut-off | | | | | | | | | | | | | |
| SA_VL107 | Integral in SA-VL108 | Schrader valve | | 20 | TBV | TBV | TBV | NA | | | | | | | |
| SA_VL108 | Danfoss GBC12S/009G7052 | Evaporator shut-off | 1/2" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SA_VL111 | Integral in SA-VL112 | Schrader valve | | 20 | TBV | TBV | TBV | NA | | | | | | | |
| SA_VL112 | Danfoss GBC12S/009G7052 | Evaporator shut-off | 1/2" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SA_VL115 | Integral in SA-VL116 | Schrader valve | | 20 | | | | NA | | | | | | | |
| SA_VL116 | Danfoss GBC12S/009G7052 | Accu evaporator shut-off | 1/2" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SA_VL117 | Danfoss KVP-12 | Accu | 1/2" | 18 | 28 | -45 | 130 | 0 - 7 | | N | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | evaporator pressure | solder | | | | | | | A | | | | | |
| SA_VL120 | Integral in SA-VL121 | Schrader valve | | 20 | | | | NA | | | | | | | |
| SA_VL121 | Danfoss GBC12S/009G7052 | Accu evaporator shut-off | 1/2" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SA_VL122 | Danfoss KVP-12 | Accu evaporator pressure | 1/2" solder | 18 | 28 | -45 | 130 | 0 - 7 | | N A | | | | | |
| SA_VL123 | Danfoss GBC22s/009G7055 | Gas line shut-off | 7/8" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SA_VL124 | Integral in SA-PM101 | Compressor Suction shut-off | | | | | | | | | | | | | |
| SA_VL125 | Integral in SA-PM101 | Compressor discharge shut-off | | | | | | | | | | | | | |
| SA_VL126 | Integral in SA-VL101 | Schrader valve | | | | | | | | | | | | | |
| SA_VL127 | Integral in SA-VL104 | Schrader valve | | | | | | | | | | | | | |
| SA_VL128 | Integral in SA-VL123 | Schrader valve | | | | | | | | | | | | | |
| SB_VL104 | Integral in SB-AC102 | Liquid line shut-off | | | | | | | | | | | | | |
| SB_VL107 | Integral in SB-VL108 | Schrader valve | | 20 | TBV | TBV | TBV | NA | | | | | | | |
| SB_VL108 | Danfoss GBC12S/009G7052 | Evaporator shut-off | 1/2" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SB_VL111 | Integral in SB-VL112 | Schrader valve | | 20 | TBV | TBV | TBV | NA | | | | | | | |
| SB_VL112 | Danfoss GBC12S/009G7052 | Evaporator shut-off | 1/2" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SB_VL115 | Integral in SB-VL116 | Schrader valve | | 20 | | | | NA | | | | | | | |
| SB_VL116 | Danfoss GBC12S/009G7052 | Accu evaporator shut-off | 1/2" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SB_VL117 | Danfoss KVP-12 | Accu evaporator pressure | 1/2" solder | 18 | 28 | -45 | 130 | 0 - 7 | | N A | | | | | |
| SB_VL120 | Integral in SB-VL121 | Schrader valve | | 20 | | | | NA | | | | | | | |
| SB_VL121 | Danfoss GBC12S/009G7052 | Accu evaporator shut-off | 1/2" solder | 20 | 48 | -40 | 150 | NA | | | | | | | |
| SB_VL122 | Danfoss KVP-12 | Accu evaporator pressure | 1/2" solder | 18 | 28 | -45 | 130 | 0 - 7 | | N A | | | | | |
| SB_VL124 | Integral in SB-PM101 | Compressor Suction shut-off | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SB_VL125 | Integral in SB-PM101 | Compressor discharge shut-off | | | | | | | | | | | | | |
| SB_VL127 | Integral in SB-VL104 | Schrader valve | | | | | | | | | | | | | |
| SB_VL128 | Integral in SB-VL123 | Schrader valve | | | | | | | | | | | | | |

Swagelok
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2741 PW Waddinxveen
The Netherlands
31-(0)182-624060

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**Medium-Flow Metering Valves, Cv up to 0.04**

**Part Number:** SS-31RS4

**Description:** SS Medium-Flow High-Pressure (5000 psig {344 bar}) Metering Valve, 1/4 in. Swagelok Tube Fitting

**Product Specifications**

| General | |
|---|---|
| Body Material | 316 Stainless Steel |
| Connection 1 Size | 1/4 in. |
| Connection 1 Type | Swagelok® Tube Fitting |
| Connection 2 Size | 1/4 in. |
| Connection 2 Type | Swagelok® Tube Fitting |
| eClass (4.1) | 37010203 |
| eClass (6.0) | 37-01-02-03 |
| UNSPSC (11.0501) | 40141609 |
| UNSPSC (4.03) | 40141600 |
| UNSPSC (SWG01) | 40141600 |

REVIEW PRODUCT CATALOG FOR COMPLETE SPECIFICATIONS INCLUDING WARNINGS AND CAUTIONS.

Safe Product Selection: When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange valve components with those of other manufacturers.



Figure 11.3-2: $CO_2$ expansion valve

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**Secondary Packed Bellows Valves, Manual and Actuated, up to 1200°F [648°C]**

**Part Number:** SS-4UW-TW

**Description:** SS Secondary Packed Bellows-Sealed Valve, Welded, Spherical Stem Tip, 1/4 in. TSW and 3/8 in. TBW

**Product Specifications**

| General | |
|---|---|
| Actuator Type | Manual |
| Body Material | Stainless Steel |
| Body Type | Straight |
| Flow Pattern | Straight (2-way) |
| Series | U Series |
| Service Class | General |
| End Connection 1 Size | 1/4 in |
| End Connection 1 Type | Tube socket weld |
| End Connection 2 Size | 1/4 in |
| End Connection 2 Type | Tube socket weld |
| Handle Color | Green |
| Handle Style | Aluminum bar |
| Bellows Material | 347 Stainless Steel |
| Body Seal | Welded |
| Cleaning | Swagelok SC-10 |
| Gasket | None |
| ID Tag | No |
| Packing | Grafoil® |
| Stem Type | Spherical |
| Surface Finish | Standard |
| Testing | Helium leak testing according to SCS-00020 |
| Stem Tip Material | Cobalt based alloy |
| Max Temperature Pressure Rating | 900°F @ 600 PSIG /482°C @ 41.3 BAR |
| Room Temperature Pressure Rating | 2500 PSIG @ 100°F /172 @ BAR 37°C |

REVIEW PRODUCT CATALOG FOR COMPLETE SPECIFICATIONS INCLUDING WARNINGS AND CAUTIONS.

Safe Product Selection: When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange valve components with those of other manufacturers.

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Figure 11.3-1: $CO_2$ shut-off valve in cooling bridge

**Swagelok** MEET THE CHALLENGE℠

**Swagelok Nederland**
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2741 PW Waddinxveen
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31-(0)182-624060

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**1-Piece, Instrumentation, 40G Series Ball Valves**

**Part Number:** SS-43GVCR4

**Description:** SS 1-Piece 40 Series Ball Valve, 2.4 Cv, 1/4 in. Male Swagelok VCR Metal Gasket Face Seal Fitting

**Product Specifications**

| General | |
|---|---|
| Actuator Type | Manual |
| Flow Path | Standard (2-way) |
| Flow Pattern | Straight (2-way) |
| Valve Material | Stainless Steel |
| End Connection 1 Size | 1/4 in |
| End Connection 1 Type | Face seal (metal gasket) VCR |
| End Connection 2 Size | 1/4 in |
| End Connection 2 Type | Face seal (metal gasket) VCR |
| Handle Color | Black |
| Handle Style | Lever |
| Approval | No Approval |
| Ball/Stem Material | Stainless Steel |
| Body Vent | No |
| Cleaning | Swagelok SC-10 |
| Lubricant | Dow M111 |
| Packing | Modified PTFE |
| Ring/Disc Material | Stainless Steel |
| Sour Gas | No |
| Testing | Testing according to WS-22 |
| Max Temperature Pressure Rating | 300°F @ 2500 PSIG /148°C @ 172 BAR |
| Orifice | 0.187 |
| Room Temperature Pressure Rating | 3000 PSIG @ 100°F /206 @ BAR 37°C |

**REVIEW PRODUCT CATALOG FOR COMPLETE SPECIFICATIONS INCLUDING WARNINGS AND CAUTIONS.**

Safe Product Selection: When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange valve components with those of other manufacturers.



Figure 11.3-3: $CO_2$ 2-way ball valve

## 1 CONSTRUCTION INFORMATION

*Exploded View of the 141 Series Type DC Actuator*

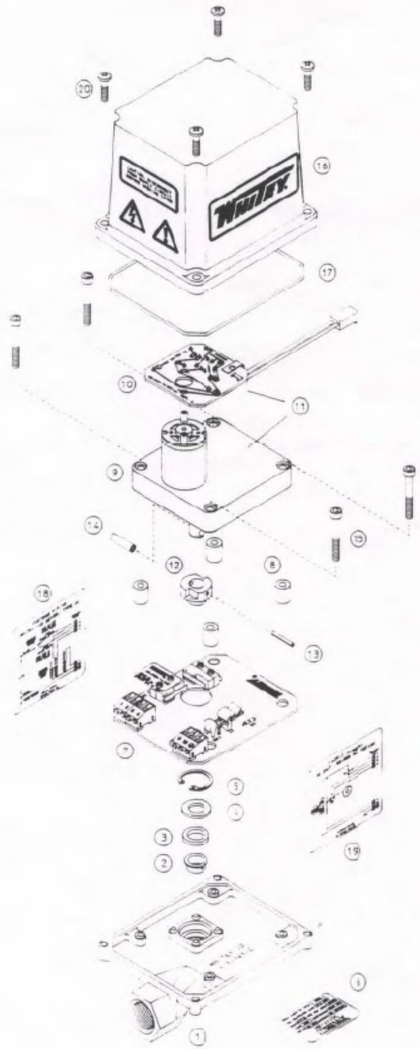


Figure 11.3-4: $CO_2$ 2-way ball valve electic drive (1)

## CONSTRUCTION INFORMATION 2

### Parts List and Materials of Construction

| ITEM | QTY | DESCRIPTION | MATERIAL |
|---|---|---|---|
| 1 | 1 | Base | Die Cast Aluminum |
| 2 | 1 | Bushing | Nylon |
| 3 | 1 | Shaft Seal | Buna-N |
| 4 | 1 | Washer | Stainless Steel |
| 5 | 1 | Retaining Ring | Steel |
| 6 | 1 | Specification Label | Polyester |
| 7 | 1 | Assembled PC Board | |
| 8 | 4 | Motor Standoffs | Nickel Plated Brass |
| 9 | 1 | DC Gearmotor | Stainless Steel Shaft |
| 10 | 1 | Assembled PC Board | |
| 11 | 1 | Gearmotor Assembly | Stainless Steel Shaft |
| 12 | 1 | Dual Cam | Nylon |
| 13 | 1 | Spring Pin | Stainless Steel |
| 14 | 1 | Roll Pin | Stainless Steel |
| 15 | 4 | Mounting Screws | Cadnium Plated Steel |
| 16 | 1 | Cover | Die Cast Aluminum |
| 17 | 1 | Cover Seal | Buna-N |
| 18 | 1 | Wiring Label | Polyester |
| 19 | 1 | Schematic Label | Polyester |
| 20 | 4 | Cover Screws | Stainless Steel |
| | 1 | User's Manual | |

### User Wiring and Internal Circuit

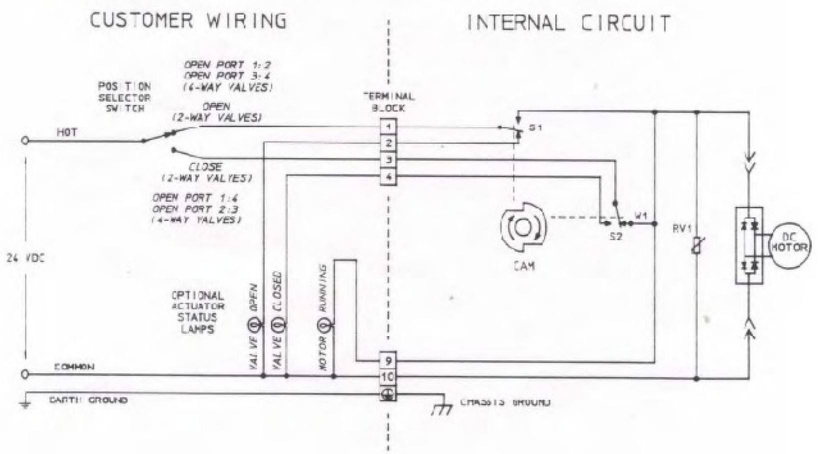
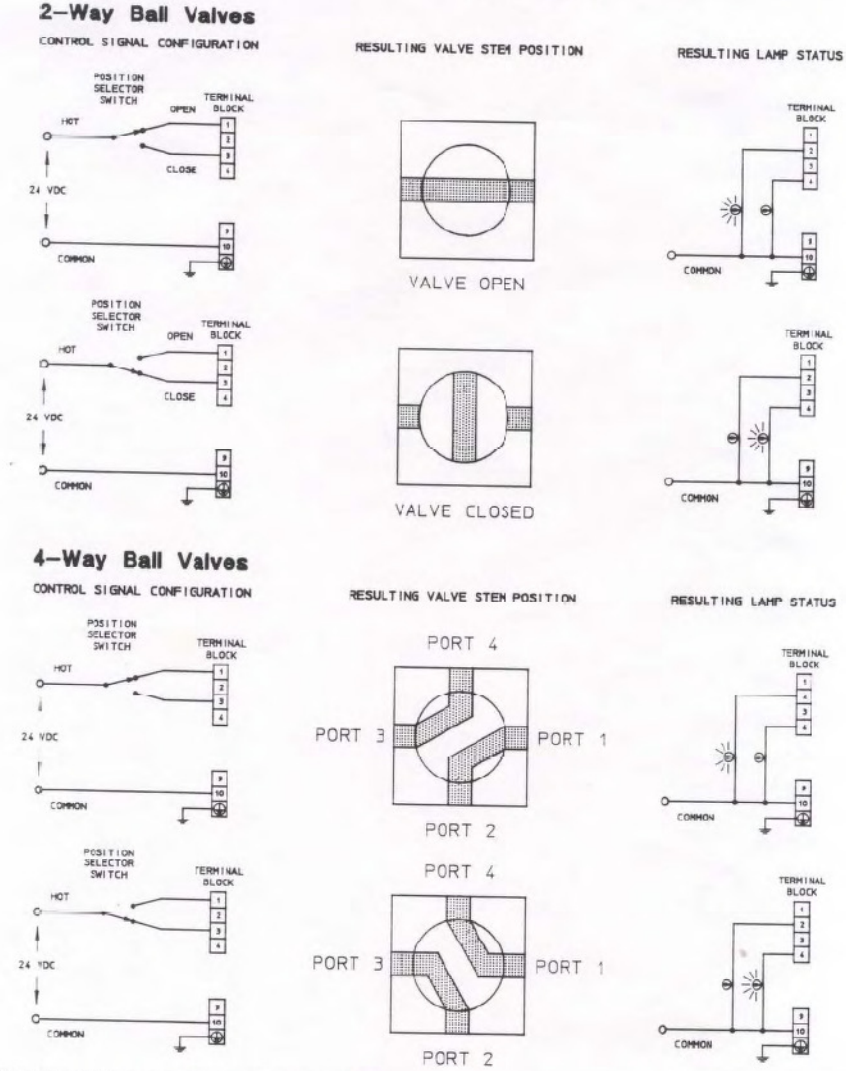



Figure 11.3-5: $CO_2$ 2-way ball valve electic drive (2)

## 3 OPERATING CHARACTERISTICS

### Valve Stem Position vs. Applied Control Signal






MS-INS-141DCE (REV. D)

**Swagelok**

MEET THE CHALLENGE℠

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Coenecoop 770
2741 PW Waddinxveen
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31-(0)182-624060

5/18/2010 7:51:02 AM

www.swagelok.com ®

### 1-Piece, Instrumentation, 40G Series Ball Valves

**Part Number:** SS-43GXVCR4

**Description:** SS 1-Piece 40G Series 3-Way Ball Valve, 0.90 Cv, 1/4 in. Male Swagelok VCR Metal Gasket Face Seal Fitting

### Product Specifications

| General | |
|---|---|
| Actuator Type | Manual |
| Flow Path | Standard (3-way) |
| Flow Pattern | Switching (3-way) |
| Valve Material | Stainless Steel |
| End Connection 1 Size | 1/4 in |
| End Connection 1 Type | Face seal (metal gasket) VCR |
| End Connection 2 Size | 1/4 in |
| End Connection 2 Type | Face seal (metal gasket) VCR |
| End Connection 3 Size | 1/4 in |
| End Connection 3 Type | Face seal (metal gasket) VCR |
| Handle Color | Black |
| Handle Style | Lever |
| Approval | No Approval |
| Ball/Stem Material | Stainless Steel |
| Body Vent | No |
| Cleaning | Swagelok SC-10 |
| Lubricant | Dow M111 |
| Packing | Modified PTFE |
| Ring/Disc Material | Stainless Steel |
| Sour Gas | No |
| Testing | Testing according to WS-22 |
| Max Temperature Pressure Rating | 300°F @ 2500 PSIG /148°C @ 172 BAR |
| Orifice | 0.187 |
| Room Temperature Pressure Rating | 2500 PSIG @ 100°F /172 @ BAR 37°C |

**REVIEW PRODUCT CATALOG FOR COMPLETE SPECIFICATIONS INCLUDING WARNINGS AND CAUTIONS.**

Safe Product Selection: When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

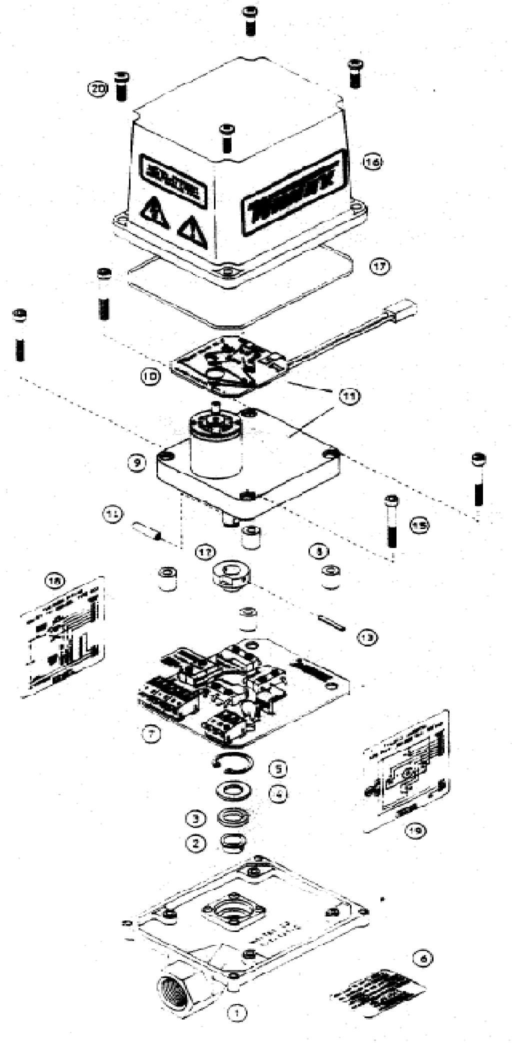
Caution: Do not mix or interchange valve components with those of other manufacturers.



Figure 11.3-6: $CO_2$ 3-way ball valve

# 1 CONSTRUCTION INFORMATION

***Exploded View of the 141 Series Type DCX Actuator***



141DCX SERIES

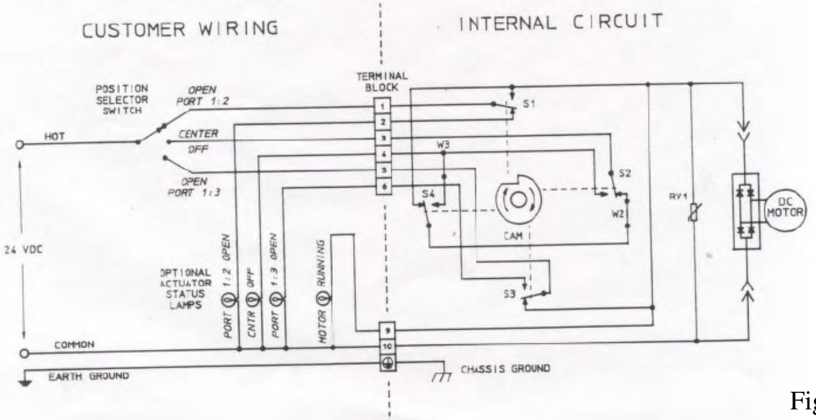
Figure 11.3-7: $CO_2$ 3-way ball valve electic drive (1)

## *CONSTRUCTION INFORMATION 2*

### *Parts List and Materials of Construction*

| ITEM | QTY | DESCRIPTION | MATERIAL |
|---|---|---|---|
| 1 | 1 | Base | Die Cast Aluminum |
| 2 | 1 | Bushing | Nylon |
| 3 | 1 | Shaft Seal | Buna-N |
| 4 | 1 | Washer | Stainless Steel |
| 5 | 1 | Retaining Ring | Steel |
| 6 | 1 | Specification Label | Polyester |
| 7 | 1 | Assembled PC Board | |
| 8 | 4 | Motor Standoffs | Nickel Plated Brass |
| 9 | 1 | DC Gearmotor | Stainless Steel Shaft |
| 10 | 1 | Assembled PC Board | |
| 11 | 1 | Gearmotor Assembly | Stainless Steel Shaft |
| 12 | 1 | Single Cam | Nylon |
| 13 | 1 | Spring Pin | Stainless Steel |
| 14 | 1 | Roll Pin | Stainless Steel |
| 15 | 4 | Mounting Screws | Cadmium Plated Steel |
| 16 | 1 | Cover | Die Cast Aluminum |
| 17 | 1 | Cover Seal | Buna-N |
| 18 | 1 | Wiring Label | Polyester |
| 19 | 1 | Schematic Label | Polyester |
| 20 | 4 | Cover Screws | Stainless Steel |
| | 1 | User's Manual | |

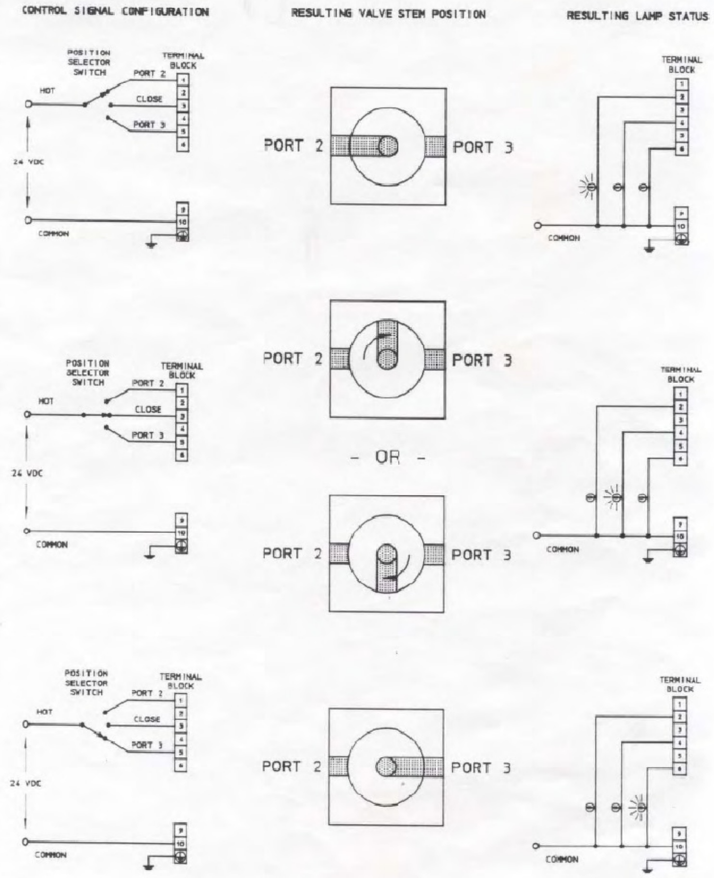
### *User Wiring and Internal Circuit*




## *3 OPERATING CHARACTERISTICS*

### *Valve Stem Position vs. Applied Control Signal*

**3–Way Ball Valves**





MS-INS-141DCX REV. B

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5/18/2010 8:00:45 AM

www.swagelok.com ®

**Lift Check Valves**

**Part Number:** SS-58SW8T

**Description:** SS Lift Check Valve, 2.20 Cv, 1/2 in. Tube Socket Weld or Pipe Butt Weld

**Product Specifications**

| General | |
|---|---|
| Body Material | 316 Stainless Steel |
| Cleaning Process | Standard Cleaning and Packaging (SC-10) |
| Connection 1 Size | 1/2 in. |
| Connection 1 Type | Tube Socket Weld |
| Connection 2 Size | 1/2 in. |
| Connection 2 Type | Tube Socket Weld |
| eClass (4.1) | 37010801 |
| eClass (6.0) | 27-29-20-01 |
| UNSPSC (11.0501) | 40141609 |
| UNSPSC (4.03) | 40141601 |
| UNSPSC (SWG01) | 40141601 |

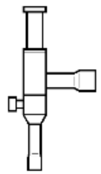
**REVIEW PRODUCT CATALOG FOR COMPLETE SPECIFICATIONS INCLUDING WARNINGS AND CAUTIONS.**

Safe Product Selection: When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange valve components with those of other manufacturers.



Figure 11.3-9: $CO_2$ 1-way poppet valve (no-return valve)



**034L0023**

Regulating range 0 - 5.5 bar, factory setting 2 bar, max. working pressure 18 bar. Access port: ¼ in. Schraeder valve for pressure testing. Max. test pressure KVP 12 - 22 = 28 bar, KVP 28 - 35 = 25.6...

SHARE

| Characteristic | Value |
|---|---|
| Type | KVP 12 |
| Weight | 0.370 Kg |
| Access port | Yes |
| Approval | C UL US LISTED |
| Approval | GOST AN30 |
| Approval file name | REFRIGERANT VALVE 53R0 |
| Cv-value [USgal/min] | 11,010 |
| Factory setting [bar] | 2,00 bar |
| Factory setting [psig] | 29,0 psig |
| Identical product | 034L0218 |
| Inlet connection type | SOLDER, ODF |
| Inlet size [in] | 1/2 IN |
| Kv-value [m³/h] | 2,500 |
| Max. test pressure [bar] | 28,0 bar |
| Max. test pressure [psig] | 405 psig |
| Max. Working Pressure ef | 18,0 bar |
| Max. Working Pressure | 260 Psig |
| Medium temperature range [°C] | -45 - 105 °C |
| Medium temperature range [°F] | -50 - 220 °F |
| Outlet connection type | SOLDER, ODF |
| Outlet size [in] | 1/2 IN |
| P band max. [bar] | 2,0 bar |
| P band max. [psi] | 29,0 psi |
| Pack format | Multi pack |
| Product description | Evaporator Pres. Reg. |
| Quantity per pack format | 12 pc |
| Rated capacity R134a [kW] | 2,80 kW |
| Rated capacity R134a [TR] | 0,90 TR |
| Rated capacity R22 [kW] | 4,00 kW |
| Rated capacity R22 [TR] | 1,30 TR |
| Rated capacity R404A/R507 [kW] | 3,60 kW |
| Rated capacity R404A/R507 [TR] | 1,20 TR |
| Rated capacity R407C [kW] | 3,70 kW |
| Rated capacity R407C [TR] | 1,20 TR |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Regulating range [bar] | 0,0 - 5,5 bar |
| Regulation range [psig] Pe | 0,00 - 80,00 psig |

Figure 11.3-10: HFC evaporator pressure regulator

Figure 11.3-11: HFC 1kW expension valve

Tolerance of coil voltage: +10 / −15%. Enclosure to IEC 529: Max. IP 67. Working principle: PWM (Pulse-width modulation). Recommended period of time: 6 Seconds. Capacity (R22): 1-16 kW. Regulation ra...

SHARE

| Characteristic | Value |
|---|---|
| Type | AKV 10-1 |
| Weight | 0.349 Kg |
| 10W a.c. MOPD [bar] | 18 bar |
| 10W a.c. MOPD [psi] | 260 psi |
| Ambient temperature | -50 - 50 °C |
| Ambient temperature range [°F] | -58 - 120 °F |
| Armature tube size | 13,5 MM |
| Catalogue number | RD.8A |
| Coil type | None |
| Cv-value [USgal/min] | 0,012 |
| Direction | Angleway |
| Function | NC |
| Inlet size [in] | 3/8 IN |
| Inlet type | SOLDER, ODF |
| Kv-value [m³/h] | 0,010 |
| Manual Operation | No |
| Max. Working Pressure ef | 52,0 bar |
| Max. Working Pressure | 754 psig |
| Medium temperature range [°C] | -50 - 60 °C |
| Medium temperature range [°F] | -58 - 140 °F |
| Min. ODP [bar] | 0,000 bar |
| Min. OPD [psi] | 0,000 psi |
| MOPD [bar/psi] | 18 bar |
| Orifice size | 0,50 |
| Orifice / Piston no. | 10-1 |
| Outlet size [in] | 1/2 IN |
| Outlet type | SOLDER, ODF |
| Pack format | Multi pack |
| Quantity per pack format | 18 pc |
| Rated capacity R22 [kW] | 1,00 kW |
| Refrigerant(s) | CFC |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Refrigerant(s) | R744 |
| Standard product | Yes |
| Type designation | Electric Expansion Valve |

Figure 11.3-12: HFC 1.4kW expension valve

Tolerance of coil voltage: +10 / −15%. Enclosure to IEC 529: Max. IP 67. Working principle: PWM (Pulse-width modulation). Recommended period of time: 6 Seconds. Capacity (R22): 1-16 kW. Regulation ra...

SHARE

| Characteristic | Value |
|---|---|
| Type | AKV 10-2 |
| Weight | 0.342 Kg |
| 10W a.c. MOPD [bar] | 18 bar |
| 10W a.c. MOPD [psi] | 260 psi |
| Ambient temperature | -50 - 50 °C |
| Ambient temperature range [°F] | -58 - 120 °F |
| Approval | GOST AN30 |
| Armature tube size | 13,5 MM |
| Catalogue number | RD.8A |
| Coil type | None |
| Cv-value [USgal/min] | 0,020 |
| Direction | Angleway |
| Function | NC |
| Inlet size [in] | 3/8 IN |
| Inlet type | SOLDER, ODF |
| Kv-value [m³/h] | 0,017 |
| Manual Operation | No |
| Max. Working Pressure ef | 52,0 bar |
| Max. Working Pressure | 754 psig |
| Medium temperature range [°C] | -50 - 60 °C |
| Medium temperature range [°F] | -58 - 140 °F |
| Min. ODP [bar] | 0,000 bar |
| Min. OPD [psi] | 0,000 psi |
| MOPD [bar/psi] | 18 bar |
| Orifice size | 0,65 |
| Orifice / Piston no. | 10-2 |
| Outlet size [in] | 1/2 IN |
| Outlet type | SOLDER, ODF |
| Pack format | Multi pack |
| Quantity per pack format | 18 pc |
| Rated capacity R22 [kW] | 1,60 kW |
| Refrigerant(s) | CFC |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Refrigerant(s) | R744 |
| Standard product | Yes |
| Type designation | Electric Expansion Valve |

Figure 11.3-13: HFC 2-way ball valve (12mm)

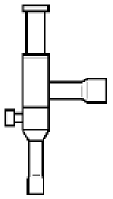
**009G7052**

Refrigerants: CFC, HCFC, HFC. Temperature range: −40 - +150°C. Max. working pressure: 45 bar. Max. test pressure: 65 bar. Approvals: UL, CSA, CE

SHARE

| Characteristic | Value |
|---|---|
| Type | GBC 12s |
| Weight | 0.320 Kg |
| Access port | Yes |
| Approval | CE |
| Approval | CSA |
| Approval | UL |
| Approval file name | REFRIGERANT VALVE 53R0 |
| Cv-value [USgal/min] | 46,580 |
| Direction | Straightway |
| Flow direction | Bi-flow |
| Inlet connection type | SOLDER, ODF |
| Inlet size [in] | 1/2 IN |
| Kv-value [m³/h] | 10,580 |
| Max. test pressure [bar] | 65,0 bar |
| Max. test pressure [psig] | 940 psig |
| Max. Working Pressure ef | 45,0 bar |
| Max. Working Pressure | 650 psig |
| Outlet connection type | SOLDER, ODF |
| Outlet size [in] | 1/2 IN |
| Pack format | Multi pack |
| Product description | Ball Valve |
| Quantity per pack format | 25 pc |
| Refrigerant(s) | CFC |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Temperature range [°C] | -40 - 150 °C |
| Temperature range [°F] | -40 - 300 °F |

Figure 11.3-14: HFC 2-way valve (22mm)



**034L0093**

Regulating range 5 - 17.5 bar, factory setting 10 bar, max. working pressure 28 bar. Access port: ¼ in. Schraeder valve for pressure testing. Max. test pressure 31 bar. Rated capacities: see technical...

SHARE

| Characteristic | Value |
|---|---|
| Type | KVR 12 |
| Weight | 0.394 Kg |
| Access port | Yes |
| Approval | C UL US LISTED |
| Approval | GOST AN30 |
| Approval file name | REFRIGERANT VALVE 53R0 |
| Factory setting [bar] | 10,00 bar |
| Factory setting [psig] | 145,0 psig |
| Identical product | 034L1293 |
| Inlet connection type | SOLDER, ODF |
| Inlet size [in] | 1/2 IN |
| Max. test pressure [bar] | 31,0 bar |
| Max. test pressure [psig] | 450 Psig |
| Max. Working Pressure ef | 28,0 bar |
| Max. Working Pressure | 406 psig |
| Medium temperature range [°C] | -45 - 105 °C |
| Medium temperature range [°F] | -50 - 220 °F |
| Outlet connection type | SOLDER, ODF |
| Outlet size [in] | 1/2 IN |
| P band max. [bar] | 6,2 bar |
| P band max. [psi] | 90,0 psi |
| Pack format | Multi pack |
| Product description | Condensing Pres. Reg. |
| Quantity per pack format | 12 pc |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Regulating range [bar] | 5,0 - 17,5 bar |
| Regulation range [psig] Pe | 73,00 - 254,00 psig |

Figure 11.3-15: HFC condenser pressure regulator

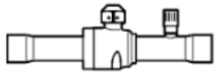
**020-0123**

Regulating range 5 - 17.5 bar, factory setting 10 bar, max. working pressure 35 bar. Access port: ¼ in. Schraeder valve for pressure testing. Max. test pressure 36 bar. Opening differential pressure...

SHARE

| Characteristic | Value |
|---|---|
| Type | NRD 12s |
| Weight | - |
| Approval | C UL US |
| Approval file name | REFRIGERANT VALVE 53R0 |
| Cv-value [USgal/min] | 2,370 |
| Direction | Straightway |
| Inlet connection type | SOLDER, ODF |
| Inlet size [in] | 1/2 IN |
| Kv-value [m³/h] | 2,050 |
| Max. Working Pressure ef | 46,0 bar |
| Max. Working Pressure | 667 psig |
| Min. Pressure drop [bar] | 1,40 bar |
| Min. pressure drop [psi] | 20,3 psi |
| Outlet connection type | SOLDER, ODF |
| Outlet size [in] | 1/2 IN |
| Pack format | Industrial pack |
| Product description | Diff. pressure reg. |
| Quantity per pack format | 40 pc |
| Refrigerant(s) | CFC |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Temperature range [°C] | -50 - 140 °C |
| Temperature range [°F] | -60 - 285 °F |

Figure 11.3-16: HFC condenser differential pressure regulator



**009G7055**

Refrigerants: CFC, HCFC, HFC. Temperature range: −40 - +150°C. Max. working pressure: 45 bar. Max. test pressure: 65 bar. Approvals: UL, CSA, CE

SHARE

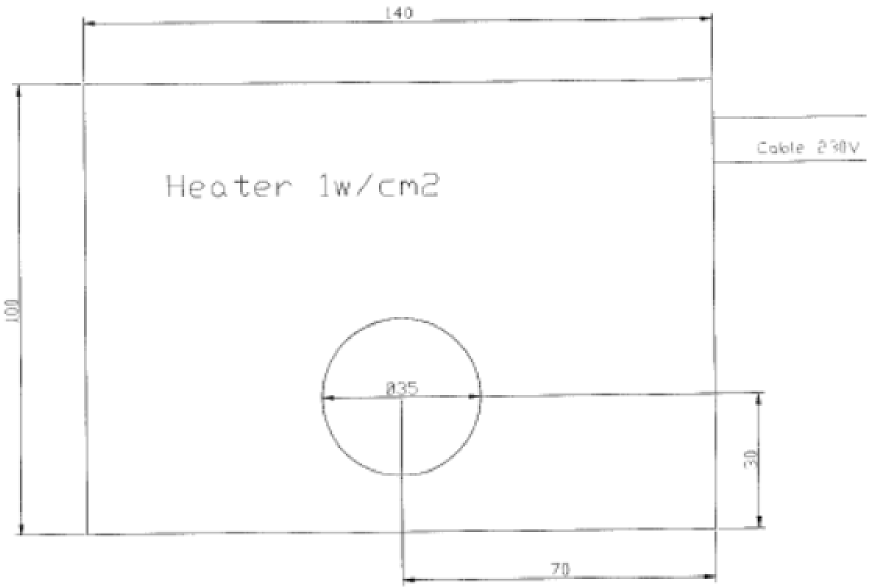
| Characteristic | Value |
|---|---|
| Type | GBC 22s |
| Weight | 0.504 Kg |
| Access port | Yes |
| Approval | CE |
| Approval | CSA |
| Approval | UL |
| Approval file name | REFRIGERANT VALVE 53R0 |
| Cv-value [USgal/min] | 124,030 |
| Direction | Straightway |
| Flow direction | Bi-flow |
| Inlet connection type | SOLDER, ODF |
| Inlet size [in] | 7/8 in |
| Inlet size [mm] | 22 MM |
| Kv-value [m³/h] | 28,170 |
| Max. test pressure [bar] | 65,0 bar |
| Max. test pressure [psig] | 940 psig |
| Max. Working Pressure ef | 45,0 bar |
| Max. Working Pressure | 650 psig |
| Outlet connection type | SOLDER, ODF |
| Outlet size [in] | 7/8 in |
| Outlet size [mm] | 22 MM |
| Pack format | Multi pack |
| Product description | Ball Valve |
| Quantity per pack format | 25 pc |
| Refrigerant(s) | CFC |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Temperature range [°C] | -40 - 150 °C |
| Temperature range [°F] | -40 - 300 °F |

#### 11.3.1.1 **Heaters**

Table 11.3-2: VTCS Heaters

| Code | Part number | Function | Supply (V) | | Power (W) | Resistance (Ohm) | Electrical Control | Output signal | Diameter (mm) | Length (mm) | No-heat length (mm) | Heated area (cm2) | Thermocouple location | Heat flux (W/cm2) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL_HT001 | 2 parallel / 3 serial Watlow K010030c500000 | Module base temperature control | 30 | DC | 34.8 | 52.3Ω/3*2 = 8.7Ω | DC Voltage regulation | | | | | 19.4 | | 1.8 |
| TL_HT002 | 2 parallel / 3 serial Watlow K010030c500000 | Module base temperature control | 30 | DC | 34.8 | 52.3Ω/3*2 = 8.7Ω | DC Voltage regulation | | | | | 19.4 | | 1.8 |
| TL_HT003 | 2 parallel / 3 serial Watlow K010030c500000 | Module base temperature control | 30 | DC | 34.8 | 52.3Ω/3*2 = 8.7Ω | DC Voltage regulation | | | | | 19.4 | | 1.8 |
| TL_HT004 | 2 parallel / 3 serial Watlow K010030c500000 | Module base temperature control | 30 | DC | 34.8 | 52.3Ω/3*2 = 8.7Ω | DC Voltage regulation | | | | | 19.4 | | 1.8 |
| TL_HT102 | Watlow: Silicon Heater pads | Pump oil heater | 240 | AC | 130 | 443.1 | PWM | | | | | 130.0 | | 1.0 |
| TL_HT103 | Watlow: KFRJ016DM003A | Liquid line damper | 220 | AC | 50 | 968 | PWM | Internal Thermocouple K | 12.7 | 410 | 350 | 23.9 | center | 2.1 |
| TL_HT104 | Watlow: KMFG1000M001A | By pass heater | 220 | AC | 2000 | 24.2 | PWM | Internal Thermocouple K | 10 | 1000 | 100 | 282.7 | center | 7.1 |
| TL_HT105 | Watlow: KFRJ015AM001A | Accumulator heater | 220 | AC | 1000 | 48.4 | PWM | Internal Thermocouple K | 12.7 | 380 | 85 | 117.7 | center | 8.5 |
| TR_HT001 | 2 parallel / 3 serial Watlow K010030c500000 | Module base temperature control | 30 | DC | 34.8 | 52.3Ω/3*2 = 8.7Ω | DC Voltage regulation | | | | | 19.4 | | 1.8 |
| TR_HT002 | 2 parallel / 3 serial Watlow K010030c500000 | Module base temperature control | 30 | DC | 34.8 | 52.3Ω/3*2 = 8.7Ω | DC Voltage regulation | | | | | 19.4 | | 1.8 |
| TR_HT003 | 2 parallel / 3 serial Watlow K010030c500000 | Module base temperature control | 30 | DC | 34.8 | 52.3Ω/3*2 = 8.7Ω | DC Voltage regulation | | | | | 19.4 | | 1.8 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TR_HT004 | 2 parallel / 3 serial Watlow K010030c500000 | Module base temperature control | 30 | DC | 34.8 | 52.3Ω/3*2 = 8.7Ω | DC Voltage regulation | | | | | 19.4 | | 1.8 |
| TR_HT102 | Watlow: TBD | Pump oil heater | 240 | AC | 130 | 443.1 | PWM | | | | | 130.0 | | 1.0 |
| TR_HT103 | Watlow: KFRJ016DM003A | Liquid line damper | 220 | AC | 50 | 968 | PWM | Internal Thermocouple K | 12.7 | 410 | 350 | 23.9 | center | 2.1 |
| TR_HT104 | Watlow: KMFG1000M001A | By pass heater | 220 | AC | 2000 | 24.2 | PWM | Internal Thermocouple K | 10 | 1000 | 100 | 282.7 | center | 7.1 |
| TR_HT105 | Watlow: KFRJ015AM001A | Accumulator heater | 220 | AC | 1000 | 48.4 | PWM | Internal Thermocouple K | 12.7 | 380 | 85 | 117.7 | center | 8.5 |
| TLR_HT102 | Watlow: TBD | Pump oil heater | 240 | AC | 130 | 443.1 | PWM | | | | | 130.0 | | 1.0 |




Betr.: **Watlow** verwarmingselementen, uw e-mail aanvraag d.d. 07-12-2006. Offerte nr. 13183.

