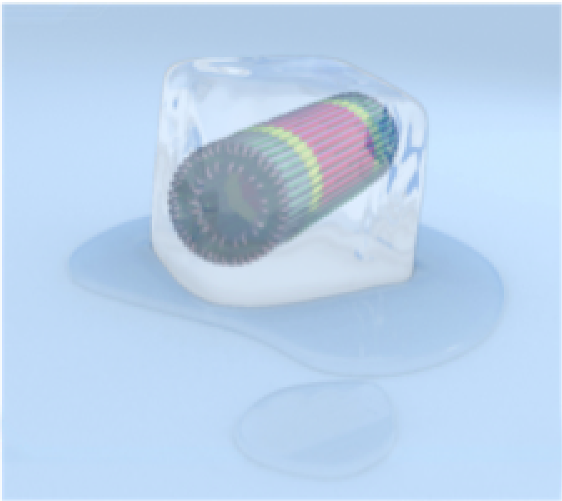

SPD Cooling on-call instructions

brought to you courtesy of

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Contents

1 Introduction

The cooling system of the SPD detector is based on the evaporation of C_4F_{10} following a Joule-Thomson cycle. Since May 2012 the cooling system performs at 100%, i.e. no modules are off because of cooling issues. Once the system is started and the detector is turned on, it is very stable and does not require close control. Nonetheless, a quick look at the status of a few parameters once a while can help to spot an arising issue. In the follow-ing a description of the system is given for better understanding of the following instructions. Then, the set of controls is described along with the monitor tools. Finally, the cases (to our best knowledge) when human intervention is required will be presented.

2 Detailed circuit description

In figure 1 the layout of the cooling system is shown, as implemented before the 2010 run. In the picture a few zones have been marked with numbered circles to spot the main components. The system includes 10 circuits one per sector. Supply lines, made of stainless steel 316L pipes of 6 (4) outer (inner) diameter, cover a distance of approximately 40 m before reaching the detector through the RB26 side of the cavern. The return lines are 12/10 outer/inner diameter in size and run for approximately 35 m. We start from zone 7, where the gas is transformed in liquid in the condenser, fed by the central chilled (6°C) water circuit. Because of pressure limitations imposed by the condenser and the (high) minimum required pressure difference for chilled water circulation, the chilled water feeds a heat exchanger to cool down the water coming from the mixed water supply lines, this last being fed to the condenser. The condenser is equipped with double pressure-relief valves, of which one is operational. The switch between the two is performed by a manual ball valve. In case of overpressure opening one of the valves, a constant small leak can appear due to incomplete closure of the valve. One has thus the possibility to switch to the second valve when access is allowed. A pressure transmitter and a temperature sensor deliver to the control PLC the information needed to regulate the pressure inside the condenser by a PID[1] loop which acts on the water regulating valve (zone 6). The system can cope with different heat dissipation rates in the detector by adjusting the freon flow rate. This is accomplished tuning the pressure at the pump outlet (see zone 5). This pressure is measured by a transmitter and then fed back into a PID loop implemented in the PLC. The PID output is converted into pump speed via a frequency inverter. The two pumps are of the rotary vane type as these have relatively low NPSH (net positive suction head) requirement, an essential concern given the near saturation state of the liquid at the pumps inlet. Nevertheless, should some cavitation occur, some parts of these pumps may wear out faster than any other plant component, so a parallel second pump is installed. One can switch from one pump to another remotely, in case a malfunctioning forces the operating pump to stop. The switching takes a time of the order of few minutes. In

