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SNS PPU HB cryomodule design change list at the time of the preliminary design review.

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1. In general all changes made to the SNS HB spare cryomodule have been incorporated into the SNS PPU HB CM's with exceptions noted below.
2. Helium Vessel
 - a. Slight changes to two welds: backing strap on head/shell weld (was fillet weld in original design and butt weld w/out backing strap in SNS prototype design) and slight increase in size to match BPVC required minimum thickness on head/NbTi fillet weld.
3. Tuner
 - a. A notch in the main frame that was needed to avoid the original HOM on the cavities has been removed from the design
4. Spaceframe
 - a. The support tubes have been extended by ~15" to act as supports for the thermal and magnetic shield extensions for both CM assembly ends.
5. Thermal Shield
 - a. The axial nitronic rod penetrations/slots in the shield patch panels have been opened up to allow more clearance.
 - b. The length of the field probe cable thermal intercept block has been reduced by ~60% and we eliminated the machine slots for the HOM cables.
 - c. The radial nitronic rod thermal intercept straps were changed from being solid copper bands to braided copper straps to allow more flexibility and prevent the potential for cracking of the solid straps that has occurred in the past.
 - d. Thermal shield end extensions at both ends of the CM have been modified to match new assembly plans at JLab.
6. Magnetic Shield
 - a. The holes for the piezo tuner have been removed from the inner shield end caps.
 - b. The shield tuner port door supports have been opened up to improve installation on the inner and outer shields.
 - c. Fixed a centering issue found on two of the outer shield opening around the FPC's.
 - d. Magnetic shield end extensions at both ends of the CM have been modified to match new assembly plans at JLab.
7. Vacuum Vessel
 - a. The end flange to shell weld configuration was changed from one where the shell butted up to the flange face to one where the flange slips over the shell.
 - b. The vessel's return end can port ID has been opened up by 1.4" to match the ID of the end can elbow. This was to accommodate changes in the end cans for adjustability. (Related to 8.a.)
 - c. The end can mounting pads had recessed pockets added to them to allow adjustability during end can alignment. (Related to 8.a.)
 - d. The end flange center penetrations were opened up to aid in a clean connection between warm/cold beam line and vacuum vessel flange. (Related to 10.a)

- e. The number of bolts at the warm/cold beamline to vacuum vessel end flange was reduced from 20 to 10 to add slots for radial compliance for the new warm to cold beam pipe design and assembly plan. (Related to 10.a)
8. End Cans
- a. After consultation with SNS, added a bellows and additional rotatable flange in both end can assemblies to allow position adjustment of the female bayonets at final assembly.
 - b. A general revision to the return end can piping and shielding to improve the clearances between the 2K piping and thermal shield.
 - c. General revision to both end cans to support the shipping G loads to be consistent with the rest of the CM.
 - d. Changed the sub-atmospheric pressure transducer mounts on the return end can to improve maintainability and added a 30/30 gauge for visible indication in the SNS tunnel.
 - e. Added thermal stabilization loops to the ¼" relief lines in the supply end can and ¼" pressure tap lines in the return end cans.
 - f. Eliminated some of the unneeded ½ NPS to ¾ NPS transitions at the exit of the female bayonets in both end cans. Piping is now all ¾ NPS.
 - g. Added or modified lifting points to both end cans to facilitate handling at JLab.
 - h. Replaced the original low pressure 2K relief on the return end can with an equivalent ASME certified relief valve.
 - i. Cleaned up some of the thermal strap designs to improve assembly and to act as supports for the shipping G loads
9. Instrumentation
- a. Will use all CERNOX temperature sensors at the request of SNS.
 - b. Added threaded mounts for the temperature sensors on the helium vessel. Similarly, added mechanical mounts for the end can temperature sensors.
 - c. Proposed changing to a right angle SMA connection on the FP cable for improved mechanical stability in the cable. SNS has had negative experience with the right angle connectors so we will not do this.
 - d. Eliminated the HOM connections on the four instrumentation port. Changed one port to a mini-CF connection for the surge tank temperature sensors on port 1. Ports 2-4 will have the mini-CF with a blank flange.
10. Cryomodule Assembly
- a. Modified the SNS HB prototype warm to cold bellows and warm beam pipe assemblies to accommodate installation in cleanroom and improved clean assembly. Eliminated one mechanical seal on the return end can side.
 - b. General revision to the SNS HB spare CM end piping assemblies to match the JLab assembly plan.
 - c. In general, adding socket weld connections to 1/4" tubing for improved weld ability. This is also done in the end cans.
 - d. The original JLab surge tank has been incorporated into the PPU design instead of the one used on the SNS spare HB CM.