Geachte heer Munneke,

Hiermee komen wij terug op bovengenoemde aanvraag. Naar aanleiding van hetgeen besproken is, bieden wij u, overeenkomstig onze algemene verkoopvoorwaarden, vrijblijvend aan:

5 st. **Watlow** wire wound silicone rubber heater met de onderstaande specificatie:

| | |
|---|---|
| - type | nog onbekend |
| - dikte | 1,4 mm (m.u.v. draadaansluiting) |
| - lengte | 140 mm |
| - breedte | 100 mm |
| - vermogen | 130 watt |
| - wattdichtheid | 1,0 W/cm² |
| - aansluitspanning | 240 volt |
| - aansluitingen | met **4000** mm teflon geïsoleerd aansluitdraad en een gat Ø 35 mm, volgens uw tekening |
| - uitvoering | volgens de standaard fabriekspecificatie |

| | |
|---|---|
| prijs per stuk | € 48,25 |
| netto eenmalige aanmaakkosten | € 90,-- |

*De fabrikant waarborgt het materiaal en de constructie van de aangeboden componentèn. Het is echter de verantwoordelijkheid van de gebruiker om zeker te stellen dat deze componenten juist zijn geselecteerd en geïnstalleerd in uw specifieke toepassing*

Figure 11.3-17: LEWA $CO_2$ pump oil heater

SEP.05.2006 09:57 +31 252676104

**KURVAL**

## ORDERBEVESTIGING / PRO FORMA FACTUUR

**Factuuradres**
FOM Instituut Nikhef
Postbus 41882
1009 DB AMSTERDAM
Nederland

**Afleveradres**
FOM Instituut Nikhef
Kruislaan 409
1098 SJ AMSTERDAM
Nederland

| Deb. Nr. | Ordernr. | Datum | Valuta | Uw referentie | Verkoper | Bet. voorwaarden | Pagina |
|---|---|---|---|---|---|---|---|
| 2087 | 1006788 | 04-AUG-06 | EUR | 38995 | Heij C. | 30 dagen | 1 van 1 |

| Artikelnummer | Omschrijving | Verwachte leverdatum | Aantal | Eenheid | Prijs | BTW % | Totaalprijs |
|---|---|---|---|---|---|---|---|
| 611335002 | Metr.Frd KMFG1000M001A Ø10x1000mm 220V-2000W - koude zone 100mm - TC "K" (loc. A) - 3000mm SLT- (TC lds. 3000mm) - Epoxy afgedicht | 18-SEP-06 | 4 | STUK | 188.85 | 19 | 755.40 |
| 600200040 | Frd. KFRJ015AM001A Ø1/2"x380mm 220V-1000W - koude zone 85mm - TC "K" (loc. A) - 3000mm SLT- (TC lds. 3000mm) - Epoxy afgedicht | 18-SEP-06 | 4 | STUK | 128.80 | 19 | 515.20 |
| | | | | | | 19 | 807.90 |

UTES by-pass heater

UTCG accu heater

Betr.: <u>**Watlow** staafelementen, uw aanvraag d.d. 17-11-2008. Offerte nr. 30102-1.</u>

Geachte heer Verlaat,

Hiermee komen wij terug op uw bovengenoemde aanvraag. Wij hebben u verzoek om een thermokoppel in het verwarmde deel alsmede een thermokoppel in de koude zone met onze leveranciersdeskundige besproken. Helaas is dit technisch niet mogelijk. Derhalve bieden wij u, overeenkomstig onze algemene leveringsvoorwaarden, vrijblijvend aan:

3 st.* metrische Firerod staafelementen met de navolgende specificatie

| | |
|---|---|
| - code | KFRJ016DM003A |
| - afmeting | Ø 1/2"x 410mm |
| - onverwarmd aan draadzijde | 350mm |
| - aansluitwaarde | 220 volt |
| - vermogen | 50 watt |
| - aansluitdraad | 150mm fiberglass aangekrimpt – langer |
| - thermokoppel | type K in het midden – eind in heated deel |
| - afdichting | epoxy hars |

1000mm

prijs per stuk € 103,--

Figure 11.3-18: $CO_2$ rod heaters

## 11.3.2 Pumps and Compressors

Table 11.3-3: VTCS Pumps and compressors

| Code | Part number | Function | Connection | Pressure Head (Bar) | Flow range (ml/s) | Supply (V) | Power (W) | Electrical Control | Manual Control | Output signal | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TL_PM101 | LEWA 475967-010.001 | Liquid pump | G 3/8 Fem | 99 max | 1 – 18 (4-65 l/h) | 380 VAC 3p 50Hz | 1500 max | on/off | Manual flow control | Membrane leak detection switch | |
| TR_PM101 | LEWA 475967-010.001 | Liquid pump | G 3/8 Fem | 99 max | 1 - 18 (4-65 l/h) | 380 VAC 3p 50Hz | 1500 max | on/off | Manual flow control | Membrane leak detection switch | |
| TLR_PM101 | LEWA 475967-010.001 | Liquid pump | G 3/8 Fem | 99 max | 1 - 18 (4-65 l/h) | 380 VAC 3p 50Hz | 1500 max | on/off | Manual flow control | Membrane leak detection switch | |
| SA_PM101 | Bitzer 2CC-3.2Y | Gas Compressor | 7/8" in / 5/8" out | 28 max | 4511 (16.2 m3/h) @ 50Hz | 380 VAC 3p 25-70Hz | | Frequency regulation | | | |
| SB_PM101 | Bitzer 2KC-05.2y | Gas Compressor | 5/8" in / 1/2" out | 28 max | 1130 (4.06 m3/h @ 50 Hz) | 380 VAC 3p 50Hz | | on/off | | | Integral in condensing aggregate: Bitzer LH32/2KC-05.2y |

## Technical Data Sheet

LEWA

| | |
|---|---|
| Customer NIKHEF<br>Kruislaan 409<br>MBO<br>1098 SJ Amsterdam<br>Netherlands | Customer-Reference No.<br>P.O. No.: 38852; Issued: 220606<br>GEVEKE 12000608<br>LEWA-Quotation-No. --000 · LEWA-Commission-No. E12-485983 · LEWA-Position 010 |

| | | | |
|---|---|---|---|
| 1 | Element | a | Page 1 of 1 |

**Enquiry Data (If operating data are incomplete LEWA takes no responsibility for the pump selection!)**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | Fluid | | CO2 | | dangerous acc. 67/548/EEC | | | |
| 3 | | | min | max | | | min | max |
| 4 | Concentration | [%] | 100.00 | 100.00 | Vapour pressure | [bar abs] | 16.87 | 16.87 |
| 5 | Fluid temperature | [°C] | -25 | -25 | Solidifying point | [°C] | -- | -- |
| 6 | Density | [g/cm3] | 1.05 | 1.05 | Solids Concentration | [%] | -- | -- |
| 7 | Viscosity | [mPa s] | 0.16 | 0.16 | Density | [g/cm3] | -- | -- |
| 8 | Required flow | [l/h] | 4.00 | 65.00 | Solids sizes | [mm] | -- | -- |
| 9 | Operating press. discharge | [bar] | 99.00 | 99.00 | Hardness | [Mohs] | -- | -- |
| 10 | Operating press. suction | [bar] | 50.0 | 50.0 | Settling rate | [m/s] | -- | -- |
| 11 | Area classification | | | | Compressibility [%] | | 0.51 | |
| 12 | Ambient conditions (temperature, climate,..) | | | | | | | |

**Design data**

| | | | | | | |
|---|---|---|---|---|---|---|
| 13 | No. 3 | | | LEWA-Serial-No. | | 485983-010. 001.002.003 |
| 14 | Type LDC1 | | horiz. (h) / vertical (v) V | Custom.-Item-No. | | |
| 15 | Crankcase | Type | LDC | Driver | Make | VEM |
| 17 | Rod thrust | [N] | 5000 | Type | | K21R 90L4 |
| 18 | Stroke adjustment | | manual (HHV) | Power | [kW] | 1.50 |
| 19 | Eccentricity | [°] | 0 | Rpm | [min-1] | 1400 |
| 20 | Gear reduction | | 8.33 | Ex-protection | | - |
| 21 | Strokes per minute | [min-1] | 168 | Protection / Insulation | | IP55 / F |
| 22 | Intermed. elem.-Type/Width | [mm] | - / - | Voltage | [V] | 400 |
| 23 | Pumphead | Type | M910S | Phases / Frequency | [Hz] | 3 / 50 |
| 24 | Plunger-Ø | [mm] | 25 | Size / Mounting | | 090 / V18 |
| 25 | Flow @ max. operating press. | [l/h] | 62.69 | Flange-Ø | [mm] | C140 |
| 26 | Max. perm. operating press. | [bar] | 100.0 | Shaft-Ø | [mm] x [mm] | 24Dx50 |
| 27 | Diaphragm condition monitor | | pressure contactor | Thermistors | | 3 |
| 28 | Vent screw | | No | design (VIK,CSA,-) | | - |
| 29 | Type of plunger sealing | | ground bush | Additional remarks : | | |
| 30 | Plunger linkage | | - | | | - |
| 31 | Valve Suction / DN | | K1 / 10 | Variable frequency drive | | - |
| 32 | Spring load | [bar] | - | Range | [Hz] | - |
| 33 | Valve Discharge / DN | | K1 / 10 | Start-up against load | | yes |
| 34 | Spring load | [bar] | - | Rated torque at max. press. | [Nm] | 3.25 |
| 35 | Setting PRV pumphead int. | [bar] | 109 | Start-up torque at max. press. | [Nm] | 12.05 |
| 36 | Setting PRV external | [bar] | 100 | Aditional remarks : | | |
| 37 | Inlet pressure/loss | [bar] | 0.06 | | | |
| 38 | Min. required suction press. | [bar abs] | 16.93 | General | | |
| 39 | Connection Suction | | ISO G 3/8 fem. | Paint | | RAL 5015 |
| 40 | Discharge | | ISO G 3/8 fem. | Name plate | | nl |
| 41 | Connection Flushing | | - | Weight | [kg] | 73 |
| 42 | Heating / Cooling | | - | Sound pressure | [dB(A)] | |
| 43 | Materials | LEWA material-Code | 3 | Ex-protection (pump) | | - |
| 44 | Pumphead / Valve body | | 1.4571 / 1.4571 | Accessories / Documentation / Remarks : | | |
| 45 | diaphragm | | PTFE | | | |
| 46 | Valve Seat / Insert ring | | 1.4122 / - | | | |
| 47 | Guide / ball | | 1.4581BZ / 1.3541 | | | |
| 48 | Spring / Sealing ring | | - / - | | | |
| 49 | Type of plunger sealing | | - | | | |
| 50 | Hydraulic fluid (diaphragm head) | | M-5 | | | |
| 51 | Intermed. fluid (sandwich diaphr.) | | Alkohol | | | |

| | | | | | |
|---|---|---|---|---|---|
| issued 24.06.06 | Name PC-To | Rev.(1) | Name | Rev.(4) | Name |
| checked | Name | Rev.(2) | Name | Rev.(5) | Name |
| checked | Name | Rev.(3) | Name | Rev.(6) | Name |

LEWA Herbert Ott GmbH + Co KG · Ulmer Strasse 10, D-71229 Leonberg · Telefon +49 (7152) 14-0 · Fax +49 (7152) 14-1303 · E-Mail lewa@lewa.de · Internet www.lewa.de
V 097_dbmodular / 09.02 / OV d594034.doc

Figure 11.3-1: LEWA $CO_2$ pump (1)

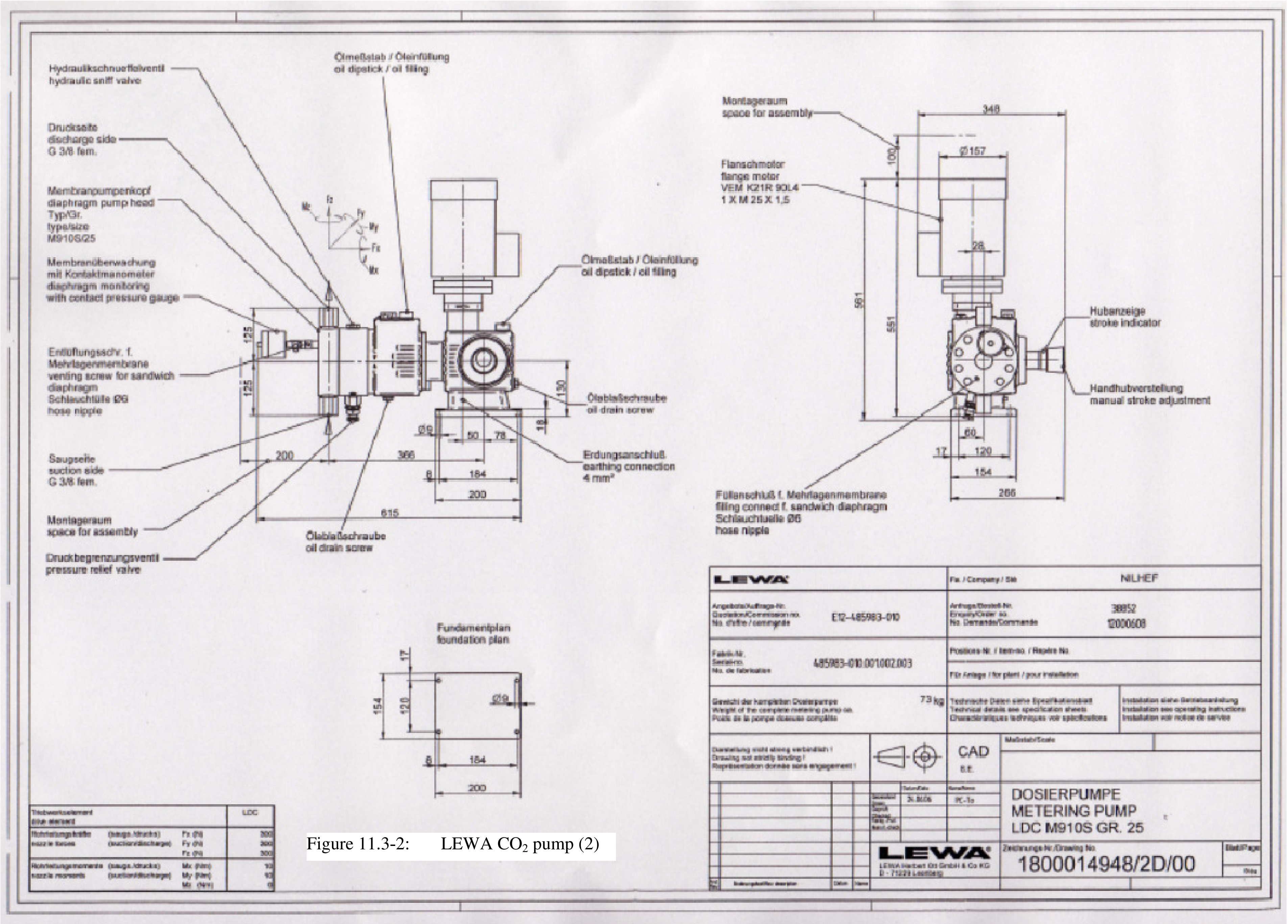



Figure 11.3-2: LEWA $CO_2$ pump (2)

## Piston compressors

Data Sheet: 2CC-3.2


- Leaflet: KP-100 (50Hz / SI)
- Leaflet: KP-105 (60Hz / IP)
- Operating Instruction: KB-100
- Spare Part List: KE-120
- Manufacturers Declaration // Decl. of Conformity // Decl. of Incorporation: KC-001
- Manufacturers Declaration // Decl. of Conformity // Decl. of Incorporation: KC-100
- Technical Information:
  KT-122 KT-140 KT-150 KT-410 KT-420 KT-500 KT-510 KT-601 KT-602 KT-660
- Show dimensional drawing
- Download CAD drawing
- Exploded View

Technical Data

| | SI | IP |
|---|---|---|
| Displacement (1450 RPM 50Hz) | 16,24 m3/h | 573.5 CFH |
| Displacement (1750 RPM 60Hz) | 19,60 m3/h | 692.2 CFH |
| No. of cylinder x bore x stroke | 2 x 55 mm x 39,3 mm | 2 x 2.17 inch x 1.55 inch |
| Motor voltage (more on request) | 380..420V Y/3/50Hz | 440..480V Y/3/60Hz |
| Max operating current | 8.5A | 8.5A |
| Winding ratio | -- | -- |
| Starting current (Rotor locked) | 35.0A Y | 35.0A Y |
| Weight | 70 kg | 154 lb |
| Max. pressure (LP/HP) | 19 / 28 bar | 275 / 403 psi |
| Connection suction line | 22 mm - 7/8' | 22 mm - 7/8' |
| Connection discharge line | 16 mm - 5/8' | 16 mm - 5/8' |
| Connection cooling water | -- | -- |
| Oil type R134a/R407C/R404A/R507A | tc<55°C: BSE32 / tc>55°C: BSE55 (Option) | tc<130°F: BSE32 / tc>130°F: BSE55 (Option) |
| Oil type R410A | -- | -- |
| Oil type R22 (R12/R502) | B5.2 (Standard) | B5.2 (Standard) |
| Oil type R744 (CO2) | -- | -- |
| Oil type R290/R1270 | Clavus G68 (Standard) | Clavus G68 (Standard) |
| Oil charge | 1,50 dm³ | 52.8 fl oz |
| Crankcase heater | 0..120 W PTC (Option) | 0..120 W PTC (Option) |

Figure 11.3-3: SA-Main HFC compressor

## Piston compressors

Data Sheet: 2KC-05.2


- Leaflet: KP-100 (50Hz / SI)
- Leaflet: KP-105 (60Hz / IP)
- Operating Instruction: KB-100
- Spare Part List: KE-120
- Manufacturers Declaration // Decl. of Conformity // Decl. of Incorporation: KC-001
- Manufacturers Declaration // Decl. of Conformity // Decl. of Incorporation: KC-100
- Technical Information:
  KT-122 KT-140 KT-150 KT-410 KT-420 KT-500 KT-510 KT-601 KT-602 KT-660
- Show dimensional drawing
- Download CAD drawing
- Exploded View

Technical Data

| | SI | IP |
|---|---|---|
| Displacement (1450 RPM 50Hz) | 4,06 m3/h | 143.4 CFH |
| Displacement (1750 RPM 60Hz) | 4,90 m3/h | 173.0 CFH |
| No. of cylinder x bore x stroke | 2 x 30 mm x 33 mm | 2 x 1.18 inch x 1.3 inch |
| Motor voltage (more on request) | 380..420V Y/3/50Hz | 440..480V Y/3/60Hz |
| Max operating current | 2.7A | 2.7A |
| Starting current (Rotor locked) | 12.0A Y | 12.0A Y |
| Weight | 43 kg | 95 lb |
| Max. pressure (LP/HP) | 19 / 28 bar | 275 / 403 psi |
| Connection suction line | 16 mm - 5/8' | 16 mm - 5/8' |
| Connection discharge line | 12 mm - 1/2' | 12 mm - 1/2' |
| Oil type R134a/R407C/R404A/R507A | tc<55°C: BSE32 / tc>55°C: BSE55 (Option) | tc<130°F: BSE32 / tc>130°F: BSE55 (Option) |
| Oil type R22 (R12/R502) | B5.2 (Standard) | B5.2 (Standard) |
| Oil type R290/R1270 | Clavus G68 (Standard) | Clavus G68 (Standard) |
| Oil charge | 1,00 dm³ | 35.2 fl oz |
| Crankcase heater | 0..60 W PTC (Option) | 0..60 W PTC (Option) |
| Motor protection | SE-B1 | SE-B1 |
| Enclosure class | IP65 | IP65 |
| Additional fan | Option | Option |
| Vibration dampers | Standard | Standard |

Figure 11.3-4: SB-Back-up HFC compressor

# 11.4 *Passive line components*

## 11.4.1 Accumulators

Table 11.4-1: VTCS accumulators

| Code | Part number | Function | Connection | Volume (Liter) | Operating Pressure (Bar) | Maximum Design Pressure (Bar) | Minimum design temperature (°C) | Maximum design temperature (°C) | Remark |
|---|---|---|---|---|---|---|---|---|---|
| TL_AC101 | TVC51 | $CO_2$ pressure control | Multiple | 14 | 74 | 135 | -55 | 30 | Nikhef engineered |
| TR_AC101 | TVC51 | $CO_2$ pressure control | Multiple | 14 | 74 | 135 | -55 | 30 | Nikhef engineered |
| SA_AC101 | Danfoss UOB 1/040B0010/040B0142 | Oil separator | 1/2" Solder | 0.52 | 28 | 36 | -40 | 120 | |
| SA_AC102 | Bitzer: F56 | Liquid buffering | 3/8" solder | 5.6 | 20 | 33 | -10 | 120 | |
| SB_AC102 | Bitzer: FS36 | Liquid buffering | 3/8" solder | 3 | 20 | 33 | -10 | 120 | Integral in condensing aggregate: Bitzer LH32/2KC-05.2y |

## Pressure vessels

Data Sheet: FS056

Abb. ähnlich / Fig. similar, © Bitzer

- Operating Instruction: DB-300
- Spare Part List: DE-110
- Manufacturers Declaration // Decl. of Conformity // Decl. of Incorporation: DC-300
- Download CAD drawing

| Technical Data | | |
|---|---|---|
| | SI | IP |
| Weight | 5,0 kg | 11.0 lb |
| Total width | 200 mm | 7.9 ' |
| Total depth | -- | -- |
| Total height | 353mm | 13.9' |
| Receiver volume refrigerant | 5,60 l | 197.09 fl.oz |
| Max. refrigerant charge 90% at 20°C | 20°C | 68°F |
| R22 | 6,1 kg | 13.4 lb |
| R134a | 6,2 kg | 13.6 lb |
| R407C | 5,8 kg | 12.9 lb |
| R404A/R507A | 5,4 kg | 11.9 lb |
| Connection inlet KL | 10mm - 3/8' | 10mm - 3/8' |
| Connection thread/ -flange | -- | -- |
| Connection outlet FL | 10 mm - 3/8' | 10 mm - 3/8' |
| Gauge | 7/16' 20 UNF | 7/16' 20 UNF |
| Connection for pressure relief valve | 1 1/4'-12 UNF (Option) | 1 1/4'-12 UNF (Option) |
| Adapter for pressure relief valve | Option | Option |
| Minimum level control | -- | -- |
| Maximum level control | -- | -- |
| Electric liquid level control | -- | -- |
| Approval according PED 97/23/EC | Standard | Standard |
| Special Approvals (on request) | Option | Option |

Figure 11.4-1: SA-Main HFC reservoir

## Pressure vessels

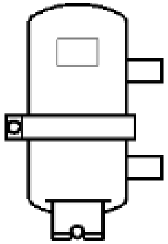
Data Sheet: FS036

Abb. ähnlich / Fig. similar, © Bitzer

- Operating Instruction: DB-300
- Spare Part List: DE-110
- Manufacturers Declaration // Decl. of Conformity // Decl. of Incorporation: DC-301
- Download CAD drawing

| Technical Data | | |
|---|---|---|
| | SI | IP |
| Weight | 3,0 kg | 6.6 lb |
| Total width | 129 mm | 5.1' |
| Total depth | -- | -- |
| Total height | 390mm | 15.4' |
| Receiver volume refrigerant | 3,0 l | 105.59 fl.oz |
| Max. refrigerant charge 90% at 20°C | 20°C | 68°F |
| R22 | 3,3 kg | 7.2 lb |
| R134a | 3,3 kg | 7.3 lb |
| R407C | 3,1 kg | 6.9 lb |
| R404A/R507A | 2,9 kg | 6.4 lb |
| Connection inlet KL | 10mm - 3/8' | 10mm - 3/8' |
| Connection thread/ -flange | -- | -- |
| Connection outlet FL | 10 mm - 3/8' | 10 mm - 3/8' |
| Gauge | 7/16' 20 UNF | 7/16' 20 UNF |
| Connection for pressure relief valve | -- | -- |
| Adapter for pressure relief valve | -- | -- |
| Minimum level control | -- | -- |
| Maximum level control | -- | -- |
| Electric liquid level control | -- | -- |
| Approval according PED 97/23/EC | Standard | Standard |
| Special Approvals (on request) | Option | Option |

Figure 11.4-2: SB-Back-up HFC reservoir



**040B0010**

Refrigerants: CFC, HCFC, HFC. Max. working pressure = 28 bar. Max. test pressure = 36.5 bar. Temperature of medium: -40 -120°C. Net volume: OUB 1: 0.52 l. OUB 4: 2.46 l. Oil reservoir: OUB 1: 0.1 l.OU...

SHARE

| Characteristic | Value |
|---|---|
| Type | OUB 1 |
| Weight | 1.150 Kg |
| Approval | UL |
| Connection size | 3/4-16 UNF-2B |
| Inlet connection type | UNION NUT |
| Max. Working Pressure ef | 28,0 bar |
| Max. Working Pressure | 406 psig |
| Net volume [USgal] | 0,14 gal US |
| Net volume [l] | 0,520 l |
| Outlet connection type | UNION NUT |
| Pack format | Multi pack |
| Product description | Oil Separator Excl. Unions |
| Quantity per pack format | 6 PC |
| Refrigerant(s) | CFC |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Return connection size | 7/16-20 UNF-1B |
| Return connection type | Flare |

Figure 11.4-3: SA-Main oil separator

## 11.4.2 Heat exchangers

Table 11.4-2: VTCS heat exchangers

| Code | Contra HX | Part number | Function | Connection | Operating Pressure (Bar) | Maximum Design Pressure (Bar) | Minimum design temperature (°C) | Maximum design temperature (°C) | Heat exchange area (mm2) |
|---|---|---|---|---|---|---|---|---|---|
| TL_HX001 | PU01_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX002 | PU02_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX003 | VL01_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX004 | VL02_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX005 | VL03_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX006 | VL04_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX007 | VL05_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX008 | VL06_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX009 | VL07_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX010 | VL08_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX011 | VL09_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX012 | VL10_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX013 | VL11_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX014 | VL12_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX015 | VL13_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX016 | VL14_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX017 | VL15_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX018 | VL16_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX021 | VL19_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX024 | VL22_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX025 | VL23_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX026 | VL24_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX027 | VL25_A | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TL_HX028 | TL_HX105 | TVC12 | Vapor transfer line | 1/2" VCR female | 90 | 135 | -50 | 30 | 953568 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TL_HX101 | SA_HX103 | TVC72 / SWEPB16DWHx12/1P-SC-H 4x1/2"INT.NPT | Main condenser | 1/2"FNPT | 68 | 135 | -55 | 30 | 164000 |
| TL_HX102 | SB_HX103 | TVC72 / SWEPB16DWHx6/1P-SC-H 4x1/2"INT.NPT | Back-up condenser | 1/2"FNPT | 68 | 135 | -55 | 30 | 410000 |
| TL_HX103 | SA_HX107 | 3/8"x0.035"x10m SS Tube integral in TVC51 | Main accu vaporator spiral | 1/4HVCR male | -68 | -135 | -55 | 30 | 299080 |
| TL_HX104 | SB_HX107 | 3/8"x0.035"x10m SS Tube integral in TVC51 | Back-up accu vaporator spiral | 1/4HVCR male | -68 | -135 | -55 | 30 | 299080 |
| TL_HX106 | TL_HX028 | TVC12 | Liquid transfer line | 1/2" VCR female | 90 | 135 | -50 | 30 | 686569 |
| TR_HX001 | PU01_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX002 | PU02_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX003 | VL01_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX004 | VL02_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX005 | VL03_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX006 | VL04_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX007 | VL05_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX008 | VL06_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX009 | VL07_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX010 | VL08_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX011 | VL09_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX012 | VL10_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX013 | VL11_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX014 | VL12_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX015 | VL13_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX016 | VL14_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX017 | VL15_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX018 | VL16_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX021 | VL19_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX024 | VL22_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX025 | VL23_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX026 | VL24_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX027 | VL25_C | TVD76 | Module cooling | OD4mmx0.7mm weld | 68 | 135 | -40 | 60 | 1436 |
| TR_HX028 | TR_HX105 | TVC12 | Vapor transfer line | 1/2" VCR female | 90 | 135 | -50 | 30 | 931624 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TR_HX101 | SA_HX105 | TVC72 / SWEPB16DWHx12/1P-SC-H 4x1/2"INT.NPT | Main condenser | 1/2"FNPT | 68 | 135 | -55 | 30 | 164000 |
| TR_HX102 | SB_HX105 | TVC72 / SWEPB16DWHx6/1P-SC-H 4x1/2"INT.NPT | Back-up condenser | 1/2"FNPT | 68 | 135 | -55 | 30 | 410000 |
| TR_HX103 | SA_HX108 | 3/8"x0.035"x10m SS Tube integral in TVC51 | Main accu vaporator spiral | 1/4HVCR male | -68 | -135 | -55 | 30 | 299080 |
| TR_HX104 | SB_HX108 | 3/8"x0.035"x10m SS Tube integral in TVC51 | Back-up accu vaporator spiral | 1/4HVCR male | -68 | -135 | -55 | 30 | 299080 |
| TR_HX105 | TLR_HX105 | TVC135 / 6x 1.5mm*0.25mm*2m | TLR pump liquid inlet cooling | 1/4HVCR female | 90 | 135 | -55 | 40 | 37699 |
| TR_HX106 | TL_HX028 | TVC12 | Liquid transfer line | 1/2" VCR female | 90 | 135 | -50 | 30 | 670769 |
| TLR_HX105 | TR_HX105 | TVC135 / 6x 1.5mm*0.25mm*2m | TLR pump liquid inlet cooling | orbital welding | 90 | 135 | -50 | 30 | xxx |
| SA_HX101 | CERN Cold water | SWEP B15Hx14 / 1P-SC-S | SA condenser | Soldering | 23 | 32 | 0 | 120 | 504000 |
| SA_HX102 | SA_HX103 super heater | SWEP B5Hx16 / 1P-SC-S | SA superheater | Soldering | 23 | 32 | -50 | 30 | 168000 |
| SA_HX103 | TL_HX101 | TVC72 / SWEPB16DWHx12/1P-SC-H 4x1/2"INT.NPT | SA main evaporator | 1/2"FNPT | 23 | 32 | -50 | 30 | 164000 |
| SA_HX104 | SA_HX105 super heater | SWEP B5Hx16 / 1P-SC-S | SA superheater | Soldering | 23 | 32 | -50 | 30 | 168000 |
| SA_HX105 | TR_HX101 | TVC72 / SWEPB16DWHx12/1P-SC-H 4x1/2"INT.NPT | SA main evaporator | 1/2"FNPT | 23 | 32 | -50 | 30 | 164000 |
| SA_HX106 | Subcooler | SWEP B5Hx16 / 1P-SC-S | SA sub cooler | Soldering | 23 | 32 | -50 | 30 | 168000 |
| SA_HX107 | TL_HX103 | 3/8"x0.035"x10m SS Tube integral in TVC51 | Main accu vaporator spiral | 1/4HVCR male | -68 | -135 | -55 | 30 | 296881 |
| SA_HX108 | TR_HX103 | 3/8"x0.035"x10m SS Tube integral in TVC51 | Main accu vaporator spiral | 1/4HVCR male | -68 | -135 | -55 | 30 | 296881 |
| SB_HX101 | Ambient air | Bitzer LH32/2KC-05.2Y integral | SB condenser | Soldering | 23 | 32 | -50 | 30 | 249319 |
| SB_HX103 | TL_HX102 | TVC72 / SWEPB16DWHx6/1P-SC-H 4x1/2"INT.NPT | SB main evaporator | 1/2"FNPT | 23 | 32 | -50 | 30 | 410000 |
| SB_HX105 | TR_HX102 | TVC72 / SWEPB16DWHx6/1P-SC-H 4x1/2"INT.NPT | SB main evaporator | 1/2"FNPT | 23 | 32 | -50 | 30 | 410000 |
| SB_HX106 | Subcooler | SWEP B5Hx16 / 1P-SC-S | SB sub cooler | Soldering | 23 | 32 | -50 | 30 | 168000 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SB_HX107 | TL_HX104 | 3/8"x0.035"x10m SS Tube integral in TVC51 | Main accu vaporator spiral | 1/4HVCR male | -68 | -135 | -55 | 30 | 296881 |
| SB_HX108 | TR_HX104 | 3/8"x0.035"x10m SS Tube integral in TVC51 | Main accu vaporator spiral | 1/4HVCR male | -68 | -135 | -55 | 30 | 296881 |

**SWEP CBE Platenwarmtewisselaar(s):**

| **Positie** | **Type** | **Artikel-nummer** | Nettoprijs per stuk | Toeslag **MSC** 24% | **Aantal** | **Totaalprijs incl. toeslag** |
|---|---|---|---|---|---|---|
| 1 | B15x14/1P-SC-S 4 x 22U | 10041-014 | € 137,00 | € 32,88 | 1 | € 169,88 |
| 2 | B16DWx12/1P-SC-S 2*3/4"+1/2"INT+3/4" / 1/2"INT | 13656-012 | € 178,00 | € 42,72 | 2 | € 441,44 |
| 3 | B5Hx16/1P-SC-S 2x22U+2x1/2" | 10004-016 | € 77,00 | € 18,48 | 2 | € 190,96 |
| 4 | B5Hx10/1P-SC-S 2*6.5+2*1/2" | 10455-010 06227.0 | € 72,00 | € 17,28 | 1 | € 89,28 |
| 5 | B5Hx10/1P-SC-S 2x12.8+2xR1/2" | L 10992-010 | € 72,00 | € 17,28 | 1 | € 89,28 |

***MSC = material surcharge:*** *wij berekenen* ***24% toeslag*** *materiaaltoeslag (MSC) vanwege de gestegen prijzen op de metaalmarkt. Dit percentage wordt per kwartaal aangepast bij wijzigingen op de metaalmarkt.*

Figure 11.4-4: VTCS plate heatexchangers

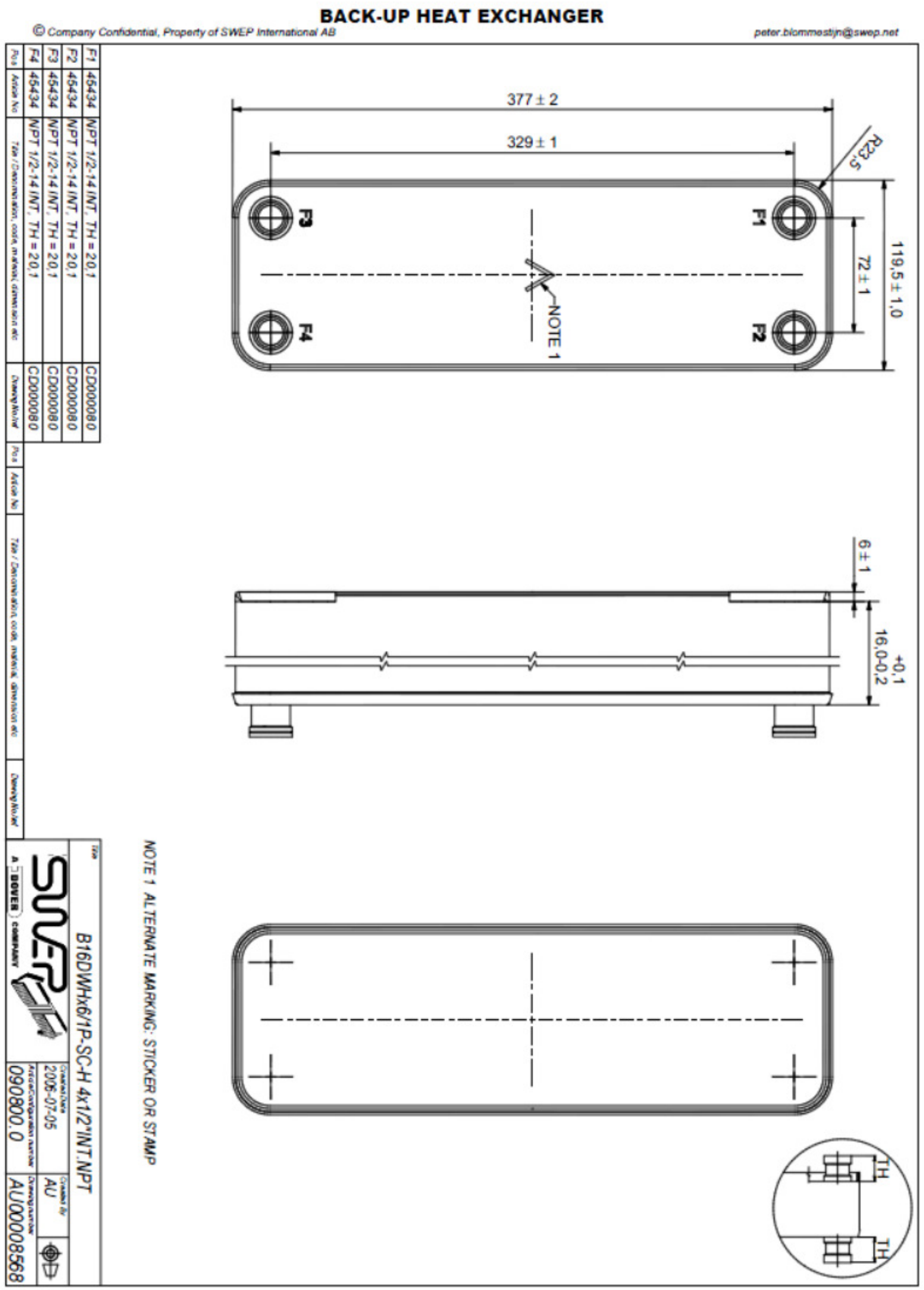



Figure 11.4-6: SB Back-up HFC evaporator

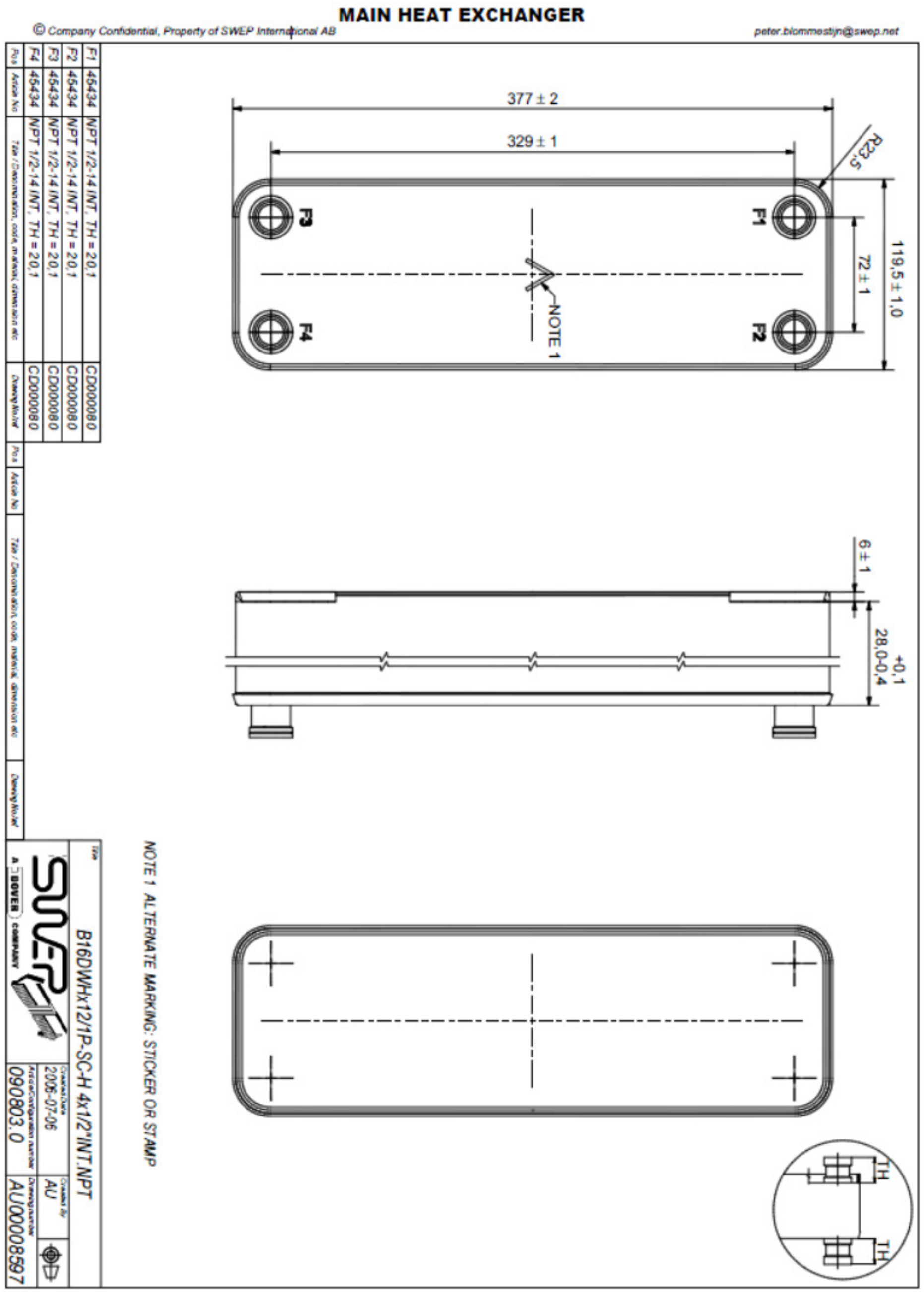



Figure 11.4-5: SA Main HFC evaporator

### 11.4.3 Relieve devices

Table 11.4-3: VTCS relieve devices

| Code | Part number | Functionality | Burst Pressure (Bar) |
|---|---|---|---|
| TL_BD001 | Swagelok SS-RDK-16-1900 | Local control box liquid line safety | 130+/- 7 bar |
| TL_BD002 | Swagelok SS-RDK-16-1900 | Local control box vapor line safety | 130+/- 7 bar |
| TL_BD002 | Swagelok SS-RDK-16-1900 | Local control box vapor line safety | 130+/- 7 bar |
| TL_BD004 | TBD | Tertiary vacuum safety | 1.5 |
| TR_BD001 | Swagelok SS-RDK-16-1900 | Local control box liquid line safety | 130+/- 7 bar |
| TR_BD002 | Swagelok SS-RDK-16-1900 | Local control box vapor line safety | 130+/- 7 bar |
| TR_BD002 | Swagelok SS-RDK-16-1900 | Local control box vapor line safety | 130+/- 7 bar |
| TR_BD004 | TBD | Tertiary vacuum safety | 1.5 |
| TL_BD101 | Swagelok SS-RDK-16-1900 | Vapor line safety | 130+/- 7 bar |
| TL_BD102 | Swagelok SS-RDK-16-1900 | Condenser safety | 130+/- 7 bar |
| TL_BD103 | Swagelok SS-RDK-16-1900 | Accumulator safety | 130+/- 7 bar |
| TL_BD104 | Swagelok SS-RDK-16-1900 | Suction line safety | 130+/- 7 bar |
| TL_BD105 | Swagelok SS-4R3A-EP | TL-PM101 safety | 130 bar |
| TL_BD106 | Swagelok SS-RDK-16-1900 | Pump outlet safety | 130+/- 7 bar |
| TL_BD107 | Swagelok SS-RDK-16-1900 | Liquid line safety | 130+/- 7 bar |
| TR_BD101 | Swagelok SS-RDK-16-1900 | Vapor line safety | 130+/- 7 bar |
| TR_BD102 | Swagelok SS-RDK-16-1900 | Condenser safety | 130+/- 7 bar |
| TR_BD103 | Swagelok SS-RDK-16-1900 | Accumulator safety | 130+/- 7 bar |
| TR_BD104 | Swagelok SS-RDK-16-1900 | Suction line safety | 130+/- 7 bar |
| TR_BD105 | Swagelok SS-4R3A-EP | TR-PM101 safety | 130 bar |
| TR_BD106 | Swagelok SS-RDK-16-1900 | Pump outlet safety | 130+/- 7 bar |
| TR_BD107 | Swagelok SS-RDK-16-1900 | Liquid line safety | 130+/- 7 bar |
| TLR_BD105 | Swagelok SS-4R3A-EP | TRL-PM101 safety | 130 bar |

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### Spare Parts and Accessories

**Part Number:** SS-RDK-16-1900

**Description:** Stainless Steel Rupture Disc Kit for 16D Series Integral Bonnet Non-Rotating Stem Valves, 1900 ± 100 psig (130 ± 6.8 bar)

### Product Specifications

| General | |
|---|---|
| eClass (4.1) | 37010904 |
| eClass (6.0) | 37-01-91-02 |
| Feature | 1900 PSI |
| UNSPSC (11.0501) | 40141616 |
| UNSPSC (4.03) | 40141616 |
| UNSPSC (SWG01) | 40141616 |

REVIEW PRODUCT CATALOG FOR COMPLETE SPECIFICATIONS INCLUDING WARNINGS AND CAUTIONS.