[1] PID=proportional-integral-derivative

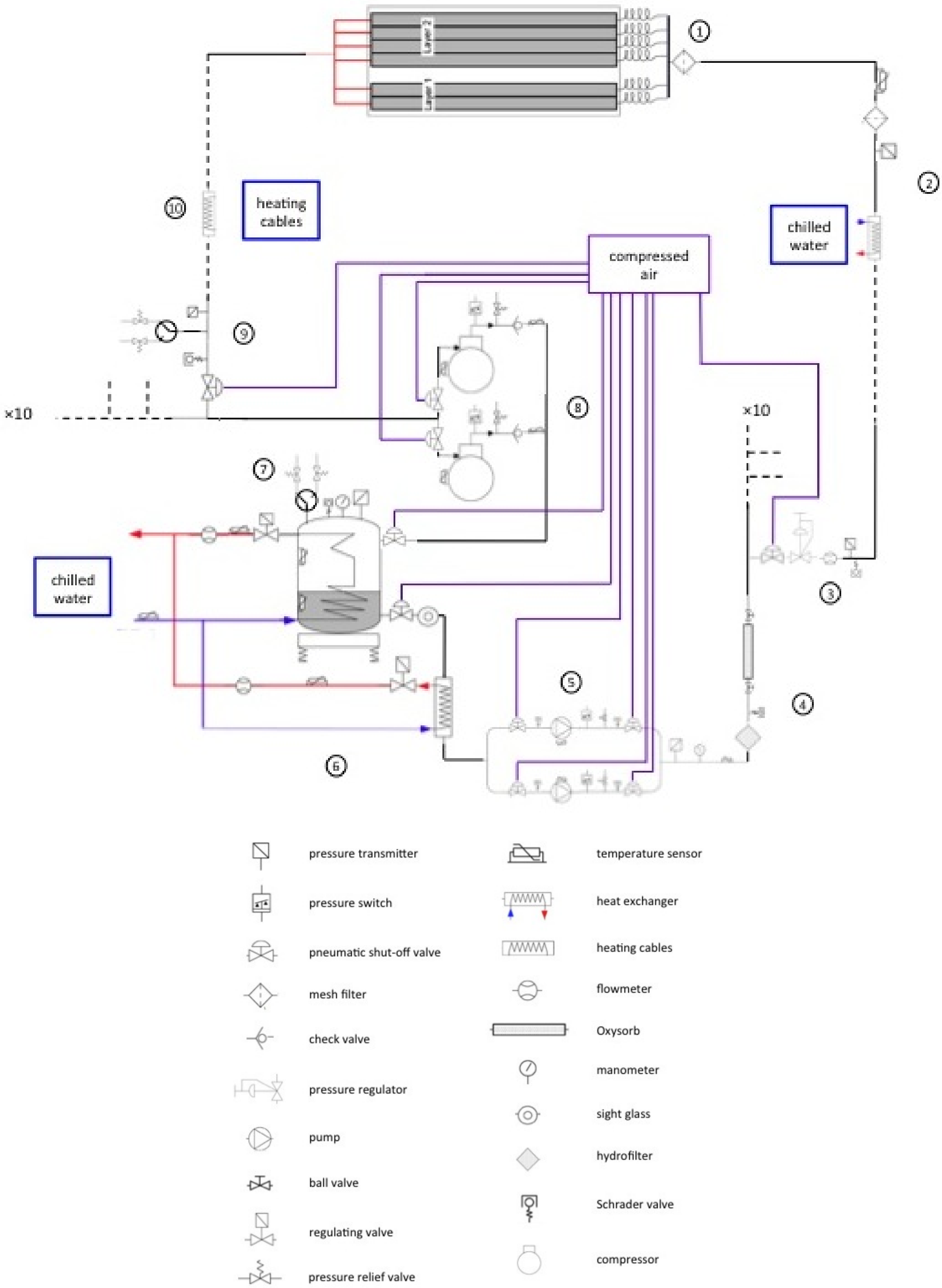

Figure 1: Layout of the SPD cooling circuit.

zone 4 two filters are present. One is a hydrofilter, which is dedicated to the removal of traces of water and HF compounds. The second is an oxysorb which guarantees a purity of $H_2O < 20$ ppb and $O_2 < 5$ ppb. Pneumatic valves close liquid supply and vapor return to/from a particular sector. In zone 3 the start of a liquid line is sketched, with the pneumatic valve, the pressure regulator (to fine-tune the flow in each sector), the flowmeter, the pressure transmitter and the Schrader valve which is used as a vacuum plug. After about 30 m of pipes, one heat ex-changer per line, fed by water at 7.5 °C is installed (zone 2) in PP4 (referred to as "subcooling"). About 2 m downstream the heat exchangers, pressure and temperature sensors are installed. This represents the point of measurement closest to the SPD. Given the very small inner diameter of the capillaries (0.5 mm), two filters with granularity of 60 μm have been placed at the end of each supply line (zone 1) and ≈ 8 m upstream (zone 2) to prevent their obstruction with dust particles. The filters in zone 2 are regularly replaced and do not show pollution, the filters in "1" are regularly cleaned except for sectors 4,5,6,7 and 9 which have been drilled (as of June 28, 2012). At approximately half-way between the detector and the cooling plant, a length of about 10 m of the return pipes has been equipped with self-regulating heating cable (total power per line ≈ 600 W) which evaporates completely the liquid still present in the lines. This avoids an excessive pressure drop along the return path (which makes difficult to control the evaporation temperature at the detector) and prevents the liquid to get in contact with the compressor membrane, which could result in serious damage. Close to the plant, a manifold hosts the ten lines which are equipped with pneumatic shut-off valves, pressure transmitters, vacuum plugs and two pressure relief valves which can be selected alternatively, for the same reason as for the condenser. These pressure relief valves are in charge of the SPD safety as along the return lines the pressure drop is small and nearly constant (≈ 300 mbar) from the cooling duct below each stave. The pressure in the return lines (common to the 10 lines) is measured by a transmitter and then fed back into a PID loop implemented in the PLC. The PID output is converted into compressor speed via a frequency inverter. During standard operation, the incoming vapor flow is constant and the compressor will stabilize at a given constant speed between 30 and 50 Hz. Note that the pressure downstream the compressor is fixed by the temperature, as explained in page 3, and kept constant with respect to the compressor frequency for a more stable compressor operation. Several pressure and temperature sensors on the plant monitor the thermodynamical conditions of the fluid and guarantee safe running parameters. Pressure switches after the pumps switch off the frequency inverter in case of overpressure. Pressure relief valves are placed in each sector of the plant (which can be divided by pneumatic valves in four separated volumes) and a number of Schrader valves provide plugs for the operations of vacuum, nitrogen ventilation, freon refill and recovery. The leak-tightness of the plant and the lines is regularly checked by means of a He-leak detector in vacuum mode. Usually a vacuum of $\approx 10^{-5}$bar is achieved in all sections and a leak rate $< 10^{-6}$ mbar$\times$l/s is measured.

3 Controls and monitors

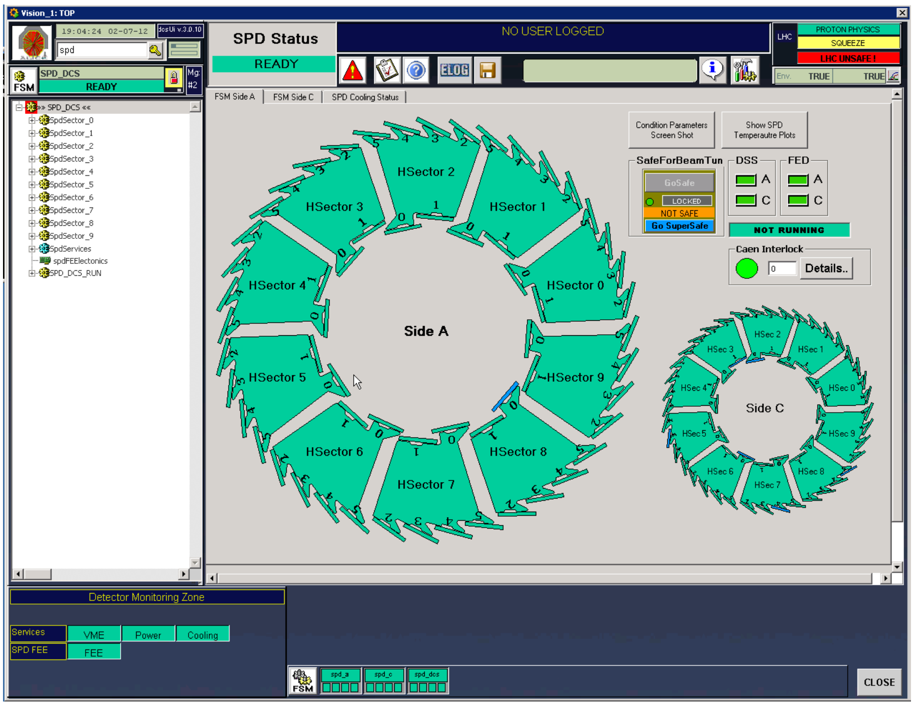

Figure 2: SPD user interface main panel.

