Meeting on Cryogenics Distribution for 400 MHz LHC RF system

23rd November 2001

Present:
Edmond Ciapala SL/HRF, Trevor Linnecar SL/HRF, Roberto Losito SL/CT,
Ralf Trant LHC/ACR, Joachim Tückmantel SL/HRF, Rob Van Weelderen LHC/ACR.
Excused: Volker Rodel.

Agenda:
1) Follow-up of actions from previous meeting 26th September 2001
2) Gas content of helium after inlet valve CV93x
3) Operating scenarios
4) TCF 50 400 W cryoplant "temporary use" in P4
5) Radiation levels from SC cavities – effects on cryo line?

1. Follow-up from 26th September.

1.1. Layout for the routing cryo lines past the RF high power system (Volker and Ralf)

The positioning of the service module in IR4 has been fixed, as well as the cryo lines to the surface plant. The routing of the flexible co-axial lines (supply in the interior, return gas on the exterior) from the service module to the RF modules has still to be fixed. The positioning of the extra tube needed to carry either the liquid helium to the module or the return gas to the flexible has also to be fixed. **(Actions – Ralf, Volker, Roberto)**

1.2. Checking of He tank design pressure and definition in specifications (Roberto)

A safety study report (TIS/TE/MC/1-2255 - 8/12/98) states that since the helium tank is contained inside a vacuum tank, the risk of outside damage in the event of rupture of the helium tank is low. The vacuum tank has a pressure safety valve operating at 2 bar*[1]. Pressure tests at 1500 mbar were carried out by the manufacturer on all helium tanks after their construction.

1.3. Clarification of allowable maximum operating and peak He tank pressures (Roberto).

The limiting pressure above which plastic deformation of the He tank becomes a risk is 1500 mbar. Every effort must be made not to exceed this level. The quench valve (QV) should open at this level and be fully open 50 mbar higher. While an electronically controlled valve using the measured cryostat pressure would easily fulfil this tight requirement, the risks of false triggering make this a risky option. The behaviour of the system in the event of quench of a number of magnets near the cavities was discussed. The Pressure Control Valve (PCV)*[.2] in the return line will close at 1400 mbar. There was agreement that it would be wise to switch the RF off in the cavities as soon as a magnet quench was detected to minimise the risk of overpressure in the He Tank with the PCV closed.*[.3]

(Action - Ed - *via Machine Protection Working Group***)**

1.4. Search for suitable valves for QV and PCV – **(Rob): Ongoing**

1.5. Check QRL D line pressure rise times and levels for quench and fault situations - Rob.

The simulations done some time ago still have to be checked but the rise time will be long, not less than 20 seconds, allowing the PCV valve time adequate time to close before a value approaching the 1500 mbar opening level of the QV is reached.

1.6. Drawing LHCACSGA0006 to be completed – Ralf, Roberto, S. Girod
Roberto presented an updated version. Ralf proposed some minor changes. A further updated version will be produced. **(Action – Roberto)**

1.7. Establish RF operation scenarios and cryo power requirements, including maximum values - Ed., Volker, Joachim and Roberto. – See Section 3 below

2. Gas content of helium after inlet valve CV93x

Supercritical helium at 3 bar and 4.6 K is expanded through the inlet CV to the module to a pressure of 1350 mbar. This will inevitably lead to the presence of He vapour in the liquid helium. Rob estimates that this should be 1.9 % of the He mass flow. The amount that can be tolerated by the cavities is not clear. Joachim referred to difficulties experienced in SM18 where modifications had to be done to the cryo system to reduce the vapour content. It would be instructive to look at the SM18 system to see what was done and what the vapour contents were before and after. **(Action - Ralf, Roberto)**

3. Operating Scenarios

Joachim presented a summary of normal and special operating situations – see attached file. For normal operation at 2 MV/m the losses *per module* are 150 W static + 100 W dynamic + 25 W reserve = 275 W total. A few watts for the coupler and cone cooling circuits should be counted. Helium supply line losses of about 10 W per line are not included. Running with one 'faulty' cavity at zero volts and the seven remaining a factor 8/7 overdriven to achieve the same total voltage is unlikely in practice but represents the upper limit for running with one cavity of the eight per ring partially degraded. The dynamic losses, taking both the increased field and the lower Q_o into account, would be increased by 10 W to 40 W in the module with all cavities fully active, making up to 315 W maximum total. This would not require additional capacity of the inlet CV.

Running with one module at double voltage to replace an absent damaged module is a hopefully unlikely scenario. Operation at high field with high intensity would not be very stable and the preferred solution would probably be the installation of the spare module. Additionally the poorer regulation attainable with the increased flow capacities has to be considered. Nevertheless if the cost of the additional inlet valve is very low compared to that for addition afterwards it might be prudent to install it at the outset, in case of a real emergency situation arising e.g. no spare module available. The dynamic losses for one module providing the voltage of two is 800 W, making a total module requirement of 950 W.
(Action: cost of additional inlet valve to estimated - Ralf/Rob and a decision taken - all)

The variation of cryo power during the ramp will normally be very slow. Around 20 minutes are needed from injection to top energy. Nevertheless it may be necessary to change RF voltage rapidly during the ramp for beam dynamics reasons. The regulation process and its parameters (valve settings, heater powers) should be studied in order to estimate the performance of the complete system under such circumstances.
(Action - Ralf, Joachim, Ed, Roberto)

4. Temporary cryoplant in IP4

The present LHC planning, with magnet installation completed and QRL available in IP4 for mid 2005, allows just a few months for RF system commissioning before start-up with beam. An ex-SPS TCF50 cryoplant with 400 W capacity is in temporary storage. Several outside institutes and companies are interested in obtaining this plant. The possibility of installing it, on a temporary basis, to make progress with RF commissioning in the event of delays in LHC installation was discussed. For the moment only a verbal agreement on a first option on this cryoplant has been made with ACR. Installation cost would be around 100 kSfr and some manpower would be needed for its operation. Any delay would therefore have to be substantial to justify its installation. It would seem reasonable however to keep the option open till the moment when a decision about the future use of the plant has to be made.

Since the meeting it has been confirmed with C. Wyss that the plant has effectively been promised to GSI in Darmstadt who are already making plans for its installation. A final decision is likely in 4 weeks.

5. Radiation levels from SC cavities (Joachim+Radiation specialists)

The maximum radiation from the SC cavity module during processing may approach several tens of krad/hr. In the worst case, however, this dose produces less than 1 Watt in the transfer lines (QRL) and will not be a problem.

List of actions:

1. Layout for the routing cryo lines past the RF high power system - Volker and Ralf
2. RF off interlock in the cavities as soon as a magnet quench was detected
   (In the adjacent sectors only - if the interlock system permits) - Ed
3. Search for suitable valves for QV and PCV – Rob
4. Drawing LHCACSGA0006 to be updated – Roberto
5. Check the SM18 cryo system mods done to reduce gas content – (Ralf and Roberto)
6. Cost of installing additional inlet valve – Rob
7. Study of the regulation process and its parameters (Ralf, Joachim, Ed, Roberto)

* *Some further points arising for discussion at future meetings:*

1. Event of He tank rupture => vacuum tank overpressure? Need for outside protection?
2. Doubling up of PCV valve for emergency overpressure protection?
3. Recovery of gas in coupler and cone circuits on PCV emergency closure?
4. Control of oscillations, remembering we have 150 Hz/mbar.
5. Expansion pot after inlet CV – should installation space be allowed in planning?

E. Ciapala, 28th November 2001