Safe Product Selection: When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange valve components with those of other manufacturers.

Figure 11.4-7: $CO_2$ Burst disc

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### Proportional Relief Valves, High Pressure

**Part Number:** SS-4R3A-EP

**Description:** SS High-Pressure Proportional Relief Valve, 1/4 in. Swagelok Tube Fitting, Ethylene Propylene Seal

### Product Specifications

| General | |
|---|---|
| Service Class | High Pressure |
| Size | 1/8in |
| Valve Material | 316 Stainless Steel |
| End Connection 1 Size | 1/4 in |
| End Connection 1 Type | Swagelok tube fitting |
| End Connection 2 Size | 1/4 in |
| End Connection 2 Type | Swagelok tube fitting |
| Approval | No Approval |
| Cleaning | Swagelok SC-10 |
| Lubricant | Dow Corning Molykote 55 Grease |
| Manual Override | No |
| Seal Material | Ethylene Propylene |
| Testing | No Optional Testing |
| Max Temperature Pressure Rating | 250°F @ 4910 PSIG /121°C @ 338 BAR |
| Room Temperature Pressure Rating | 6000 PSIG @ 100°F /413 @ BAR 37°C |

REVIEW PRODUCT CATALOG FOR COMPLETE SPECIFICATIONS INCLUDING WARNINGS AND CAUTIONS.

Safe Product Selection: When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange valve components with those of other manufacturers.

Figure 11.4-8: $CO_2$ Spring relieve valve

## 11.4.4 Filters

Table 11.4-4: VTCS filters

| Code | Part number | Function | Connection | Operating Pressure (Bar) | Maximum Design Pressure (Bar) | Minimum design temperature (°C) | Maximum design temperature (°C) | Pories (micron) |
|---|---|---|---|---|---|---|---|---|
| TL_FL001 | Swagelok SS-4FW-VCR-15 | TL-VL002 protection | 1/4" male VCR | 100 | 413 | -28 | 37 | 15 |
| TL_FL002 | Swagelok element ss-4f-k4-15 | Evaporator Capillary protection | | | | | | 15 |
| TR_FL001 | Swagelok SS-4FW-VCR-15 | TL-VR002 protection | 1/4" male VCR | 100 | 413 | -28 | 37 | 15 |
| TR_FL002 | Swagelok element ss-4f-k4-15 | Evaporator Capillary protection | | 100 | 413 | -28 | 37 | 15 |
| TL_FL101 | Swagelok ss-4TF-TW-15 | Transfer tube filter | 3/8" Weld | 100 | 413 | -28 | 37 | 15 |
| TL_FL102 | Swagelok ss-4TF-TW-15 | TL-VL109 protection | 1/4" Weld | 100 | 413 | -28 | 37 | 15 |
| TR_FL101 | Swagelok ss-4TF-TW-15 | Transfer tube filter | 3/8" Weld | 100 | 413 | -28 | 37 | 15 |
| TR_FL102 | Swagelok ss-4TF-TW-15 | TL-VR109 protection | 1/4" Weld | 100 | 413 | -28 | 37 | 15 |
| TR_FL103 | Swagelok SS-4FW-VCR-15 | TLR pump culling capillary protection | 1/4" male VCR | 100 | 413 | -28 | 37 | 15 |
| SA_FL101 | Danfoss DML 033s/023Z5050 | Liquid line filtering | 3/8 solder | | | | | |
| SB_FL101 | Danfoss DML032s/023Z5048 | Liquid line filtering | 1/4 solder | | | | | |

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## All-Welded In-Line Filters

**Part Number:** SS-4FW-VCR-15

**Description:** Stainless Steel All-Welded In-Line Filter, 1/4 in. Male VCR, 15 Micron Pore Size

## Product Specifications

| General | |
|---|---|
| Body Material | 316 Stainless Steel |
| Cleaning Process | Special Cleaning and Packaging (SC-11) |
| Connection 1 Size | 1/4 in. |
| Connection 1 Type | VCR® Metal Gasket Face Seal Fitting |
| Connection 2 Size | 1/4 in. |
| Connection 2 Type | VCR® Metal Gasket Face Seal Fitting |
| eClass (4.1) | 36101905 |
| eClass (6.0) | 36-10-20-00 |
| Feature | 15 Micron Element Pore Size |
| UNSPSC (11.0501) | 40161516 |
| UNSPSC (4.03) | 40161500 |
| UNSPSC (SWG01) | 40161500 |

REVIEW PRODUCT CATALOG FOR COMPLETE SPECIFICATIONS INCLUDING WARNINGS AND CAUTIONS.

Safe Product Selection: When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange valve components with those of other manufacturers.



Figure 11.4-9: $CO_2$ Inline filter

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## Tee-Type Filters

**Part Number:** SS-4TF-TW-15

**Description:** Stainless Steel Tee-Type Particulate Filter, 1/4 in. Tube Socket Weld and 3/8 in. Tube Butt Weld, 15 Micron Pore Size

## Product Specifications

| General | |
|---|---|
| Body Material | 316 Stainless Steel |
| Cleaning Process | Standard Cleaning and Packaging (SC-10) |
| Connection 1 Size | 1/4 and 3/8 in. |
| Connection 1 Type | Tube Socket Weld and Tube Butt Weld |
| Connection 2 Size | 1/4 and 3/8 in. |
| Connection 2 Type | Tube Socket Weld and Tube Butt Weld |
| eClass (4.1) | 36101905 |
| eClass (6.0) | 36-10-20-90 |
| Feature | 15 Micron Element Pore Size |
| UNSPSC (11.0501) | 40161500 |
| UNSPSC (4.03) | 40161500 |
| UNSPSC (SWG01) | 40161500 |

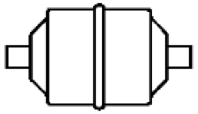
REVIEW PRODUCT CATALOG FOR COMPLETE SPECIFICATIONS INCLUDING WARNINGS AND CAUTIONS.

Safe Product Selection: When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange valve components with those of other manufacturers.

Figure 11.4-10: $CO_2$ T-filter

Figure 11.4-11: SB-Back-up filter



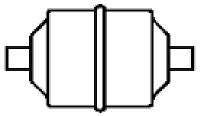
**023Z8048**

Optimized for HFC refrigerants and polyolester (POE) or polyalkyl glycol (PAG) oils. 100% 3Å Molecular Sieve. Temperature range: -40°C - +70°C.

SHARE

| Characteristic | Value |
|---|---|
| Type | DML 032S |
| Weight | 0.206 Kg |
| Acid capacity [g] | 0,58 g |
| Acid capacity [oz] | 0,021 oz |
| Approval | UL |
| Connection material | Cu |
| Core size | 03 cu.in. |
| Felt mat/hole design | 0 |
| Inlet connection size [in] | 1/4 IN |
| Inlet connection type | SOLDER, ODF |
| Max. Working Pressure ef | 46,0 bar |
| Max. Working Pressure | 667 psig |
| Net volume [fluid oz] | 1,28 foz US |
| Net volume [l] | 0,038 l |
| Outlet connection size [in] | 1/4 IN |
| Outlet connection type | SOLDER, ODF |
| Pack format | Industrial pack |
| Product description | Liquid line filter drier |
| Quantity per pack format | 28 pc |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Shell volume [foz US] | 2,71 foz US |
| Shell volume [l] | 0,08 l |
| Solid core surface [cm2] | 82 cm2 |
| Solid core volume [cm3] | 41 cm3 |
| Solid core surface [in2] | 12,71 in2 |
| Solid core volume [in3] | 2,50 in3 |
| Temperature range [°C] | -40 - 70 °C |
| Temperature range [°F] | -40 - 160 °F |
| Type designation | DML 032S |

Figure 11.4-12: SA-Main filter



**023Z8050**

Optimized for HFC refrigerants and polyolester (POE) or polyalkyl glycol (PAG) oils. 100% 3Å Molecular Sieve. Temperature range: -40°C - +70°C.

SHARE

| Characteristic | Value |
|---|---|
| Type | DML 033S |
| Weight | 0.213 Kg |
| Acid capacity [g] | 0,58 g |
| Acid capacity [oz] | 0,021 oz |
| Approval | UL |
| Connection material | Cu |
| Core size | 03 cu.in. |
| Felt mat/hole design | 0 |
| Inlet connection size [in] | 3/8 IN |
| Inlet connection type | SOLDER, ODF |
| Max. Working Pressure ef | 46,0 bar |
| Max. Working Pressure | 667 psig |
| Net volume [fluid oz] | 1,28 foz US |
| Net volume [l] | 0,038 l |
| Outlet connection size [in] | 3/8 IN |
| Outlet connection type | SOLDER, ODF |
| Pack format | Industrial pack |
| Product description | Liquid line filter drier |
| Quantity per pack format | 28 pc |
| Refrigerant(s) | HCFC |
| Refrigerant(s) | HFC |
| Shell volume [foz US] | 2,71 foz US |
| Shell volume [l] | 0,08 l |
| Solid core surface [cm2] | 82 cm2 |
| Solid core volume [cm3] | 41 cm3 |
| Solid core surface [in2] | 12,71 in2 |
| Solid core volume [in3] | 2,50 in3 |
| Temperature range [°C] | -40 - 70 °C |
| Temperature range [°F] | -40 - 160 °F |
| Type designation | DML 033S |

## 11.5 *System analyses results*

### 11.5.1 SA-Main Chiller

Model outcome of a nominal SA operation. Figure 11.5-1 shows the state points in the P-H diagram.

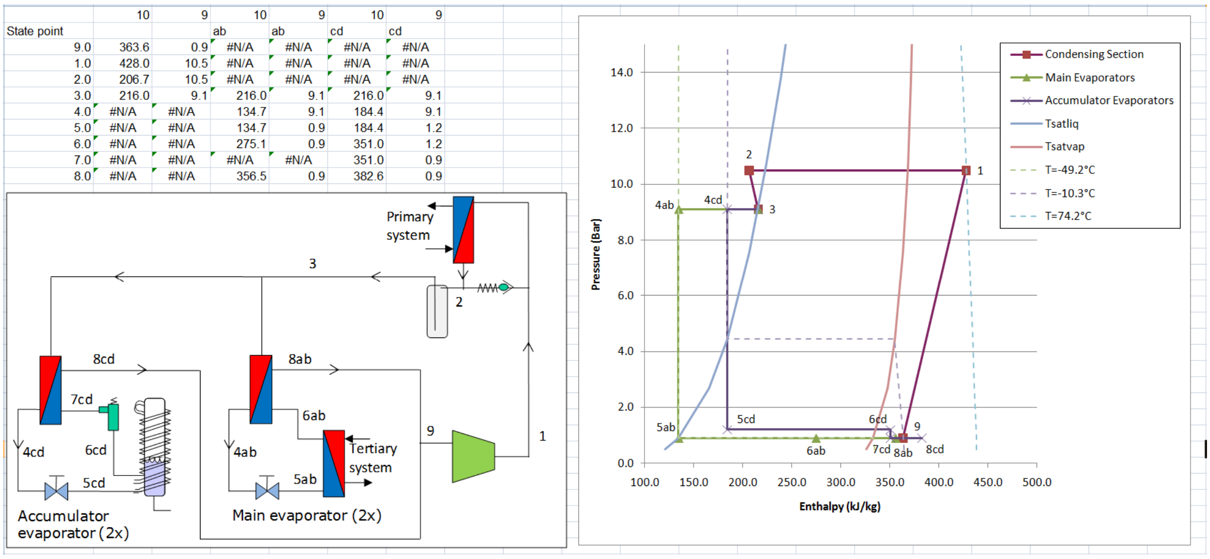



Figure 11.5-1: SA-chiller operation in the pressure enthalpy diagram.

Table 11.5-1 Volumes and operational states of the SA-Main chiller

| Section | Volume (mL) | Pressure (Bar) | Enthalpy (kJ/kg) | Temp. ('C) | Rho (kg/m3) | Mass (g) |
|---|---|---|---|---|---|---|
| SA_S.01.01 | 649.9 | 10.5 | 427.9 | 74.1 | 40.2 | 26.1 |
| SA_S.01.02 | 112.6 | 10.5 | 427.9 | 74.1 | 40.2 | 4.5 |
| SA_S.01.03 | 441.0 | 10.5 | 317.3 | 17.6 | 83.1 | 36.7 |
| SA_S.01.04 | 43.3 | 10.5 | 206.7 | 6.0 | 1134.6 | 49.1 |
| SA_S.02.01 | 47.2 | 9.1 | 216.0 | 12.5 | 1105.2 | 52.1 |
| SA_S.02.02 | 5600.0 | 9.1 | 216.0 | 12.5 | 566.1 | 3167.2 |
| SA_S.02.03 | 130.4 | 9.1 | 216.0 | 12.5 | 1105.2 | 144.1 |
| SA_S.03.01 | 200.0 | 9.1 | 175.4 | -17.1 | 1222.1 | 244.4 |
| SA_S.03.02 | 34.3 | 9.1 | 134.7 | -49.2 | 1326.7 | 45.5 |
| SA_S.03.03 | 49.0 | 0.9 | 134.7 | -49.2 | 950.7 | 47.6 |
| SA_S.03.04 | 366.0 | 0.9 | 204.9 | -49.2 | 14.0 | 5.1 |
| SA_S.03.05 | 96.2 | 0.9 | 275.2 | -49.2 | 7.0 | 0.7 |
| SA_S.03.06 | 48.1 | 0.9 | 275.2 | -49.2 | 7.0 | 0.3 |
| SA_S.03.07 | 175.0 | 0.9 | 315.8 | -49.2 | 5.5 | 1.0 |
| SA_S.03.08 | 63.5 | 0.9 | 356.5 | -19.2 | 4.3 | 0.3 |
| SA_S.04.01 | 200.0 | 9.1 | 175.4 | -17.1 | 1222.1 | 244.4 |
| SA_S.04.02 | 48.5 | 9.1 | 134.7 | -49.2 | 1326.7 | 64.4 |
| SA_S.04.03 | 81.4 | 0.9 | 134.7 | -49.2 | 950.7 | 79.0 |
| SA_S.04.04 | 366.0 | 0.9 | 245.6 | -49.2 | 8.9 | 3.3 |
| SA_S.04.05 | 159.8 | 0.9 | 275.2 | -49.2 | 7.0 | 1.1 |
| SA_S.04.06 | 76.0 | 0.9 | 275.2 | -49.2 | 7.0 | 0.5 |
| SA_S.04.07 | 175.0 | 0.9 | 315.8 | -49.2 | 5.5 | 1.0 |
| SA_S.04.08 | 63.5 | 0.9 | 356.5 | -19.2 | 4.3 | 0.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| SA_S.05.01 | 200.0 | 9.1 | 200.2 | 1.3 | 1152.9 | 230.6 |
| SA_S.05.02 | 25.5 | 9.1 | 184.4 | -10.3 | 1197.6 | 30.5 |
| SA_S.06.01 | 24.5 | 1.2 | 184.4 | -43.2 | 29.5 | 0.7 |
| SA_S.06.02 | 490.0 | 1.2 | 267.7 | -43.2 | 10.1 | 5.0 |
| SA_S.06.03 | 57.7 | 1.2 | 351.0 | -25.0 | 6.0 | 0.3 |
| SA_S.06.04 | 25.0 | 1.2 | 351.0 | -25.0 | 6.0 | 0.1 |
| SA_S.06.05 | 51.0 | 0.9 | 351.0 | -26.0 | 4.5 | 0.2 |
| SA_S.07.01 | 49.0 | 1.2 | 184.4 | -43.2 | 29.5 | 1.4 |
| SA_S.07.02 | 490.0 | 1.2 | 267.7 | -43.2 | 10.1 | 5.0 |
| SA_S.07.03 | 105.9 | 1.2 | 351.0 | -25.0 | 6.0 | 0.6 |
| SA_S.07.04 | 25.0 | 1.2 | 351.0 | -25.0 | 6.0 | 0.1 |
| SA_S.07.05 | 42.3 | 0.9 | 351.0 | -26.0 | 4.5 | 0.2 |
| SA_S.08.01 | 6.7 | 0.9 | 351.0 | -26.0 | 4.5 | 0.0 |
| SA_S.08.02 | 175.0 | 0.9 | 366.8 | -6.4 | 4.1 | 0.7 |
| SA_S.08.03 | 63.5 | 0.9 | 382.6 | 12.5 | 3.8 | 0.2 |
| SA_S.09.01 | 1046.1 | 0.9 | 363.6 | -10.4 | 4.2 | 4.4 |
| SA_S.09.02 | 237.7 | 0.9 | 363.6 | -10.4 | 4.2 | 1.0 |
| SA_S.09.03 | 0.0 | 5.7 | 427.9 | 68.8 | 21.1 | 0.0 |
| | ======= | | | | | ======= |
| Total volume | 12.34 | | | | Total mass: | 4500 |

Table 11.5-2 Overview of the volumes, charge and reservoir levels of the SA-Main chiller

| | | |
|---|---|---|
| Discharge and condensing section | 1.25 | Liter |
| Liquid and buffer section: | 5.78 | Liter |
| Branch 1 (to left condenser) | 1.03 | Liter |
| Branch 2 (to right condenser) | 1.17 | Liter |
| Branch 3&4 liquid inlet | 0.23 | Liter |
| Branch 3 (to left accu) | 0.65 | Liter |
| Branch 4 (to right accu) | 0.71 | Liter |
| Branch 3&4 vapor outlet | 0.25 | Liter |
| Cold gas section | 1.28 | Liter |
| System volume w.o. reservoir | 6.74 | Liter |
| Total system volume | 12.34 | Liter |
| Max flooded volume | 2.85 | Liter |
| Reservoir volume | 5.60 | Liter |
| Filling | 4.5 | kg |
| Homogeneous filling | 0.36 | kg/L |
| Maximum buffer level | 74.10% | |
| Nominal buffer level | 48.98% | |
| Minimum buffer level | 14.25% | |

## 11.5.2 SB-Back-up Chiller

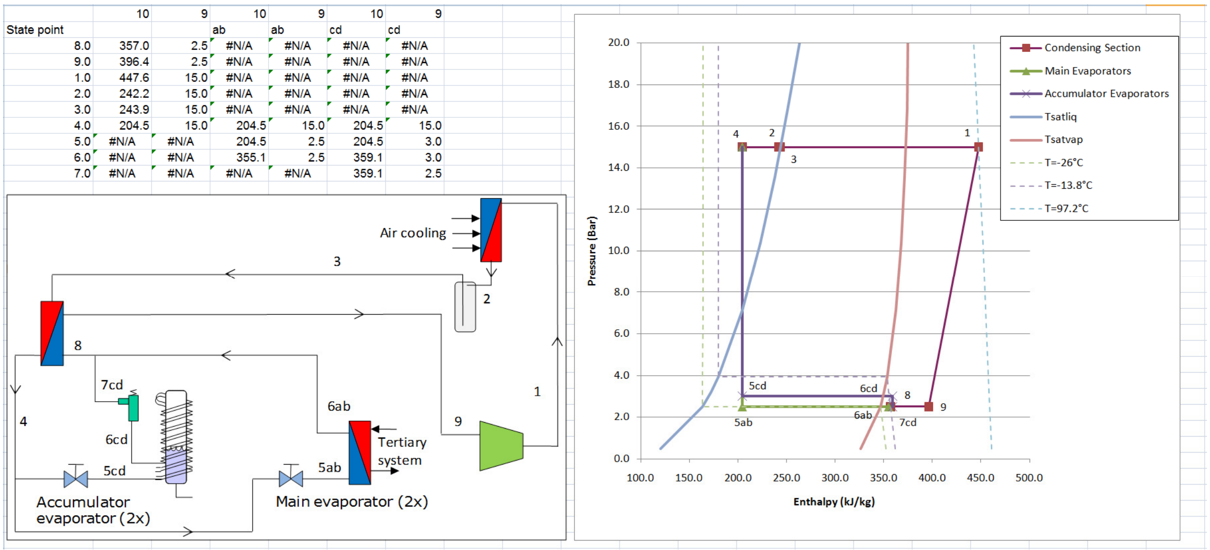



Figure 11.5-2: SB-chiller operation in the pressure enthalpy diagram.

Table 11.5-3 Volumes and operational states of the SB-Back-up chiller

| Section | Volume (mL) | Pressure (Bar) | Enthalpy (kJ/kg) | Temp. ('C) | Rho (kg/m3) | Mass (g) |
|---|---|---|---|---|---|---|
| SB_S.01.01 | 132.8 | 15.0 | 447.6 | 97.2 | 54.7 | 7.3 |
| SB_S.01.02 | 690.0 | 15.0 | 344.9 | 31.1 | 102.9 | 71.0 |
| SB_S.02.01 | 4.7 | 15.0 | 242.2 | 30.0 | 1023.1 | 4.8 |
| SB_S.02.02 | 3000.0 | 15.0 | 243.9 | 31.1 | 1017.0 | 2216.9 |
| SB_S.02.03 | 106.4 | 15.0 | 243.9 | 31.1 | 1017.0 | 108.2 |
| SB_S.05.01 | 200.0 | 15.0 | 224.7 | 18.5 | 1082.7 | 216.9 |
| SB_S.05.02 | 11.6 | 15.0 | 205.5 | 5.1 | 1141.4 | 13.3 |
| SB_S.03.03 | 63.7 | 2.5 | 205.5 | -26.0 | 55.6 | 3.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| SB_S.03.04 | 183.0 | 2.5 | 280.3 | -26.0 | 20.5 | 3.8 |
| SB_S.03.05 | 125.1 | 2.5 | 355.1 | -16.0 | 12.5 | 1.6 |
| SB_S.03.08 | 37.5 | 2.5 | 355.1 | -16.0 | 12.5 | 0.5 |
| SB_S.04.03 | 81.4 | 2.5 | 205.5 | -26.0 | 55.6 | 4.6 |
| SB_S.04.04 | 183.0 | 2.5 | 280.3 | -26.0 | 20.5 | 3.8 |
| SB_S.04.05 | 159.8 | 2.5 | 355.1 | -16.0 | 12.5 | 2.0 |
| SB_S.04.08 | 37.5 | 2.5 | 355.1 | -16.0 | 12.5 | 0.5 |
| SB_S.06.01 | 39.2 | 2.5 | 205.5 | -26.0 | 55.6 | 3.0 |
| SB_S.06.02 | 490.0 | 2.5 | 282.9 | -26.0 | 20.1 | 12.2 |
| SB_S.06.03 | 86.6 | 2.5 | 3603 | -10.0 | 12.1 | 1.3 |
| SB_S.06.04 | 25.0 | 2.5 | 360.3 | -10.0 | 12.1 | 0.4 |
| SB_S.06.06 | 25.0 | 2.5 | 360.3 | -10 | 12.1 | 0.3 |
| SB_S.07.01 | 49.0 | 2.5 | 205.5 | -26.0 | 55.6 | 3.8 |
| SB_S.07.02 | 490.0 | 2.5 | 282.9 | -26.0 | 20.1 | 12.2 |
| SB_S.07.03 | 105.9 | 2.5 | 360.3 | -10.0 | 12.1 | 1.6 |
| SB_S.07.04 | 25.0 | 2.5 | 360.3 | -10.0 | 12.1 | 0.4 |
| SB_S.07.06 | 25.0 | 2.5 | 360.3 | -10 | 12.1 | 0.3 |
| SB_S.08.01 | 237.3 | 2.5 | 358.1 | -12.6 | 12.3 | 2.9 |
| SB_S.08.01 | 175.0 | 2.5 | 377.2 | 9.5 | 11.1 | 1.9 |
| SB_S.09.01 | 112.4 | 2.5 | 396.4 | 31.1 | 10.2 | 1.1 |
| SB_S.09.03 | 0.0 | 8.8 | 422.0 | 66.3 | 33.9 | 0.0 |
| | ======= | | | | | ======= |
| Total volume | 6.90 | | | | Total mass: | 2700 |

Table 11.5-4 Overview of the volumes, charge and reservoir levels of the SB-Back-up chiller

| | | |
|---|---|---|
| Discharge and condensing section | 0.82 | Liter |
| Liquid and buffer section: | 3.32 | Liter |
| Branch 1 (to left condenser) | 0.41 | Liter |
| Branch 2 (to right condenser) | 0.46 | Liter |
| Branch 3 (to left accu) | 0.67 | Liter |
| Branch 4 (to right accu) | 0.69 | Liter |
| Cold gas section | 0.52 | Liter |
| System volume w.o. buffer | 3.90 | Liter |
| Total system volume | 6.90 | Liter |
| Max flooded volume | 1.90 | Liter |
| Reservoir | 3.00 | Liter |
| Filling | 2.7 | kg |
| Homogeneous filling | 0.39 | kg/L |
| Maximum buffer level | 83.75% | |
| Nominal buffer level | 70.26% | |
| Minimum buffer level | 14.00% | |

### 11.5.3 Tertiary $CO_2$ systems

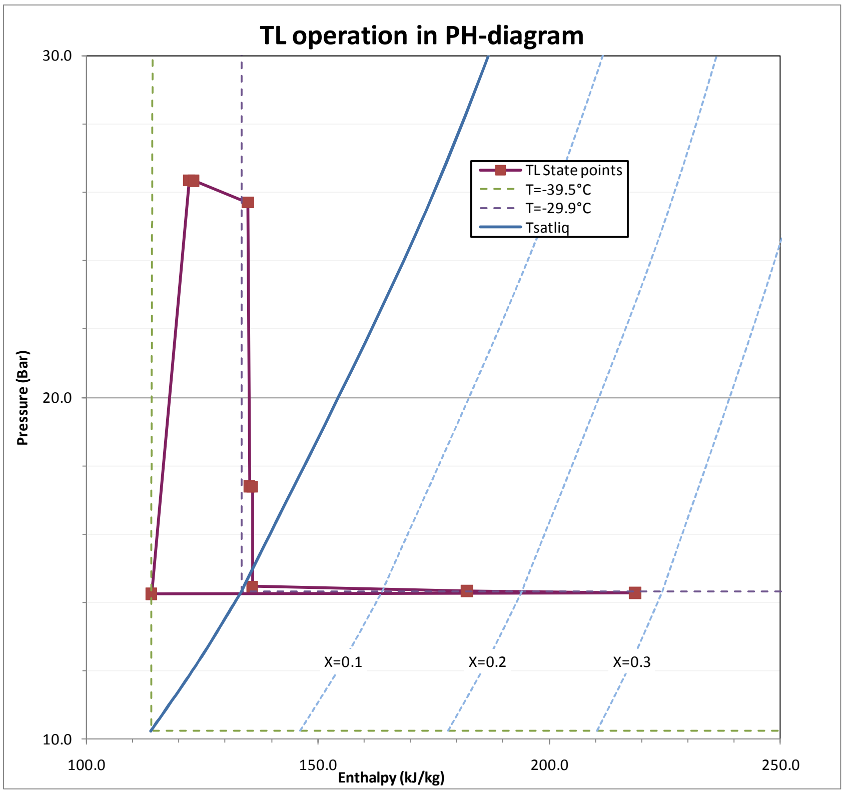



Figure 11.5-3: TL system in the PH-diagram. Detector power =489 Watt, Tsetpoint is -30ºC

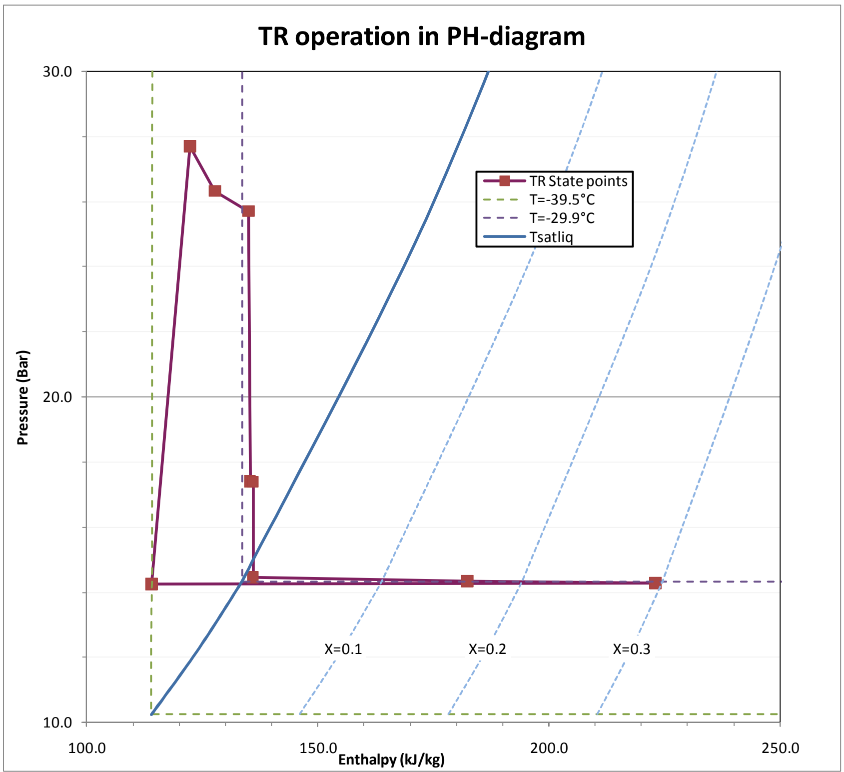



Figure 11.5-4: TR system in the PH-diagram. Detector power =489 Watt, Tsetpoint is -30ºC

Table 11.5-5 Volumes and operational states of the TL and TRL System

| **Section** | **Volume (mL)** | **Pressure (Bar)** | **Enthalpy (kJ/kg)** | **Temp. ('C)** | **Rho (kg/m3)** | **Mass (g)** |
|---|---|---|---|---|---|---|
| TL_S.01.01 | 25.1 | 26.4 | 122.2 | -35.5 | 1103.0 | 27.7 |
| TL_S.01.04 | 22.2 | 26.3 | 123.2 | -35.0 | 1100.9 | 24.5 |
| TL_S.01.05 | 605.0 | 26.4 | 526.5 | 70.0 | 44.4 | 26.9 |
| TL_S.01.06 | 9.5 | 26.3 | 123.5 | -34.8 | 1100.2 | 10.4 |
| TL_S.02.01 | 38.3 | 26.3 | 124.5 | -34.4 | 1098.3 | 42.0 |
| TL_S.02.02 | 784.1 | 26.0 | 131.8 | -30.8 | 1083.1 | 849.2 |
| TL_S.03.01 | 38.7 | 25.7 | 135.0 | -29.2 | 1076.4 | 41.7 |
| TL_S.03.02 | 7.8 | 17.4 | 135.2 | -29.1 | 1072.8 | 8.4 |
| TL_S.03.03 | 18.7 | 17.4 | 135.8 | -28.8 | 1071.5 | 20.1 |
| TL_S.04.01-27 | 51.4 | 14.5 | 135.8 | -29.6 | 929.6 | 47.8 |
| TL_S.05.01-27 | 8.3 | 14.4 | 181.3 | -29.8 | 201.1 | 1.7 |
| TL_S.06.01-27 | 40.3 | 14.4 | 181.3 | -29.8 | 200.0 | 8.1 |
| TL_S.07.01 | 120.0 | 14.3 | 181.3 | -29.9 | 199.8 | 24.0 |
| TL_S.08.01 | 66.0 | 14.3 | 182.3 | -29.9 | 196.5 | 13.0 |
| TL_S.08.02 | 106.2 | 14.3 | 184.0 | -29.9 | 190.9 | 20.3 |
| TL_S.09.01 | 23.0 | 14.3 | 184.2 | -29.9 | 190.1 | 4.4 |
| TR_S.09.02 | 5844.4 | 14.3 | 204.4 | -29.9 | 144.9 | 846.6 |
| TL_S.09.99 | 93.2 | 14.3 | 217.1 | -30.0 | 123.4 | 11.5 |
| TL_S.10.01 | 44.8 | 14.3 | 218.0 | -30.0 | 122.1 | 5.5 |
| TL_S.10.02 | 36.0 | 14.3 | 218.5 | -30.0 | 121.4 | 4.4 |
| TL_S.11.01 | 305.0 | 14.3 | 222.7 | -30.0 | 116.3 | 35.5 |
| TL_S.11.02 | 6.4 | 14.3 | 113.0 | -40.0 | 1117.6 | 7.1 |
| TL_S.12.01 | 122.0 | 14.3 | 468.4 | 0.0 | 30.8 | 3.8 |
| TL_S.12.02 | 6.4 | 14.3 | 468.4 | 0.0 | 30.8 | 0.2 |
| TL_S.13.01 | 23.0 | 14.3 | 113.9 | -39.5 | 1115.7 | 25.7 |
| TL_S.13.02 | 36.0 | 14.3 | 114.3 | -39.3 | 1114.9 | 40.1 |
| TL_S.14.01 | 74.5 | 14.3 | 468.4 | 0.0 | 30.8 | 2.3 |
| TL_S.14.02 | 75.4 | 14.3 | 468.4 | 0.0 | 30.8 | 2.3 |
| TL_S.14.03 | 110.8 | 14.3 | 468.4 | 0.0 | 30.8 | 3.4 |
| TL_S.15.01 | 23.4 | 14.3 | 436.8 | -30.0 | 121.4 | 2.8 |
| TL_S.15.02 | 14203.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9828.3 |
| TLR_S.01.01 | 29.1 | 17.4 | 463.9 | 0.0 | 38.6 | 1.1 |
| TLR_S.13.02 | 32.3 | 14.3 | 284.1 | -30.5 | 558.6 | 9.4 |
| | ======= | | | | | ======= |
| Total Volume: | 23030.3 | | | | Total $CO_2$: | 12000.0 |

Table 11.5-6 Volumes and operational states of the TR-System

| **Section** | **Volume (mL)** | **Pressure (Bar)** | **Enthalpy (kJ/kg)** | **Temp. ('C)** | **Rho (kg/m3)** | **Mass (g)** |
|---|---|---|---|---|---|---|
| TR_S.01.01 | 41.5 | 27.7 | 122.3 | -35.4 | 1103.1 | 45.8 |
| TR_S.01.02 | 9.0 | 26.3 | 126.5 | -33.4 | 1094.1 | 9.9 |
| TR_S.01.03 | 5.5 | 26.3 | 126.7 | -33.2 | 1093.7 | 6.1 |
| TR_S.01.04 | 27.3 | 26.3 | 127.7 | -32.8 | 1091.7 | 29.8 |
| TR_S.01.05 | 605.0 | 26.3 | 526.5 | 70.0 | 44.4 | 26.9 |
| TR_S.01.06 | 9.5 | 26.3 | 128.1 | -32.6 | 1091.0 | 10.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| TR_S.02.01 | 26.1 | 26.3 | 129.0 | -32.1 | 1089.0 | 28.5 |
| TR_S.02.02 | 766.0 | 26.0 | 132.7 | -30.3 | 1081.3 | 828.3 |
| TR_S.03.01 | 46.3 | 25.7 | 135.1 | -29.2 | 1076.2 | 49.9 |
| TR_S.03.02 | 7.8 | 17.4 | 135.3 | -29.0 | 1072.6 | 8.4 |
| TR_S.03.03 | 18.7 | 17.4 | 135.9 | -28.7 | 1071.3 | 20.1 |
| TR_S.04.01-27 | 51.4 | 14.5 | 135.9 | -29.6 | 921.6 | 47.4 |
| TR_S.05.01-27 | 8.3 | 14.4 | 181.4 | -29.8 | 200.7 | 1.7 |
| TR_S.06.01-27 | 40.3 | 14.4 | 181.4 | -29.8 | 199.6 | 8.1 |
| TR_S.07.01 | 120.0 | 14.3 | 181.4 | -29.9 | 199.4 | 23.9 |
| TR_S.08.01 | 66.0 | 14.3 | 182.4 | -29.9 | 196.1 | 12.9 |
| TR_S.08.02 | 117.5 | 14.3 | 184.1 | -29.9 | 190.5 | 22.4 |
| TR_S.09.01 | 23.0 | 14.3 | 184.3 | -29.9 | 189.7 | 4.4 |
| TR_S.09.02 | 5710.0 | 14.3 | 205.7 | -29.9 | 143.0 | 816.4 |
| TR_S.09.99 | 72.7 | 14.3 | 221.7 | -30.0 | 117.7 | 8.5 |
| TR_S.10.01 | 37.2 | 14.3 | 222.6 | -30.0 | 116.6 | 4.3 |
| TR_S.10.02 | 36.0 | 14.3 | 223.1 | -30.0 | 115.9 | 4.2 |
| TR_S.11.01 | 305.0 | 14.3 | 227.3 | -30.0 | 111.3 | 33.9 |
| TR_S.11.02 | 5.8 | 14.3 | 113.0 | -40.0 | 1117.6 | 6.4 |
| TR_S.12.01 | 122.0 | 14.3 | 468.4 | 0.0 | 30.8 | 3.8 |
| TR_S.12.02 | 5.8 | 14.3 | 468.4 | 0.0 | 30.8 | 0.2 |
| TR_S.13.01 | 23.0 | 14.3 | 113.9 | -39.5 | 1115.7 | 25.7 |
| TR_S.13.02 | 36.0 | 14.3 | 114.3 | -39.3 | 1114.9 | 40.1 |
| TR_S.14.01 | 74.5 | 14.3 | 468.4 | 0.0 | 30.8 | 2.3 |
| TR_S.14.02 | 75.4 | 14.3 | 468.4 | 0.0 | 30.8 | 2.3 |
| TR_S.14.03 | 110.8 | 14.3 | 468.4 | 0.0 | 30.8 | 3.4 |
| TR_S.15.01 | 16.1 | 14.3 | 436.8 | -30.0 | 115.9 | 1.9 |
| TR_S.15.02 | 14203.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9862.0 |
| | ======= | | | | | ======= |
| Total Volume: | 22822.6 | | | | Total $CO_2$ | 12000.0 |

Table 11.5-7 Summary of the Tertiary volume.