You can find the panels of the cooling controls and monitors in the SPD user interface - ask for instructions how to access it. Once you are logged in the right machine and started the SPD user interface, you will see the panel shown in figure 2. In the lower left side you can see a "Detector Monitoring Zone" where a few buttons inform you on the general status of the main systems, the cooling among them. Green means that it's ok, yellow that a warning or a partial malfunctioning is present, red that a major failure occurred. If there is even a partial malfunctioning, the detector will be heavily affected and you will realize it soon, while a warning is an invitation to check a few parameters, as it will be explained later. Not all warnings are reflected by this button and for this reason you should follow the "regular checks" list given later rather than trust this sign.
By clicking the "SPD Cooling Status" tab of this panel, you are presented the panel shown in figure 3. For each sector, numbered from 0 to 9, the following values are shown: temperature side C, temperature side A, heaters (temperature), pressure side C, pressure side A, flow (rate), power consumption. Then a button close to each sector number informs you about the status of the cooling loop (green=open, red=closed). The temperature and pressure on side C are issued by the sensors in point 2 of figure 1. The heaters temperature refers to the temperature between the heating cable and the return pipe at the beginning of the heater (point 10 of figure 1). Temperature and pressure of side A (the return) are picked a few meters

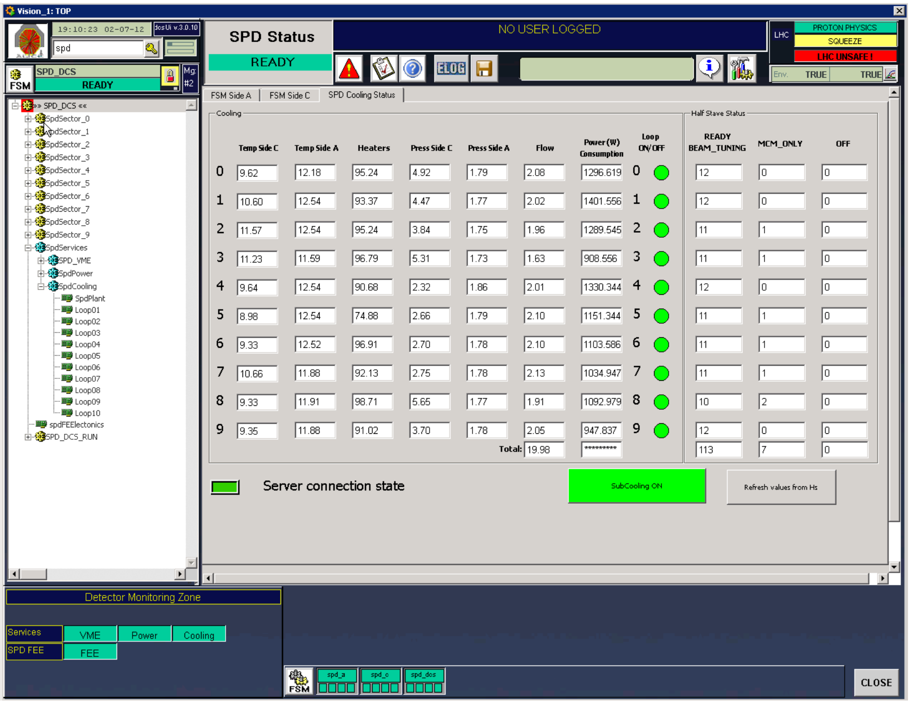

Figure 3: SPD cooling status panel.

Sector	0	1	2	3	4	5	6	7	8	9
Loop	10	9	8	5	4	3	2	1	7	6

Table 1: Correspondence between loop and sector number

before the heaters. The flow is measured at the liquid manifold of the plant by the Bronkhorst "Coriolis-force-based" flowmeters. In the right end of this panel you can find three windows per sector showing respectively the number of half-staves "on" (potentially useful for data taking), those in "MCM only" status and the "off" ones. A button below these fields allows you to refresh these values from the hardware and it is a good idea to do it if you are not sure if something has changed. Right-clicking on one numerical field, a window is opened and the corresponding trend plot is generated. Using the fields at the bottom of this window and by the mouse wheel (slowly!) while pointing on the axes, you can adjust the range shown. The button in the bottom part, named "Subcooling on" is a command to turn on and off (in this case the color turns red and the text changes accordingly) the circulation of the water in the ten heat-exchangers placed in PP4 (all at once). This has an impact on the startup procedure of the sectors with drilled filters and on the cooling conditions of the sectors with filters not yet treated - more details will be given later. On the left side of the SPD user interface, under SpdServices, SpdCooling, there are the controls of each loop, see fig.4. The loop number is not the sector number, the correspondence between the two is given in table 3. From the panel

