CMS FPIX Upgrade Cooling Specifications 11/13/2008

These specifications are written for the proposed CO_2 cooling system and associated parts of the detector upgrade. The intention is that these points be discussed and agreed before detailed design work is done.

1. Maximum heat load is 15 watts/blade.
   reason: Expected heat load with 50% contingency. Heat load is not expected to increase. This is for sizing the detector cooling tubes and substrate, not the cooling plant.
2. There will be eight blades per half-disk.
   reason: Blade layout is being developed. The number and size of blades may change, but the total heat load should not.
3. System operates with panel temperature from -20 to 25C.
   reason: Allow commissioning without dry gas purge.
   reason: The requirement to operate at room temperature would cause the detector tube size to increase.
   reason: The requirement to operate at room temperature increases the design pressure.
   reason: If existing tubing is used with pressure limitations, the maximum operating temperature will be limited and either a refrigerant storage or recharging system will be needed.
4. Average temperature stability should be +/- 2C with the detector on.
   reason: AOH temperature is not part of this specification.
5. Minimum operating temperature with no heat load, i.e. detector on or off, is -30C.
   reason: Low coolant temperature permits bigger ΔT in substrate.
6. Panel must withstand a sudden change in coolant temperature from 20C to -30C with the panel initially at 20C.
   reason: Check thermal contractions between the tube and substrate during rapid cooldown.
7. Cooldown rate must be at least 10C/hour for a complete system cooldown with detectors off.
   reason: Cooling system capacity.
8. Maximum ambient temperature is 40C. Refrigerant shall be retained at this temperature.
   reason: This is a non-operational condition used to determine the design pressure of the cooling system. If the tubing can not take this pressure, either a refrigerant storage or recharging system will be needed.
9. Design for a depressurization accident with the detector tube initially full of liquid.
   reason: Assume that no new liquid would be added. It may be necessary to assume that liquid is added to the tubes depending on the size of the breaks.
10. Normal operation shall be automated so that operations is simply cooling system on/off control and setting the detector temperature.
11. The control system should tie in with CMS or CERN monitoring system.
12. Interlocks must protect the cooling plant and detector against equipment damage.
13. Detector temperature measurements shall be generously applied to cover every thermal concern.
14. Mechanical equipment shall be backed up with spare equipment that starts automatically if the lead equipment fails.
    reason: This system is design to have little or no down time due to equipment failure.
15. Equipment and valves in the detector hall shall be minimized.
    reason: To allow adjustment or repair without dropping the beam.
16. Equipment, instruments and valves in the detector hall shall be radiation resistant.

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18. Radiation length of the existing blades is 3.64%, of which the cooling channel contributes 1.17%. Radiation length of the upgraded substrate, cooling channel and thermal spreader will be less than 0.6%. See docdb 500 for details.
    reason: This is thought to be reasonable based on preliminary calculations.
19. Individual blades must be removable by brazing or mechanical connections. Heat from brazing must be intercepted without heating the blade. Joints are needed at PP0 and PP1.
    reason: The final specification regarding joints must consider ease of repair, mass, material and radiation compatibility and the availability of skilled technicians.
20. Tubing length from PP1 to PP0 is about five meters and follows a tortuous path. Make sure the tube routing with insulation will fit through the limited space. The existing tubing has an 0.472 inch (12 mm) outside diameter.
21. The cooling plant and main transfer lines should deliver 10kW capacity for phase one and be expandable to 20kW for phase two.
    reason: These cooling capacities will handle both the barrel and pixel cooling with phase one and the increased intensity of phase two.
22. Thermal interference from other cooling or heating systems must be considered.
    reason: Using tubes in the existing bundle won't work since there is no insulation between them. Or a more complex and energy consuming system is needed. This requirement is contrary to the goal of re-using the existing tubing.
    reason: This includes thermal effects of BPIX on FPIX.
23. Dielectric breaks must be installed at PP0 between the detector and the piping to PP1.
    reason: The leader of detector grounding plans should confirm this.
24. Total refrigerant leak rate should be less than 1e-2 atm-cc/sec.
    reason: Based on the modest cost of carbon dioxide and with the intention to avoid the cost of mass spec leak detection.