| Subsystem | TL volume (mL) | TR Volume (mL) |
|---|---|---|
| Evaporator | 220.0 | 220.0 |
| Liquid feed | 944.4 | 957.8 |
| Vapor return | 6213.7 | 6062.4 |
| SA-Condenser | 311.4 | 310.8 |
| SB-Condenser | 128.4 | 127.8 |
| Liquid Suction | 59.1 | 59.1 |
| By-pass | 260.7 | 260.7 |
| Dampers | 605.0 | 605.0 |
| Accumulator section | 14226.4 | 14219.1 |
| Accumulator | 14203.0 | 14203.0 |
| Total Volume | 22969.0 | 22822.6 |
| Loop Volume | 8766.0 | 8619.6 |
| Plant Volume | 15728.6 | 15748.5 |
| Transfer Volume | 7240.4 | 7074.2 |

| | Enthalpy | Pressure | Temperature | Vapor Quality |
|---|---|---|---|---|
| TL State points | | | | |
| 9.0 | 114.9 | 65.8 | -39.5 | Subcooled |
| 1.0 | 122.5 | 78.7 | -35.7 | Supercritical |
| 2.0 | 123.3 | 78.6 | -35.3 | Supercritical |
| 3.0 | 180.3 | 78.0 | -7.4 | Supercritical |
| 4.0 | 180.4 | 68.8 | -7.5 | Subcooled |
| 5.0 | 180.8 | 68.8 | -7.3 | Subcooled |
| 6.0 | 180.8 | 65.9 | -7.3 | Subcooled |
| 7.0 | 181.3 | 65.9 | -7.1 | Subcooled |
| 8.0 | 155.5 | 65.8 | -19.2 | Subcooled |
| 9.0 | 114.9 | 65.8 | -39.5 | Subcooled |
| Taccumulator | 26 | ℃ | | |
| Tliquid | -40 | ℃ | | |
| Tevap_out | -7.345407 | ℃ | | |
| Xevap-out | Subcooled | - | | |
| Ttransfer_return | -19.21 | ℃ | | |
| Xtransfer_return | Subcooled | - | | |
| Qdetector | 0 | Watt | | |
| Qenvirionement | 431.10387 | Watt | | |
| Qtransfer_internal | 588.86655 | Watt | | |
| Qpreheater | 0 | Watt | | |
| Massflow | 10.886526 | g/s | | |
| Probe level | -4.53% | - | | |

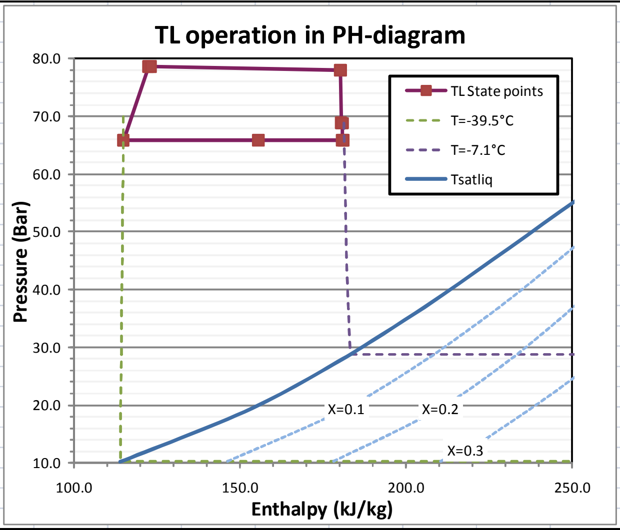



Figure 11.5-5: TL system Start-up. Detector power =0 Watt, SP = +26ºC

| | Enthalpy | Pressure | Temperature | Vapor Quality |
|---|---|---|---|---|
| TL State points | | | | |
| 9.0 | 114.2 | 26.5 | -39.5 | Subcooled |
| 1.0 | 121.8 | 39.3 | -35.8 | Subcooled |
| 2.0 | 122.6 | 39.3 | -35.3 | Subcooled |
| 3.0 | 175.4 | 38.6 | -10.2 | Subcooled |
| 4.0 | 175.6 | 29.5 | -10.3 | Subcooled |
| 5.0 | 176.0 | 29.5 | -10.2 | Subcooled |
| 6.0 | 176.0 | 26.6 | -10.2 | Subcooled |
| 7.0 | 176.6 | 26.5 | -10.0 | 0.00 |
| 8.0 | 157.2 | 26.5 | -18.7 | Subcooled |
| 9.0 | 114.2 | 26.5 | -39.5 | Subcooled |
| Taccumulator | -10 | ℃ | | |
| Tliquid | -40 | ℃ | | |
| Tevap_out | -10.23261 | ℃ | | |
| Xevap-out | Subcooled | - | | |
| Ttransfer_return | -18.68 | ℃ | | |
| Xtransfer_return | Subcooled | - | | |
| Qdetector | 0 | Watt | | |
| Qenvirionement | 443.88926 | Watt | | |
| Qtransfer_internal | 540.18437 | Watt | | |
| Qpreheater | 0 | Watt | | |
| Massflow | 10.78595 | g/s | | |
| Probe level | 24.14% | - | | |

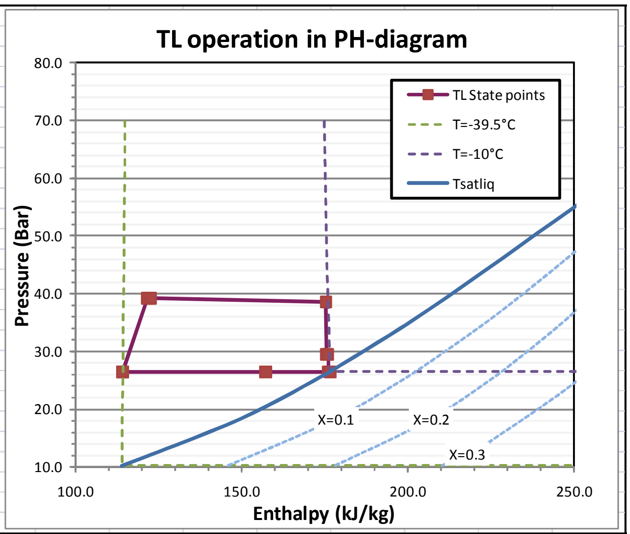



Figure 11.5-6: TL system operation. Detector power =0 Watt, SP = -10ºC

| | Enthalpy | Pressure | Temperature | Vapor Quality |
|---|---|---|---|---|
| TL State points | | | | |
| 9.0 | 114.2 | 26.5 | -39.5 | Subcooled |
| 1.0 | 121.8 | 39.2 | -35.8 | Subcooled |
| 2.0 | 122.6 | 39.2 | -35.3 | Subcooled |
| 3.0 | 175.9 | 38.6 | -10.0 | Subcooled |
| 4.0 | 176.1 | 29.5 | -10.1 | Subcooled |
| 5.0 | 176.5 | 29.5 | -9.9 | Subcooled |
| 6.0 | 176.5 | 26.6 | -10.0 | Subcooled |
| 7.0 | 222.4 | 26.5 | -10.0 | 0.18 |
| 8.0 | 200.2 | 26.5 | -10.0 | 0.09 |
| 9.0 | 114.2 | 26.5 | -39.5 | Subcooled |
| Taccumulator | -10 | ℃ | | |
| Tliquid | -40 | ℃ | | |
| Tevap_out | -9.946126 | ℃ | | |
| Xevap-out | 0.17 | - | | |
| Ttransfer_return | -10.00 | ℃ | | |
| Xtransfer_return | 0.09 | - | | |
| Qdetector | 489 | Watt | | |
| Qenvirionement | 415.24795 | Watt | | |
| Qtransfer_internal | 546.9371 | Watt | | |
| Qpreheater | 0 | Watt | | |
| Massflow | 10.78595 | g/s | | |
| Probe level | 57.51% | - | | |

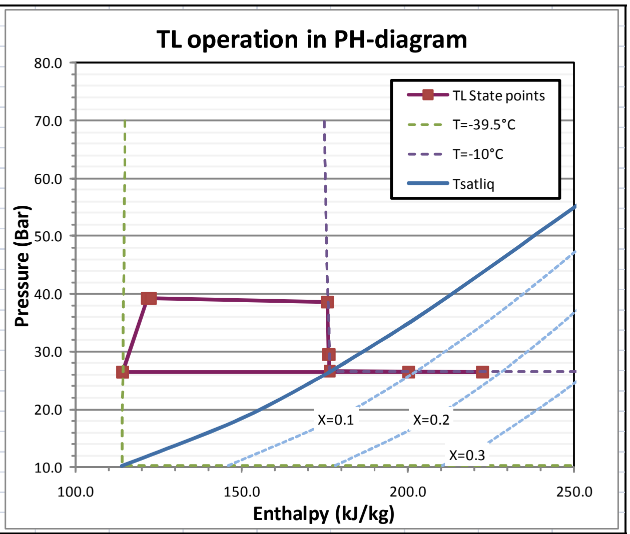



Figure 11.5-7: TL system operation. Detector power =489 Watt, SP = -10ºC

| | Enthalpy | Pressure | Temperature | Vapor Quality |
|---|---|---|---|---|
| TL State points | | | | |
| 9.0 | 114.0 | 14.3 | -39.5 | Subcooled |
| 1.0 | 122.2 | 26.2 | -35.5 | Subcooled |
| 2.0 | 123.2 | 26.2 | -35.0 | Subcooled |
| 3.0 | 134.9 | 25.6 | -29.2 | Subcooled |
| 4.0 | 135.2 | 17.3 | -29.1 | Subcooled |
| 5.0 | 135.8 | 17.3 | -28.8 | Subcooled |
| 6.0 | 135.8 | 14.4 | -29.8 | 0.01 |
| 7.0 | 136.8 | 14.3 | -29.9 | 0.01 |
| 8.0 | 173.1 | 14.3 | -30.0 | 0.13 |
| 9.0 | 114.0 | 14.3 | -39.5 | Subcooled |
| | | | | |
| Taccumulator | -30 | °C | | |
| Tliquid | -40 | °C | | |
| Tevap_out | -29.92868 | °C | | |
| Xevap-out | 0.01 | - | | |
| Ttransfer_return | -30.00 | °C | | |
| Xtransfer_return | 0.13 | - | | |
| Qdetector | 0 | Watt | | |
| Qenvirionement | 637.13425 | Watt | | |
| Qtransfer_internal | 95.526677 | Watt | | |
| Qpreheater | 0 | Watt | | |
| Massflow | 10.752936 | g/s | | |
| Probe level | 50.30% | - | | |

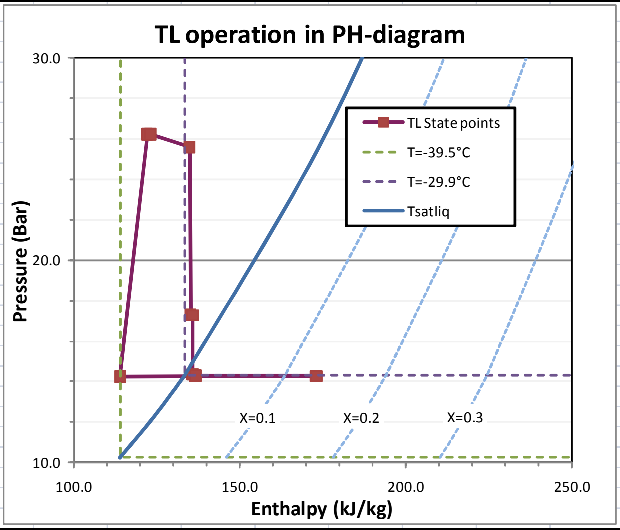



Figure 11.5-8: TL system operation. Detector power =0 Watt, SP = -30ºC

| | Enthalpy | Pressure | Temperature | Vapor Quality |
|---|---|---|---|---|
| TL State points | | | | |
| 9.0 | 114.0 | 14.3 | -39.5 | Subcooled |
| 1.0 | 122.2 | 26.4 | -35.5 | Subcooled |
| 2.0 | 123.2 | 26.3 | -35.0 | Subcooled |
| 3.0 | 135.0 | 25.7 | -29.2 | Subcooled |
| 4.0 | 135.2 | 17.4 | -29.1 | Subcooled |
| 5.0 | 135.8 | 17.4 | -28.8 | Subcooled |
| 6.0 | 135.8 | 14.5 | -29.6 | 0.01 |
| 7.0 | 182.3 | 14.3 | -29.9 | 0.16 |
| 8.0 | 218.5 | 14.3 | -30.0 | 0.28 |
| 9.0 | 114.0 | 14.3 | -39.5 | Subcooled |
| | | | | |
| Taccumulator | -30 | °C | | |
| Tliquid | -40 | °C | | |
| Tevap_out | -29.84483 | °C | | |
| Xevap-out | 0.16 | - | | |
| Ttransfer_return | -30.00 | °C | | |
| Xtransfer_return | 0.28 | - | | |
| Qdetector | 489 | Watt | | |
| Qenvirionement | 636.81366 | Watt | | |
| Qtransfer_internal | 98.939219 | Watt | | |
| Qpreheater | 0 | Watt | | |
| Massflow | 10.752936 | g/s | | |
| Probe level | 61.39% | - | | |

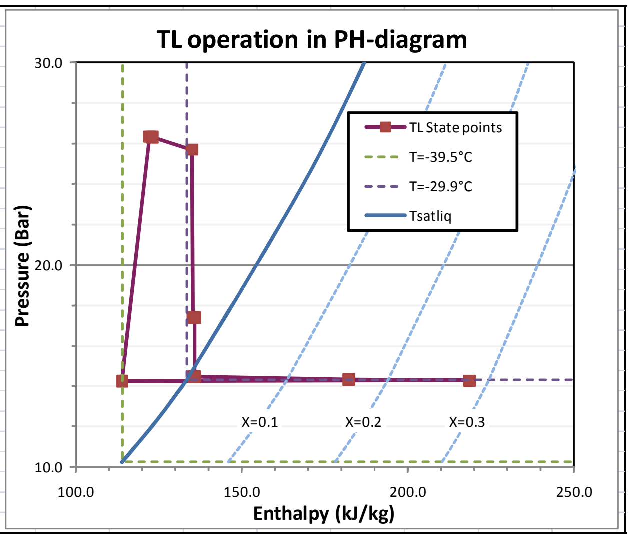



Figure 11.5-9: TL system operation. Detector power =489 Watt, SP = -30ºC

# 11.6 *PLC Alarms and warnings*

Table 11.6-1 PLC alarms and corresponding values and actions.

| Alarm Category | Alert Type | Alert Cause | PLC label | PVSS label | General actions / Failure Category | Proceeding | Triggered by | Timer involved | Timer setting PVSS label | Timer value | Running timer | Running Timer PVSS label | Treshold PLC variable | Treshold PVSS label | Treshold value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Base plate | Alarm | Base plate freezing alarm | Tx_base_freezing | Tx_BA001---base_freezing | SA-Failure | restart | 2 of TL_TT037, TL_TT038, TL_TT039, TL_TT040 | | | | | | BASEPLATE_FREEZING | Tx_BL001---BASEPLATE_FREEZING | 0 |
| | Alarm | Base plate too hot | TLbase_too_hot_TT037 | TL_BA002---base_too_hot_TT037 | heater process termination | continue procedures | TL_TT037 | | | | | | MAX_TEMP_BASEPLATE | TL_BL002---MAX_TEMP_BASEPLATE | 27 |
| | | | TLbase_too_hot_TT038 | TL_BA003---base_too_hot_TT038 | heater process termination | continue procedures | TL_TT038 | | | | | | MAX_TEMP_BASEPLATE | TL_BL002---MAX_TEMP_BASEPLATE | 27 |
| | | | TLbase_too_hot_TT039 | TL_BA004---base_too_hot_TT039 | heater process termination | continue procedures | TL_TT039 | | | | | | MAX_TEMP_BASEPLATE | TL_BL002---MAX_TEMP_BASEPLATE | 27 |
| | | | TLbase_too_hot_TT040 | TL_BA005---base_too_hot_TT040 | heater process termination | continue procedures | TL_TT040 | | | | | | MAX_TEMP_BASEPLATE | TL_BL002---MAX_TEMP_BASEPLATE | 27 |
| | Alarm | FM455 error per channel | TLbase_TT037_error | TL_BA006---base_TT037_error | Switch off TL_HT001 | continue procedures | | | | | | | | | |
| | | | TLbase_TT038_error | TL_BA007---base_TT038_error | Switch off TL_HT002 | | | | | | | | | | |
| | | | TLbase_TT039_error | TL_BA008---base_TT039_error | Switch off TL_HT003 | | | | | | | | | | |
| | | | TLbase_TT040_error | TL_BA009---base_TT040_error | Switch off TL_HT004 | | | | | | | | | | |
| | Warning | Base plate too cold | TLbase_too_cold_TT037 | TL_BW002---base_too_cold_TT037 | | continue procedures | TL_TT037 | | | | | | MIN_TEMP_BASEPLATE | TL_BL003---MIN_TEMP_BASEPLATE | 18 |
| | | | TLbase_too_cold_TT038 | TL_BW003---base_too_cold_TT038 | | | TL_TT038 | | | | | | MIN_TEMP_BASEPLATE | TL_BL003---MIN_TEMP_BASEPLATE | 18 |
| | | | TLbase_too_cold_TT039 | TL_BW004---base_too_cold_TT039 | | | TL_TT039 | | | | | | MIN_TEMP_BASEPLATE | TL_BL003---MIN_TEMP_BASEPLATE | 18 |
| | | | TLbase_too_cold_TT040 | TL_BW005---base_too_cold_TT040 | | | TL_TT040 | | | | | | MIN_TEMP_BASEPLATE | TL_BL003---MIN_TEMP_BASEPLATE | 18 |
| | Alarm | Base plate too hot | TRbase_too_hot_TT037 | TR_BA002---base_too_hot_TT037 | heater process termination | continue procedures | TR_TT037 | | | | | | MAX_TEMP_BASEPLATE | TR_BL002---MAX_TEMP_BASEPLATE | 27 |
| | | | TRbase_too_hot_TT038 | TR_BA003---base_too_hot_TT038 | heater process termination | continue procedures | TR_TT038 | | | | | | MAX_TEMP_BASEPLATE | TR_BL002---MAX_TEMP_BASEPLATE | 27 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TRbase_too_hot_TT039 | TR_BA004---base_too_hot_TT039 | heater process termination | continue procedures | TR_TT039 | | | | | | MAX_TEMP_BASEPLATE | TR_BL002---MAX_TEMP_BASEPLATE | 27 |
| | | | TRbase_too_hot_TT040 | TR_BA005---base_too_hot_TT040 | heater process termination | continue procedures | TR_TT040 | | | | | | MAX_TEMP_BASEPLATE | TR_BL002---MAX_TEMP_BASEPLATE | 27 |
| | Alarm | FM455 error per channel | TRbase_TT037_error | TR_BA006---base_TT037_error | Switch off TR_HT001 | continue procedures | | | | | | | | | |
| | | | TRbase_TT038_error | TR_BA007---base_TT038_error | Switch off TR_HT002 | | | | | | | | | | |
| | | | TRbase_TT039_error | TR_BA008---base_TT039_error | Switch off TR_HT003 | | | | | | | | | | |
| | | | TRbase_TT040_error | TR_BA009---base_TT040_error | Switch off TR_HT004 | | | | | | | | | | |
| | Warning | Base plate too cold | TRbase_too_cold_TT037 | TR_BW002---base_too_cold_TT037 | | continue procedures | TR_TT037 | | | | | | MIN_TEMP_BASEPLATE | TR_BL003---MIN_TEMP_BASEPLATE | 18 |
| | | | TRbase_too_cold_TT038 | TR_BW003---base_too_cold_TT038 | | | TR_TT038 | | | | | | MIN_TEMP_BASEPLATE | TR_BL003---MIN_TEMP_BASEPLATE | 18 |
| | | | TRbase_too_cold_TT039 | TR_BW004---base_too_cold_TT039 | | | TR_TT039 | | | | | | MIN_TEMP_BASEPLATE | TR_BL003---MIN_TEMP_BASEPLATE | 18 |
| | | | TRbase_too_cold_TT040 | TR_BW005---base_too_cold_TT040 | | | TR_TT040 | | | | | | MIN_TEMP_BASEPLATE | TR_BL003---MIN_TEMP_BASEPLATE | 18 |
| | | General FM455 alarm | FM455_error | Tx_BA002---FM455_error | | | | | | | | | | | |
| Heater | Alarm | Tx Clixon alarm | Clixon_alarm | Tx_HA101---Clixon_alarm | Heater relais off | continue procedures | Clixon_status | | | | | | | | 1 |
| | Alarm | TL Bridge heater too hot | bridge_htr2_too_hot_TL | TL_HA030---bridge_htr2_to o_hot | Bridge heater relais off | continue procedures | TL_TT045, smoke sniffer | | | | | | BridgeHeater_max | Tx_HL030---BridgeHeater_max | 40 |
| | Alarm | TL pump oil too cold | TL_HT102_too_cold | TL_HA101---HT102_too_cold | TL pump failure | restart | TL_TT122 | | | | | | TL_R_LR_HT102_MIN | Tx_HL101---R_LR_HT102_MIN | 10 |
| | Alarm | TL pump oil too hot | TL_HT102_too_hot | TL_HA102---HT102_too_hot | Heater relais off | continue procedures | TL_TT122 | | | | | | TL_HT102_MAX | TL_HL102---HT102_MAX | 50 |
| | Alarm | TL damper heater too hot | TL_HT103_too_hot | TL_HA103---HT103_too_hot | Heater relais off | continue procedures | TL_TT123 | | | | | | TL_HT103_MAX | TL_HL103---HT103_MAX | 160 |
| | Alarm | TL by-pass heater too hot | TL_HT104_too_hot | TL_HA104---HT104_too_hot | Heater relais off, SA-failure | restart | TL_TT124 | | | | | | TL_HT104_MAX | TL_HL104---HT104_MAX | 120 |
| | Alarm | TL accu heater too hot | TL_HT105_too_hot | TL_HA105---HT105_too_hot | Heater relais off | continue procedures | TL_TT125 | | | | | | TL_HT105_MAX | TL_HL105---HT105_MAX | 160 |
| | Alarm | TL_HT102 thermocouple error | TL_TT122_error | TL_HA112---TT122_error | Heater relais off | continue procedures | TL_TT122_error | | | | | | | | 1 |
| | Alarm | TL_HT103 thermocouple error | TL_TT123_error | TL_HA113---TT123_error | Heater relais off | continue procedures | TL_TT123_error | | | | | | | | 1 |
| | Alarm | TL_HT104 thermocouple error | TL_TT124_error | TL_HA114---TT124_error | Heater relais off | continue procedures | TL_TT124_error | | | | | | | | 1 |
| | Alarm | TL_HT105 thermocouple error | TL_TT125_error | TL_HA115---TT125_error | Heater relais off | continue procedures | TL_TT125_error | | | | | | | | 1 |
| | Warning | TL pump oil too warm | TL_HT102_hot_warning | TL_HW102---HT102_hot_warning | Switch off TL_HT102 | continue procedures | TL_TT122 | | | | | | TL_HT102_MAX_WARN | TL_HL106---HT102_MAX_WARN | 40 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Warning | TL damper heater too warm | TL_HT103_hot_warning | TL_HW103---HT103_hot_warning | Switch off TL_HT103 | continue procedures | TL_TT123 | | | | | | TL_HT103_MAX_WARN | TL_HL107---HT103_MAX_WARN | 120 |
| | Warning | TL by-pass heater too warm | TL_HT104_hot_warning | TL_HW104---HT104_hot_warning | Switch off TL_HT104, SA-failure | restart | TL_TT124 | | | | | | TL_HT104_MAX_WARN | TL_HL108---HT104_MAX_WARN | 80 |
| | Warning | TL accu heater too warm | TL_HT105_hot_warning | TL_HW105---HT105_hot_warning | Switch off TL_HT105 | continue procedures | TL_TT125 | | | | | | TL_HT105_MAX_WARN | TL_HL109---HT105_MAX_WARN | 120 |
| | Alarm | TL Bridge heater too hot | bridge_htr1_too_hot_TR | TR_HA030---bridge_htr1_too_hot | Bridge heater relais off | continue procedures | TR_TT045, smoke sniffer | | | | | | BridgeHeater_max | Tx_HL030---BridgeHeater_max | 40 |
| | Alarm | TR pump oil too cold | TR_HT102_too_cold | TR_HA101---HT102_too_cold | TR pump failure | restart | TR_TT122 | | | | | | TR_R_LR_HT102_MIN | Tx_HL101---R_LR_HT102_MIN | 10 |
| | Alarm | TR pump oil too hot | TR_HT102_too_hot | TR_HA102---HT102_too_hot | Heater relais off | continue procedures | TR_TT122 | | | | | | TR_HT102_MAX | TR_HL102---HT102_MAX | 50 |
| | Alarm | TR damper heater too hot | TR_HT103_too_hot | TR_HA103---HT103_too_hot | Heater relais off | continue procedures | TR_TT123 | | | | | | TR_HT103_MAX | TR_HL103---HT103_MAX | 160 |
| | Alarm | TR by-pass heater too hot | TR_HT104_too_hot | TR_HA104---HT104_too_hot | Heater relais off, SA-failure | restart | TR_TT124 | | | | | | TR_HT104_MAX | TR_HL104---HT104_MAX | 120 |
| | Alarm | TR accu heater too hot | TR_HT105_too_hot | TR_HA105---HT105_too_hot | Heater relais off | continue procedures | TR_TT125 | | | | | | TR_HT105_MAX | TR_HL105---HT105_MAX | 160 |
| | Alarm | TR_HT102 thermocouple error | TR_TT122_error | TR_HA112---TT122_error | Heater relais off | continue procedures | TR_TT122_error | | | | | | | | 1 |
| | Alarm | TR_HT103 thermocouple error | TR_TT123_error | TR_HA113---TT123_error | Heater relais off | continue procedures | TR_TT123_error | | | | | | | | 1 |
| | Alarm | TR_HT104 thermocouple error | TR_TT124_error | TR_HA114---TT124_error | Heater relais off | continue procedures | TR_TT124_error | | | | | | | | 1 |
| | Alarm | TR_HT105 thermocouple error | TR_TT125_error | TR_HA115---TT125_error | Heater relais off | continue procedures | TR_TT125_error | | | | | | | | 1 |
| | Warning | TR pump oil too warm | TR_HT102_hot_warning | TR_HW102---HT102_hot_warning | Switch off TR_HT102 | continue procedures | TR_TT122 | | | | | | TR_HT102_MAX_WARN | TR_HL106---HT102_MAX_WARN | 40 |
| | Warning | TR damper heater too warm | TR_HT103_hot_warning | TR_HW103---HT103_hot_warning | Switch off TR_HT103 | continue procedures | TR_TT123 | | | | | | TR_HT103_MAX_WARN | TR_HL107---HT103_MAX_WARN | 120 |
| | Warning | TR by-pass heater too warm | TR_HT104_hot_warning | TR_HW104---HT104_hot_warning | Switch off TR_HT104, SA-failure | restart | TR_TT124 | | | | | | TR_HT104_MAX_WARN | TR_HL108---HT104_MAX_WARN | 80 |
| | Warning | TR accu heater too warm | TR_HT105_hot_warning | TR_HW105---HT105_hot_warning | Switch off TR_HT105 | continue procedures | TR_TT125 | | | | | | TR_HT105_MAX_WARN | TR_HL109---HT105_MAX_WARN | 120 |
| | Alarm | TLR pump oil too cold | TLR_HT102_too_cold | TLR_HA101---HT102_too_cold | TLR pump failure | restart | TLR_TT122 | | | | | | TL_R_LR_HT102_MIN | Tx_HL101---R_LR_HT102_MIN | 10 |
| | Alarm | TLR pump oil too hot | TLR_HT102_too_hot | TLR_HA102---HT102_too_hot | Heater relais off | continue procedures | TLR_TT122 | | | | | | TLR_HT102_MAX | TLR_HL102---HT102_MAX | 50 |
| | Alarm | TLR_HT102 thermocouple error | TLR_TT122_error | TLR_HA112---TT122_error | Heater relais off | continue procedures | TLR_TT122_error | | | | | | | | 1 |
| | Warning | TLR pump oil too warm | TLR_HT102_hot_warning | TLR_HW102---HT102_hot_warning | Switch off TLR_HT102 | continue procedures | TLR_TT122 | | | | | | TLR_HT102_MAX_WARN | TLR_HL106---HT102_MAX_WARN | 40 |
| Pressure | Alarm | TL Pump head pressure too high | TL_PT104_TOO_HIGH | TL_PA101---PT104_TOO_HIGH | TL pump failure | restart | TL_PT104 | | | | | | TL_PT104_MAX | TL_PL101---PT104_MAX | 85 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alarm | TL Pump dP too high | TL_PT104_101_TOO_HIGH | TL_PA102---PT104_101_TOO_HIGH | TL pump failure | restart | TL_PT104 - TL_PT101 | WAIT_DISABLE_HIGHP_VL103 | Tx_SC102---WAIT_DISABLE_HIGHP_VL103 | 20 sec | TL_sw_vl103_dis_high_p | TL_PC102---sw_vl103_dis_high_p | TL_PT104_101_MAXDIFF | TL_PL102---PT104_101_MAXDIFF | 25 |
| | Alarm | TL Pump dP too low | TL_PT104_101_TOO_LOW | TL_PA103---PT104_101_TOO_LOW | TL pump failure | restart | TL_PT104 - TL_PT101 | TL_MAX_STARTTIME | TL_SC103---TL_MAX_STARTTIME | 5 min | TL_PM101_starttimer | TL_PC103---PM101_starttimer | TL_PT104_101_MINDIFF | TL_PL103---PT104_101_MINDIFF | 2 |
| | | | | | | | | WAIT_DISABLE_LOWP | Tx_SC104---WAIT_DISABLE_LOWP | 1 min | TL_sw_trans_dis_low_p | TL_PC104---sw_trans_dis_low_p | | | |
| | | | | | | | | WAIT_DP_ALARM | Tx_SC105---WAIT_DP_ALARM | 10 sec | TL_pump_wait_timer | TL_PC105---pump_wait_timer | | | |
| | Alarm | TL Membrane alarm | TL_PM101_membr_alarm | TL_PA106---PM101_membr_alarm | TL pump failure | restart | TL_PT103_stat_membr | | | | | | | | 1 |
| | Alarm | TL Accu pressure too high | TL_ACCU_PRES_TOO_HIGH | TL_PA107---ACCU_PRES_TOO_HIGH | Switch off TL_HT105 | continue procedures | TL_PT102 | | | | | | TL_PT102_max | TL_PL107---PT102_max | 68 |
| | Alarm | TL any PT too high (closed volumes) | TL_ANY_PT_TOO_HIGH | TL_PA108---ANY_PT_TOO_HIGH | open all internal TL valves | reset procedures | TL_PT101, TL_PT102, TL_PT104 | | | | | | MAX_PRESS_CLOSED_VOLUME | TL_PL108---MAX_PRESS_CLOSED_VOLUME | 99 |
| | Alarm | TR Pump head pressure too high | TR_PT104_TOO_HIGH | TR_PA101---PT104_TOO_HIGH | TR pump failure | restart | TR_PT104 | | | | | | TR_PT104_MAX | TR_PL101---PT104_MAX | 85 |
| | Alarm | TR Pump dP too high | TR_PT104_101_TOO_HIGH | TR_PA102---PT104_101_TOO_HIGH | TR pump failure | restart | TR_PT104 - TR_PT101 | WAIT_DISABLE_HIGHP_VL103 | Tx_SC102---WAIT_DISABLE_HIGHP_VL103 | 20 sec | TR_sw_vl103_dis_high_p | TR_PC102---sw_vl103_dis_high_p | TR_PT104_101_MAXDIFF | TR_PL102---PT104_101_MAXDIFF | 25 |
| | Alarm | TR Pump dP too low | TR_PT104_101_TOO_LOW | TR_PA103---PT104_101_TOO_LOW | TR pump failure | restart | TR_PT104 - TR_PT101 | TR_MAX_STARTTIME | TR_SC103---TR_MAX_STARTTIME | 5 min | TR_PM101_starttimer | TR_PC103---PM101_starttimer | TR_PT104_101_MINDIFF | TR_PL103---PT104_101_MINDIFF | 2 |
| | | | | | | | | WAIT_DISABLE_LOWP | Tx_SC104---WAIT_DISABLE_LOWP | 1 min | TR_sw_trans_dis_low_p | TR_PC104---sw_trans_dis_low_p | | | |
| | | | | | | | | WAIT_DP_ALARM | Tx_SC105---WAIT_DP_ALARM | 10 sec | TR_pump_wait_timer | TR_PC105---pump_wait_timer | | | |
| | Alarm | TR Membrane alarm | TR_PM101_membr_alarm | TR_PA106---PM101_membr_alarm | TR pump failure | restart | TR_PT103_stat_membr | | | | | | | | 1 |
| | Alarm | TR Accu pressure too high | TR_ACCU_PRES_TOO_HIGH | TR_PA107---ACCU_PRES_TOO_HIGH | Switch off TR_HT105 | continue procedures | TR_PT102 | | | | | | TR_PT102_max | TR_PL107---PT102_max | 68 |
| | Alarm | TR any PT too high (closed volumes) | TR_ANY_PT_TOO_HIGH | TR_PA108---ANY_PT_TOO_HIGH | open all internal TR valves | reset procedures | TL_PT101 or TL_PT102 or TL_PT104 | | | | | | MAX_PRESS_CLOSED_VOLUME | TR_PL108---MAX_PRESS_CLOSED_VOLUME | 99 |
| | Alarm | TLR Pump head pressure too high | TLR_PT104_TOO_HIGH | TLR_PA101---PT104_TOO_HIGH | TLR pump failure | restart | Tx_PT104 | | | | | | TLR_PT104_MAX | TLR_PL101---PT104_MAX | 85 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alarm | TLR Pump dP too high | TLR_PT104_101_TOO_HIGH | TLR_PA102---PT104-101_TOO_HIGH | TLR pump failure | restart | Tx_PT104 - Tx_PT101 | WAIT_DISABLE_HIGHP_VL103 | Tx_SC102---WAIT_DISABLE_HIGHP_VL103 | 20 sec | | | TLR_PT104_101_MAXDIFF | TLR_PL102---Tx_PT104_101_MAXDIFF | 25 |
| | Alarm | TLR Pump dP too low | TLR_PT104_101_TOO_LOW | TLR_PA103---PT104-101_TOO_LOW | TLR pump failure | restart | Tx_PT104 - Tx_PT101 | TLR_MAX_STARTTIME | TLR_SC103---TLR_MAX_STARTTIME | 45 min | TLR_PM101_starttimer | TLR_PC103---PM101_starttimer | TLR_PT104_101_MINDIFF | TLR_PL103---Tx_PT104_101_MINDIFF | 2 |
| | | | | | | | | WAIT_DISABLE_LOWP | Tx_SC104---WAIT_DISABLE_LOWP | 1 min | | | | | |
| | | | | | | | | WAIT_DP_ALARM | Tx_SC105---WAIT_DP_ALARM | 10 sec | | | | | |
| | Alarm | TLR Membrane alarm | TLR_PM101_membr_alarm | TLR_PA106---PM101_membr_alarm | TLR pump failure | restart | TLR_PT103_stat_membr | | | | | | | | 1 |
| | Alarm | SA Discharge pressure too high | SA_PT108_TOO_HIGH | SA_PA101---SA_PT108_TOO_HIGH | SA-failure | restart | SA_PT108 | | | | | | Hardware setting | | 21.5 |
| | Alarm | SA Suction pressure too low | SA_PT108_TOO_LOW | SA_PA102---SA_PT108_TO O_LOW | SA-failure | restart | SA_PT108 | | | | | | Hardware setting | | 0.55 |
| | Alarm | SA liquid in compressor | SA_COMPR_LIQUID_IN | SA_PA103---SA_COMPR_LIQUID_IN | SA-failure | restart | SA_TT121 - SA_PT107_TSAT | SA_MAX_STARTTIME | SA_SC103---SA_MAX_STARTTIME | 5 min | SA_PM101_starttimer | SA_PC103---PM101_starttimer | | | |
| | | | | | | | | SA_WAIT_LIQUID_ALARM | SA_SC104---SA_WAIT_LIQUID_ALARM | 30 sec | SA_wait_liquid_alarm | SA_PC104---wait_liquid_alarm | DIFF_SA_TT121_PT107_TSAT | SL_PL104---DIFF_SA_TT121_PT107_TSAT | 2 |
| | Alarm | SB Discharge pressure too high | SB_PT108_TOO_HIGH | SB_PA101---SB_PT108_TOO_HIGH | SB-failure | restart | SB_PT108 | | | | | | Hardware setting | | 19.5 |
| | Alarm | SB Suction pressure too low | SB_PT108_TOO_LOW | SB_PA102---SB_PT108_TOO_LOW | SB-failure | restart | SB_PT108 | | | | | | Hardware setting | | 0.8 |
| | Alarm | SB liquid in compressor | SB_COMPR_LIQUID_IN | SB_PA103---SB_COMPR_LIQUID_IN | SB-failure | restart | SB_TT121 - SB_PT107_TSAT | SB_MAX_STARTTIME | SB_SC103---SB_MAX_STARTTIME | 5 min | SB_PM101_starttimer | SB_PC103---PM101_starttimer | | | |
| | | | | | | | | SB_WAIT_LIQUID_ALARM | SB_SC104---SB_WAIT_LIQUID_ALARM | 30 sec | SB_wait_liquid_alarm | SB_PC104---wait_liquid_alarm | DIFF_SB_TT121_PT103_TSAT | SB_PL104---DIFF_SB_TT121_PT103_TSAT | 2 |
| | | | | | | | | | | | | | DIFF_SB_TT121_PT104_TSAT | SB_PL105---DIFF_SB_TT121_PT104_TSAT | 2 |
| Miscalaneous | Warning | TL Maxium set point reached | TL_accu_max_setpoint | TL_MW101---accu_max_setpoint | Saturate set point | continue procedures | TL_PT102 | | | | | | TL_max_accu_setp | TL_ML101---max_accu_setp | 26 |
| | Warning | TL Accu timeout | TL_accu_timeout_alarm | TL_MW102---accu_timeout_alarm | none | continue procedures | TL_PT102 | TIMEOUT_ACCU_HTR | Tx_SC101---TIMEOUT_ACCU_HTR | 30 min | TL_ACCU_TIMER | TL_MC102---ACCU_TIMER | | | |
| | Alarm | TL $CO_2$ frost alarm due to SA | TL_CO$_2$_frost_alarm | TL_MA101---CO$_2$_frost_alarm | SA-failure | restart | TL_TT112 | | | | | | CO$_2$_lowest_temp | Tx_ML101---CO$_2$_lowest_temp | -50 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alarm | TL $CO_2$ frost alarm due to SB | TL_$CO_2$_frost_alarm_SB | TL_MA102---$CO_2$_frost_alarm_SB | SB-failure | reset procedures | TL_TT112 | SB_WAIT_FROST_ALARM | SB_SC102---SB_WAIT_FROST_ALARM | 5 min | SB_wait_frost_alarm | TL_MC103---wait_frost_alarm | $CO_2$_lowest_temp | Tx_ML101---$CO_2$_lowest_temp | -50 |
| | Alarm | TL pump thermal relay | TL_PM101_therm_relay_on | TL_MA103---PM101_therm_relay_on | TL pump failure | restart | TL_PM101_Th_rel_status | | | | | | | | |
| | Alarm | TL too warm | TL_too_warm_accu | TL_MA104---too_warm_accu | SA-failure | restart | TL-PT102_TSAT - TL_target_accu_setpoint | | | | | | Too_Warm_Threshold | Tx_ML104---Too_Warm_Threshold | 10 |
| | | | TL_too_warm_cookie | TL_MA105---too_warm_cookie | Interlock cooling ready | continue procedures | TL_mean_evaporator - TL_target_accu_setpoint | | | | | | Too_Warm_Threshold | Tx_ML104---Too_Warm_Threshold | 10 |
| | Warning | TR Maxium set point reached | TR_accu_max_setpoint | TR_MW101---accu_max_setpoint | Saturate set point | continue procedures | TR_PT102 | | | | | | TR_max_accu_setp | TR_ML101---max_accu_setp | 26 |
| | Warning | TR Accu timeout | TR_accu_timeout_alarm1 | TR_MW102---accu_timeout_alarm1 | none | continue procedures | TR_PT102 | TIMEOUT_ACCU_HTR | Tx_SC101---TIMEOUT_ACCU_HTR | 30 min | TR_ACCU_TIMER | TL_MC102---ACCU_TIMER | | | |
| | Alarm | TR $CO_2$ frost alarm due to SA | TR_$CO_2$_frost_alarm | TR_MA101---$CO_2$_frost_alarm | SA-failure | restart | TR_TT112 | | | | | | $CO_2$_lowest_temp | Tx_ML101---$CO_2$_lowest_temp | -50 |
| | Alarm | TR $CO_2$ frost alarm due to SB | TR_$CO_2$_frost_alarm_SB | TR_MA102---$CO_2$_frost_alarm_SB | SB-failure | reset procedures | TR_TT112 | SB_WAIT_FROST_ALARM | SB_SC102---SB_WAIT_FROST_ALARM | 5 min | SB_wait_frost_alarm | TR_MC103---wait_frost_alarm | $CO_2$_lowest_temp | Tx_ML101---$CO_2$_lowest_temp | -50 |
| | Alarm | TR pump thermal relay | TR_PM101_therm_relay_on | TR_MA103---PM101_therm_relay_on | TR pump failure | restart | TR_PM101_Th_rel_status | | | | | | | | |
| | Alarm | TR too warm | TR_too_warm_accu | TR_MA104---too_warm_accu | SA-failure | restart | TR-PT102_TSAT - TR_target_accu_setpoint | | | | | | Too_Warm_Threshold | Tx_ML104---Too_Warm_Threshold | 10 |
| | | | TR_too_warm_cookie | TR_MA105---too_warm_cookie | Interlock cooling ready | continue procedures | TR_mean_evaporator - TR_target_accu_setpoint | | | | | | Too_Warm_Threshold | Tx_ML104---Too_Warm_Threshold | 10 |
| | Alarm | TLR pump thermal relay | TLR_PM101_therm_relay_on | TLR_MA103---PM101_therm_relay_on | TLRpump failure | restart | TLR_PM101_Th_rel_status | | | | | | | | |
| | Alarm | SA compressor drive fault | SA_drive_fault | SA_MA101---SA_drive_fault | SA-failure | restart | | | | | | | | | |
| | Alarm | SA compressor drive alarm | SA_drive_alarm | SA_MA102---SA_drive_alarm | SA-failure | restart | | | | | | | | | |
| | Alarm | SA compresor motor protection | SA_PM101_motorprotection | SA_MA103---SA_PM101_motorprotection | SA failure | restart | SA_motor_protect_ok | | | | | | | | 0 |
| | Alarm | Cooling water too warm | PA_coolingwater_too_hot | SA_MA104---PA_coolingwater_too_hot | SA-failure | restart | PA_TT101 | | | | | | PA_TT101_MAX | PA_ML101---PA_TT101_MAX | 10 |
| | Alarm | SB compresor thermal relay | SB_PM101_therm_relay_on | SB_MA103---SB_PM101_therm_relay_on | SB failure | reset procedures | SB_PM101_threlay_normope | | | | | | | | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alarm | SA power group failure | exd1311_pwr(SA)_alarm | xx_MA101---exd1311_pwr(SA)_alarm | SA-failure | restart | exd1311_pwrd(SA), exd1311_notpwrd(SA) | | | | | | | | |
| | Alarm | By-pass heater power failure | exd1306_pwr(htr)_alarm | xx_MA102---exd1306_pwr(htr)_alarm | If used then SA-failure | If used then restart | exd1306_pwrd(heaters), exd1306_notpwrd(heaters), tl_cooldown_power_bypass, tr_cooldown_power_bypass | | | | | | | | |
| | Alarm | Diesel group power failure | esd205_pwr(diesel)_alarm | xx_MA103---esd205_pwr(diesel)_alarm | | reset procedures | esd205_pwrd(diesel), esd205_notpwrd(diesel) | | xx-SC103---WAIT_POWER_RETURN | | | xx_MC103---PowerReturnTlimer | | | |
| | Alarm | $CO_2$ vent alarm | venting_alarm | xx_MA104---venting_alarm | Global enable off | reset procedures | Vacuum system | | | | | | Hardware setting | | 1150 mbar |
| | Alarm | General Haptas alarm | haptas_alarm | xx_MA105---haptas_alarm | | continue procedures | | | | | | | | | |
| | Alarm | TL Haptas alarm | TL_haptas_error_vector | TL_MA105---haptas_error_vector | | continue procedures | | | | | TL_haptas_timer | TL_MC105---haptas_timer | | | |
| | Alarm | TR Haptas alarm | TR_haptas_error_vector | TR_MA105---haptas_error_vector | | continue procedures | | | | | TR_haptas_timer | TR_MC105---haptas_timer | | | |
| | Alarm | TLR Haptas alarm | TLR_haptas_error_vector | TLR_MA105---haptas_error_vector | | continue procedures | | | | | TLR_haptas_timer | TLR_MC105---haptas_timer | | | |
| Valve | Alarm | TL_VL102 timeout | TL_VL102_alarm | TL_VA102---VL102_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TL_VL102_timer | TL_VC102---VL102_timer | | | |
| | Alarm | TL_VL103 timeout | TL_VL103_alarm | TL_VA103---VL103_alarm | | continue, procedure maybe get stucked | | TIMEOUT_3WAY_VALVE | Tx_SC107---TIMEOUT_3WAY_VALVE | 10 sec | TL_VL103_timer | TL_VC103---VL103_timer | | | |
| | Alarm | TL_VL104 timeout | TL_VL104_alarm | TL_VA104---VL104_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TL_VL104_timer | TL_VC104---VL104_timer | | | |
| | Alarm | TL_VL109 timeout | TL_VL109_alarm | TL_VA109---VL109_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TL_VL109_timer | TL_VC109---VL109_timer | | | |
| | Alarm | TL_VL111 timeout | TL_VL111_alarm | TL_VA111---VL111_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TL_VL111_timer | TL_VC111---VL111_timer | | | |
| | Alarm | TL_VL112 timeout | TL_VL112_alarm | TL_VA112---VL112_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TL_VL112_timer | TL_VC112---VL112_timer | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alarm | TR_VL102 timeout | TR_VL102_alarm | TR_VA102---VL102_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TR_VL102_timer | TR_VC102---VL102_timer | | | |
| | Alarm | TR_VL103 timeout | TR_VL103_alarm | TR_VA103---VL103_alarm | | continue, procedure maybe get stucked | | TIMEOUT_3WAY_VALVE | Tx_SC107---TIMEOUT_3WAY_VALVE | 10 sec | TR_VL103_timer | TR_VC103---VL103_timer | | | |
| | Alarm | TR_VL104 timeout | TR_VL104_alarm | TR_VA104---VL104_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TR_VL104_timer | TR_VC104---VL104_timer | | | |
| | Alarm | TR_VL108 timeout | TR_VL108_alarm | TR_VA108---VL108_alarm | | continue, procedure maybe get stucked | | TIMEOUT_3WAY_VALVE | Tx_SC107---TIMEOUT_3WAY_VALVE | 10 sec | TR_VL108_timer | TR_VC108---VL108_timer | | | |
| | Alarm | TR_VL109 timeout | TR_VL109_alarm | TR_VA109---VL109_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TR_VL109_timer | TR_VC109---VL109_timer | | | |
| | Alarm | TR_VL111 timeout | TR_VL111_alarm | TR_VA111---VL111_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TR_VL111_timer | TR_VC111---VL111_timer | | | |
| | Alarm | TR_VL112 timeout | TR_VL112_alarm | TR_VA112---VL112_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TR_VL112_timer | TR_VC112---VL112_timer | | | |
| | Alarm | TLR_VL101 timeout | TLR_VL101_alarm | TLR_VA101---VL101_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TLR_VL101_timer | TLR_VC101---VL101_timer | | | |
| | Alarm | TLR_VL109 timeout | TLR_VL109_alarm | TLR_VA109---VL109_alarm | | continue, procedure maybe get stucked | | TIMEOUT_3WAY_VALVE | Tx_SC107---TIMEOUT_3WAY_VALVE | 10 sec | TLR_VL109_timer | TLR_VC109---VL109_timer | | | |
| | Alarm | TLR_VL110 timeout | TLR_VL110_alarm | TLR_VA110---VL110_alarm | | continue, procedure maybe get stucked | | TIMEOUT_3WAY_VALVE | Tx_SC107---TIMEOUT_3WAY_VALVE | 10 sec | TLR_VL110_timer | TLR_VC110---VL110_timer | | | |
| | Alarm | TLR_VL111 timeout | TLR_VL111_alarm | TLR_VA111---VL111_alarm | | continue, procedure maybe get stucked | | TIMEOUT_2WAY_VALVE | Tx_SC106---TIMEOUT_2WAY_VALVE | 5 sec | TLR_VL111_timer | TLR_VC111---VL111_timer | | | |

## 11.7 *PVSS logging of variables.*

Most of the PLC variables are exported to PVSS for monitoring or logging. Most of the variables can be monitored using a preset trending page. The trending pages can be viewed by starting the trending monitor on one of the online computers using the following link: ***G:\online\ecs\Shortcuts38\VELO\VEDCSVMC\VEDCSVMC_UI_fwTrending.lnk***. Under the tree node ***VEDCSVMC:VTCS_DataExport*** preset pages can be viewed. Table 11.7-3 shows the PVSS data points and the corresponding pages. From these pages CSV files can be exported for cooling data analyses.