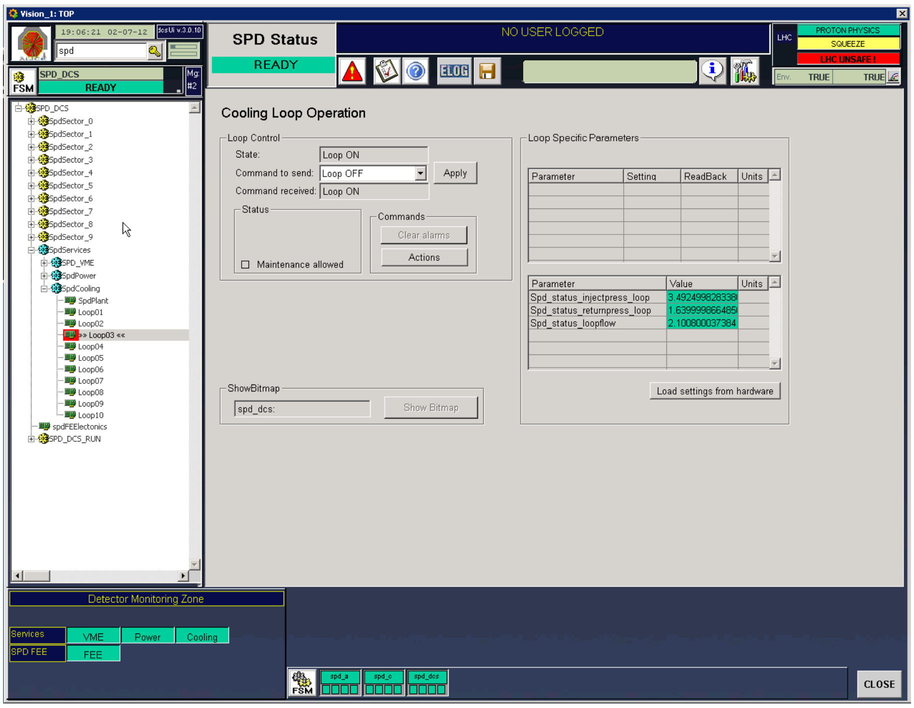

Figure 4: Single loop control panel.

loop	ON	OFF	LOCKED
liquid side valve	open	closed	closed
gas side valve	open	open	closed
heater switch	on	off	off

Table 2: Definition of the status of a loop.

of each loop you can change the status of the loop and read the main parameters, i.e. liquid pressure gas pressure and flow rate. The status of a loop is defined by the statuses of the liquid-side valve, of the gas-side valve and of the heater. The available statuses are described in table 3. Note that the difference between "off" and "locked" stays in the gas-side valve status. In normal condotions, we want to keep the gas-side valve open, so the compressor can keep the return pressure at the setpoint. When an alarm is triggered or a special condition is verified (e.g. a leak) you may want to completely isolate the line. The safety valves are installed in such a position that they are not excluded from the line if one closes the return valve, ensuring the protection from high pressure. To change the status of the loop, you need to select the status you want from the pull-down menu, then press the "Apply" button. The status will change in the field above the one you changed, meaning that the command has been issued (indeed, it is a change of value of a variable). Then, after a few seconds, the field below the menu should change accordingly, meaning that the command has been received by the PLC on the plant and executed. The

"Actions" button is for experts and should not be used.

Again on the left side of the SPD user interface, under "SpdServices", "SpdCooling", there is the "SpdPlant" item. If you double click on it, or right-click and choose "VIEW PANEL", the Cooling Plant Operation panel will appear in the right side of the interface, as shown in fig. 5. For the shifter's sake, the most interesting elements

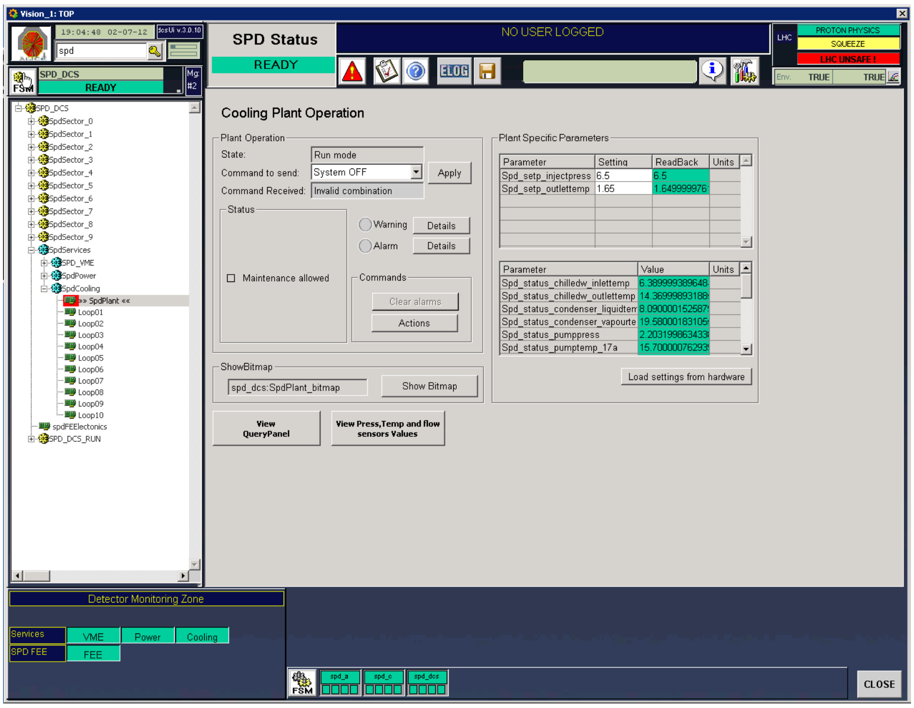

Figure 5: Plant control panel.

are the "Warning" and "Alarm" "lights", with their "Details" buttons, and the "Show Bitmap" button. If something happens to the system, probably a warning or an alarm (or both) will be issued, changing to red the color of the corresponding light. In this case you should click on the "Details" button. A window will pop up (see fig. 6): take note of the bit turned on, checking all the "words" switching to the next by the pull-down menu, as this information could be useful for the cooling piquet (see later). Another important point is the possibility to set the liquid- and gas-side pressures. It may happen that you need to change the first one. You can find these parameters in the top right panel ("Plant specific parameters"); to change one of the values you have to click on the white field showing the set value, a new window will pop up where you can put the new value as shown in fig.??. You should put the pressure (in bar) you want in the free white field and press "Apply" and then "Close". The green field will change when the PLC on the plant has received the new status. You can also read various other parameters of the plant in the lines just below the pressure fields, but they are not reliable at the moment. By the way, a more comprehensive and intuitive view is shown when you click on the "Show Bitmap" button. A panel like the one shown in figure 8 will appear, where

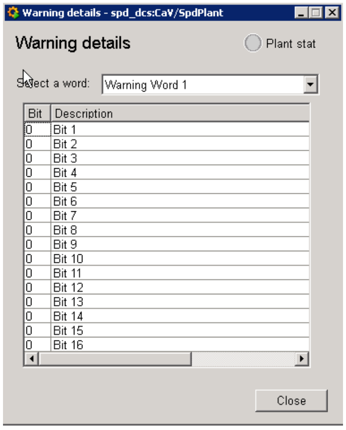

Figure 6: Warning bit list.