Table 11.7-1: Sensor labeling and location of the A side detector

| | | Silicon Type | Module Number # | Temperature Board# | Repeater Location 1 | Repeater Location 2 | NTC00 (Cookie) | NTC01 (Silicon) | LV Branch Controller | LV Easycrate | LV Easyboard | LV Current channel | NTC00 label for cooling analyzes | NTC01 label for cooling analyzes | LV label for Cooling Analyses | VTCS heat exchanger # | VTCS Inlet tube sensor # | VTCS 1st cookie sensor # | VTCS last cookie sensor # | VTCS Outlet tube sensor # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PU01_A | B | R | | 1 | 0 | 1 | 2 | 3 | 9 | 2 | 4 | 3 | VL_TT102 | VL_TT103 | VL_HT101 | | | | | |
| | | | | | | | | | | | | | | | | TL_HX001 | TL_TT001 | TL_TT002 | TL_TT003 | TL_TT004 |
| PU02_A | T | R | | 1 | 4 | 5 | 6 | 7 | 9 | 2 | 4 | 0 | VL_TT106 | VL_TT107 | VL_HT102 | | | | | |
| | | | | | | | | | | | | | | | | TL_HX002 | | | TL_TT005 | |
| VL01_A | B | R | | 1 | 12 | 13 | 14 | 15 | 9 | 2 | 4 | 9 | VL_TT114 | VL_TT115 | VL_HT103 | | | | | |
| | T | Phi | | 1 | 8 | 9 | 10 | 11 | 9 | 2 | 4 | 6 | VL_TT110 | VL_TT111 | VL_HT203 | TL_HX003 | | | TL_TT006 | |
| VL02_A | B | Phi | | 1 | 20 | 21 | 22 | 23 | 9 | 0 | 0 | 3 | VL_TT122 | VL_TT123 | VL_HT104 | | | | | |
| | T | R | | 1 | 16 | 17 | 18 | 19 | 9 | 0 | 0 | 0 | VL_TT118 | VL_TT119 | VL_HT204 | TL_HX004 | | | TL_TT007 | |
| VL03_A | B | R | | 1 | 28 | 29 | 30 | 31 | 9 | 0 | 0 | 9 | VL_TT130 | VL_TT131 | VL_HT105 | | | | | |
| | T | Phi | | 1 | 24 | 25 | 26 | 27 | 9 | 0 | 0 | 6 | VL_TT126 | VL_TT127 | VL_HT205 | TL_HX005 | | | TL_TT008 | |
| VL04_A | B | Phi | | 1 | 36 | 37 | 38 | 39 | 9 | 0 | 4 | 3 | VL_TT138 | VL_TT139 | VL_HT106 | | | | | |
| | T | R | | 1 | 32 | 33 | 34 | 35 | 9 | 0 | 4 | 0 | VL_TT134 | VL_TT135 | VL_HT206 | TL_HX006 | | | TL_TT009 | |
| VL05_A | B | R | | 1 | 44 | 45 | 46 | 47 | 9 | 0 | 4 | 9 | VL_TT146 | VL_TT147 | VL_HT107 | | | | | |
| | T | Phi | | 1 | 40 | 41 | 42 | 43 | 9 | 0 | 4 | 6 | VL_TT142 | VL_TT143 | VL_HT207 | TL_HX007 | | | TL_TT010 | |
| VL06_A | B | Phi | | 1 | 52 | 53 | 54 | 55 | 9 | 0 | 8 | 3 | VL_TT154 | VL_TT155 | VL_HT108 | | | | | |
| | T | R | | 1 | 48 | 49 | 50 | 51 | 9 | 0 | 8 | 0 | VL_TT150 | VL_TT151 | VL_HT208 | TL_HX008 | | | TL_TT011 | |
| VL07_A | B | R | | 1 | 60 | 61 | 62 | 63 | 9 | 0 | 8 | 9 | VL_TT162 | VL_TT163 | VL_HT109 | | | | | |
| | T | Phi | | 1 | 56 | 57 | 58 | 59 | 9 | 0 | 8 | 6 | VL_TT158 | VL_TT159 | VL_HT209 | TL_HX009 | | | TL_TT012 | |
| VL08_A | B | Phi | | 2 | 4 | 5 | 6 | 7 | 9 | 0 | 12 | 3 | VL_TT206 | VL_TT207 | VL_HT110 | | | | | |
| | T | R | | 2 | 0 | 1 | 2 | 3 | 9 | 0 | 12 | 0 | VL_TT202 | VL_TT203 | VL_HT210 | TL_HX010 | | | TL_TT013 | |
| VL09_A | B | R | | 2 | 12 | 13 | 14 | 15 | 9 | 0 | 12 | 9 | VL_TT214 | VL_TT215 | VL_HT111 | | | | | |
| | T | Phi | | 2 | 8 | 9 | 10 | 11 | 9 | 0 | 12 | 6 | VL_TT210 | VL_TT211 | VL_HT211 | TL_HX011 | | | TL_TT014 | |
| VL10_A | B | Phi | | 2 | 20 | 21 | 22 | 23 | 9 | 0 | 16 | 3 | VL_TT222 | VL_TT223 | VL_HT112 | | | | | |
| | T | R | | 2 | 16 | 17 | 18 | 19 | 9 | 0 | 16 | 0 | VL_TT218 | VL_TT219 | VL_HT212 | TL_HX012 | TL_TT015 | TL_TT016 | TL_TT017 | TL_TT018 |
| VL11_A | B | R | | 2 | 28 | 29 | 30 | 31 | 9 | 0 | 16 | 9 | VL_TT230 | VL_TT231 | VL_HT113 | | | | | |
| | T | Phi | | 2 | 24 | 25 | 26 | 27 | 9 | 0 | 16 | 6 | VL_TT226 | VL_TT227 | VL_HT213 | TL_HX013 | | | TL_TT019 | |
| VL12_A | B | Phi | | 2 | 36 | 37 | 38 | 39 | 9 | 1 | 0 | 3 | VL_TT238 | VL_TT239 | VL_HT114 | | | | | |
| | T | R | | 2 | 32 | 33 | 34 | 35 | 9 | 1 | 0 | 0 | VL_TT234 | VL_TT235 | VL_HT214 | TL_HX014 | | | TL_TT020 | |
| VL13_A | B | R | | 2 | 44 | 45 | 46 | 47 | 9 | 1 | 0 | 9 | VL_TT246 | VL_TT247 | VL_HT115 | | | | | |
| | T | Phi | | 2 | 40 | 41 | 42 | 43 | 9 | 1 | 0 | 6 | VL_TT242 | VL_TT243 | VL_HT215 | TL_HX015 | | | TL_TT021 | |
| VL14_A | B | Phi | | 2 | 52 | 53 | 54 | 55 | 9 | 1 | 4 | 3 | VL_TT254 | VL_TT255 | VL_HT116 | | | | | |
| | T | R | | 2 | 48 | 49 | 50 | 51 | 9 | 1 | 4 | 0 | VL_TT250 | VL_TT251 | VL_HT216 | TL_HX016 | | | TL_TT022 | |
| VL15_A | B | R | | 2 | 60 | 61 | 62 | 63 | 9 | 1 | 4 | 9 | VL_TT262 | VL_TT263 | VL_HT117 | | | | | |
| | T | Phi | | 2 | 56 | 57 | 58 | 59 | 9 | 1 | 4 | 6 | VL_TT258 | VL_TT259 | VL_HT217 | TL_HX017 | | | TL_TT023 | |
| VL16_A | B | Phi | | 3 | 4 | 5 | 6 | 7 | 9 | 1 | 8 | 3 | VL_TT306 | VL_TT307 | VL_HT118 | | | | | |
| | T | R | | 3 | 0 | 1 | 2 | 3 | 9 | 1 | 8 | 0 | VL_TT302 | VL_TT303 | VL_HT218 | TL_HX018 | | | TL_TT024 | |
| VL17_A | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | TL_HX019 | | | | |
| VL18_A | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | TL_HX020 | | | | |
| VL19_A | B | R | | 3 | 12 | 13 | 14 | 15 | 9 | 1 | 8 | 9 | VL_TT314 | VL_TT315 | VL_HT121 | | | | | |
| | T | Phi | | 3 | 8 | 9 | 10 | 11 | 9 | 1 | 8 | 6 | VL_TT310 | VL_TT311 | VL_HT221 | TL_HX021 | | | TL_TT025 | |
| VL20_A | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | TL_HX022 | | | | |
| VL21_A | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | TL_HX023 | | | | |
| VL22_A | B | Phi | | 3 | 20 | 21 | 22 | 23 | 9 | 1 | 12 | 3 | VL_TT322 | VL_TT323 | VL_HT124 | | | | | |
| | T | R | | 3 | 16 | 17 | 18 | 19 | 9 | 1 | 12 | 0 | VL_TT318 | VL_TT319 | VL_HT224 | TL_HX024 | | | TL_TT026 | |
| VL23_A | B | R | | 3 | 28 | 29 | 30 | 31 | 9 | 1 | 12 | 9 | VL_TT330 | VL_TT331 | VL_HT125 | | | | | |
| | T | Phi | | 3 | 24 | 25 | 26 | 27 | 9 | 1 | 12 | 6 | VL_TT326 | VL_TT327 | VL_HT225 | TL_HX025 | | | TL_TT027 | |
| VL24_A | B | Phi | | 3 | 36 | 37 | 38 | 39 | 9 | 1 | 16 | 3 | VL_TT338 | VL_TT339 | VL_HT126 | | | | | |
| | T | R | | 3 | 32 | 33 | 34 | 35 | 9 | 1 | 16 | 0 | VL_TT334 | VL_TT335 | VL_HT226 | TL_HX026 | | | TL_TT028 | |
| VL25_A | B | R | | 3 | 44 | 45 | 46 | 47 | 9 | 1 | 16 | 9 | VL_TT346 | VL_TT347 | VL_HT127 | | | | | |
| | T | Phi | | 3 | 40 | 41 | 42 | 43 | 9 | 1 | 16 | 6 | VL_TT342 | VL_TT343 | VL_HT227 | TL_HX027 | TL_TT029 | TL_TT030 | TL_TT031 | TL_TT032 |

Table 11.7-2: Sensor labeling and location of the C side detector

| | | Silicon Type | Module Number # | Temperature Board# | Repeater Location 1 | Repeater Location 2 | NTC00 (Cookie) | NTC01 (Silicon) | LV Branch Controller | LV Easycrate | LV Easyboard | LV Current channel | NTC00 label for cooling analyzes | NTC01 label for cooling analyzes | LV label for Cooling Analyses | VTCS heat exchanger # | VTCS Inlet tube sensor # | VTCS 1st cookie sensor # | VTCS last cookie sensor # | VTCS Outlet tube sensor # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PU01_C | T | R | | 1 | 0 | 1 | 2 | 3 | 9 | 2 | 0 | 0 | VR_TT102 | VR_TT103 | VR_HT101 | | | | | |
| | | | | | | | | | | | | | | | | TR_HX001 | TR_TT001 | TR_TT002 | TR_TT003 | TR_TT004 |
| PU02_C | B | R | | 1 | 4 | 5 | 6 | 7 | 9 | 2 | 0 | 3 | VR_TT106 | VR_TT107 | VR_HT102 | | | | | |
| | | | | | | | | | | | | | | | | TR_HX002 | | | TR_TT005 | |
| VL01_C | T | Phi | 36 | 1 | 8 | 9 | 10 | 11 | 9 | 2 | 0 | 6 | VR_TT110 | VR_TT111 | VR_HT103 | | | | | |
| | B | R | | 1 | 12 | 13 | 14 | 15 | 9 | 2 | 0 | 9 | VR_TT114 | VR_TT115 | VR_HT203 | TR_HX003 | | | TR_TT006 | |
| VL02_C | T | R | 32 | 1 | 16 | 17 | 18 | 19 | 6 | 0 | 0 | 0 | VR_TT118 | VR_TT119 | VR_HT104 | | | | | |
| | B | Phi | | 1 | 20 | 21 | 22 | 23 | 6 | 0 | 0 | 3 | VR_TT122 | VR_TT123 | VR_HT204 | TR_HX004 | | | TR_TT007 | |
| VL03_C | T | Phi | 51 | 1 | 24 | 25 | 26 | 27 | 6 | 0 | 0 | 6 | VR_TT126 | VR_TT127 | VR_HT105 | | | | | |
| | B | R | | 1 | 28 | 29 | 30 | 31 | 6 | 0 | 0 | 9 | VR_TT130 | VR_TT131 | VR_HT205 | TR_HX005 | | | TR_TT008 | |
| VL04_C | T | R | 45 | 1 | 32 | 33 | 34 | 35 | 6 | 0 | 4 | 0 | VR_TT134 | VR_TT135 | VR_HT106 | | | | | |
| | B | Phi | | 1 | 36 | 37 | 38 | 39 | 6 | 0 | 4 | 3 | VR_TT138 | VR_TT139 | VR_HT206 | TR_HX006 | | | TR_TT009 | |
| VL05_C | T | Phi | 50 | 1 | 40 | 41 | 42 | 43 | 6 | 0 | 4 | 6 | VR_TT142 | VR_TT143 | VR_HT107 | | | | | |
| | B | R | | 1 | 44 | 45 | 46 | 47 | 6 | 0 | 4 | 9 | VR_TT146 | VR_TT147 | VR_HT207 | TR_HX007 | | | TR_TT010 | |
| VL06_C | T | R | 42 | 1 | 48 | 49 | 50 | 51 | 6 | 0 | 8 | 0 | VR_TT150 | VR_TT151 | VR_HT108 | | | | | |
| | B | Phi | | 1 | 52 | 53 | 54 | 55 | 6 | 0 | 8 | 3 | VR_TT154 | VR_TT155 | VR_HT208 | TR_HX008 | | | TR_TT011 | |
| VL07_C | T | Phi | 33 | 1 | 56 | 57 | 58 | 59 | 6 | 0 | 8 | 6 | VR_TT158 | VR_TT159 | VR_HT109 | | | | | |
| | B | R | | 1 | 60 | 61 | 62 | 63 | 6 | 0 | 8 | 9 | VR_TT162 | VR_TT163 | VR_HT209 | TR_HX009 | | | TR_TT012 | |
| VL08_C | T | R | 38 | 2 | 0 | 1 | 2 | 3 | 6 | 0 | 12 | 0 | VR_TT202 | VR_TT203 | VR_HT110 | | | | | |
| | B | Phi | | 2 | 4 | 5 | 6 | 7 | 6 | 0 | 12 | 3 | VR_TT206 | VR_TT207 | VR_HT210 | TR_HX010 | | | TR_TT013 | |
| VL09_C | T | Phi | 44 | 2 | 8 | 9 | 10 | 11 | 6 | 0 | 12 | 6 | VR_TT210 | VR_TT211 | VR_HT111 | | | | | |
| | B | R | | 2 | 12 | 13 | 14 | 15 | 6 | 0 | 12 | 9 | VR_TT214 | VR_TT215 | VR_HT211 | TR_HX011 | | | TR_TT014 | |
| VL10_C | T | R | 35 | 2 | 16 | 17 | 18 | 19 | 6 | 0 | 16 | 0 | VR_TT218 | VR_TT219 | VR_HT112 | | | | | |
| | B | Phi | | 2 | 20 | 21 | 22 | 23 | 6 | 0 | 16 | 3 | VR_TT222 | VR_TT223 | VR_HT212 | TR_HX012 | TR_TT015 | TR_TT016 | TR_TT017 | TR_TT018 |
| VL11_C | T | Phi | 55 | 2 | 24 | 25 | 26 | 27 | 6 | 0 | 16 | 6 | VR_TT226 | VR_TT227 | VR_HT113 | | | | | |
| | B | R | | 2 | 28 | 29 | 30 | 31 | 6 | 0 | 16 | 9 | VR_TT230 | VR_TT231 | VR_HT213 | TR_HX013 | | | TR_TT019 | |
| VL12_C | T | R | 25 | 2 | 32 | 33 | 34 | 35 | 6 | 1 | 0 | 0 | VR_TT234 | VR_TT235 | VR_HT114 | | | | | |
| | B | Phi | | 2 | 36 | 37 | 38 | 39 | 6 | 1 | 0 | 3 | VR_TT238 | VR_TT239 | VR_HT214 | TR_HX014 | | | TR_TT020 | |
| VL13_C | T | Phi | 29 | 2 | 40 | 41 | 42 | 43 | 6 | 1 | 0 | 6 | VR_TT242 | VR_TT243 | VR_HT115 | | | | | |
| | B | R | | 2 | 44 | 45 | 46 | 47 | 6 | 1 | 0 | 9 | VR_TT246 | VR_TT247 | VR_HT215 | TR_HX015 | | | TR_TT021 | |
| VL14_C | T | R | 23 | 2 | 48 | 49 | 50 | 51 | 6 | 1 | 4 | 0 | VR_TT250 | VR_TT251 | VR_HT116 | | | | | |
| | B | Phi | | 2 | 52 | 53 | 54 | 55 | 6 | 1 | 4 | 3 | VR_TT254 | VR_TT255 | VR_HT216 | TR_HX016 | | | TR_TT022 | |
| VL15_C | T | Phi | 31 | 2 | 56 | 57 | 58 | 59 | 6 | 1 | 4 | 6 | VR_TT258 | VR_TT259 | VR_HT117 | | | | | |
| | B | R | | 2 | 60 | 61 | 62 | 63 | 6 | 1 | 4 | 9 | VR_TT262 | VR_TT263 | VR_HT217 | TR_HX017 | | | TR_TT023 | |
| VL16_C | T | R | 30 | 3 | 0 | 1 | 2 | 3 | 6 | 1 | 8 | 0 | VR_TT302 | VR_TT303 | VR_HT118 | | | | | |
| | B | Phi | | 3 | 4 | 5 | 6 | 7 | 6 | 1 | 8 | 3 | VR_TT306 | VR_TT307 | VR_HT218 | TR_HX018 | | | TR_TT024 | |
| VL17_C | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | TR_HX019 | | | | |
| VL18_C | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | TR_HX020 | | | | |
| VL19_C | T | Phi | 52 | 3 | 8 | 9 | 10 | 11 | 6 | 1 | 8 | 6 | VR_TT310 | VR_TT311 | VR_HT121 | | | | | |
| | B | R | | 3 | 12 | 13 | 14 | 15 | 6 | 1 | 8 | 9 | VR_TT314 | VR_TT315 | VR_HT221 | TR_HX021 | | | TR_TT025 | |
| VL20_C | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | TR_HX022 | | | | |
| VL21_C | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | TR_HX023 | | | | |
| VL22_C | T | R | 37 | 3 | 16 | 17 | 18 | 19 | 6 | 1 | 12 | 0 | VR_TT318 | VR_TT319 | VR_HT124 | | | | | |
| | B | Phi | | 3 | 20 | 21 | 22 | 23 | 6 | 1 | 12 | 3 | VR_TT322 | VR_TT323 | VR_HT224 | TR_HX024 | | | TR_TT026 | |
| VL23_C | T | Phi | 27 | 3 | 24 | 25 | 26 | 27 | 6 | 1 | 12 | 6 | VR_TT326 | VR_TT327 | VR_HT125 | | | | | |
| | B | R | | 3 | 28 | 29 | 30 | 31 | 6 | 1 | 12 | 9 | VR_TT330 | VR_TT331 | VR_HT225 | TR_HX025 | | | TR_TT027 | |
| VL24_C | T | R | 24 | 3 | 32 | 33 | 34 | 35 | 6 | 1 | 16 | 0 | VR_TT334 | VR_TT335 | VR_HT126 | | | | | |
| | B | Phi | | 3 | 36 | 37 | 38 | 39 | 6 | 1 | 16 | 3 | VR_TT338 | VR_TT339 | VR_HT226 | TR_HX026 | | | TR_TT028 | |
| VL25_C | T | Phi | 28 | 3 | 40 | 41 | 42 | 43 | 6 | 1 | 16 | 6 | VR_TT342 | VR_TT343 | VR_HT127 | | | | | |
| | B | R | | 3 | 44 | 45 | 46 | 47 | 6 | 1 | 16 | 9 | VR_TT346 | VR_TT347 | VR_HT227 | TR_HX027 | TR_TT029 | TR_TT030 | TR_TT031 | TR_TT032 |

Table 11.7-3: PVSS data points , corresponding monitoring pages and export labels.

| PVSS label | PVSS identifier | Value | PVSS Data Point | PVSS Trending page | CSV export label |
|---|---|---|---|---|---|
| sniffer_overruled | StateBit | state | VEDCSVMC:VTCS_sniffer_overruled.state | PLC_States_1 | IL_SNFov.stat |
| chilled_water_overruled | StateBit | state | VEDCSVMC:VTCS_chilled_water_overruled.state | PLC_States_1 | IL_CHWov.stat |
| allowcooling_a_overruled | StateBit | state | VEDCSVMC:VTCS_allowcooling_a_overruled.state | PLC_States_1 | IL_ALAov.stat |
| allowcooling_c_overruled | StateBit | state | VEDCSVMC:VTCS_allowcooling_c_overruled.state | PLC_States_1 | IL_ALCov.stat |
| vacuum_ok_overruled | StateBit | state | VEDCSVMC:VTCS_vacuum_ok_overruled.state | PLC_States_1 | IL_VACov.stat |
| coolingoff2vac_overruled | StateBit | state | VEDCSVMC:VTCS_coolingoff2vac_overruled.state | PLC_States_1 | IL_C2Vov.stat |
| cooling_rdy_a_overruled | StateBit | state | VEDCSVMC:VTCS_cooling_rdy_a_overruled.state | PLC_States_1 | IL_CRAov.stat |
| cooling_rdy_c_overruled | StateBit | state | VEDCSVMC:VTCS_cooling_rdy_c_overruled.state | PLC_States_1 | IL_CRCov.stat |
| sniffer_ok | StateBit | state | VEDCSVMC:VTCS_sniffer_ok.state | PLC_States_1 | IL_SNFok.stat |
| chilled_water_ok | StateBit | state | VEDCSVMC:VTCS_chilled_water_ok.state | PLC_States_1 | IL_CHWok.stat |
| allowcooling_a | StateBit | state | VEDCSVMC:VTCS_allowcooling_a.state | PLC_States_1 | IL_ALAok.stat |
| allowcooling_c | StateBit | state | VEDCSVMC:VTCS_allowcooling_c.state | PLC_States_1 | IL_ALCok.stat |
| vacuum_ok | StateBit | state | VEDCSVMC:VTCS_vacuum_ok.state | PLC_States_1 | IL_VACok.stat |
| coolingoff_to_vacuum | StateBit | state | VEDCSVMC:VTCS_coolingoff_to_vacuum.state | PLC_States_1 | IL_C2Vok.stat |
| cooling_rdy_a | StateBit | state | VEDCSVMC:VTCS_cooling_rdy_a.state | PLC_States_1 | IL_CRAok.stat |
| cooling_rdy_c | StateBit | state | VEDCSVMC:VTCS_cooling_rdy_c.state | PLC_States_1 | IL_CRCok.stat |
| intlck_smoke_alert | StateBit | state | VEDCSVMC:VTCS_intlck_smoke_alert.state | PLC_States_1 | IL_SNFal.stat |
| intlck_water_alert | StateBit | state | VEDCSVMC:VTCS_intlck_water_alert.state | PLC_States_1 | IL_CHWal.stat |
| intlck_allowCoolA_alert | StateBit | state | VEDCSVMC:VTCS_intlck_allowCoolA_alert.state | PLC_States_1 | IL_ALAal.stat |
| intlck_allowCoolC_alert | StateBit | state | VEDCSVMC:VTCS_intlck_allowCoolC_alert.state | PLC_States_1 | IL_ALCal.stat |
| intlck_vacuum_alert | StateBit | state | VEDCSVMC:VTCS_intlck_vacuum_alert.state | PLC_States_1 | IL_VACal.stat |
| global_enable | StateBit | state | VEDCSVMC:VTCS_global_enable.state | PLC_States_1 | IL_GLBen.stat |
| venting_alarm | StateBit | state | VEDCSVMC:VTCS_venting_alarm.state | PLC_States_1 | IL_VENal.stat |
| Aside_$CO_2$status | StateDword | state | VEDCSVMC:VTCS_Aside_$CO_2$status.state | | |
| Cside_$CO_2$status | StateDword | state | VEDCSVMC:VTCS_Cside_$CO_2$status.state | | |
| Chiller_status | StateDword | state | VEDCSVMC:VTCS_Chiller_status.state | | |
| TL_valves2default_proc | StateDword | state | VEDCSVMC:VTCS_TL_valves2default_proc.state | | |
| TR_valves2default_proc | StateDword | state | VEDCSVMC:VTCS_TR_valves2default_proc.state | | |
| TLR_valves2default_proc | StateDword | state | VEDCSVMC:VTCS_TLR_valves2default_proc.state | | |
| SwitchTransferLine_proc | StateDword | state | VEDCSVMC:VTCS_SwitchTransferLine_proc.state | | |
| SASBswitchover_proc | StateWord | state | VEDCSVMC:VTCS_SASBswitchover_proc.state | | |
| TLTLRswitchover_proc | StateWord | state | VEDCSVMC:VTCS_TLTLRswitchover_proc.state | | |
| TRTLRswitchover_proc | StateWord | state | VEDCSVMC:VTCS_TRTLRswitchover_proc.state | | |
| TLRswitchoff_proc | StateWord | state | VEDCSVMC:VTCS_TLRswitchoff_proc.state | | |
| TL_CoolingOn | StateBit | state | VEDCSVMC:VTCS_TL_CoolingOn.state | PLC_States_1 | TL_STcon.stat |
| TL_OverBypass | StateBit | state | VEDCSVMC:VTCS_TL_OverBypass.state | PLC_States_1 | TL_ST2bp.stat |
| TL_overTLpump | StateBit | state | VEDCSVMC:VTCS_TL_overTLpump.state | PLC_States_1 | TL_ST2lp.stat |
| TL_overTLRpump | StateBit | state | VEDCSVMC:VTCS_TL_overTLRpump.state | PLC_States_1 | TL_ST2mp.stat |
| TL_overSA | StateBit | state | VEDCSVMC:VTCS_TL_overSA.state | PLC_States_1 | TL_ST2sA.stat |
| TL_overSB | StateBit | state | VEDCSVMC:VTCS_TL_overSB.state | PLC_States_1 | TL_ST2sB.stat |
| TL_overBridgeHeater | StateBit | state | VEDCSVMC:VTCS_TL_overBridgeHeater.state | PLC_States_1 | TL_ST2bh.stat |
| TL_AccuCoolingSA | StateBit | state | VEDCSVMC:VTCS_TL_AccuCoolingSA.state | PLC_States_1 | TL_STacA.stat |
| TL_AccuCoolingSB | StateBit | state | VEDCSVMC:VTCS_TL_AccuCoolingSB.state | PLC_States_1 | TL_STacB.stat |

| | | | | | |
|---|---|---|---|---|---|
| TR_CoolingOn | StateBit | state | VEDCSVMC:VTCS_TR_CoolingOn.state | PLC_States_1 | TR_STcon.stat |
| TR_OverBypass | StateBit | state | VEDCSVMC:VTCS_TR_OverBypass.state | PLC_States_1 | TR_ST2bp.stat |
| TR_overTRpump | StateBit | state | VEDCSVMC:VTCS_TR_overTRpump.state | PLC_States_1 | TR_ST2lp.stat |
| TR_overTRRpump | StateBit | state | VEDCSVMC:VTCS_TR_overTRRpump.state | PLC_States_1 | TR_ST2mp.stat |
| TR_overSA | StateBit | state | VEDCSVMC:VTCS_TR_overSA.state | PLC_States_1 | TR_ST2sA.stat |
| TR_overSB | StateBit | state | VEDCSVMC:VTCS_TR_overSB.state | PLC_States_1 | TR_ST2sB.stat |
| TR_overBridgeHeater | StateBit | state | VEDCSVMC:VTCS_TR_overBridgeHeater.state | PLC_States_1 | TR_ST2bh.stat |
| TR_AccuCoolingSA | StateBit | state | VEDCSVMC:VTCS_TR_AccuCoolingSA.state | PLC_States_1 | TR_STacA.stat |
| TR_AccuCoolingSB | StateBit | state | VEDCSVMC:VTCS_TR_AccuCoolingSB.state | PLC_States_1 | TR_STacB.stat |
| TLR_PumpClaimed | StateBit | state | VEDCSVMC:VTCS_TLR_PumpClaimed.state | PLC_States_1 | TM_STpCL.stat |
| SA_CoolingOn | StateBit | state | VEDCSVMC:VTCS_SA_CoolingOn.state | PLC_States_1 | SA_ST101.stat |
| SB_CoolingOn | StateBit | state | VEDCSVMC:VTCS_SB_CoolingOn.state | PLC_States_1 | SB_ST101.stat |
| PVSS_FSM_A_OFF | StateBit | state | VEDCSVMC:VTCS_PVSS_FSM_A_OFF.state | PLC_States_2 | PV_FSM01.stat |
| PVSS_FSM_A_STARTINGUP | StateBit | state | VEDCSVMC:VTCS_PVSS_FSM_A_STARTINGUP.state | PLC_States_2 | PV_FSM02.stat |
| PVSS_FSM_A_READY | StateBit | state | VEDCSVMC:VTCS_PVSS_FSM_A_READY.state | PLC_States_2 | PV_FSM03.stat |
| PVSS_FSM_A_ERROR | StateBit | state | VEDCSVMC:VTCS_PVSS_FSM_A_ERROR.state | PLC_States_2 | PV_FSM04.stat |
| PVSS_FSM_C_OFF | StateBit | state | VEDCSVMC:VTCS_PVSS_FSM_C_OFF.state | PLC_States_2 | PV_FSM05.stat |
| PVSS_FSM_C_STARTINGUP | StateBit | state | VEDCSVMC:VTCS_PVSS_FSM_C_STARTINGUP.state | PLC_States_2 | PV_FSM06.stat |
| PVSS_FSM_C_READY | StateBit | state | VEDCSVMC:VTCS_PVSS_FSM_C_READY.state | PLC_States_2 | PV_FSM07.stat |
| PVSS_FSM_C_ERROR | StateBit | state | VEDCSVMC:VTCS_PVSS_FSM_C_ERROR.state | PLC_States_2 | PV_FSM08.stat |
| $CO_2$_TL_mode | StateByte | state | VEDCSVMC:VTCS_$CO_2$_TL_mode.state | | |
| $CO_2$_TR_mode | StateByte | state | VEDCSVMC:VTCS_$CO_2$_TR_mode.state | | |
| TLR_PM101_mode | StateByte | state | VEDCSVMC:VTCS_TLR_PM101_mode.state | | |
| SA_mode | StateByte | state | VEDCSVMC:VTCS_SA_mode.state | | |
| SB_mode | StateByte | state | VEDCSVMC:VTCS_SB_mode.state | | |
| dr_an1_0 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_0.byte | | |
| dr_an1_1 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_1.byte | | |
| dr_an1_2 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_2.byte | | |
| dr_an1_3 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_3.byte | | |
| dr_an1_4 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_4.byte | | |
| dr_an1_5 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_5.byte | | |
| dr_an1_6 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_6.byte | | |
| dr_an1_7 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_7.byte | | |
| dr_an1_8 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_8.byte | | |
| dr_an1_9 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_9.byte | | |
| dr_an1_10 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_10.byte | | |
| dr_an1_11 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_11.byte | | |
| dr_an1_12 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_12.byte | | |
| dr_an1_13 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_13.byte | | |
| dr_an1_14 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_14.byte | | |
| dr_an1_15 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_15.byte | | |
| dr_an1_16 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_16.byte | | |
| dr_an1_17 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_17.byte | | |
| dr_an1_18 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_18.byte | | |
| dr_an1_19 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_19.byte | | |
| dr_an1_20 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_20.byte | | |
| dr_an1_21 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_21.byte | | |
| dr_an1_22 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_22.byte | | |
| dr_an1_23 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_23.byte | | |

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|---|---|---|---|---|---|
| dr_an1_24 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an1_24.byte | | |
| dr_an2_0 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_0.byte | | |
| dr_an2_1 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_1.byte | | |
| dr_an2_2 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_2.byte | | |
| dr_an2_3 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_3.byte | | |
| dr_an2_4 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_4.byte | | |
| dr_an2_5 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_5.byte | | |
| dr_an2_6 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_6.byte | | |
| dr_an2_7 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_7.byte | | |
| dr_an2_8 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_8.byte | | |
| dr_an2_9 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_9.byte | | |
| dr_an2_10 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_10.byte | | |
| dr_an2_11 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_11.byte | | |
| dr_an2_12 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_12.byte | | |
| dr_an2_13 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_13.byte | | |
| dr_an2_14 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_14.byte | | |
| dr_an2_15 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_15.byte | | |
| dr_an2_16 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_16.byte | | |
| dr_an2_17 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_17.byte | | |
| dr_an2_18 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_18.byte | | |
| dr_an2_19 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_19.byte | | |
| dr_an2_20 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_20.byte | | |
| dr_an2_21 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_21.byte | | |
| dr_an2_22 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_22.byte | | |
| dr_an2_23 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_23.byte | | |
| dr_an2_24 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an2_24.byte | | |
| dr_an3_0 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_0.byte | | |
| dr_an3_1 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_1.byte | | |
| dr_an3_2 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_2.byte | | |
| dr_an3_3 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_3.byte | | |
| dr_an3_4 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_4.byte | | |
| dr_an3_5 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_5.byte | | |
| dr_an3_6 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_6.byte | | |
| dr_an3_7 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_7.byte | | |
| dr_an3_8 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_8.byte | | |
| dr_an3_9 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_9.byte | | |
| dr_an3_10 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_10.byte | | |
| dr_an3_11 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_11.byte | | |
| dr_an3_12 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_12.byte | | |
| dr_an3_13 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_13.byte | | |
| dr_an3_14 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_14.byte | | |
| dr_an3_15 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_15.byte | | |
| dr_an3_16 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_16.byte | | |
| dr_an3_17 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_17.byte | | |
| dr_an3_18 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_18.byte | | |
| dr_an3_19 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_19.byte | | |
| dr_an3_20 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_20.byte | | |
| dr_an3_21 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_21.byte | | |
| dr_an3_22 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_22.byte | | |

| | | | | | |
|---|---|---|---|---|---|
| dr_an3_23 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_23.byte | | |
| dr_an3_24 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an3_24.byte | | |
| dr_an4_0 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_0.byte | | |
| dr_an4_1 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_1.byte | | |
| dr_an4_2 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_2.byte | | |
| dr_an4_3 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_3.byte | | |
| dr_an4_4 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_4.byte | | |
| dr_an4_5 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_5.byte | | |
| dr_an4_6 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_6.byte | | |
| dr_an4_7 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_7.byte | | |
| dr_an4_8 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_8.byte | | |
| dr_an4_9 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_9.byte | | |
| dr_an4_10 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_10.byte | | |
| dr_an4_11 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_11.byte | | |
| dr_an4_12 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_12.byte | | |
| dr_an4_13 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_13.byte | | |
| dr_an4_14 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_14.byte | | |
| dr_an4_15 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_15.byte | | |
| dr_an4_16 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_16.byte | | |
| dr_an4_17 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_17.byte | | |
| dr_an4_18 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_18.byte | | |
| dr_an4_19 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_19.byte | | |
| dr_an4_20 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_20.byte | | |
| dr_an4_21 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_21.byte | | |
| dr_an4_22 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_22.byte | | |
| dr_an4_23 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_23.byte | | |
| dr_an4_24 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_an4_24.byte | | |
| dr_fm455_0 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_0.byte | | |
| dr_fm455_1 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_1.byte | | |
| dr_fm455_2 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_2.byte | | |
| dr_fm455_3 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_3.byte | | |
| dr_fm455_4 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_4.byte | | |
| dr_fm455_5 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_5.byte | | |
| dr_fm455_6 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_6.byte | | |
| dr_fm455_7 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_7.byte | | |
| dr_fm455_8 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_8.byte | | |
| dr_fm455_9 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_9.byte | | |
| dr_fm455_10 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_10.byte | | |
| dr_fm455_11 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_11.byte | | |
| dr_fm455_12 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_12.byte | | |
| dr_fm455_13 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_13.byte | | |
| dr_fm455_14 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_14.byte | | |
| dr_fm455_15 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_15.byte | | |
| dr_fm455_16 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_16.byte | | |
| dr_fm455_17 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_17.byte | | |
| dr_fm455_18 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_18.byte | | |
| dr_fm455_19 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_19.byte | | |
| dr_fm455_20 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_20.byte | | |
| dr_fm455_21 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_21.byte | | |