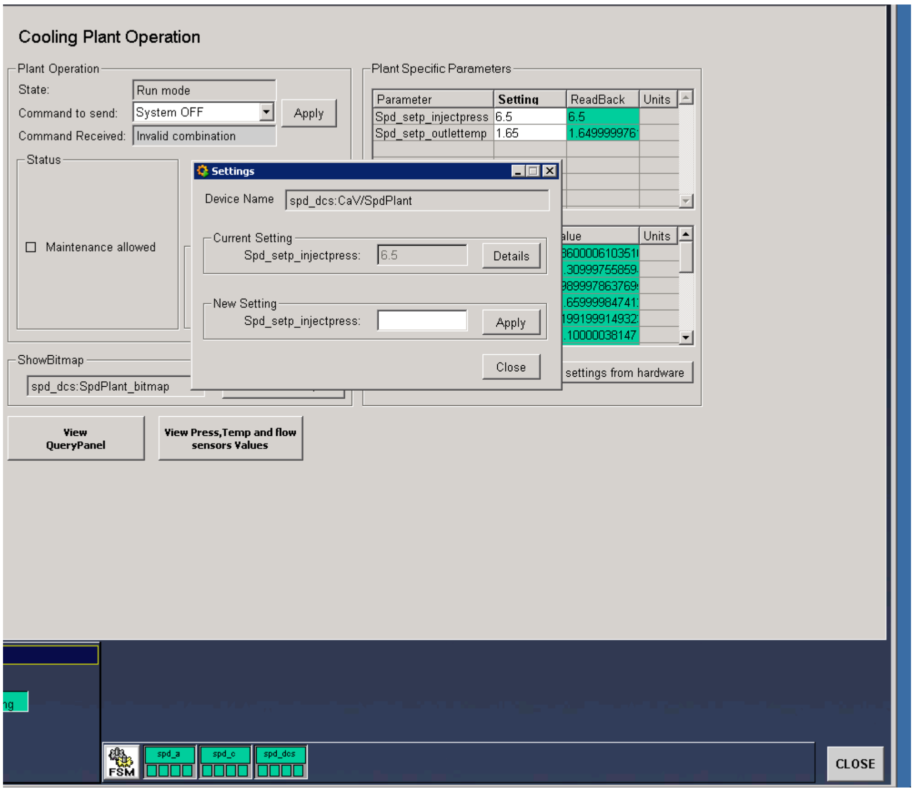

Figure 7: The pressure set panel which pops up when you clic on the value (white field) in the main panel (see text).

a very simple scheme of the plant is show with some measurement points which are relevant for the monitoring of the running conditions. On the left you find the ten values (one per line) of the return pressure. All the ten lines are connected to a manifold, then you should read approximately the same value, the differences being

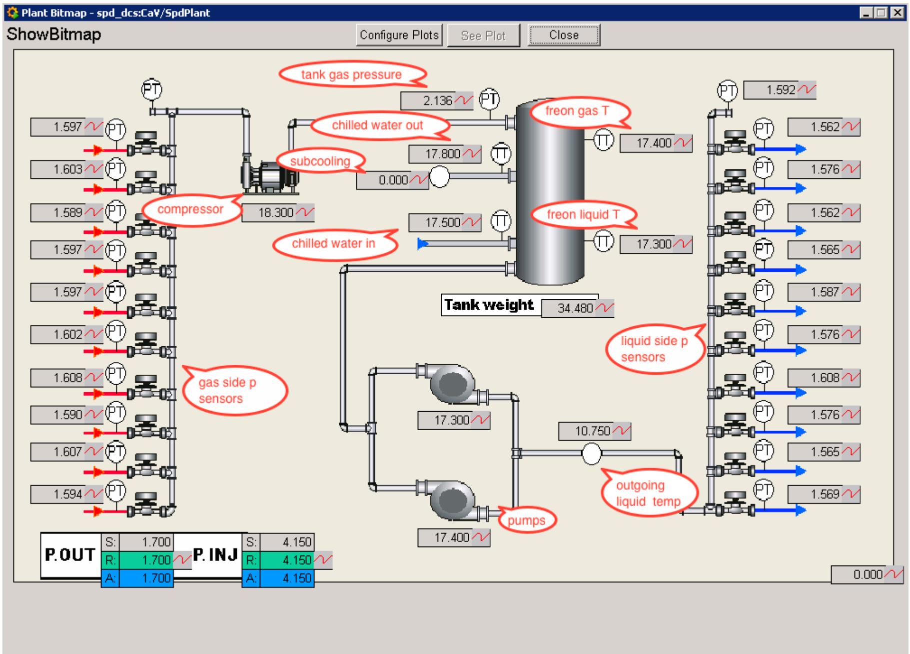

Figure 8: System monitor panel.

due to the calibration procedure and anyway limited to 1-2%, well below the needed accuracy. On the opposite side, the same number of sensors is dedicated to the liquid pressure. Here you can read very different values because the pressure is controlled by a pressure reducer in each line, in order to equalize the flow rate. On top of the manifold there is another pressure sensor which is meant to check the pressure in the same manifold when the valves are closed; remember that these valves are "normally closed", meaning that in case the plant is in STOP mode because an alarm has been triggered or the piquet changed the status, the liquid manifold is isolated and the pressure can rise to dangerous values, when a safety valve opens to let the excess fluid go in the atmosphere. The temperatures shown at the compressor and pumps are read by a sensor installed on the motors' bodies to check for dangerous stress. The tank gas pressure (typically 2.2 bar) is maintained by the chilled water flow. The in-out temperatures of this water are now 6.5-14°C, but can vary following the set point at the source and different running conditions (different freon flow, e.g. if part of the detector is turned off). The temperature of the chilled water used to subcool the liquid after the tank and before the pumps is shown, usually T=8.5°C. The outgoing liquid temperature is rather high due the contact of the liquid with the pumps, which are heated up by their electric motor. The freon liquid and gas temperatures are also shown. The last is useful, if compared to the gas pressure, to check the equation of state of the C_4F_{10}, when the plant is in stop mode since, at least, one hour. An excess of pressure is an indication of serious air contamination. In this case the cooling power is seriously reduced and action from the experts is required. In running conditions the gas is around 20°C and the liquid around 8°C (chilled water at 6.5°C). Finally, in the bottom left part a panel with liquid and gas pressure is present, with set, readback and actual values, respectively the value you set in this interface, the value set at the plant PLC and the value currently used in the PID loop.

4 Periodical checks

Here we list the periodical checks that you should perform in order to be sure that the system is working properly and that is not going to face a major problem.

1. Tank mass.
   Clicking on the icon to the right of the mass number display, you are presented with a window showing the plot of the tank mass values of the last two hours. Click on the "Y axes" menu and select the only available item, so a scale with the values in kg is drawn. Two hours is a rather short period to evaluate a possible leak unless it is really big. To obtain a wider time range click on the "Time Range" menu and a window will pop up (see fig. 9). where you should

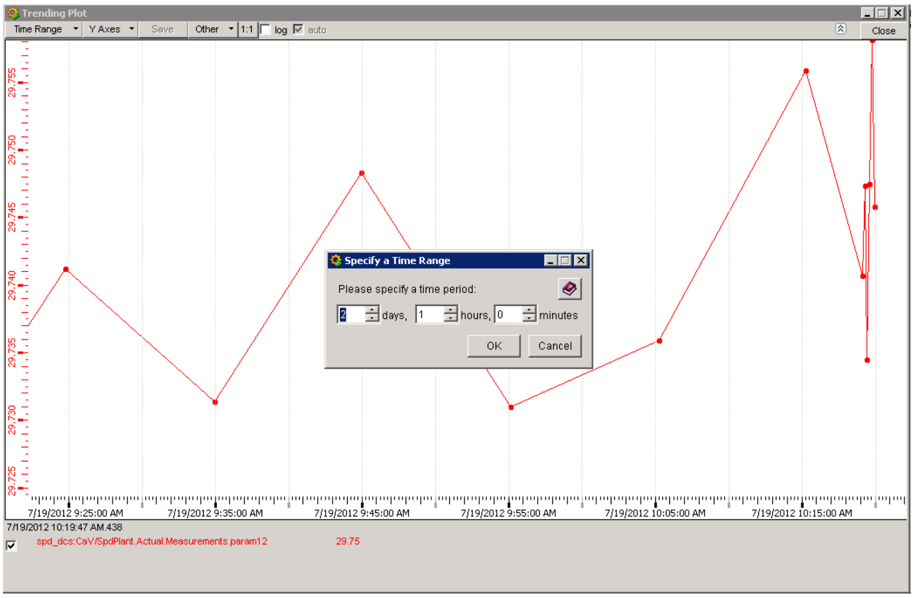

Figure 9: Tank mass trend with choice of time span open.

   set 14 days and then click ok. The plot will change as shown in fig. 10 where you can see the oscillations, due to changes in environmental conditions and normal behavior of the system, on a generally decreasing trend. In the plot shown the leak is approximately 10-20 g/day, which is an acceptable value. You should check at the beginning of your shift how much it is in order to compare later, say once every 3-4 days. A better view is shown in fig. 11 where the y axis has been compressed to show a wider range. You can do this pointing wherever on the axis and using (slowly!) the mouse wheel.

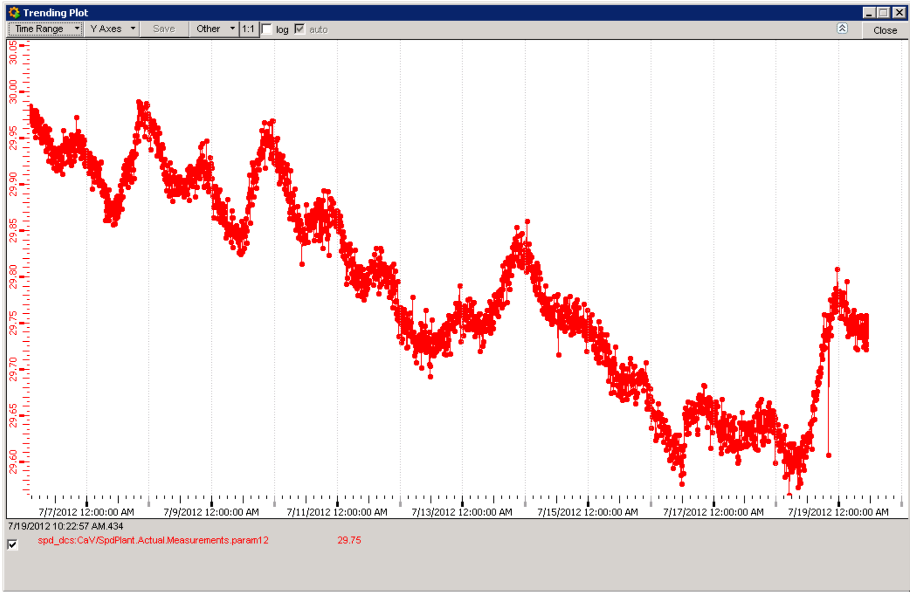

Figure 10: Tank mass trend over a two weeks period.

Figure 11: Same as fig. 10 but with wider y-range.

2. Flow rate

   The value of the flow rate can be checked on the panel shown in fig. 3, described in section 3. Variations of the order of a few 1% are acceptable and due to normal oscillations of the thermodynamical conditions of the fluids. Losses (not oscillations) of flow-rate of the order of 10% should be reported to the experts to trigger further investigation. No action is required from your side in this case. In the event of big enhancement of the flow rate (never happened...) a leak could have appeared and the best policy is to turn off the corresponding sector and bring the loop to the LOCKED status (see fig.4). You should check in this case the tank mass trend, which will show a drop, but then in less than an hour should stabilize.

3. Heaters temperature
   The heaters' temperature is shown in the third column of the panel in figure 3. Usually a temperature between 75°C and 100°C is measured. If one of the values drops at temperatures ¡50°C, probably the heater is off either because of a connection failure or because a circuit breaker has been triggered. You can find in section 5.8 more details.