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| dr_fm455_22 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_22.byte | | |
| dr_fm455_23 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_23.byte | | |
| dr_fm455_24 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_24.byte | | |
| dr_fm455_25 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_25.byte | | |
| dr_fm455_26 | MiscalaneousBytes | byte | VEDCSVMC:VTCS_dr_fm455_26.byte | | |
| TL_TT001 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT001.T | TL_Detector_Temperature | TL_TT001.temp |
| TL_TT001 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT001.status | | |
| TL_TT002 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT002.T | TL_Detector_Temperature | TL_TT002.temp |
| TL_TT002 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT002.status | | |
| TL_TT003 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT003.T | TL_Detector_Temperature | TL_TT003.temp |
| TL_TT003 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT003.status | | |
| TL_TT004 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT004.T | TL_Detector_Temperature | TL_TT004.temp |
| TL_TT004 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT004.status | | |
| TL_TT005 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT005.T | TL_Detector_Temperature | TL_TT005.temp |
| TL_TT005 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT005.status | | |
| TL_TT006 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT006.T | TL_Detector_Temperature | TL_TT006.temp |
| TL_TT006 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT006.status | | |
| TL_TT007 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT007.T | TL_Detector_Temperature | TL_TT007.temp |
| TL_TT007 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT007.status | | |
| TL_TT008 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT008.T | TL_Detector_Temperature | TL_TT008.temp |
| TL_TT008 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT008.status | | |
| TL_TT009 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT009.T | TL_Detector_Temperature | TL_TT009.temp |
| TL_TT009 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT009.status | | |
| TL_TT010 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT010.T | TL_Detector_Temperature | TL_TT010.temp |
| TL_TT010 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT010.status | | |
| TL_TT011 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT011.T | TL_Detector_Temperature | TL_TT011.temp |
| TL_TT011 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT011.status | | |
| TL_TT012 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT012.T | TL_Detector_Temperature | TL_TT012.temp |
| TL_TT012 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT012.status | | |
| TL_TT013 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT013.T | TL_Detector_Temperature | TL_TT013.temp |
| TL_TT013 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT013.status | | |
| TL_TT014 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT014.T | TL_Detector_Temperature | TL_TT014.temp |
| TL_TT014 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT014.status | | |
| TL_TT015 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT015.T | TL_Detector_Temperature | TL_TT015.temp |
| TL_TT015 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT015.status | | |
| TL_TT016 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT016.T | TL_Detector_Temperature | TL_TT016.temp |
| TL_TT016 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT016.status | | |
| TL_TT017 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT017.T | TL_Detector_Temperature | TL_TT017.temp |
| TL_TT017 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT017.status | | |
| TL_TT018 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT018.T | TL_Detector_Temperature | TL_TT018.temp |
| TL_TT018 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT018.status | | |
| TL_TT019 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT019.T | TL_Detector_Temperature | TL_TT019.temp |
| TL_TT019 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT019.status | | |
| TL_TT020 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT020.T | TL_Detector_Temperature | TL_TT020.temp |
| TL_TT020 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT020.status | | |
| TL_TT021 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT021.T | TL_Detector_Temperature | TL_TT021.temp |
| TL_TT021 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT021.status | | |
| TL_TT022 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT022.T | TL_Detector_Temperature | TL_TT022.temp |
| TL_TT022 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT022.status | | |

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| TL_TT023 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT023.T | TL_Detector_Temperature | TL_TT023.temp |
| TL_TT023 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT023.status | | |
| TL_TT024 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT024.T | TL_Detector_Temperature | TL_TT024.temp |
| TL_TT024 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT024.status | | |
| TL_TT025 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT025.T | TL_Detector_Temperature | TL_TT025.temp |
| TL_TT025 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT025.status | | |
| TL_TT026 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT026.T | TL_Detector_Temperature | TL_TT026.temp |
| TL_TT026 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT026.status | | |
| TL_TT027 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT027.T | TL_Detector_Temperature | TL_TT027.temp |
| TL_TT027 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT027.status | | |
| TL_TT028 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT028.T | TL_Detector_Temperature | TL_TT028.temp |
| TL_TT028 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT028.status | | |
| TL_TT029 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT029.T | TL_Detector_Temperature | TL_TT029.temp |
| TL_TT029 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT029.status | | |
| TL_TT030 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT030.T | TL_Detector_Temperature | TL_TT030.temp |
| TL_TT030 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT030.status | | |
| TL_TT031 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT031.T | TL_Detector_Temperature | TL_TT031.temp |
| TL_TT031 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT031.status | | |
| TL_TT032 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT032.T | TL_Detector_Temperature | TL_TT032.temp |
| TL_TT032 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT032.status | | |
| TL_TT033 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT033.T | TL_Detector_Temperature | TL_TT033.temp |
| TL_TT033 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT033.status | | |
| TL_TT034 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT034.T | TL_Detector_Temperature | TL_TT034.temp |
| TL_TT034 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT034.status | | |
| TL_TT035 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT035.T | TL_Detector_Temperature | TL_TT035.temp |
| TL_TT035 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT035.status | | |
| TL_TT036 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT036.T | TL_Detector_Temperature | TL_TT036.temp |
| TL_TT036 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT036.status | | |
| TL_TT037 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT037.T | TL_Detector_Temperature | TL_TT037.temp |
| TL_TT037 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT037.status | | |
| TL_TT038 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT038.T | TL_Detector_Temperature | TL_TT038.temp |
| TL_TT038 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT038.status | | |
| TL_TT039 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT039.T | TL_Detector_Temperature | TL_TT039.temp |
| TL_TT039 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT039.status | | |
| TL_TT040 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT040.T | TL_Detector_Temperature | TL_TT040.temp |
| TL_TT040 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT040.status | | |
| TL_TT041 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT041.T | TL_Detector_Temperature | TL_TT041.temp |
| TL_TT041 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT041.status | | |
| TL_TT042 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT042.T | TL_Detector_Temperature | TL_TT042.temp |
| TL_TT042 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT042.status | | |
| TL_TT043 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT043.T | TL_Detector_Temperature | TL_TT043.temp |
| TL_TT043 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT043.status | | |
| TL_TT044 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT044.T | TL_Detector_Temperature | TL_TT044.temp |
| TL_TT044 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT044.status | | |
| TL_TT045 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT045.T | TL_Detector_Temperature | TL_TT045.temp |
| TL_TT045 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT045.status | | |
| TL_TT046 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT046.T | TL_Detector_Temperature | TL_TT046.temp |
| TL_TT046 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT046.status | | |
| TL_TT047 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT047.T | TL_Detector_Temperature | TL_TT047.temp |

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| TL_TT047 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT047.status | | |
| TL_TT048 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT048.T | TL_Detector_Temperature | TL_TT048.temp |
| TL_TT048 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT048.status | | |
| TL_TT101 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT101.T | TL_System_Sensor_A | TL_TT101.temp |
| TL_TT101 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT101.status | | |
| TL_TT102 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT102.T | TL_System_Sensor_A | TL_TT102.temp |
| TL_TT102 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT102.status | | |
| TL_TT103 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT103.T | TL_System_Sensor_A | TL_TT103.temp |
| TL_TT103 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT103.status | | |
| TL_TT104 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT104.T | TL_System_Sensor_A | TL_TT104.temp |
| TL_TT104 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT104.status | | |
| TL_TT105 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT105.T | TL_System_Sensor_A | TL_TT105.temp |
| TL_TT105 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT105.status | | |
| TL_TT106 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT106.T | TL_System_Sensor_A | TL_TT106.temp |
| TL_TT106 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT106.status | | |
| TL_TT107 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT107.T | TL_System_Sensor_A | TL_TT107.temp |
| TL_TT107 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT107.status | | |
| TL_TT108 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT108.T | TL_System_Sensor_A | TL_TT108.temp |
| TL_TT108 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT108.status | | |
| TL_TT109 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT109.T | TL_System_Sensor_A | TL_TT109.temp |
| TL_TT109 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT109.status | | |
| TL_TT110 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT110.T | TL_System_Sensor_A | TL_TT110.temp |
| TL_TT110 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT110.status | | |
| xx_TTamb | TemperatureTransmitter | T | VEDCSVMC:VTCS_xx_TTamb.T | TL_System_Sensor_A | xx_TTamb.temp |
| xx_TTamb | TemperatureTransmitter | status | VEDCSVMC:VTCS_xx_TTamb.status | | |
| TL_TT112 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT112.T | TL_System_Sensor_A | TL_TT112.temp |
| TL_TT112 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT112.status | | |
| TL_TT113 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT113.T | TL_System_Sensor_A | TL_TT113.temp |
| TL_TT113 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT113.status | | |
| TL_TT114 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT114.T | TL_System_Sensor_A | TL_TT114.temp |
| TL_TT114 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT114.status | | |
| TL_TT115 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT115.T | TL_System_Sensor_A | TL_TT115.temp |
| TL_TT115 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT115.status | | |
| TL_TT116 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT116.T | TL_System_Sensor_A | TL_TT116.temp |
| TL_TT116 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT116.status | | |
| TL_TT117 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT117.T | TL_System_Sensor_A | TL_TT117.temp |
| TL_TT117 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT117.status | | |
| TL_TT118 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT118.T | TL_System_Sensor_A | TL_TT118.temp |
| TL_TT118 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT118.status | | |
| TL_TT119 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT119.T | TL_System_Sensor_A | TL_TT119.temp |
| TL_TT119 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT119.status | | |
| TL_TT120 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT120.T | TL_System_Sensor_A | TL_TT120.temp |
| TL_TT120 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT120.status | | |
| TL_TT121 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT121.T | TL_System_Sensor_A | TL_TT121.temp |
| TL_TT121 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT121.status | | |
| TL_TT122 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT122.T | TL_System_Sensor_A | TL_TT122.temp |
| TL_TT122 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT122.status | | |
| TL_TT123 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT123.T | TL_System_Sensor_A | TL_TT123.temp |
| TL_TT123 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT123.status | | |

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| TL_TT124 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT124.T | TL_System_Sensor_A | TL_TT124.temp |
| TL_TT124 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT124.status | | |
| TL_TT125 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TL_TT125.T | TL_System_Sensor_A | TL_TT125.temp |
| TL_TT125 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TL_TT125.status | | |
| TR_TT001 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT001.T | TR_Detector_Temperature | TR_TT001.temp |
| TR_TT001 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT001.status | | |
| TR_TT002 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT002.T | TR_Detector_Temperature | TR_TT002.temp |
| TR_TT002 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT002.status | | |
| TR_TT003 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT003.T | TR_Detector_Temperature | TR_TT003.temp |
| TR_TT003 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT003.status | | |
| TR_TT004 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT004.T | TR_Detector_Temperature | TR_TT004.temp |
| TR_TT004 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT004.status | | |
| TR_TT005 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT005.T | TR_Detector_Temperature | TR_TT005.temp |
| TR_TT005 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT005.status | | |
| TR_TT006 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT006.T | TR_Detector_Temperature | TR_TT006.temp |
| TR_TT006 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT006.status | | |
| TR_TT007 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT007.T | TR_Detector_Temperature | TR_TT007.temp |
| TR_TT007 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT007.status | | |
| TR_TT008 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT008.T | TR_Detector_Temperature | TR_TT008.temp |
| TR_TT008 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT008.status | | |
| TR_TT009 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT009.T | TR_Detector_Temperature | TR_TT009.temp |
| TR_TT009 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT009.status | | |
| TR_TT010 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT010.T | TR_Detector_Temperature | TR_TT010.temp |
| TR_TT010 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT010.status | | |
| TR_TT011 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT011.T | TR_Detector_Temperature | TR_TT011.temp |
| TR_TT011 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT011.status | | |
| TR_TT012 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT012.T | TR_Detector_Temperature | TR_TT012.temp |
| TR_TT012 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT012.status | | |
| TR_TT013 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT013.T | TR_Detector_Temperature | TR_TT013.temp |
| TR_TT013 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT013.status | | |
| TR_TT014 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT014.T | TR_Detector_Temperature | TR_TT014.temp |
| TR_TT014 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT014.status | | |
| TR_TT015 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT015.T | TR_Detector_Temperature | TR_TT015.temp |
| TR_TT015 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT015.status | | |
| TR_TT016 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT016.T | TR_Detector_Temperature | TR_TT016.temp |
| TR_TT016 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT016.status | | |
| TR_TT017 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT017.T | TR_Detector_Temperature | TR_TT017.temp |
| TR_TT017 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT017.status | | |
| TR_TT018 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT018.T | TR_Detector_Temperature | TR_TT018.temp |
| TR_TT018 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT018.status | | |
| TR_TT019 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT019.T | TR_Detector_Temperature | TR_TT019.temp |
| TR_TT019 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT019.status | | |
| TR_TT020 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT020.T | TR_Detector_Temperature | TR_TT020.temp |
| TR_TT020 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT020.status | | |
| TR_TT021 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT021.T | TR_Detector_Temperature | TR_TT021.temp |
| TR_TT021 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT021.status | | |
| TR_TT022 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT022.T | TR_Detector_Temperature | TR_TT022.temp |
| TR_TT022 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT022.status | | |
| TR_TT023 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT023.T | TR_Detector_Temperature | TR_TT023.temp |

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| TR_TT023 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT023.status | | |
| TR_TT024 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT024.T | TR_Detector_Temperature | TR_TT024.temp |
| TR_TT024 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT024.status | | |
| TR_TT025 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT025.T | TR_Detector_Temperature | TR_TT025.temp |
| TR_TT025 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT025.status | | |
| TR_TT026 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT026.T | TR_Detector_Temperature | TR_TT026.temp |
| TR_TT026 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT026.status | | |
| TR_TT027 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT027.T | TR_Detector_Temperature | TR_TT027.temp |
| TR_TT027 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT027.status | | |
| TR_TT028 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT028.T | TR_Detector_Temperature | TR_TT028.temp |
| TR_TT028 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT028.status | | |
| TR_TT029 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT029.T | TR_Detector_Temperature | TR_TT029.temp |
| TR_TT029 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT029.status | | |
| TR_TT030 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT030.T | TR_Detector_Temperature | TR_TT030.temp |
| TR_TT030 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT030.status | | |
| TR_TT031 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT031.T | TR_Detector_Temperature | TR_TT031.temp |
| TR_TT031 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT031.status | | |
| TR_TT032 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT032.T | TR_Detector_Temperature | TR_TT032.temp |
| TR_TT032 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT032.status | | |
| TR_TT033 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT033.T | TR_Detector_Temperature | TR_TT033.temp |
| TR_TT033 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT033.status | | |
| TR_TT034 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT034.T | TR_Detector_Temperature | TR_TT034.temp |
| TR_TT034 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT034.status | | |
| TR_TT035 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT035.T | TR_Detector_Temperature | TR_TT035.temp |
| TR_TT035 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT035.status | | |
| TR_TT036 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT036.T | TR_Detector_Temperature | TR_TT036.temp |
| TR_TT036 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT036.status | | |
| TR_TT037 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT037.T | TR_Detector_Temperature | TR_TT037.temp |
| TR_TT037 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT037.status | | |
| TR_TT038 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT038.T | TR_Detector_Temperature | TR_TT038.temp |
| TR_TT038 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT038.status | | |
| TR_TT039 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT039.T | TR_Detector_Temperature | TR_TT039.temp |
| TR_TT039 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT039.status | | |
| TR_TT040 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT040.T | TR_Detector_Temperature | TR_TT040.temp |
| TR_TT040 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT040.status | | |
| TR_TT041 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT041.T | TR_Detector_Temperature | TR_TT041.temp |
| TR_TT041 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT041.status | | |
| TR_TT042 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT042.T | TR_Detector_Temperature | TR_TT042.temp |
| TR_TT042 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT042.status | | |
| TR_TT043 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT043.T | TR_Detector_Temperature | TR_TT043.temp |
| TR_TT043 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT043.status | | |
| TR_TT044 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT044.T | TR_Detector_Temperature | TR_TT044.temp |
| TR_TT044 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT044.status | | |
| TR_TT045 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT045.T | TR_Detector_Temperature | TR_TT045.temp |
| TR_TT045 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT045.status | | |
| TR_TT046 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT046.T | TR_Detector_Temperature | TR_TT046.temp |
| TR_TT046 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT046.status | | |
| TR_TT047 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT047.T | TR_Detector_Temperature | TR_TT047.temp |
| TR_TT047 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT047.status | | |

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| TR_TT048 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT048.T | TR_Detector_Temperature | TR_TT048.temp |
| TR_TT048 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT048.status | | |
| TR_TT101 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT101.T | TR_System_Sensor_A | TR_TT101.temp |
| TR_TT101 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT101.status | | |
| TR_TT102 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT102.T | TR_System_Sensor_A | TR_TT102.temp |
| TR_TT102 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT102.status | | |
| TR_TT103 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT103.T | TR_System_Sensor_A | TR_TT103.temp |
| TR_TT103 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT103.status | | |
| TR_TT104 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT104.T | TR_System_Sensor_A | TR_TT104.temp |
| TR_TT104 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT104.status | | |
| TR_TT105 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT105.T | TR_System_Sensor_A | TR_TT105.temp |
| TR_TT105 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT105.status | | |
| TR_TT106 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT106.T | TR_System_Sensor_A | TR_TT106.temp |
| TR_TT106 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT106.status | | |
| TR_TT107 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT107.T | TR_System_Sensor_A | TR_TT107.temp |
| TR_TT107 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT107.status | | |
| TR_TT108 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT108.T | TR_System_Sensor_A | TR_TT108.temp |
| TR_TT108 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT108.status | | |
| TR_TT109 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT109.T | TR_System_Sensor_A | TR_TT109.temp |
| TR_TT109 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT109.status | | |
| TR_TT110 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT110.T | TR_System_Sensor_A | TR_TT110.temp |
| TR_TT110 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT110.status | | |
| TR_TT111 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT111.T | TR_System_Sensor_A | TR_TT111.temp |
| TR_TT111 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT111.status | | |
| TR_TT112 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT112.T | TR_System_Sensor_A | TR_TT112.temp |
| TR_TT112 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT112.status | | |
| TR_TT113 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT113.T | TR_System_Sensor_A | TR_TT113.temp |
| TR_TT113 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT113.status | | |
| TR_TT114 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT114.T | TR_System_Sensor_A | TR_TT114.temp |
| TR_TT114 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT114.status | | |
| TR_TT115 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT115.T | TR_System_Sensor_A | TR_TT115.temp |
| TR_TT115 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT115.status | | |
| TR_TT116 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT116.T | TR_System_Sensor_A | TR_TT116.temp |
| TR_TT116 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT116.status | | |
| TR_TT117 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT117.T | TR_System_Sensor_A | TR_TT117.temp |
| TR_TT117 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT117.status | | |
| TR_TT118 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT118.T | TR_System_Sensor_A | TR_TT118.temp |
| TR_TT118 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT118.status | | |
| TR_TT119 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT119.T | TR_System_Sensor_A | TR_TT119.temp |
| TR_TT119 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT119.status | | |
| TR_TT120 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT120.T | TR_System_Sensor_A | TR_TT120.temp |
| TR_TT120 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT120.status | | |
| TR_TT121 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT121.T | TR_System_Sensor_A | TR_TT121.temp |
| TR_TT121 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT121.status | | |
| TR_TT122 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT122.T | TR_System_Sensor_A | TR_TT122.temp |
| TR_TT122 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT122.status | | |
| TR_TT123 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT123.T | TR_System_Sensor_A | TR_TT123.temp |
| TR_TT123 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT123.status | | |
| TR_TT124 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT124.T | TR_System_Sensor_A | TR_TT124.temp |

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| TR_TT124 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT124.status | | |
| TR_TT125 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TR_TT125.T | TR_System_Sensor_A | TR_TT125.temp |
| TR_TT125 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TR_TT125.status | | |
| TLR_TT112 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TLR_TT112.T | TLR_SystemSensors | TM_TT112.temp |
| TLR_TT112 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TLR_TT112.status | | |
| TLR_TT113 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TLR_TT113.T | TLR_SystemSensors | TM_TT113.temp |
| TLR_TT113 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TLR_TT113.status | | |
| TLR_TT114 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TLR_TT114.T | TLR_SystemSensors | TM_TT114.temp |
| TLR_TT114 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TLR_TT114.status | | |
| TLR_TT115 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TLR_TT115.T | TLR_SystemSensors | TM_TT115.temp |
| TLR_TT115 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TLR_TT115.status | | |
| TLR_TT122 | TemperatureTransmitter | T | VEDCSVMC:VTCS_TLR_TT122.T | TLR_SystemSensors | TM_TT12.temp |
| TLR_TT122 | TemperatureTransmitter | status | VEDCSVMC:VTCS_TLR_TT122.status | | |
| SA_TT101 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT101.T | SA_SystemValues | SA_TT101.temp |
| SA_TT101 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT101.status | | |
| SA_TT102 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT102.T | SA_SystemValues | SA_TT102.temp |
| SA_TT102 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT102.status | | |
| SA_TT103 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT103.T | SA_SystemValues | SA_TT103.temp |
| SA_TT103 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT103.status | | |
| SA_TT104 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT104.T | SA_SystemValues | SA_TT104.temp |
| SA_TT104 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT104.status | | |
| SA_TT105 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT105.T | SA_SystemValues | SA_TT105.temp |
| SA_TT105 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT105.status | | |
| SA_TT106 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT106.T | SA_SystemValues | SA_TT106.temp |
| SA_TT106 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT106.status | | |
| SA_TT107 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT107.T | SA_SystemValues | SA_TT107.temp |
| SA_TT107 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT107.status | | |
| SA_TT108 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT108.T | SA_SystemValues | SA_TT108.temp |
| SA_TT108 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT108.status | | |
| SA_TT109 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT109.T | SA_SystemValues | SA_TT109.temp |
| SA_TT109 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT109.status | | |
| SA_TT110 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT110.T | SA_SystemValues | SA_TT110.temp |
| SA_TT110 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT110.status | | |
| SA_TT111 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT111.T | SA_SystemValues | SA_TT111.temp |
| SA_TT111 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT111.status | | |
| SA_TT112 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT112.T | SA_SystemValues | SA_TT112.temp |
| SA_TT112 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT112.status | | |
| SA_TT113 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT113.T | SA_SystemValues | SA_TT113.temp |
| SA_TT113 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT113.status | | |
| SA_TT114 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT114.T | SA_SystemValues | SA_TT114.temp |
| SA_TT114 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT114.status | | |
| SA_TT115 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT115.T | SA_SystemValues | SA_TT115.temp |
| SA_TT115 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT115.status | | |
| SA_TT116 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT116.T | SA_SystemValues | SA_TT116.temp |
| SA_TT116 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT116.status | | |
| SA_TT117 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT117.T | SA_SystemValues | SA_TT117.temp |
| SA_TT117 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT117.status | | |
| SA_TT118 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT118.T | SA_SystemValues | SA_TT118.temp |
| SA_TT118 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT118.status | | |

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| SA_TT119 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT119.T | SA_SystemValues | SA_TT119.temp |
| SA_TT119 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT119.status | | |
| SA_TT120 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT120.T | SA_SystemValues | SA_TT120.temp |
| SA_TT120 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT120.status | | |
| SA_TT121 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT121.T | SA_SystemValues | SA_TT121.temp |
| SA_TT121 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT121.status | | |
| SA_TT122 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SA_TT122.T | SA_SystemValues | SA_TT122.temp |
| SA_TT122 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SA_TT122.status | | |
| SB_TT101 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT101.T | SB_SystemValues | SB_TT101.temp |
| SB_TT101 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT101.status | | |
| SB_TT102 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT102.T | SB_SystemValues | SB_TT102.temp |
| SB_TT102 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT102.status | | |
| SB_TT104 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT104.T | SB_SystemValues | SB_TT104.temp |
| SB_TT104 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT104.status | | |
| SB_TT105 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT105.T | SB_SystemValues | SB_TT105.temp |
| SB_TT105 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT105.status | | |
| SB_TT107 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT107.T | SB_SystemValues | SB_TT107.temp |
| SB_TT107 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT107.status | | |
| SB_TT109 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT109.T | SB_SystemValues | SB_TT109.temp |
| SB_TT109 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT109.status | | |
| SB_TT111 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT111.T | SB_SystemValues | SB_TT111.temp |
| SB_TT111 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT111.status | | |
| SB_TT113 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT113.T | SB_SystemValues | SB_TT113.temp |
| SB_TT113 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT113.status | | |
| SB_TT114 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT114.T | SB_SystemValues | SB_TT114.temp |
| SB_TT114 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT114.status | | |
| SB_TT115 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT115.T | SB_SystemValues | SB_TT115.temp |
| SB_TT115 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT115.status | | |
| SB_TT116 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT116.T | SB_SystemValues | SB_TT116.temp |
| SB_TT116 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT116.status | | |
| SB_TT117 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT117.T | SB_SystemValues | SB_TT117.temp |
| SB_TT117 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT117.status | | |
| SB_TT118 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT118.T | SB_SystemValues | SB_TT118.temp |
| SB_TT118 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT118.status | | |
| SB_TT119 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT119.T | SB_SystemValues | SB_TT119.temp |
| SB_TT119 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT119.status | | |
| SB_TT121 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT121.T | SB_SystemValues | SB_TT121.temp |
| SB_TT121 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT121.status | | |
| SB_TT122 | TemperatureTransmitter | T | VEDCSVMC:VTCS_SB_TT122.T | SB_SystemValues | SB_TT122.temp |
| SB_TT122 | TemperatureTransmitter | status | VEDCSVMC:VTCS_SB_TT122.status | | |
| PA_TT101 | TemperatureTransmitter | T | VEDCSVMC:VTCS_PA_TT101.T | SA_SystemValues | PA_TT101.temp |
| PA_TT101 | TemperatureTransmitter | status | VEDCSVMC:VTCS_PA_TT101.status | | |
| PA_TT102 | TemperatureTransmitter | T | VEDCSVMC:VTCS_PA_TT102.T | SA_SystemValues | PA_TT102.temp |
| PA_TT102 | TemperatureTransmitter | status | VEDCSVMC:VTCS_PA_TT102.status | | |
| PB_TT101 | TemperatureTransmitter | T | VEDCSVMC:VTCS_PB_TT101.T | SB_SystemValues | PB_TT101.temp |
| PB_TT101 | TemperatureTransmitter | status | VEDCSVMC:VTCS_PB_TT101.status | | |
| TL_PT001 | PressureTransmitter | P | VEDCSVMC:VTCS_TL_PT001.P | TL_System_Sensors_A | TL_PT001.pres |
| TL_PT001 | PressureTransmitter | status | VEDCSVMC:VTCS_TL_PT001.status | | |
| TL_PT001 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TL_PT001.Tsat | TL_System_Sensors_A | TL_PT001.tsat |

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| TL_PT002 | PressureTransmitter | P | VEDCSVMC:VTCS_TL_PT002.P | TL_System_Sensors_A | TL_PT002.pres |
| TL_PT002 | PressureTransmitter | status | VEDCSVMC:VTCS_TL_PT002.status | | |
| TL_PT002 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TL_PT002.Tsat | TL_System_Sensors_A | TL_PT002.tsat |
| TL_PT003 | PressureTransmitter | P | VEDCSVMC:VTCS_TL_PT003.P | TL_System_Sensors_A | TL_PT003.pres |
| TL_PT003 | PressureTransmitter | status | VEDCSVMC:VTCS_TL_PT003.status | | |
| TL_PT003 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TL_PT003.Tsat | TL_System_Sensors_A | TL_PT003.tsat |
| TL_PT004 | PressureTransmitter | P | VEDCSVMC:VTCS_TL_PT004.P | TL_System_Sensors_A | TL_PT004.pres |
| TL_PT004 | PressureTransmitter | status | VEDCSVMC:VTCS_TL_PT004.status | | |
| TL_PT004 | PressureTransmitter | NA | | | |
| TL_PT101 | PressureTransmitter | P | VEDCSVMC:VTCS_TL_PT101.P | TL_System_Sensors_A | TL_PT101.pres |
| TL_PT101 | PressureTransmitter | status | VEDCSVMC:VTCS_TL_PT101.status | | |
| TL_PT101 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TL_PT101.Tsat | TL_System_Sensors_A | TL_PT101.tsat |
| TL_PT102 | PressureTransmitter | P | VEDCSVMC:VTCS_TL_PT102.P | TL_System_Sensors_A | TL_PT102.pres |
| TL_PT102 | PressureTransmitter | status | VEDCSVMC:VTCS_TL_PT102.status | | |
| TL_PT102 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TL_PT102.Tsat | TL_System_Sensors_A | TL_PT102.tsat |
| TL_PT103 | PressureSwitch | P | VEDCSVMC:VTCS_TL_PT103.P | | |
| TL_PT103 | PressureSwitch | status | VEDCSVMC:VTCS_TL_PT103.status | | |
| TL_PT103 | PressureSwitch | NA | | | |
| TL_PT104 | PressureTransmitter | P | VEDCSVMC:VTCS_TL_PT104.P | TL_System_Sensors_A | TL_PT104.pres |
| TL_PT104 | PressureTransmitter | status | VEDCSVMC:VTCS_TL_PT104.status | | |
| TL_PT104 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TL_PT104.Tsat | TL_System_Sensors_A | TL_PT104.tsat |
| TR_PT001 | PressureTransmitter | P | VEDCSVMC:VTCS_TR_PT001.P | TR_System_Sensors_A | TR_PT001.pres |
| TR_PT001 | PressureTransmitter | status | VEDCSVMC:VTCS_TR_PT001.status | | |
| TR_PT001 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TR_PT001.Tsat | TR_System_Sensors_A | TR_PT001.tsat |
| TR_PT002 | PressureTransmitter | P | VEDCSVMC:VTCS_TR_PT002.P | TR_System_Sensors_A | TR_PT002.pres |
| TR_PT002 | PressureTransmitter | status | VEDCSVMC:VTCS_TR_PT002.status | | |
| TR_PT002 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TR_PT002.Tsat | TR_System_Sensors_A | TR_PT002.tsat |
| TR_PT003 | PressureTransmitter | P | VEDCSVMC:VTCS_TR_PT003.P | TR_System_Sensors_A | TR_PT003.pres |
| TR_PT003 | PressureTransmitter | status | VEDCSVMC:VTCS_TR_PT003.status | | |
| TR_PT003 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TR_PT003.Tsat | TR_System_Sensors_A | TR_PT003.tsat |
| TR_PT004 | PressureTransmitter | P | VEDCSVMC:VTCS_TR_PT004.P | TR_System_Sensors_A | TR_PT004.pres |
| TR_PT004 | PressureTransmitter | status | VEDCSVMC:VTCS_TR_PT004.status | | |
| TR_PT101 | PressureTransmitter | P | VEDCSVMC:VTCS_TR_PT101.P | TR_System_Sensors_A | TR_PT101.pres |
| TR_PT101 | PressureTransmitter | status | VEDCSVMC:VTCS_TR_PT101.status | | |
| TR_PT101 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TR_PT101.Tsat | TR_System_Sensors_A | TR_PT101.tsat |
| TR_PT102 | PressureTransmitter | P | VEDCSVMC:VTCS_TR_PT102.P | TR_System_Sensors_A | TR_PT102.pres |
| TR_PT102 | PressureTransmitter | status | VEDCSVMC:VTCS_TR_PT102.status | | |
| TR_PT102 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TR_PT102.Tsat | TR_System_Sensors_A | TR_PT102.tsat |
| TR_PT103 | PressureSwitch | P | VEDCSVMC:VTCS_TR_PT103.P | | |
| TR_PT103 | PressureSwitch | status | VEDCSVMC:VTCS_TR_PT103.status | | |
| TR_PT104 | PressureTransmitter | P | VEDCSVMC:VTCS_TR_PT104.P | TR_System_Sensors_A | TR_PT104.pres |
| TR_PT104 | PressureTransmitter | status | VEDCSVMC:VTCS_TR_PT104.status | | |
| TR_PT104 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_TR_PT104.Tsat | TR_System_Sensors_A | TR_PT104.tsat |
| TLR_PT103 | PressureSwitch | P | VEDCSVMC:VTCS_TLR_PT103.P | | |
| TLR_PT103 | PressureSwitch | status | VEDCSVMC:VTCS_TLR_PT103.status | | |
| SA_PT101 | PressureTransmitter | P | VEDCSVMC:VTCS_SA_PT101.P | SA_SystemValues | SA_PT101.pres |
| SA_PT101 | PressureTransmitter | status | VEDCSVMC:VTCS_SA_PT101.status | | |
| SA_PT101 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SA_PT101.Tsat | SA_SystemValues | SA_PT101.tsat |
| SA_PT102 | PressureTransmitter | P | VEDCSVMC:VTCS_SA_PT102.P | SA_SystemValues | SA_PT102.pres |

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| SA_PT102 | PressureTransmitter | status | VEDCSVMC:VTCS_SA_PT102.status | | |
| SA_PT102 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SA_PT102.Tsat | SA_SystemValues | SA_PT102.tsat |
| SA_PT103 | PressureTransmitter | P | VEDCSVMC:VTCS_SA_PT103.P | SA_SystemValues | SA_PT103.pres |
| SA_PT103 | PressureTransmitter | status | VEDCSVMC:VTCS_SA_PT103.status | | |
| SA_PT103 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SA_PT103.Tsat | SA_SystemValues | SA_PT103.tsat |
| SA_PT104 | PressureTransmitter | P | VEDCSVMC:VTCS_SA_PT104.P | SA_SystemValues | SA_PT104.pres |
| SA_PT104 | PressureTransmitter | status | VEDCSVMC:VTCS_SA_PT104.status | | |
| SA_PT104 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SA_PT104.Tsat | SA_SystemValues | SA_PT104.tsat |
| SA_PT105 | PressureTransmitter | P | VEDCSVMC:VTCS_SA_PT105.P | SA_SystemValues | SA_PT105.pres |
| SA_PT105 | PressureTransmitter | status | VEDCSVMC:VTCS_SA_PT105.status | | |
| SA_PT105 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SA_PT105.Tsat | SA_SystemValues | SA_PT105.tsat |
| SA_PT106 | PressureTransmitter | P | VEDCSVMC:VTCS_SA_PT106.P | SA_SystemValues | SA_PT106.pres |
| SA_PT106 | PressureTransmitter | status | VEDCSVMC:VTCS_SA_PT106.status | | |
| SA_PT106 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SA_PT106.Tsat | SA_SystemValues | SA_PT106.tsat |
| SA_PT107 | PressureTransmitter | P | VEDCSVMC:VTCS_SA_PT107.P | SA_SystemValues | SA_PT107.pres |
| SA_PT107 | PressureTransmitter | status | VEDCSVMC:VTCS_SA_PT107.status | | |
| SA_PT107 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SA_PT107.Tsat | SA_SystemValues | SA_PT107.tsat |
| SA_PT108 | PressureSwitch | P | VEDCSVMC:VTCS_SA_PT108.P | SA_SystemValues | SA_PT108.pres |
| SA_PT108 | PressureSwitch | status | VEDCSVMC:VTCS_SA_PT108.status | | |
| SB_PT102 | PressureTransmitter | P | VEDCSVMC:VTCS_SB_PT102.P | SB_SystemValues | SB_PT102.pres |
| SB_PT102 | PressureTransmitter | status | VEDCSVMC:VTCS_SB_PT102.status | | |
| SB_PT102 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SB_PT102.Tsat | SB_SystemValues | SB_PT102.tsat |
| SB_PT103 | PressureTransmitter | P | VEDCSVMC:VTCS_SB_PT103.P | SB_SystemValues | SB_PT103.pres |
| SB_PT103 | PressureTransmitter | status | VEDCSVMC:VTCS_SB_PT103.status | | |
| SB_PT103 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SB_PT103.Tsat | SB_SystemValues | SB_PT103.tsat |
| SB_PT104 | PressureTransmitter | P | VEDCSVMC:VTCS_SB_PT104.P | SB_SystemValues | SB_PT104.pres |
| SB_PT104 | PressureTransmitter | status | VEDCSVMC:VTCS_SB_PT104.status | | |
| SB_PT104 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SB_PT104.Tsat | SB_SystemValues | SB_PT104.tsat |
| SB_PT105 | PressureTransmitter | P | VEDCSVMC:VTCS_SB_PT105.P | SB_SystemValues | SB_PT105.pres |
| SB_PT105 | PressureTransmitter | status | VEDCSVMC:VTCS_SB_PT105.status | | |
| SB_PT105 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SB_PT105.Tsat | SB_SystemValues | SB_PT105.tsat |
| SB_PT106 | PressureTransmitter | P | VEDCSVMC:VTCS_SB_PT106.P | SB_SystemValues | SB_PT106.pres |
| SB_PT106 | PressureTransmitter | status | VEDCSVMC:VTCS_SB_PT106.status | | |
| SB_PT106 | PressureTransmitter | Tsat | VEDCSVMC:VTCS_SB_PT106.Tsat | SB_SystemValues | SB_PT106.tsat |
| SB_PT108 | PressureSwitch | P | VEDCSVMC:VTCS_SB_PT108.P | SB_SystemValues | SB_PT108.pres |
| SB_PT108 | PressureSwitch | status | VEDCSVMC:VTCS_SB_PT108.status | | |
| TL_VL102 | Automatic2WayValve | status | VEDCSVMC:VTCS_TL_VL102.status | | |
| TL_VL103 | Automatic3WayValve | status | VEDCSVMC:VTCS_TL_VL103.status | | |
| TL_VL104 | Automatic2WayValve | status | VEDCSVMC:VTCS_TL_VL104.status | | |
| TL_VL109 | Automatic2WayValve | status | VEDCSVMC:VTCS_TL_VL109.status | | |
| TL_VL111 | Automatic2WayValve | status | VEDCSVMC:VTCS_TL_VL111.status | | |
| TL_VL112 | Automatic2WayValve | status | VEDCSVMC:VTCS_TL_VL112.status | | |
| TR_VL102 | Automatic2WayValve | status | VEDCSVMC:VTCS_TR_VL102.status | | |
| TR_VL103 | Automatic3WayValve | status | VEDCSVMC:VTCS_TR_VL103.status | | |
| TR_VL104 | Automatic2WayValve | status | VEDCSVMC:VTCS_TR_VL104.status | | |
| TR_VL108 | Automatic3WayValve | status | VEDCSVMC:VTCS_TR_VL108.status | | |
| TR_VL109 | Automatic2WayValve | status | VEDCSVMC:VTCS_TR_VL109.status | | |
| TR_VL111 | Automatic2WayValve | status | VEDCSVMC:VTCS_TR_VL111.status | | |
| TR_VL112 | Automatic2WayValve | status | VEDCSVMC:VTCS_TR_VL112.status | | |

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| TLR_VL101 | Automatic3WayValve | status | VEDCSVMC:VTCS_TLR_VL101.status | | |
| TLR_VL109 | Automatic3WayValve | status | VEDCSVMC:VTCS_TLR_VL109.status | | |
| TLR_VL110 | Automatic2WayValve | status | VEDCSVMC:VTCS_TLR_VL110.status | | |
| TLR_VL111 | Automatic2WayValve | status | VEDCSVMC:VTCS_TLR_VL111.status | | |
| SA_VL106 | AutomaticRegulatingValve | Position | VEDCSVMC:VTCS_SA_VL106.Position | SA_SystemValues | SA_VL106.posi |
| SA_VL106 | AutomaticRegulatingValve | status | VEDCSVMC:VTCS_SA_VL106.status | | |
| SA_VL110 | AutomaticRegulatingValve | Position | VEDCSVMC:VTCS_SA_VL110.Position | SA_SystemValues | SA_VL110.posi |
| SA_VL110 | AutomaticRegulatingValve | status | VEDCSVMC:VTCS_SA_VL110.status | | |
| SA_VL114 | AutomaticRegulatingValve | Position | VEDCSVMC:VTCS_SA_VL114.Position | SA_SystemValues | SA_VL114.posi |
| SA_VL114 | AutomaticRegulatingValve | status | VEDCSVMC:VTCS_SA_VL114.status | | |
| SA_VL119 | AutomaticRegulatingValve | Position | VEDCSVMC:VTCS_SA_VL119.Position | SA_SystemValues | SA_VL119.posi |
| SA_VL119 | AutomaticRegulatingValve | status | VEDCSVMC:VTCS_SA_VL119.status | | |
| SB_VL106 | AutomaticRegulatingValve | Position | VEDCSVMC:VTCS_SB_VL106.Position | SB_SystemValues | SB_VL106.posi |
| SB_VL106 | AutomaticRegulatingValve | status | VEDCSVMC:VTCS_SB_VL106.status | | |
| SB_VL110 | AutomaticRegulatingValve | Position | VEDCSVMC:VTCS_SB_VL110.Position | SB_SystemValues | SB_VL110.posi |
| SB_VL110 | AutomaticRegulatingValve | status | VEDCSVMC:VTCS_SB_VL110.status | | |
| SB_VL114 | AutomaticRegulatingValve | Position | VEDCSVMC:VTCS_SB_VL114.Position | SB_SystemValues | SB_VL114.posi |
| SB_VL114 | AutomaticRegulatingValve | status | VEDCSVMC:VTCS_SB_VL114.status | | |
| SB_VL119 | AutomaticRegulatingValve | Position | VEDCSVMC:VTCS_SB_VL119.Position | SB_SystemValues | SB_VL119.posi |
| SB_VL119 | AutomaticRegulatingValve | status | VEDCSVMC:VTCS_SB_VL119.status | | |
| TL_LT101 | LevelTransmitter | Level | VEDCSVMC:VTCS_TL_LT101.Level | TL_System_Sensors_A | TL_LT101.levl |
| TL_LT101 | LevelTransmitter | status | VEDCSVMC:VTCS_TL_LT101.status | | |
| TL_LT101 | LevelTransmitter | raw | VEDCSVMC:VTCS_TL_LT101.raw | TL_System_Sensors_A | TL_LT101.rawl |
| TR_LT101 | LevelTransmitter | Level | VEDCSVMC:VTCS_TR_LT101.Level | TR_System_Sensors_A | TR_LT101.levl |
| TR_LT101 | LevelTransmitter | status | VEDCSVMC:VTCS_TR_LT101.status | | |
| TR_LT101 | LevelTransmitter | raw | VEDCSVMC:VTCS_TR_LT101.raw | TR_System_Sensors_A | TR_LT101.rawl |
| TL_HT001 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT001.Power | TL_System_Sensors_B | TL_HT001.powr |
| TL_HT002 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT002.Power | TL_System_Sensors_B | TL_HT002.powr |
| TL_HT003 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT003.Power | TL_System_Sensors_B | TL_HT003.powr |
| TL_HT004 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT004.Power | TL_System_Sensors_B | TL_HT004.powr |
| TL_HT001 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT001.Power | TL_System_Sensors_B | TL_HT001.powr |
| TL_HT002 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT002.Power | TL_System_Sensors_B | TL_HT002.powr |
| TL_HT003 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT003.Power | TL_System_Sensors_B | TL_HT003.powr |
| TL_HT004 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT004.Power | TL_System_Sensors_B | TL_HT004.powr |
| TL_HT001 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT001.Power | TL_System_Sensors_B | TL_HT001.powr |
| TL_HT002 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT002.Power | TL_System_Sensors_B | TL_HT002.powr |
| TL_HT003 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT003.Power | TL_System_Sensors_B | TL_HT003.powr |
| TL_HT004 | BasePlateHeater | Power | VEDCSVMC:VTCS_TL_HT004.Power | TL_System_Sensors_B | TL_HT004.powr |
| TL_HT030 | HeaterSwitch | bit | VEDCSVMC:VTCS_TL_HT030.bit | TL_System_Sensors_A | TL_HT030.PWon |
| TL_HT101 | Heater | Power | VEDCSVMC:VTCS_TL_HT101.Power | TL_System_Sensors_B | TL_HT101.powr |
| TL_HT102 | Heater | Power | VEDCSVMC:VTCS_TL_HT102.Power | TL_System_Sensors_B | TL_HT102.powr |
| TL_HT103 | Heater | Power | VEDCSVMC:VTCS_TL_HT103.Power | TL_System_Sensors_B | TL_HT103.powr |
| TL_HT104 | Heater | Power | VEDCSVMC:VTCS_TL_HT104.Power | TL_System_Sensors_B | TL_HT104.powr |
| TL_HT105 | Heater | Power | VEDCSVMC:VTCS_TL_HT105.Power | TL_System_Sensors_B | TL_HT105.powr |
| TR_HT001 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT001.Power | TR_System_Sensors_B | TR_HT001.powr |
| TR_HT002 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT002.Power | TR_System_Sensors_B | TR_HT002.powr |
| TR_HT003 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT003.Power | TR_System_Sensors_B | TR_HT003.powr |
| TR_HT004 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT004.Power | TR_System_Sensors_B | TR_HT004.powr |
| TR_HT001 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT001.Power | TR_System_Sensors_B | TR_HT001.powr |