5 Actions and reactions

This section is the most important of this short manual. We resume here, as far as we know the events that can happen to the system and the deviations from standard conditions that call for an action from the shifter/on-call.
Often the reaction to an event demands the intervention of the Detector Cooling Piquet. In the case you are asked later in this document to call the DCP, this means:

- Ask the SL to call the Detector Cooling Piquet (DCP from now on) - be sure you do not omit "DETECTOR", or you will get the wrong piquet (the Cooling Piquet, who is dedicated to general cooling service, e.g. cavern ventilation)
- If for some reason you have to do it by yourself, call the Technical Control Room (72201) or the CCC (77600)
- Tell also the number where you are calling from, or where they can reach you, as the piquet MUST call you back
- In case you do not have feedback after a reasonable delay, say half an hour, call back.

Most cases when the DCP is needed refer to sudden system stops, in which case, as first action, you should stick to the following **VERY IMPORTANT** procedure with high priority.

In case the system stops during data taking, the main goal is to be back on track as soon as possible. For this reason, in such a case, alert immediately the DCP which should be asked to call you back as soon as possible. In the meantime, set the liquid-side pressure to 4 bar. Then, if:

- the stop si due to a pump/compressor failure or another failure whose effect is over (e.g. a temporary water failure)
- no other alarms are present which prevent the restart of the system

you ask for the reset of the alarm and the restart of the cooling system immediately, putting it in RUN mode, if it is the case with the spare pump or compressor. When the system is running, wait for a few (10) minutes in order to let the pressure and temperature stabilize and raise the pressure on the liquid side to the nominal value (6.5 bar) in steps of 0.5 bar. When done, you should again wait a few minutes, while you can (ask to) reset the alarms from the DCS position and prepare to restart the detector. Check of course before that all the loops are ON.

5.1 Sudden system stop

In this section we describe in detail the possible reasons of a sudden system stop. In this event you will realize immediately that the liquid-side pressure and consequently the flow rate dropped to zero, causing the whole SPD to trigger the interlock and then shut down. There is no explicit message for the shifter about the source of the problem, but one (or more) alarm bit that you should check and note down (see page 10). Close all the loops and set the liquid pressure to 4 bar. If and when the problem is solved, you can go back to normal settings (we will refer to this definition in the following), i.e. all loops open and the pressure set at the nominal value in steps of 0.5 bar (6.5 bar currently), or whatever was before the stop. Then you have to warn the Detector Cooling Piquet, following the procedure as described at the beginning of this section. The DCP will inform you about the nature of the failure and what he can do to restart the system. In some cases a bit of caution is needed, you find below the possible causes and, if the case, the action needed.

1. Low tank liquid mass ($<$ 10 kg)
   In this case, the reason for having lost all the liquid has to be found, and the tank refilled. An access is needed, at least of one day.
2. Tank liquid mass diminution ($>$ 2 kg/min)
   The reasons for this event may be several. Check if the mass trend has inverted the slope or is stable, this should exclude that a major problem occurred to the tank. The DCP can try to reset the alarm, so the plant can go back to RUN mode. Then you can try to go back to normal settings.
3. Pump failure
   The DCP can restart the plant operating the other pump. When done, go back to normal settings.

4. Pump overheating
   Same as above.

5. Booster (compressor) failure
   An electrical problem has been detected. The DCP has to restart the system with the other compressor, then go back to normal settings.

6. Booster (compressor) overheating
   Same as above, but because of overheating of the compressor's motor.

7. Compressor downstream overpressure
   This condition has been found when the chilled water stops working, then the temperature of the fluid inside the tank increases up to values close to room temperature. The pressure in the tank (then downstream the compressor) raises as well up to dangerous values. You should check the temperature of the chilled water, which in this case should show a positive trend, going to the alarm level in 20'. If not, it could be a problem related to the regulating valve of the chilled water flow. In the first case a general problem is probably present, so the TCR should be called in order to call the right experts. When the temperature of the water is back to normal values, you can ask the DCP to restart the system, then go back to running conditions. In all other cases, the DCP should have the means to understand where is the problem and how to proceed. If access is needed and available, an expert should be called.

8. Compressor upstream overpressure
   A problem raised on the compressor. The DCP should switch to the other compressor and restart the system. When done, go back to running conditions.

9. PLC failure (I/O, UC, etc.)
   The DCP will inform you on the possibility/timing to restart the system. Ask for a restart with all lines closed (not locked) and 3 bars (probably you could not do this before). When done, go back to normal settings.

10. Hot/cold PLC start Same as before.

11. High chilled water temperature (>20°C)

12. Compressed air failure
    If the problem is local to SPD, probably an access is needed. If the problem comes from the distribution service, you have to wait for news from the DCP or TCR. Of course, if the normal operation is reestablished you can restart the system.

13. Condenser pressure < 1.6 bar
    This alarm could be due to the chilled water regulating valve which is blocked on the open position. Or it can be a leak located close to the tank. A pressure too low may result in cavitation of the pump, with possibly destructive effects. Check the tank mass trend of the last 24 h, to exclude serious leaks . Ask

the DCP to put the plant in STANDBY mode for a short time (1/2 hour) and check that tank mass increases slowly. The absolute level depends on the previous conditions and on the reason of the alarm, but you should anyway have a level higher than the running value (check). If you are at this point with no warnings/alarms, can ask the DCP to put the plant in run mode and restart the cooling.

14. Evaporation pressure > 2.7 bar
    The pressure in the return lines is going beyond the setpoint of the safety valves, STOP of the plant is issued to try to avoid the opening of the valves. For the sake of prudence, ask the DCP to restart with the other compressor, then go back to normal conditions.

15. Liquid outlet pressure > 8 bar
    The sensor triggering this alarm is located on the top of the liquid manifold. Such a high pressure may be due to a high pump rate or by a sudden shut off of all the liquid-side valves. In any case, follow the stop procedure, check with the DCP that there is no permanent damage (e.g. leaks, loss of control on the PLC, etc.) and restart the system. If the problem appears again, an expert has to intervene.