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| TR_HT002 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT002.Power | TR_System_Sensors_B | TR_HT002.powr |
| TR_HT003 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT003.Power | TR_System_Sensors_B | TR_HT003.powr |
| TR_HT004 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT004.Power | TR_System_Sensors_B | TR_HT004.powr |
| TR_HT001 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT001.Power | TR_System_Sensors_B | TR_HT001.powr |
| TR_HT002 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT002.Power | TR_System_Sensors_B | TR_HT002.powr |
| TR_HT003 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT003.Power | TR_System_Sensors_B | TR_HT003.powr |
| TR_HT004 | BasePlateHeater | Power | VEDCSVMC:VTCS_TR_HT004.Power | TR_System_Sensors_B | TR_HT004.powr |
| TR_HT030 | HeaterSwitch | bit | VEDCSVMC:VTCS_TR_HT030.bit | TR_System_Sensors_A | TR_HT030.PWon |
| TR_HT101 | Heater | Power | VEDCSVMC:VTCS_TR_HT101.Power | TR_System_Sensors_B | TR_HT101.powr |
| TR_HT102 | Heater | Power | VEDCSVMC:VTCS_TR_HT102.Power | TR_System_Sensors_B | TR_HT102.powr |
| TR_HT103 | Heater | Power | VEDCSVMC:VTCS_TR_HT103.Power | TR_System_Sensors_B | TR_HT103.powr |
| TR_HT104 | Heater | Power | VEDCSVMC:VTCS_TR_HT104.Power | TR_System_Sensors_B | TR_HT104.powr |
| TR_HT105 | Heater | Power | VEDCSVMC:VTCS_TR_HT105.Power | TR_System_Sensors_B | TR_HT105.powr |
| TLR_HT102 | Heater | Power | VEDCSVMC:VTCS_TLR_HT102.Power | TLR_SystemSensors | TM_HT102.powr |
| Tx_HTenb | HeaterSwitch | bit | VEDCSVMC:VTCS_Tx_HTenb.bit | TL_System_Sensors_B | Tx_HTenb.stat |
| Tx_HTclx | HeaterSwitch | bit | VEDCSVMC:VTCS_Tx_HTclx.bit | TL_System_Sensors_B | Tx_HTclx.stat |
| TL_PM101 | Pump | On | VEDCSVMC:VTCS_TL_PM101.On | TL_System_Sensors_B | TL_PM101.SWon |
| TL_PM101 | Pump | Th_rel_status | VEDCSVMC:VTCS_TL_PM101.Th_rel_status | TL_System_Sensors_B | TL_PM101.TRon |
| TL_PM101 | Pump | pres_ok | VEDCSVMC:VTCS_TL_PM101.pres_ok | TL_System_Sensors_B | TL_PM101.PRok |
| TL_PM101 | Pump | valves_ok | VEDCSVMC:VTCS_TL_PM101.valves_ok | TL_System_Sensors_B | TL_PM101.VLok |
| TR_PM101 | Pump | On | VEDCSVMC:VTCS_TR_PM101.On | TR_System_Sensors_B | TR_PM101.SWon |
| TR_PM101 | Pump | Th_rel_status | VEDCSVMC:VTCS_TR_PM101.Th_rel_status | TR_System_Sensors_B | TR_PM101.TRon |
| TR_PM101 | Pump | pres_ok | VEDCSVMC:VTCS_TR_PM101.pres_ok | TR_System_Sensors_B | TR_PM101.PRok |
| TR_PM101 | Pump | valves_ok | VEDCSVMC:VTCS_TR_PM101.valves_ok | TR_System_Sensors_B | TR_PM101.VLok |
| TLR_PM101 | Pump | On | VEDCSVMC:VTCS_TLR_PM101.On | TLR_SystemSensors | TM_PM101.SWon |
| TLR_PM101 | Pump | Th_rel_status | VEDCSVMC:VTCS_TLR_PM101.Th_rel_status | TLR_SystemSensors | TM_PM101.TRon |
| TLR_PM101 | Pump | pres_ok | VEDCSVMC:VTCS_TLR_PM101.pres_ok | TLR_SystemSensors | TM_PM101.PRok |
| TLR_PM101 | Pump | valves_ok | VEDCSVMC:VTCS_TLR_PM101.valves_ok | TLR_SystemSensors | TM_PM101.VLok |
| TLR_PM101 | Pump | NA | | | |
| SA_PM101 | ControlledCompressor | FREQ_ACTUAL | VEDCSVMC:VTCS_SA_PM101.FREQ_ACTUAL | SA_SystemValues | SA_PM101.FRac |
| SA_PM101 | ControlledCompressor | FREQ_SETP | VEDCSVMC:VTCS_SA_PM101.FREQ_SETP | SA_SystemValues | SA_PM101.FRtr |
| SA_PM101 | ControlledCompressor | On | VEDCSVMC:VTCS_SA_PM101.On | SA_SystemValues | SA_PM101.SWon |
| SA_PM101 | ControlledCompressor | motor_protect_ok | VEDCSVMC:VTCS_SA_PM101.motor_protect_ok | SA_SystemValues | SA_PM101.MPok |
| SA_PM101 | ControlledCompressor | pres_ok | VEDCSVMC:VTCS_SA_PM101.pres_ok | SA_SystemValues | SA_PM101.PRok |
| SA_PM101 | ControlledCompressor | CURRENT | VEDCSVMC:VTCS_SA_PM101.CURRENT | SA_SystemValues | SA_PM101.curr |
| SA_PM101 | ControlledCompressor | CTRL_WORD1 | VEDCSVMC:VTCS_SA_PM101.CTRL_WORD1 | | |
| SA_PM101 | ControlledCompressor | CTRL_WORD2 | VEDCSVMC:VTCS_SA_PM101.CTRL_WORD2 | | |
| SA_PM101 | ControlledCompressor | STATUS_WORD1 | VEDCSVMC:VTCS_SA_PM101.STATUS_WORD1 | | |
| SA_PM101 | ControlledCompressor | STATUS_WORD2 | VEDCSVMC:VTCS_SA_PM101.STATUS_WORD2 | | |
| SB_PM101 | Compressor | On | VEDCSVMC:VTCS_SB_PM101.On | SB_SystemValues | SB_PM101.SWon |
| SB_PM101 | Compressor | Th_rel_status | VEDCSVMC:VTCS_SB_PM101.Th_rel_status | SB_SystemValues | SB_PM101.TRon |
| SB_PM101 | Compressor | pres_ok | VEDCSVMC:VTCS_SB_PM101.pres_ok | SB_SystemValues | SB_PM101.PRok |
| TL_BA001---base_freezing | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BA001---base_freezing.Alarm | TL_Alarms | TL_BA001.alrm |
| TL_BA002---base_too_hot_TT037 | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BA002---base_too_hot_TT037.Alarm | TL_Alarms | TL_BA002.alrm |
| TL_BA003---base_too_hot_TT038 | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BA003---base_too_hot_TT038.Alarm | TL_Alarms | TL_BA003.alrm |
| TL_BA004---base_too_hot_TT039 | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BA004---base_too_hot_TT039.Alarm | TL_Alarms | TL_BA004.alrm |
| TL_BA005---base_too_hot_TT040 | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BA005--- | TL_Alarms | TL_BA005.alrm |

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| | | | base_too_hot_TT040.Alarm | | |
| TL_BA006---base_TT037_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BA006---base_TT037_error.Alarm | TL_Alarms | TL_BA006.alrm |
| TL_BA007---base_TT038_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BA007---base_TT038_error.Alarm | TL_Alarms | TL_BA007.alrm |
| TL_BA008---base_TT039_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BA008---base_TT039_error.Alarm | TL_Alarms | TL_BA008.alrm |
| TL_BA009---base_TT040_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BA009---base_TT040_error.Alarm | TL_Alarms | TL_BA009.alrm |
| TL_BW002---base_too_cold_TT037 | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BW002---base_too_cold_TT037.Alarm | TL_Alarms | TL_BW002.alrm |
| TL_BW003---base_too_cold_TT038 | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BW003---base_too_cold_TT038.Alarm | TL_Alarms | TL_BW003.alrm |
| TL_BW004---base_too_cold_TT039 | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BW004---base_too_cold_TT039.Alarm | TL_Alarms | TL_BW004.alrm |
| TL_BW005---base_too_cold_TT040 | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_BW005---base_too_cold_TT040.Alarm | TL_Alarms | TL_BW005.alrm |
| TR_BA001---base_freezing | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BA001---base_freezing.Alarm | TR_Alarms | TR_BA001.alrm |
| TR_BA002---base_too_hot_TT037 | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BA002---base_too_hot_TT037.Alarm | TR_Alarms | TR_BA002.alrm |
| TR_BA003---base_too_hot_TT038 | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BA003---base_too_hot_TT038.Alarm | TR_Alarms | TR_BA003.alrm |
| TR_BA004---base_too_hot_TT039 | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BA004---base_too_hot_TT039.Alarm | TR_Alarms | TR_BA004.alrm |
| TR_BA005---base_too_hot_TT040 | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BA005---base_too_hot_TT040.Alarm | TR_Alarms | TR_BA005.alrm |
| TR_BA006---base_TT037_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BA006---base_TT037_error.Alarm | TR_Alarms | TR_BA006.alrm |
| TR_BA007---base_TT038_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BA007---base_TT038_error.Alarm | TR_Alarms | TR_BA007.alrm |
| TR_BA008---base_TT039_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BA008---base_TT039_error.Alarm | TR_Alarms | TR_BA008.alrm |
| TR_BA009---base_TT040_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BA009---base_TT040_error.Alarm | TR_Alarms | TR_BA009.alrm |
| TR_BW002---base_too_cold_TT037 | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BW002---base_too_cold_TT037.Alarm | TR_Alarms | TR_BW002.alrm |
| TR_BW003---base_too_cold_TT038 | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BW003---base_too_cold_TT038.Alarm | TR_Alarms | TR_BW003.alrm |
| TR_BW004---base_too_cold_TT039 | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BW004---base_too_cold_TT039.Alarm | TR_Alarms | TR_BW004.alrm |
| TR_BW005---base_too_cold_TT040 | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_BW005---base_too_cold_TT040.Alarm | TR_Alarms | TR_BW005.alrm |
| Tx_BA002---FM455_error | AlarmBit | Alarm | VEDCSVMC:VTCS_Tx_BA002---FM455_error.Alarm | TLR_SA_SB_xx_Alarms | Tx_BA002.alrm |
| Tx_BA003---baseplate_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_Tx_BA003---baseplate_alarm.Alarm | TLR_SA_SB_xx_Alarms | Tx_BA003.alrm |
| Tx_HA101---Clixon_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_Tx_HA101---Clixon_alarm.Alarm | TLR_SA_SB_xx_Alarms | Tx_HA101.alrm |
| TL_HA030---bridge_htr2_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA030---bridge_htr2_too_hot.Alarm | TL_Alarms | TL_HA030.alrm |
| TL_HA101---HT102_too_cold | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA101---HT102_too_cold.Alarm | TL_Alarms | TL_HA101.alrm |
| TL_HA102---HT102_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA102---HT102_too_hot.Alarm | TL_Alarms | TL_HA102.alrm |
| TL_HA103---HT103_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA103---HT103_too_hot.Alarm | TL_Alarms | TL_HA103.alrm |
| TL_HA104---HT104_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA104---HT104_too_hot.Alarm | TL_Alarms | TL_HA104.alrm |
| TL_HA105---HT105_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA105---HT105_too_hot.Alarm | TL_Alarms | TL_HA105.alrm |
| TL_HA111---TT121_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA111---TT121_error.Alarm | TL_Alarms | TL_HA111.alrm |
| TL_HA112---TT122_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA112---TT122_error.Alarm | TL_Alarms | TL_HA112.alrm |
| TL_HA113---TT123_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA113---TT123_error.Alarm | TL_Alarms | TL_HA113.alrm |
| TL_HA114---TT124_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA114---TT124_error.Alarm | TL_Alarms | TL_HA114.alrm |
| TL_HA115---TT125_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HA115---TT125_error.Alarm | TL_Alarms | TL_HA115.alrm |
| TL_HW102---HT102_hot_warning | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HW102---HT102_hot_warning.Alarm | TL_Alarms | TL_HW102.alrm |
| TL_HW103---HT103_hot_warning | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HW103--- | TL_Alarms | TL_HW103.alrm |

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| | | | HT103_hot_warning.Alarm | | |
| TL_HW104---HT104_hot_warning | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HW104---HT104_hot_warning.Alarm | TL_Alarms | TL_HW104.alrm |
| TL_HW105---HT105_hot_warning | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_HW105---HT105_hot_warning.Alarm | TL_Alarms | TL_HW105.alrm |
| TR_HA030---bridge_htr1_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA030---bridge_htr1_too_hot.Alarm | TR_Alarms | TR_HA030.alrm |
| TR_HA101---HT102_too_cold | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA101---HT102_too_cold.Alarm | TR_Alarms | TR_HA101.alrm |
| TR_HA102---HT102_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA102---HT102_too_hot.Alarm | TR_Alarms | TR_HA102.alrm |
| TR_HA103---HT103_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA103---HT103_too_hot.Alarm | TR_Alarms | TR_HA103.alrm |
| TR_HA104---HT104_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA104---HT104_too_hot.Alarm | TR_Alarms | TR_HA104.alrm |
| TR_HA105---HT105_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA105---HT105_too_hot.Alarm | TR_Alarms | TR_HA105.alrm |
| TR_HA111---TT121_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA111---TT121_error.Alarm | TR_Alarms | TR_HA111.alrm |
| TR_HA112---TT122_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA112---TT122_error.Alarm | TR_Alarms | TR_HA112.alrm |
| TR_HA113---TT123_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA113---TT123_error.Alarm | TR_Alarms | TR_HA113.alrm |
| TR_HA114---TT124_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA114---TT124_error.Alarm | TR_Alarms | TR_HA114.alrm |
| TR_HA115---TT125_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HA115---TT125_error.Alarm | TR_Alarms | TR_HA115.alrm |
| TR_HW102---HT102_hot_warning | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HW102---HT102_hot_warning.Alarm | TR_Alarms | TR_HW102.alrm |
| TR_HW103---HT103_hot_warning | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HW103---HT103_hot_warning.Alarm | TR_Alarms | TR_HW103.alrm |
| TR_HW104---HT104_hot_warning | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HW104---HT104_hot_warning.Alarm | TR_Alarms | TR_HW104.alrm |
| TR_HW105---HT105_hot_warning | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_HW105---HT105_hot_warning.Alarm | TR_Alarms | TR_HW105.alrm |
| TLR_HA101---HT102_too_cold | AlarmBit | Alarm | VEDCSVMC:VTCS_TLR_HA101---HT102_too_cold.Alarm | TLR_SA_SB_xx_Alarms | TM_HA101.alrm |
| TLR_HA102---HT102_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_TLR_HA102---HT102_too_hot.Alarm | TLR_SA_SB_xx_Alarms | TM_HA102.alrm |
| TLR_HA112---TT122_error | AlarmBit | Alarm | VEDCSVMC:VTCS_TLR_HA112---TT122_error.Alarm | TLR_SA_SB_xx_Alarms | TM_HA112.alrm |
| TLR_HW102---HT102_hot_warning | AlarmBit | Alarm | VEDCSVMC:VTCS_TLR_HW102---HT102_hot_warning.Alarm | TLR_SA_SB_xx_Alarms | TM_HW102.alrm |
| TL_PA101---PT104_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_PA101---PT104_TOO_HIGH.Alarm | TL_Alarms | TL_PA101.alrm |
| TL_PA102---PT104_101_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_PA102---PT104_101_TOO_HIGH.Alarm | TL_Alarms | TL_PA102.alrm |
| TL_PA103---PT104_101_TOO_LOW | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_PA103---PT104_101_TOO_LOW.Alarm | TL_Alarms | TL_PA103.alrm |
| TL_PA106---PM101_membr_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_PA106---PM101_membr_alarm.Alarm | TL_Alarms | TL_PA106.alrm |
| TL_PA107---ACCU_PRES_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_PA107---ACCU_PRES_TOO_HIGH.Alarm | TL_Alarms | TL_PA107.alrm |
| TL_PA108---ANY_PT_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_PA108---ANY_PT_TOO_HIGH.Alarm | TL_Alarms | TL_PA108.alrm |
| TR_PA101---PT104_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_PA101---PT104_TOO_HIGH.Alarm | TR_Alarms | TR_PA101.alrm |
| TR_PA102---PT104_101_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_PA102---PT104_101_TOO_HIGH.Alarm | TR_Alarms | TR_PA102.alrm |
| TR_PA103---PT104_101_TOO_LOW | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_PA103---PT104_101_TOO_LOW.Alarm | TR_Alarms | TR_PA103.alrm |
| TR_PA106---PM101_membr_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_PA106---PM101_membr_alarm.Alarm | TR_Alarms | TR_PA106.alrm |
| TR_PA107---ACCU_PRES_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_PA107---ACCU_PRES_TOO_HIGH.Alarm | TR_Alarms | TR_PA107.alrm |
| TR_PA108---ANY_PT_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_PA108---ANY_PT_TOO_HIGH.Alarm | TR_Alarms | TR_PA108.alrm |

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|---|---|---|---|---|---|
| TLR_PA101---PT104_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TLR_PA101---PT104_TOO_HIGH.Alarm | TLR_SA_SB_xx_Alarms | TM_PA101.alrm |
| TLR_PA102---PT104-101_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_TLR_PA102---PT104-101_TOO_HIGH.Alarm | TLR_SA_SB_xx_Alarms | TM_PA102.alrm |
| TLR_PA103---PT104-101_TOO_LOW | AlarmBit | Alarm | VEDCSVMC:VTCS_TLR_PA103---PT104-101_TOO_LOW.Alarm | TLR_SA_SB_xx_Alarms | TM_PA103.alrm |
| TLR_PA106---PM101_membr_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_TLR_PA106---PM101_membr_alarm.Alarm | TLR_SA_SB_xx_Alarms | TM_PA106.alrm |
| SA_PA101---SA_PT108_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_SA_PA101---SA_PT108_TOO_HIGH.Alarm | TLR_SA_SB_xx_Alarms | SA_PA101.alrm |
| SA_PA102---SA_PT108_TOO_LOW | AlarmBit | Alarm | VEDCSVMC:VTCS_SA_PA102---SA_PT108_TOO_LOW.Alarm | TLR_SA_SB_xx_Alarms | SA_PA102.alrm |
| SA_PA103---SA_COMPR_LIQUID_IN | AlarmBit | Alarm | VEDCSVMC:VTCS_SA_PA103---SA_COMPR_LIQUID_IN.Alarm | TLR_SA_SB_xx_Alarms | SA_PA103.alrm |
| SB_PA101---SB_PT108_TOO_HIGH | AlarmBit | Alarm | VEDCSVMC:VTCS_SB_PA101---SB_PT108_TOO_HIGH.Alarm | TLR_SA_SB_xx_Alarms | SB_PA101.alrm |
| SB_PA102---SB_PT108_TOO_LOW | AlarmBit | Alarm | VEDCSVMC:VTCS_SB_PA102---SB_PT108_TOO_LOW.Alarm | TLR_SA_SB_xx_Alarms | SB_PA102.alrm |
| SB_PA103---SB_COMPR_LIQUID_IN | AlarmBit | Alarm | VEDCSVMC:VTCS_SB_PA103---SB_COMPR_LIQUID_IN.Alarm | TLR_SA_SB_xx_Alarms | SB_PA103.alrm |
| TL_MW101---accu_max_setpoint | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_MW101---accu_max_setpoint.Alarm | TL_Alarms | TL_MW101.alrm |
| TL_MW102---accu_timeout_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_MW102---accu_timeout_alarm.Alarm | TL_Alarms | TL_MW102.alrm |
| TL_MA101---$CO_2$_frost_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_MA101---$CO_2$_frost_alarm.Alarm | TL_Alarms | TL_MA101.alrm |
| TL_MA102---$CO_2$_frost_alarm_SB | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_MA102---$CO_2$_frost_alarm_SB.Alarm | TL_Alarms | TL_MA102.alrm |
| TL_MA103---PM101_therm_relay_on | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_MA103---PM101_therm_relay_on.Alarm | TL_Alarms | TL_MA103.alrm |
| TL_MA104---too_warm_accu | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_MA104---too_warm_accu.Alarm | TL_Alarms | TL_MA104.alrm |
| TL_MA105---too_warm_cookie | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_MA105---too_warm_cookie.Alarm | TL_Alarms | TL_MA105.alrm |
| TL_MA106---too_warm | AlarmBit | Alarm | VEDCSVMC:VTCS_TL_MA106---too_warm.Alarm | TL_Alarms | TL_MA106.alrm |
| TR_MW101---accu_max_setpoint | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_MW101---accu_max_setpoint.Alarm | TR_Alarms | TR_MW101.alrm |
| TR_MW102---accu_timeout_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_MW102---accu_timeout_alarm.Alarm | TR_Alarms | TR_MW102.alrm |
| TR_MA101---$CO_2$_frost_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_MA101---$CO_2$_frost_alarm.Alarm | TR_Alarms | TR_MA101.alrm |
| TR_MA102---$CO_2$_frost_alarm_SB | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_MA102---$CO_2$_frost_alarm_SB.Alarm | TR_Alarms | TR_MA102.alrm |
| TR_MA103---PM101_therm_relay_on | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_MA103---PM101_therm_relay_on.Alarm | TR_Alarms | TR_MA103.alrm |
| TR_MA104---too_warm_accu | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_MA104---too_warm_accu.Alarm | TR_Alarms | TR_MA104.alrm |
| TR_MA105---too_warm_cookie | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_MA105---too_warm_cookie.Alarm | TR_Alarms | TR_MA105.alrm |
| TR_MA106---too_warm | AlarmBit | Alarm | VEDCSVMC:VTCS_TR_MA106---too_warm.Alarm | TR_Alarms | TR_MA106.alrm |
| TLR_MA103---PM101_therm_relay_on | AlarmBit | Alarm | VEDCSVMC:VTCS_TLR_MA103---PM101_therm_relay_on.Alarm | TLR_SA_SB_xx_Alarms | TM_MA10.alrm |
| SA_MA101---SA_drive_fault | AlarmBit | Alarm | VEDCSVMC:VTCS_SA_MA101---SA_drive_fault.Alarm | TLR_SA_SB_xx_Alarms | SA_MA101.alrm |
| SA_MA102---SA_drive_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_SA_MA102---SA_drive_alarm.Alarm | TLR_SA_SB_xx_Alarms | SA_MA102.alrm |
| SA_MA103---SA_PM101_motorprotection | AlarmBit | Alarm | VEDCSVMC:VTCS_SA_MA103---SA_PM101_motorprotection.Alarm | TLR_SA_SB_xx_Alarms | SA_MA103.alrm |
| SA_MA104---PA_coolingwater_too_hot | AlarmBit | Alarm | VEDCSVMC:VTCS_SA_MA104---PA_coolingwater_too_hot.Alarm | TLR_SA_SB_xx_Alarms | SA_MA104.alrm |
| SB_MA103---SB_PM101_therm_relay_on | AlarmBit | Alarm | VEDCSVMC:VTCS_SB_MA103---SB_PM101_therm_relay_on.Alarm | TLR_SA_SB_xx_Alarms | SB_MA103.alrm |
| xx_MA101---exd1311_pwr(SA)_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_xx_MA101--- | TLR_SA_SB_xx_Alarms | xx_MA101.alrm |

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| | | | exd1311_pwr(SA)_alarm.Alarm | | |
| xx_MA102---exd1306_pwr(htr)_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_xx_MA102---exd1306_pwr(htr)_alarm.Alarm | TLR_SA_SB_xx_Alarms | xx_MA102.alrm |
| xx_MA103---esd205_pwr(diesel)_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_xx_MA103---esd205_pwr(diesel)_alarm.Alarm | TLR_SA_SB_xx_Alarms | xx_MA103.alrm |
| xx_MA104---venting_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_xx_MA104---venting_alarm.Alarm | TLR_SA_SB_xx_Alarms | xx_MA104.alrm |
| xx_MA105---haptas_alarm | AlarmBit | Alarm | VEDCSVMC:VTCS_xx_MA105---haptas_alarm.Alarm | TLR_SA_SB_xx_Alarms | xx_MA105.alrm |
| xx_MA106---ref_pt100_error | AlarmBit | Alarm | VEDCSVMC:VTCS_xx_MA106---ref_pt100_error.Alarm | TLR_SA_SB_xx_Alarms | xx_MA106.alrm |
| TL_MA105---haptas_error_vector | AlarmByte | Alarm | VEDCSVMC:VTCS_TL_MA105---haptas_error_vector.Alarm | | |
| TR_MA105---haptas_error_vector | AlarmByte | Alarm | VEDCSVMC:VTCS_TR_MA105---haptas_error_vector.Alarm | | |
| TLR_MA105---haptas_error_vector | AlarmByte | Alarm | VEDCSVMC:VTCS_TLR_MA105---haptas_error_vector.Alarm | | |
| TL_VA102---VL102_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TL_VA102---VL102_alarm.Alarm | | |
| TL_VA103---VL103_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TL_VA103---VL103_alarm.Alarm | | |
| TL_VA104---VL104_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TL_VA104---VL104_alarm.Alarm | | |
| TL_VA109---VL109_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TL_VA109---VL109_alarm.Alarm | | |
| TL_VA111---VL111_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TL_VA111---VL111_alarm.Alarm | | |
| TL_VA112---VL112_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TL_VA112---VL112_alarm.Alarm | | |
| TR_VA102---VL102_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TR_VA102---VL102_alarm.Alarm | | |
| TR_VA103---VL103_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TR_VA103---VL103_alarm.Alarm | | |
| TR_VA104---VL104_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TR_VA104---VL104_alarm.Alarm | | |
| TR_VA108---VL108_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TR_VA108---VL108_alarm.Alarm | | |
| TR_VA109---VL109_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TR_VA109---VL109_alarm.Alarm | | |
| TR_VA111---VL111_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TR_VA111---VL111_alarm.Alarm | | |
| TR_VA112---VL112_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TR_VA112---VL112_alarm.Alarm | | |
| TLR_VA101---VL101_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TLR_VA101---VL101_alarm.Alarm | | |
| TLR_VA109---VL109_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TLR_VA109---VL109_alarm.Alarm | | |
| TLR_VA110---VL110_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TLR_VA110---VL110_alarm.Alarm | | |
| TLR_VA111---VL111_alarm | AlarmByte | Alarm | VEDCSVMC:VTCS_TLR_VA111---VL111_alarm.Alarm | | |
| TL_PC102---sw_vl103_dis_high_p | ClockTimer | timer | VEDCSVMC:VTCS_TL_PC102---sw_vl103_dis_high_p.timer | TL_TR_Timers | TL_PC102.CLtm |
| TL_PC103---PM101_starttimer | ClockTimer | timer | VEDCSVMC:VTCS_TL_PC103---PM101_starttimer.timer | TL_TR_Timers | TL_PC103.CLtm |
| TL_PC104---sw_trans_dis_low_p | ClockTimer | timer | VEDCSVMC:VTCS_TL_PC104---sw_trans_dis_low_p.timer | TL_TR_Timers | TL_PC104.CLtm |
| TL_PC105---pump_wait_timer | ClockTimer | timer | VEDCSVMC:VTCS_TL_PC105---pump_wait_timer.timer | TL_TR_Timers | TL_PC105.CLtm |
| TR_PC102---sw_vl103_dis_high_p | ClockTimer | timer | VEDCSVMC:VTCS_TR_PC102---sw_vl103_dis_high_p.timer | TL_TR_Timers | TR_PC102.CLtm |
| TR_PC103---PM101_starttimer | ClockTimer | timer | VEDCSVMC:VTCS_TR_PC103---PM101_starttimer.timer | TL_TR_Timers | TR_PC103.CLtm |
| TR_PC104---sw_trans_dis_low_p | ClockTimer | timer | VEDCSVMC:VTCS_TR_PC104---sw_trans_dis_low_p.timer | TL_TR_Timers | TR_PC104.CLtm |
| TR_PC105---pump_wait_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_PC105---pump_wait_timer.timer | TL_TR_Timers | TR_PC105.CLtm |
| TLR_PC103---PM101_starttimer | ClockTimer | timer | VEDCSVMC:VTCS_TLR_PC103---PM101_starttimer.timer | xx_Timers | TM_PC103.CLtm |
| SA_PC103---PM101_starttimer | ClockTimer | timer | VEDCSVMC:VTCS_SA_PC103---PM101_starttimer.timer | xx_Timers | SA_PC103.CLtm |
| SA_PC104---wait_liquid_alarm | ClockTimer | timer | VEDCSVMC:VTCS_SA_PC104---wait_liquid_alarm.timer | xx_Timers | SA_PC104.CLtm |
| SB_PC103---PM101_starttimer | ClockTimer | timer | VEDCSVMC:VTCS_SB_PC103---PM101_starttimer.timer | xx_Timers | SB_PC103.CLtm |
| SB_PC104---wait_liquid_alarm | ClockTimer | timer | VEDCSVMC:VTCS_SB_PC104---wait_liquid_alarm.timer | xx_Timers | SB_PC104.CLtm |
| TL_MC102---ACCU_TIMER | ClockTimer | timer | VEDCSVMC:VTCS_TL_MC102---ACCU_TIMER.timer | TL_TR_Timers | TL_MC102.CLtm |
| TL_MC103---wait_frost_alarm | ClockTimer | timer | VEDCSVMC:VTCS_TL_MC103---wait_frost_alarm.timer | TL_TR_Timers | TL_MC103.CLtm |
| TR_MC102---ACCU_TIMER | ClockTimer | timer | VEDCSVMC:VTCS_TR_MC102---ACCU_TIMER.timer | TL_TR_Timers | TR_MC102.CLtm |
| TR_MC103---wait_frost_alarm | ClockTimer | timer | VEDCSVMC:VTCS_TR_MC103---wait_frost_alarm.timer | TL_TR_Timers | TR_MC103.CLtm |
| TL_MC105---haptas_timer | ClockTimer | timer | VEDCSVMC:VTCS_TL_MC105---haptas_timer.timer | TL_TR_Timers | TL_MC105.CLtm |
| TR_MC105---haptas_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_MC105---haptas_timer.timer | TL_TR_Timers | TR_MC105.CLtm |

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|---|---|---|---|---|---|
| TLR_MC105---haptas_timer | ClockTimer | timer | VEDCSVMC:VTCS_TLR_MC105---haptas_timer.timer | xx_Timers | TM_MC105.CLtm |
| TL_VC102---VL102_timer | ClockTimer | timer | VEDCSVMC:VTCS_TL_VC102---VL102_timer.timer | TL_TR_Timers | TL_VC102.CLtm |
| TL_VC103---VL103_timer | ClockTimer | timer | VEDCSVMC:VTCS_TL_VC103---VL103_timer.timer | TL_TR_Timers | TL_VC103.CLtm |
| TL_VC104---VL104_timer | ClockTimer | timer | VEDCSVMC:VTCS_TL_VC104---VL104_timer.timer | TL_TR_Timers | TL_VC104.CLtm |
| TL_VC109---VL109_timer | ClockTimer | timer | VEDCSVMC:VTCS_TL_VC109---VL109_timer.timer | TL_TR_Timers | TL_VC109.CLtm |
| TL_VC111---VL111_timer | ClockTimer | timer | VEDCSVMC:VTCS_TL_VC111---VL111_timer.timer | TL_TR_Timers | TL_VC111.CLtm |
| TL_VC112---VL112_timer | ClockTimer | timer | VEDCSVMC:VTCS_TL_VC112---VL112_timer.timer | TL_TR_Timers | TL_VC112.CLtm |
| TR_VC102---VL102_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_VC102---VL102_timer.timer | TL_TR_Timers | TR_VC102.CLtm |
| TR_VC103---VL103_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_VC103---VL103_timer.timer | TL_TR_Timers | TR_VC103.CLtm |
| TR_VC104---VL104_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_VC104---VL104_timer.timer | TL_TR_Timers | TR_VC104.CLtm |
| TR_VC108---VL108_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_VC108---VL108_timer.timer | TL_TR_Timers | TR_VC108.CLtm |
| TR_VC109---VL109_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_VC109---VL109_timer.timer | TL_TR_Timers | TR_VC109.CLtm |
| TR_VC111---VL111_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_VC111---VL111_timer.timer | TL_TR_Timers | TR_VC111.CLtm |
| TR_VC112---VL112_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_VC112---VL112_timer.timer | TL_TR_Timers | TR_VC112.CLtm |
| TLR_VC101---VL101_timer | ClockTimer | timer | VEDCSVMC:VTCS_TLR_VC101---VL101_timer.timer | xx_Timers | TM_VC110.CLtm |
| TLR_VC109---VL109_timer | ClockTimer | timer | VEDCSVMC:VTCS_TLR_VC109---VL109_timer.timer | xx_Timers | TM_VC109.CLtm |
| TLR_VC110---VL110_timer | ClockTimer | timer | VEDCSVMC:VTCS_TLR_VC110---VL110_timer.timer | xx_Timers | TM_VC110.CLtm |
| TLR_VC111---VL111_timer | ClockTimer | timer | VEDCSVMC:VTCS_TLR_VC111---VL111_timer.timer | xx_Timers | TM_VC111.CLtm |
| TL_HC101---Rth_update_timer | ClockTimer | timer | VEDCSVMC:VTCS_TL_HC101---Rth_update_timer.timer | TL_TR_Timers | TL_HC101.CLtm |
| TR_HC101---Rth_update_timer | ClockTimer | timer | VEDCSVMC:VTCS_TR_HC101---Rth_update_timer.timer | TL_TR_Timers | TR_HC101.CLtm |
| TL_MC106---PM101_maintenance | ClockTimer | timer | VEDCSVMC:VTCS_TL_MC106---PM101_maintenance.timer | TL_TR_Timers | TL_MC106.CLtm |
| TR_MC106---PM101_maintenance | ClockTimer | timer | VEDCSVMC:VTCS_TR_MC106---PM101_maintenance.timer | TL_TR_Timers | TR_MC106.CLtm |
| TLR_MC106---PM101_maintenance | ClockTimer | timer | VEDCSVMC:VTCS_TLR_MC106---PM101_maintenance.timer | xx_Timers | TM_MC106.CLtm |
| TL_MC107---wait_cool_transf | ClockTimer | timer | VEDCSVMC:VTCS_TL_MC107---wait_cool_transf.timer | TL_TR_Timers | TL_MC107.CLtm |
| TR_MC107---wait_cool_transf | ClockTimer | timer | VEDCSVMC:VTCS_TR_MC107---wait_cool_transf.timer | TL_TR_Timers | TR_MC107.CLtm |
| TL_PC106---wait_low_p | ClockTimer | timer | VEDCSVMC:VTCS_TL_PC106---wait_low_p.timer | TL_TR_Timers | TL_PC106.CLtm |
| TR_PC106---wait_low_p | ClockTimer | timer | VEDCSVMC:VTCS_TR_PC106---wait_low_p.timer | TL_TR_Timers | TR_PC106.CLtm |
| xx_MC103---PowerReturnTIimer | ClockTimer | timer | VEDCSVMC:VTCS_xx_MC103---PowerReturnTIimer.timer | xx_Timers | xx_MC103.CLtm |
| TR_PC106---wait_low_p | ClockTimer | timer | VEDCSVMC:VTCS_TR_PC106---wait_low_p.timer | TL_TR_Timers | TR_PC106.CLtm |
| Tx_SC101---TIMEOUT_ACCU_HTR | ClockSetting | timer | VEDCSVMC:VTCS_Tx_SC101---TIMEOUT_ACCU_HTR.timer | xx_Timers | Tx_SC101.CLsp |
| Tx_SC102---WAIT_DISABLE_HIGHP_VL103 | ClockSetting | timer | VEDCSVMC:VTCS_Tx_SC102---WAIT_DISABLE_HIGHP_VL103.timer | xx_Timers | Tx_SC102.CLsp |
| Tx_SC103---WAITTIME_PUMP_SUBCOOL | ClockSetting | timer | VEDCSVMC:VTCS_Tx_SC103---WAITTIME_PUMP_SUBCOOL.timer | xx_Timers | Tx_SC103.CLsp |
| Tx_SC104---WAIT_DISABLE_LOWP | ClockSetting | timer | VEDCSVMC:VTCS_Tx_SC104---WAIT_DISABLE_LOWP.timer | xx_Timers | Tx_SC104.CLsp |
| Tx_SC105---WAIT_DP_ALARM | ClockSetting | timer | VEDCSVMC:VTCS_Tx_SC105---WAIT_DP_ALARM.timer | xx_Timers | Tx_SC105.CLsp |
| Tx_SC106---TIMEOUT_2WAY_VALVE | ClockSetting | timer | VEDCSVMC:VTCS_Tx_SC106---TIMEOUT_2WAY_VALVE.timer | xx_Timers | Tx_SC106.CLsp |
| Tx_SC107---TIMEOUT_3WAY_VALVE | ClockSetting | timer | VEDCSVMC:VTCS_Tx_SC107---TIMEOUT_3WAY_VALVE.timer | xx_Timers | Tx_SC107.CLsp |
| Tx-SC108---MAX_TIME_COOL_TRANS_LINE | ClockSetting | timer | VEDCSVMC:VTCS_Tx-SC108---MAX_TIME_COOL_TRANS_LINE.timer | xx_Timers | Tx-SC108.CLsp |
| Tx-SC109---WAIT_DP_ALARM | ClockSetting | timer | VEDCSVMC:VTCS_Tx-SC109---WAIT_DP_ALARM.timer | xx_Timers | Tx-SC109.CLsp |
| xx-SC103---WAIT_POWER_RETURN | ClockSetting | timer | VEDCSVMC:VTCS_xx-SC103---WAIT_POWER_RETURN.timer | xx_Timers | xx-SC103.CLsp |
| TL_SC103---MAX_STARTTIME | ClockSetting | timer | VEDCSVMC:VTCS_TL_SC103---MAX_STARTTIME.timer | TL_TR_Timers | TL_SC103.CLsp |
| TR_SC103---MAX_STARTTIME | ClockSetting | timer | VEDCSVMC:VTCS_TR_SC103---MAX_STARTTIME.timer | TL_TR_Timers | TR_SC103.CLsp |

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|---|---|---|---|---|---|
| TLR_SC103---MAX_STARTTIME | ClockSetting | timer | VEDCSVMC:VTCS_TLR_SC103---MAX_STARTTIME.timer | xx_Timers | TM_SC103.CLsp |
| SA_SC103---MAX_STARTTIME | ClockSetting | timer | VEDCSVMC:VTCS_SA_SC103---MAX_STARTTIME.timer | xx_Timers | SA_SC103.CLsp |
| SA_SC104---WAIT_LIQUID_ALARM | ClockSetting | timer | VEDCSVMC:VTCS_SA_SC104---WAIT_LIQUID_ALARM.timer | xx_Timers | SA_SC104.CLsp |
| SB_SC102---WAIT_FROST_ALARM | ClockSetting | timer | VEDCSVMC:VTCS_SB_SC102---WAIT_FROST_ALARM.timer | xx_Timers | SB_SC102.CLsp |
| SB_SC103---MAX_STARTTIME | ClockSetting | timer | VEDCSVMC:VTCS_SB_SC103---MAX_STARTTIME.timer | xx_Timers | SB_SC103.CLsp |
| SB_SC104---WAIT_LIQUID_ALARM | ClockSetting | timer | VEDCSVMC:VTCS_SB_SC104---WAIT_LIQUID_ALARM.timer | xx_Timers | SB_SC104.CLsp |
| Tx_BL001---BASEPLATE_FREEZING | Limit | Limit | VEDCSVMC:VTCS_Tx_BL001---BASEPLATE_FREEZING.Limit | Tx_Limits | Tx_BL001.lmit |
| TL_BL002---MAX_TEMP_BASEPLATE | Limit | Limit | VEDCSVMC:VTCS_TL_BL002---MAX_TEMP_BASEPLATE.Limit | Tx_Limits | TL_BL002.lmit |
| TL_BL003---MIN_TEMP_BASEPLATE | Limit | Limit | VEDCSVMC:VTCS_TL_BL003---MIN_TEMP_BASEPLATE.Limit | Tx_Limits | TL_BL003.lmit |
| TR_BL002---MAX_TEMP_BASEPLATE | Limit | Limit | VEDCSVMC:VTCS_TR_BL002---MAX_TEMP_BASEPLATE.Limit | Tx_Limits | TR_BL002.lmit |
| TR_BL003---MIN_TEMP_BASEPLATE | Limit | Limit | VEDCSVMC:VTCS_TR_BL003---MIN_TEMP_BASEPLATE.Limit | Tx_Limits | TR_BL003.lmit |
| Tx_HL030---BridgeHeater_max | Limit | Limit | VEDCSVMC:VTCS_Tx_HL030---BridgeHeater_max.Limit | Tx_Limits | Tx_HL030.lmit |
| Tx_HL101---HT102_MIN | Limit | Limit | VEDCSVMC:VTCS_Tx_HL101---HT102_MIN.Limit | Tx_Limits | Tx_HL101.lmit |
| TL_HL102---HT102_MAX | Limit | Limit | VEDCSVMC:VTCS_TL_HL102---HT102_MAX.Limit | Tx_Limits | TL_HL102.lmit |
| TL_HL103---HT103_MAX | Limit | Limit | VEDCSVMC:VTCS_TL_HL103---HT103_MAX.Limit | Tx_Limits | TL_HL103.lmit |
| TL_HL104---HT104_MAX | Limit | Limit | VEDCSVMC:VTCS_TL_HL104---HT104_MAX.Limit | Tx_Limits | TL_HL104.lmit |
| TL_HL105---HT105_MAX | Limit | Limit | VEDCSVMC:VTCS_TL_HL105---HT105_MAX.Limit | Tx_Limits | TL_HL105.lmit |
| TL_HL106---HT102_MAX_WARN | Limit | Limit | VEDCSVMC:VTCS_TL_HL106---HT102_MAX_WARN.Limit | Tx_Limits | TL_HL106.lmit |
| TL_HL107---HT103_MAX_WARN | Limit | Limit | VEDCSVMC:VTCS_TL_HL107---HT103_MAX_WARN.Limit | Tx_Limits | TL_HL107.lmit |
| TL_HL108---HT104_MAX_WARN | Limit | Limit | VEDCSVMC:VTCS_TL_HL108---HT104_MAX_WARN.Limit | Tx_Limits | TL_HL108.lmit |
| TL_HL109---HT105_MAX_WARN | Limit | Limit | VEDCSVMC:VTCS_TL_HL109---HT105_MAX_WARN.Limit | Tx_Limits | TL_HL109.lmit |
| TR_HL102---HT102_MAX | Limit | Limit | VEDCSVMC:VTCS_TR_HL102---HT102_MAX.Limit | Tx_Limits | TR_HL102.lmit |
| TR_HL103---HT103_MAX | Limit | Limit | VEDCSVMC:VTCS_TR_HL103---HT103_MAX.Limit | Tx_Limits | TR_HL103.lmit |
| TR_HL104---HT104_MAX | Limit | Limit | VEDCSVMC:VTCS_TR_HL104---HT104_MAX.Limit | Tx_Limits | TR_HL104.lmit |
| TR_HL105---HT105_MAX | Limit | Limit | VEDCSVMC:VTCS_TR_HL105---HT105_MAX.Limit | Tx_Limits | TR_HL105.lmit |
| TR_HL106---HT102_MAX_WARN | Limit | Limit | VEDCSVMC:VTCS_TR_HL106---HT102_MAX_WARN.Limit | Tx_Limits | TR_HL106.lmit |
| TR_HL107---HT103_MAX_WARN | Limit | Limit | VEDCSVMC:VTCS_TR_HL107---HT103_MAX_WARN.Limit | Tx_Limits | TR_HL107.lmit |
| TR_HL108---HT104_MAX_WARN | Limit | Limit | VEDCSVMC:VTCS_TR_HL108---HT104_MAX_WARN.Limit | Tx_Limits | TR_HL108.lmit |
| TR_HL109---HT105_MAX_WARN | Limit | Limit | VEDCSVMC:VTCS_TR_HL109---HT105_MAX_WARN.Limit | Tx_Limits | TR_HL109.lmit |
| TLR_HL102---HT102_MAX | Limit | Limit | VEDCSVMC:VTCS_TLR_HL102---HT102_MAX.Limit | Tx_Limits | TM_HL10.lmit |
| TLR_HL106---HT102_MAX_WARN | Limit | Limit | VEDCSVMC:VTCS_TLR_HL106---HT102_MAX_WARN.Limit | Tx_Limits | TM_HL10.lmit |
| TL_PL101---PT104_MAX | Limit | Limit | VEDCSVMC:VTCS_TL_PL101---PT104_MAX.Limit | Tx_Limits | TL_PL101.lmit |
| TL_PL102---PT104_101_MAXDIFF | Limit | Limit | VEDCSVMC:VTCS_TL_PL102---PT104_101_MAXDIFF.Limit | Tx_Limits | TL_PL102.lmit |

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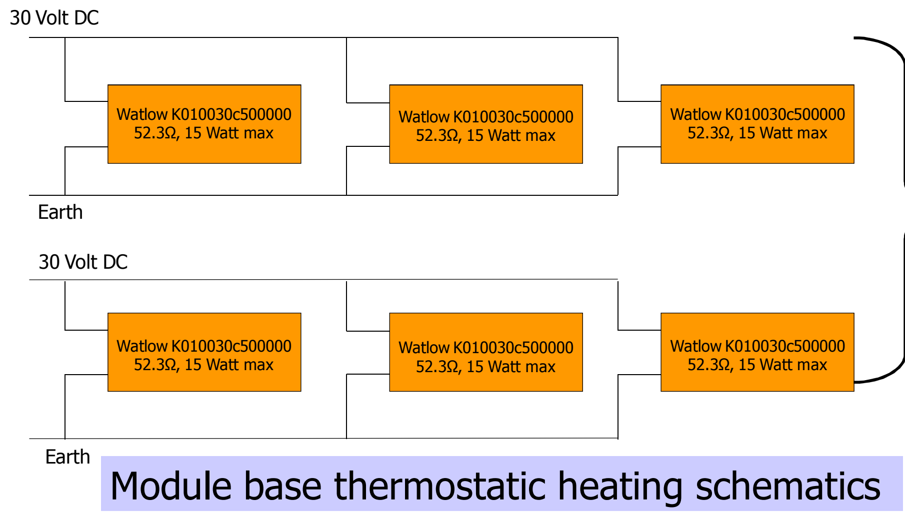
|---|---|---|---|---|---|
| TL_PL103---PT104_101_MINDIFF | Limit | Limit | VEDCSVMC:VTCS_TL_PL103---PT104_101_MINDIFF.Limit | Tx_Limits | TL_PL103.lmit |
| TL_PL107---PT102_max | Limit | Limit | VEDCSVMC:VTCS_TL_PL107---PT102_max.Limit | Tx_Limits | TL_PL107.lmit |
| Tx_PL108---MAX_PRESS_CLOSED_VOLUME | Limit | Limit | VEDCSVMC:VTCS_Tx_PL108---MAX_PRESS_CLOSED_VOLUME.Limit | Tx_Limits | Tx_PL108.lmit |
| TR_PL101---PT104_MAX | Limit | Limit | VEDCSVMC:VTCS_TR_PL101---PT104_MAX.Limit | Tx_Limits | TR_PL101.lmit |
| TR_PL102---PT104_101_MAXDIFF | Limit | Limit | VEDCSVMC:VTCS_TR_PL102---PT104_101_MAXDIFF.Limit | Tx_Limits | TR_PL102.lmit |
| TR_PL103---PT104_101_MINDIFF | Limit | Limit | VEDCSVMC:VTCS_TR_PL103---PT104_101_MINDIFF.Limit | Tx_Limits | TR_PL103.lmit |
| TR_PL107---PT102_max | Limit | Limit | VEDCSVMC:VTCS_TR_PL107---PT102_max.Limit | Tx_Limits | TR_PL107.lmit |
| TLR_PL101---PT104_MAX | Limit | Limit | VEDCSVMC:VTCS_TLR_PL101---PT104_MAX.Limit | Tx_Limits | TM_PL101.lmit |
| TLR_PL102---PT104_101_MAXDIFF | Limit | Limit | VEDCSVMC:VTCS_TLR_PL102---PT104_101_MAXDIFF.Limit | Tx_Limits | TM_PL102.lmit |
| TLR_PL103---PT104_101_MINDIFF | Limit | Limit | VEDCSVMC:VTCS_TLR_PL103---PT104_101_MINDIFF.Limit | Tx_Limits | TM_PL103.lmit |
| SL_PL104---DIFF_SA_TT121_PT107_TSAT | Limit | Limit | VEDCSVMC:VTCS_SL_PL104---DIFF_SA_TT121_PT107_TSAT.Limit | Sx_Limits | SL_PL104.lmit |
| SB_PL104---DIFF_SB_TT121_PT103_TSAT | Limit | Limit | VEDCSVMC:VTCS_SB_PL104---DIFF_SB_TT121_PT103_TSAT.Limit | Sx_Limits | SB_PL104.lmit |
| SB_PL105---DIFF_SB_TT121_PT104_TSAT | Limit | Limit | VEDCSVMC:VTCS_SB_PL105---DIFF_SB_TT121_PT104_TSAT.Limit | Sx_Limits | SB_PL105.lmit |
| TL_ML101---max_accu_setp | Limit | Limit | VEDCSVMC:VTCS_TL_ML101---max_accu_setp.Limit | Tx_Limits | TL_ML101.lmit |
| Tx_ML101---$CO_2$_lowest_temp | Limit | Limit | VEDCSVMC:VTCS_Tx_ML101---$CO_2$_lowest_temp.Limit | Tx_Limits | Tx_ML101.lmit |
| Tx_ML104---Too_Warm_Threshold | Limit | Limit | VEDCSVMC:VTCS_Tx_ML104---Too_Warm_Threshold.Limit | Tx_Limits | Tx_ML104.lmit |
| Tx_ML105---Rth_MAX | Limit | Limit | VEDCSVMC:VTCS_Tx_ML105---Rth_MAX.Limit | Tx_Limits | Tx_ML105.lmit |
| Tx_ML106---Rth_MIN | Limit | Limit | VEDCSVMC:VTCS_Tx_ML106---Rth_MIN.Limit | Tx_Limits | Tx_ML106.lmit |
| Tx_ML107---HT105_MAX_HLM | Limit | Limit | VEDCSVMC:VTCS_Tx_ML107---HT105_MAX_HLM.Limit | Tx_Limits | Tx_ML107.lmit |
| Tx_ML107---HT105_MIN_HLM | Limit | Limit | VEDCSVMC:VTCS_Tx_ML107---HT105_MIN_HLM.Limit | Tx_Limits | Tx_ML107.lmit |
| TR_ML101---max_accu_setp | Limit | Limit | VEDCSVMC:VTCS_TR_ML101---max_accu_setp.Limit | Tx_Limits | TR_ML101.lmit |
| PA_ML101---TT101_MAX | Limit | Limit | VEDCSVMC:VTCS_PA_ML101---TT101_MAX.Limit | Sx_Limits | PA_ML101.lmit |
| xx_ML101---MAX_HAPTAS_CALIBR_ERROR | Limit | Limit | VEDCSVMC:VTCS_xx_ML101---MAX_HAPTAS_CALIBR_ERROR.Limit | Tx_Limits | xx_ML101.lmit |
| Sx_ML101---SASB_takeover_threshold | Limit | Limit | VEDCSVMC:VTCS_Sx_ML101---SASB_takeover_threshold.Limit | Sx_Limits | Sx_ML101.lmit |
| TL_AC101 | Accumulator | SETPOINT | VEDCSVMC:VTCS_TL_AC101.SETPOINT | TL_System_Sensors_A | TL_AC101.SPac |
| TL_AC101 | Accumulator | TARGET_SETPOINT | VEDCSVMC:VTCS_TL_AC101.TARGET_SETPOINT | TL_System_Sensors_A | TL_AC101.SPtr |
| TL_AC101 | Accumulator | Rth | VEDCSVMC:VTCS_TL_AC101.Rth | TL_System_Sensors_A | TL_AC101.Rthm |
| TR_AC101 | Accumulator | SETPOINT | VEDCSVMC:VTCS_TR_AC101.SETPOINT | TR_System_Sensors_A | TR_AC101.SPac |
| TR_AC101 | Accumulator | TARGET_SETPOINT | VEDCSVMC:VTCS_TR_AC101.TARGET_SETPOINT | TR_System_Sensors_A | TR_AC101.SPtr |
| TR_AC101 | Accumulator | Rth | VEDCSVMC:VTCS_TR_AC101.Rth | TR_System_Sensors_A | TR_AC101.Rthm |

## 11.8 *Additioanl base plate heater information*




| Heater Assembly # | Controlled by T-Sensor #: |
|---|---|
| Tx-HT01 | Tx-TT37 |
| Tx-HT02 | Tx-TT38 |
| Tx-HT03 | Tx-TT39 |
| Tx-HT04 | Tx-TT40 |

Figure 11.8-1: Baseplate heater electrical layout

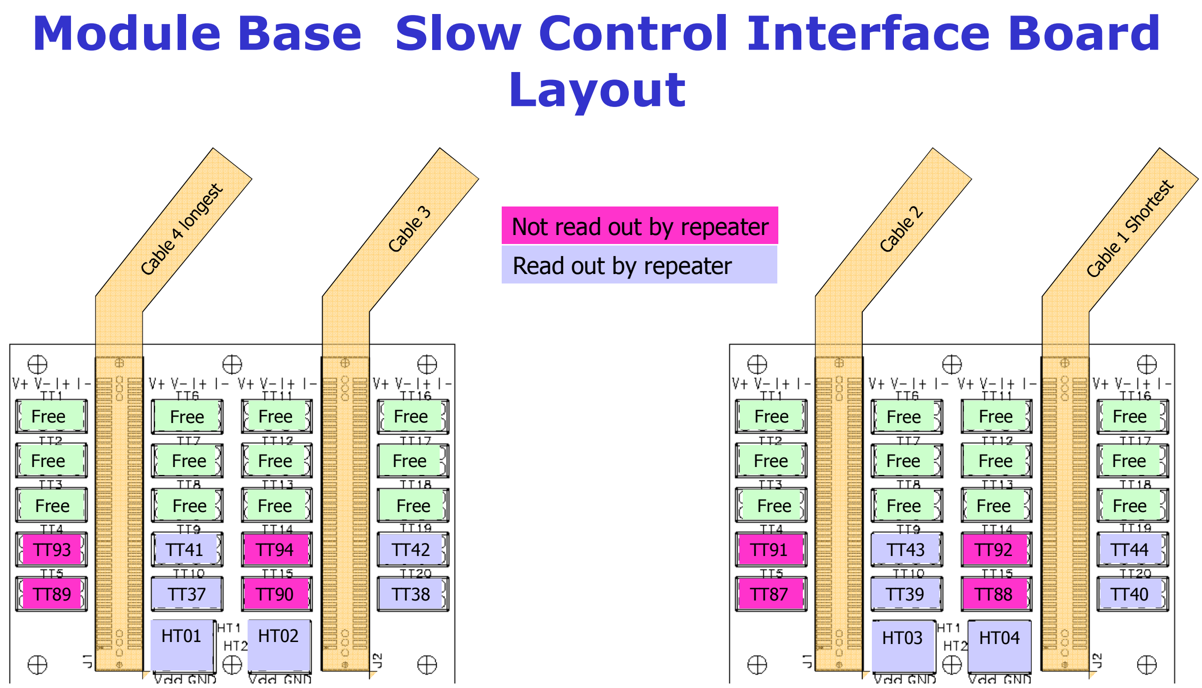



Figure 11.8-2: Baseplate heater cable connectors

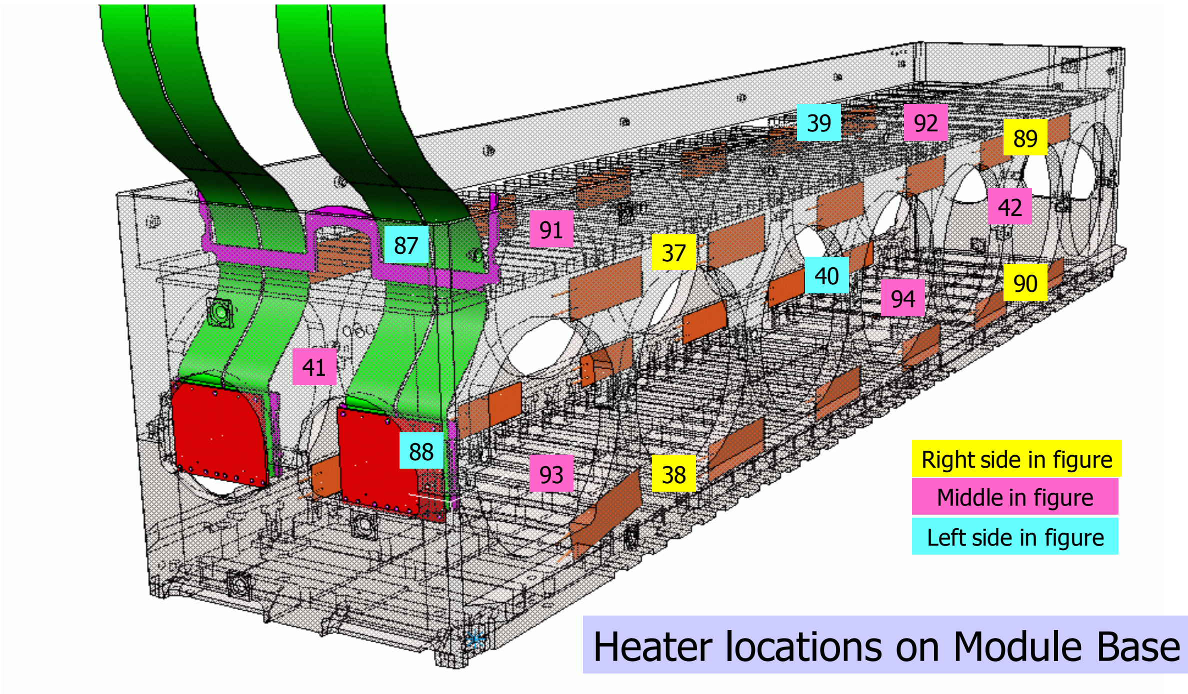



Figure 11.8-3: Base plate heater temperature sensor locations

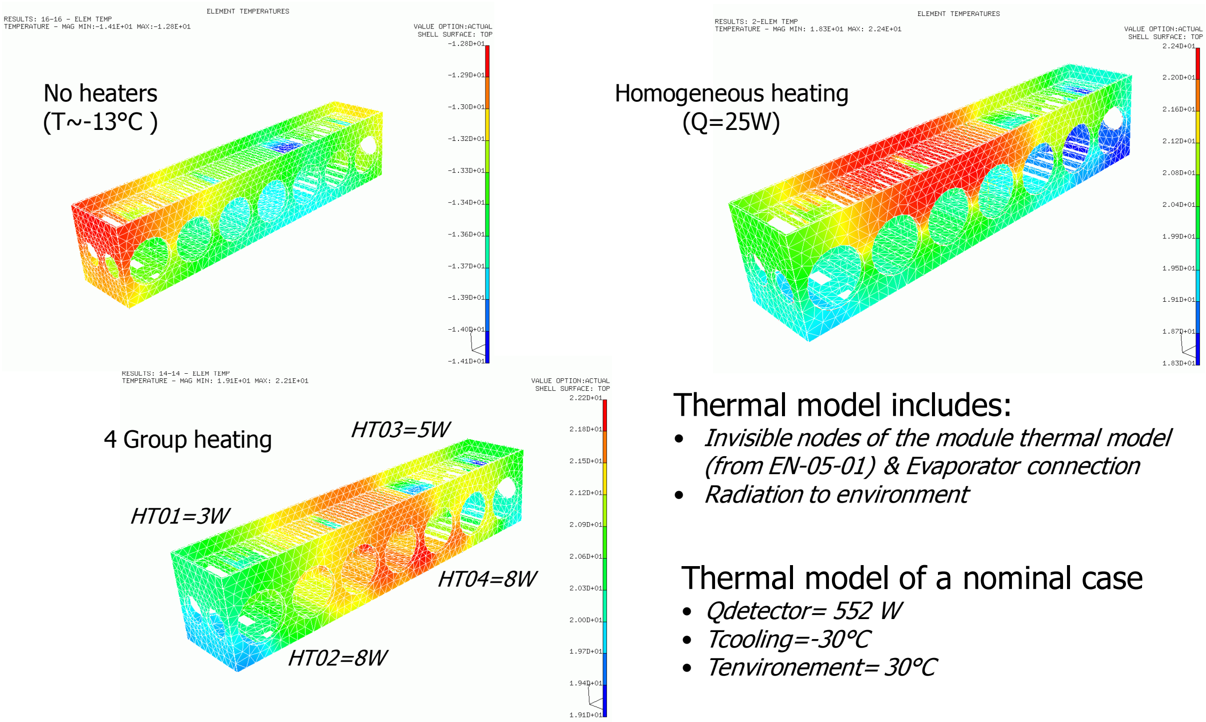



Figure 11.8-4: Base plate thermal simulation

## 11.9 *Additional evaporator information*

**INPUT**

$bar := 0.1 \frac{N}{mm^2}$ — *Conversion factor*

$k := 1.5$ — *Safety factor*

$P := 100bar$ — *Pressure*

$H_2 := 18.5mm$ — *Diameter conflat knife*

$n := 6$ — *Number of bolts*

$C := 500 \frac{N}{mm}$ — *Sealing force (C=300-500N/mm)*

$C_{min} := 300 \frac{N}{mm}$ — *Minimum sealing force*

$d_{m4} := 4mm$ — *Diameter bolts*

$d_{m4.A} := 3.5mm$ — *Minor diameter bolts*

$kN := 1000N$ — *Conversion factor*

$p := 0.7mm$ — *Pitch*

$\beta := 60deg$ — *apex angle*

$\phi := atan\left(\frac{p}{\pi \cdot d_{m4.A}}\right)$ — *Pitch angle*

$\phi = 3.6\,deg$

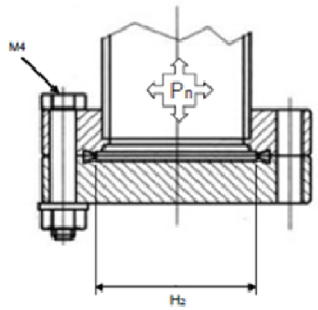
$\mu_k := 0.15$ — *Friction factor*

$\rho := atan\left(\frac{\mu_k}{cos\left(\frac{\beta}{2}\right)}\right)$ — *Friction angle*

$\rho = 9.83\,deg$

$Nm := N \cdot m$ — *Conversion factor*

**CALCULATION**




Internal pressure

$P_n := k \cdot P$ — $P_n = 15 \frac{N}{mm^2}$

Pressure load

$A_p := 0.25 \cdot \pi \cdot H_2^2$ — *flange surface*

$F_p := P_n \cdot A_p$ — $F_p = 4 \times 10^3 N$ — *pressure load*

$F_{p.b} := \frac{F_p}{n}$ — $F_{p.b} = 672 N$ — *force per bolt*

Sealing force

$omtrek := \pi \cdot H_2$ — $omtrek = 58.1 mm$ — *circumferential conflat knife*

$F_{seal} := C \cdot omtrek$ — $F_{seal} = 2.9 \times 10^4 N$ — *sealing force in bolts*

$F_{seal.b} := \frac{F_{seal}}{n}$ — $F_{seal.b} = 4.8 \times 10^3 N$ — *sealing force per bo*

$\sigma := \frac{(F_{p.b} + F_{seal.b})}{0.25 \cdot \pi \cdot d_{m4}^2}$ — $\sigma = 438.9 \frac{N}{mm^2}$ — *tensile stress per bo*

$F_{b.total} := F_{seal.b} + F_{p.b}$ — $F_{b.total} = 5.5kN$ — *total force per bolt*

Max.negative force in m4 bolt (12.9): 6,8 kN

Yield stress of m4 bolt (12.9): 1100 N/mm^2

*Bolt strength is sufficient*

Minimum Sealing force:

$F_{seal.min} := C_{min} \cdot omtrek$ — $F_{seal.min} = 1.7 \times 10^4 N$

$F_{seal} - F_p > F_{seal.min}$

$F_{seal} - F_p = 2.5 \times 10^4 N$

Calculation of torque on the bolts

$T_t := \left(F_{b.total} \cdot tan(\phi + \rho) \cdot \frac{d_{m4A}}{2}\right)$ — $T_t = 2.3\,Nm$ — Torque from turning

$T_f := \mu_k \cdot F_{b.total} \cdot 1.3 \cdot \frac{d_{m4}}{2}$ — $T_f = 2.2\,Nm$ — Torque from friction

$T := T_t + T_f$ — $T = 4.5\,Nm$ — Total torque

Max. Torque on m4 bolt(12.9): 5.2Nm

Figure 11.9-1: Calculation of the evaporator inlet connector connection

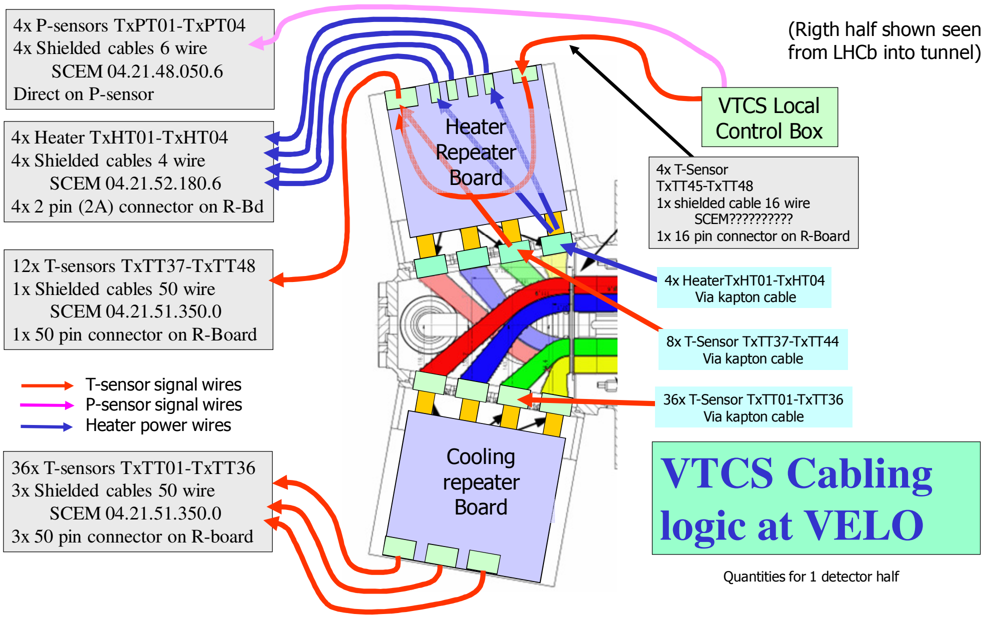



Figure 11.9-2: Evaporator and module base cabling to PLC

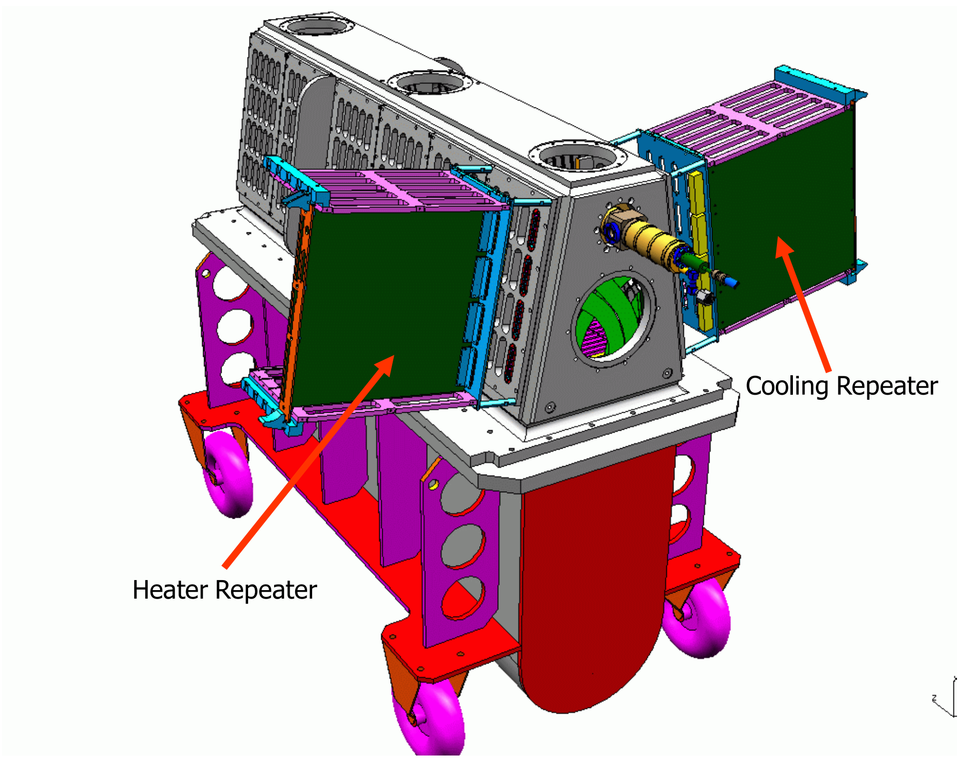



Figure 11.9-3: Cooling repeaterboards

## Evaporator Temperature sensor cabling situation in side the secondary vacuum

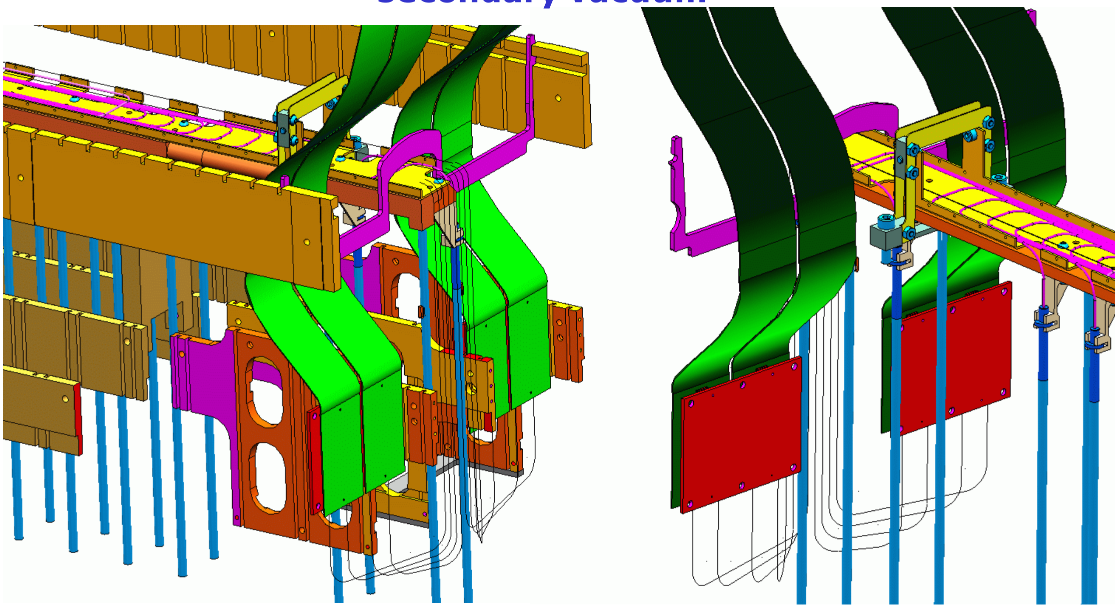


Figure 11.9-4: Evaporator kapton cable 1

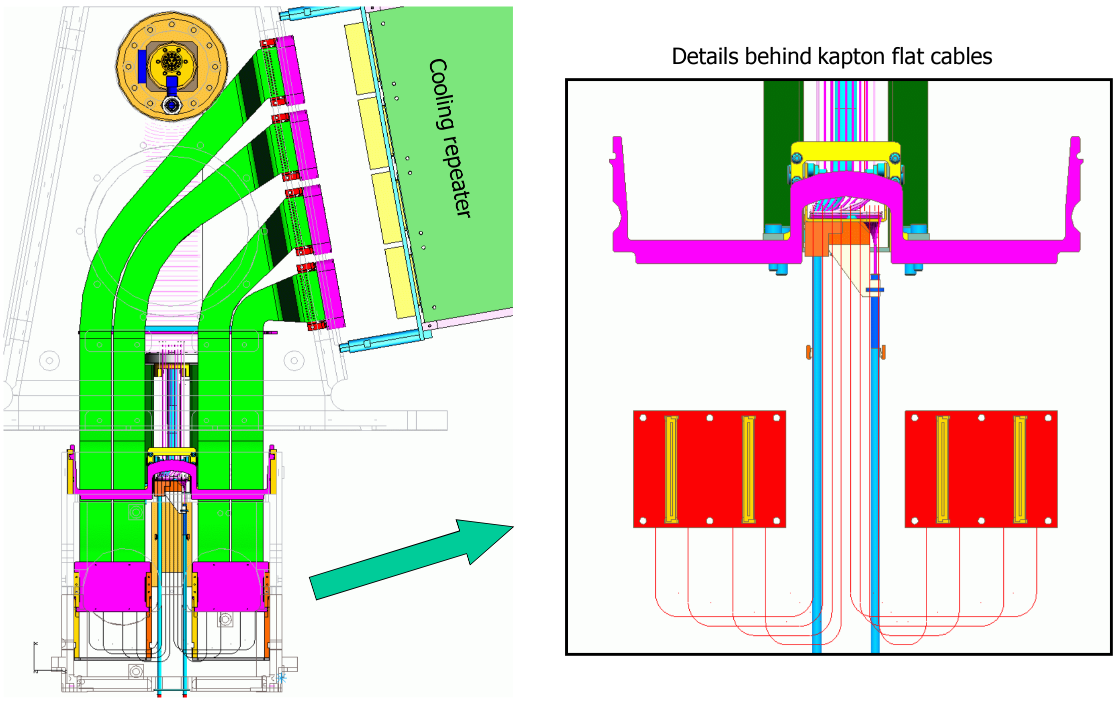



Figure 11.9-5: Evaporator kapton cable 2

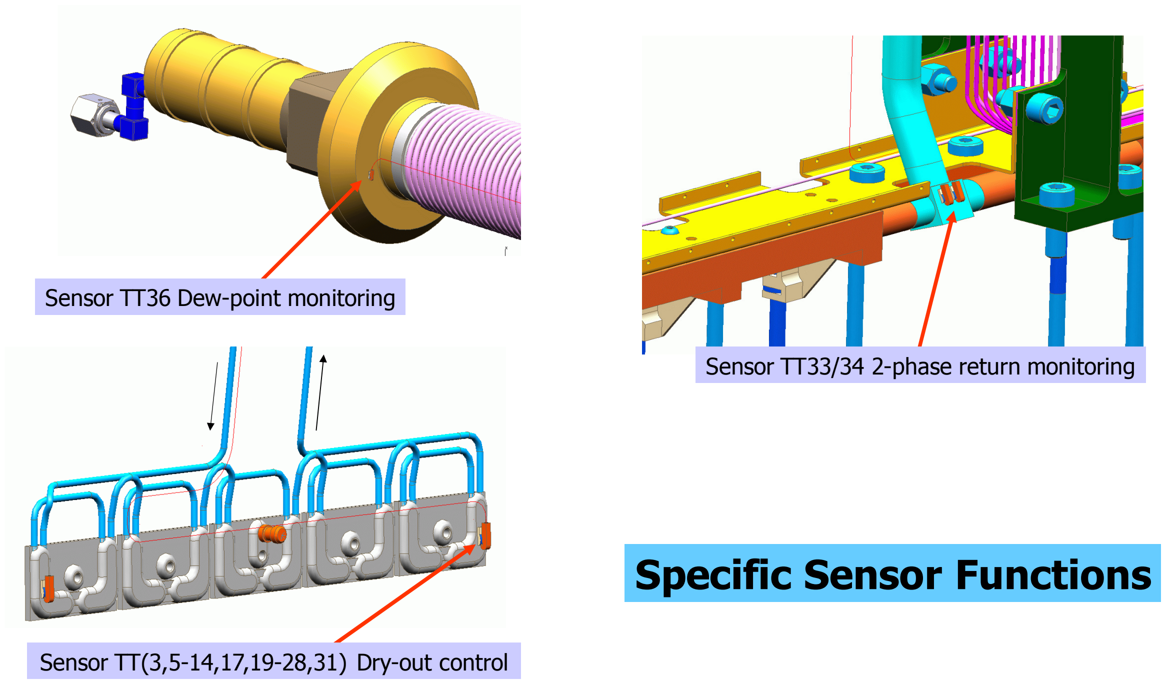



Figure 11.9-6: Evaporator ktemperature sensor locations

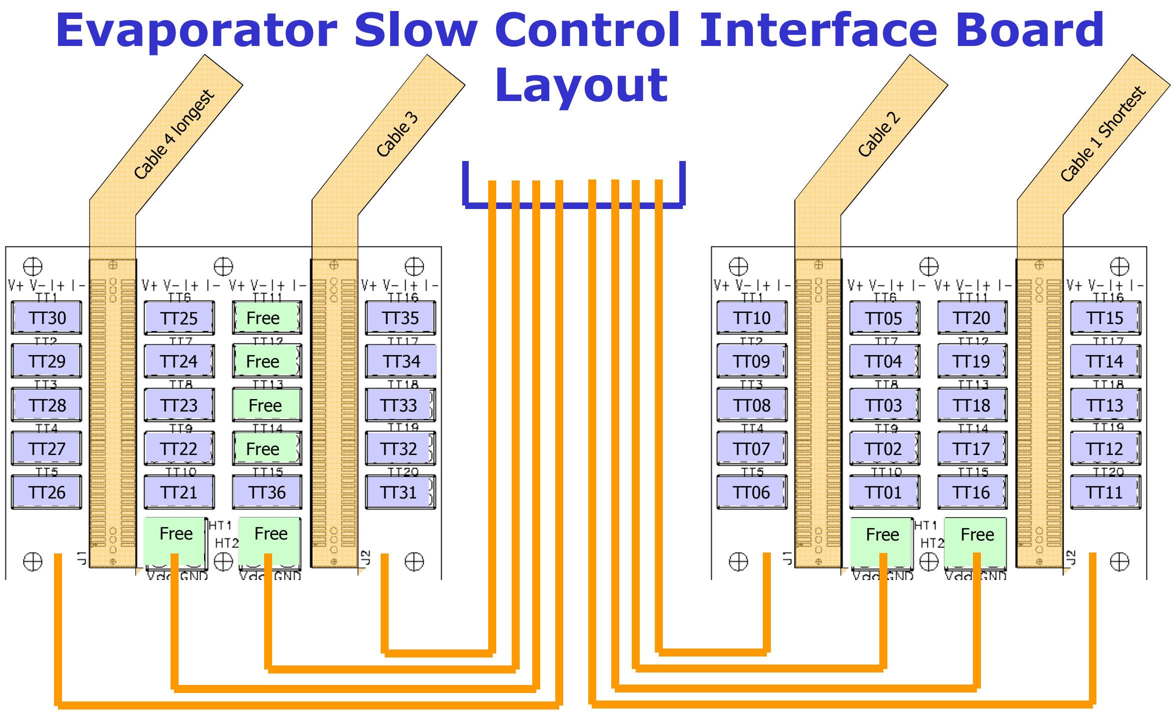



Figure 11.9-7: Evaporator temperature sensor interface board layout

| Senor Label | | Length (mm) | | Senor Label | | Length (mm) |
|---|---|---|---|---|---|---|
| TT | 1 | 430 | | TT | 20 | 1340 |
| TT | 2 | 860 | | TT | 21 | 1380 |
| TT | 3 | 850 | | TT | 22 | 1410 |
| TT | 4 | 410 | | TT | 23 | 1430 |
| TT | 5 | 890 | | TT | 24 | 1450 |
| TT | 6 | 1010 | | TT | 25 | 1610 |
| TT | 7 | 1030 | | TT | 26 | 1780 |
| TT | 8 | 1060 | | TT | 27 | 1820 |
| TT | 9 | 1080 | | TT | 28 | 1870 |
| TT | 10 | 1100 | | TT | 29 | 1480 |
| TT | 11 | 1170 | | TT | 30 | 1900 |
| TT | 12 | 1200 | | TT | 31 | 1920 |
| TT | 13 | 1220 | | TT | 32 | 1490 |
| TT | 14 | 1250 | | TT | 33 | 1380 |
| TT | 15 | 840 | | TT | 34 | 1370 |
| TT | 16 | 1300 | | TT | 35 | 1370 |
| TT | 17 | 1300 | | TT | 36 | 2260 |
| TT | 18 | 860 | | | | ======= |
| TT | 19 | 1310 | | total (mm) | | 46430 |
| | | | | Average (mm) | | 1290 |

- Cable lengths are from TT sensor to soldering patch on interface board. Over length is included

- All shown lengths are similar for the left and right detector. Shown are the sensors of 1 detector half. Every sensor need to be fabricated 2 times.

- Sensor ID TT37 – TT48, will be cut to length when assembled. Pre made length for all will be **1500 mm**

Figure 11.9-8: Evaporator temperature senosor cabling length