16. Liquid pumps manual valves closed
    This alarm is triggered if somebody closed (manually) the valve(s) just after the pump(s). Clearly this is possible if there was access to the cavern. Be sure that this operation has been done on purpose, say because there is a problem on one of the pumps. Then you should ask the DCP or somebody from EN/CV/DC to switch to the other pump. If the valve was closed by mistake, an expert has to go back in the cavern and open it. The case could also be that there is a malfunctioning in a contact and there is a false alarm. Probably an access to the cavern is needed, if it is not possible you have to stop the cooling system (see section B) and ask DCP for a restart with the other pump.

17. Pressure stability
    The pressure in the liquid manifold has been above the set point more than 400 mbar for more than 2'. Ask the DCP to restart with the other pump, then go back to running conditions.

18. Breakers fault (1-4 or 5-7)
    A circuit breaker has been triggered. Depending on which one, an access may be needed to restore the breaker, then restart the system. Agree with the SL and the DCP if action can be taken immediately or not and if an expert is needed.

5.2 UPS intervention

The UPS is protecting the pumps and the control rack of the cooling system. By now, there is no control over the reaction time and no follow-up from the PLC is foreseen. If there is a power glitch or a power cut for a short time, the UPS allows 20' to take action. If the event causing the UPS activation has been temporary, there is nothing to do. If there is a persistent power cut, after a few minutes you should stop the system (see section B). Note that before you turn off the cooling, the detector has to be turned off.

5.3 General electrical failure

When a general power failure happens, it involves both the cavern services and detectors and the control room...everything. The system is designed in order not to undergo permanent damages from this event. Call CCC in order to get the DCP; consider longer reaction times because each and every system shares the emergency. Ask the DCP to wait to restart the system until you get the DCS controls back. At that point follow the "stop" instructions (in section B). Check with the Shift Leader that the cavern services are back, most intersting to you the chilled water and the subcooling (coming from the TOF cooling plant: ask the TOF expert, who should be around, given the situation). Then you can ask the DCP to put back the plant in RUN mode, and finally go to normal running conditions. Be patient, it will take probably hours before you get there.

5.4 Cavern electrical failure

With respect to the previous case, this one should be less tough, as you should still have the controls available. Then follow the procedure as in the previous case.

5.5 Suspect leak

Refer to sect. 1 for instructions on how to check the tank mass trend. Typically, an event like e.g. the partial opening of a safety valve will produce a sharp change in the slope of the trend. If you observe such an event, log it and notify one of the experts (you don't need to do it during the night, can wait for normal working hours). This kind of events usually change the leak from a few tens of g/day to 100-200 g/day. In case the leak is dramatically big (order of kg's/day), go to the "Flow rate" item of this list and check the single lines following those instructions. If you cannot identify a single leaking line, you have to call an expert immediately. In case you cannot reach an expert, try to do on the trend plot a gross evaluation of the leak: when you are left with 2 hours lifetime, the best you can do is ask for the exclusion of the SPD from the run, turn it off (see the general SPD on-call instructions for this) then close all the 10 lines, as explained above. Consider that this event never happened and it is very unlikely, so be careful not to over-react!

5.6 Subcooling failure

The subcooling failure will affect a few half-staves, mostly on sector 3, changing the temperature. No other effect is foreseen. Do nothing but logging and notifying the experts.

5.7 Chilled water failure

If the chilled water flow stops or the temperature increases slowly e.g. because the chillers stopped, you will not realize until the alarm for high pressure in the tank or for high water temperature have been triggered. At this point, the detector is OFF and the plant is in STOP mode. Agree with the shift leader to call the TCR if it's out of working hours or the technical coordinator during normal working time. You should obtain then some pieces of information about the problem. When solved, you can call the DCP to reset the plant and put it in RUN mode, then you can go back to normal running conditions. If by chance you realize that the water temperature is increasing, consider that you have $\approx$20 minutes from the start of the rise before the plant stops. Warn the shift leader about the problem, try to get info on the issue from TCR (night) or from our technical coordination (day). Inform also the DCP. There is no other possible action from your side. (ALTERNATIVA: SPD OFF E PLANT IN STD-BY, ma se l'acqua ritorna?)

5.8 Heaters failure

A circuit breaker intervention or a short circuit can turn off one pair or more of heaters (there are 2 heating cables per line). The effect will be an accumulation of liquid in the return line, what you can realize looking at the tank mass trend. This will show a negative trend which will stabilize after 0.5-1 kg has been drawn from the tank, in approximately 0.5 h. If the heaters off are 1 or 2, this event is not dangerous for the system as the fluid will partially fill the line, but will always be recovered by the compressor, which will be working at higher frequency. No action is required but logging the event and inform the expert as soon as possible, during working hours. If the heaters go all off, consider that if the tank has less than 22 kg you'll probably run out of freon soon, and an alarm of empty tank will be issued stopping the system. An access is needed as soon as possible to restore the power in the heaters.

Appendices

A Useful telephone numbers

Check that they are up to date.

- SPD cooling responsible: Rosario Turrisi, 164991 **- EXPERT**
- ITS cooling coordinator: Claudio Bortolin, 160491 **- EXPERT**
- SPD project leader: Vito Manzari, 163187
- Technical Control Room 72201
- Cern Control Center (CCC) 77600
- Sebastien Roussee (EN/CV/DC contact for ALICE-SPD) 163650

B Start & stop procedures

B.1 Start

We assume that the plant is in RUN mode (check in the panel shown in fig.5 and that all lines have to be operated. Set the liquid-side pressure to 3 bar. Check that the subcooling is off. Go to each loop panel and change the status to ON. Note that the operation is completed when the STATUS goes to OFF, NOT the readback. When all lines are open, wait 5' to have the input lines completely filled. Then raise the liquid-side pressure to the nominal value (see below). After a few minutes (5) the cooling should be effective in all sectors. You can check on the temperature monitor panel that all sectors have a temperature drop from 20°Cto 15-17°C(depending on conditions). Current pressure values are: 6.5 bar on the liquid side, 1.65 on the gas side. Check! Eventually, turn on the subcooling.

B.2 Stop

In case you have to stop the cooling or if the has been an alarm and you have to restart from there, set the liquid-side pressure to 3 bar and close all the loops (put to OFF status) going to the single loop panels. Again the operation is completed when the STATUS goes to OFF, NOT the readback.