DESIGN OF CRYOGENIC SYSTEM FOR SEVERAL SUPER-CONDUCTING MODULES AT NATIONAL SYNCHROTRON RADIATION RESEARCH CENTER

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Abstract

National Synchrotron Radiation Research Center (NSRRC) is planning to install two 500 MHz super-conducting radio frequency (SRF) cavit114ies and six super-conducting magnet (SM) modules. For the cryogenic requirements, we are presently constructing a helium cryogenic system. The cryostat properties of the SRF cavities and the SM modules are so different that in our design the cryogenic system has two cryogenic plants (465W or 110 liters per hour @ 4.5 K for every plant), one is for the SRF cavities and the other is for the SM modules. The two plants are independent in normal operation. However, when the cryogenic plant for the SRF cavities shuts down, the other one can be transferred to supply the SRF cavities, and we design a distribution valve box to carry out the transformation.

NSRRC REQUIREMENTS

National Synchrotron Radiation Research Center (NSRRC) is a third-generational 1.5 Gev light source. There are 23 beam-lines now in NSRRC to supply light from IR to hard x-ray for experiments. Initially NSRRC does not have any super-conducting systems. To promote the storage ring, NSRRC is planning to replace the initial conventional radio frequency (RF) cavity by the super-conducting radio frequency (SRF) cavity, and install some super-conducting magnet (SM) modules as hard x-ray beam-line sources.

There are totally two 500 MHz SRF cavities and six SM modules will be installed in the storage ring. Figure 1 shows their locations, where the refrigerators and the liquid helium main Dewars are located on a platform beside the storage ring. The estimated heat leak of these

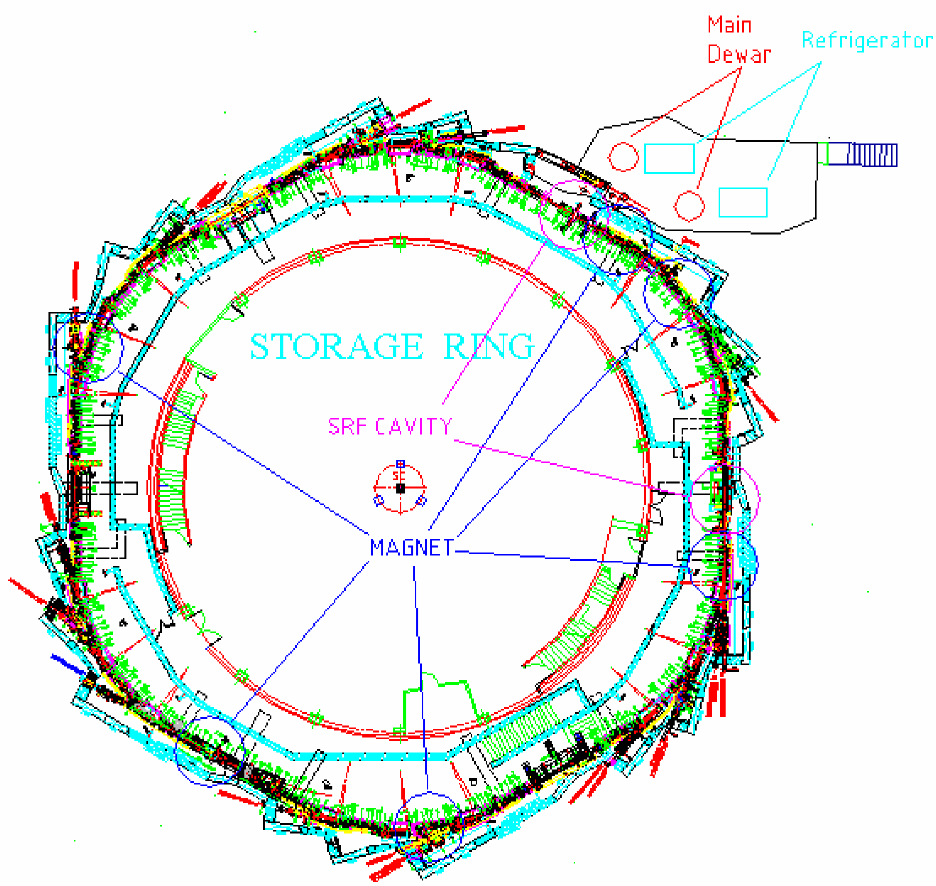

Figure 1: Locations of SRF cavities and SM modules.

super conducting systems, associated valve boxes, and cryogenic transfer lines are shown in Fig. 2. For the cryogenic requirements, we are planning to construct a cryogenic system with two cryogenic plants (herein named MCP1 for SRF cavities and MCP2 for SM modules), and the capacity of every plant is 465W or 110 L/hr @ 4.5 K.

The cryogenic quality demands of the SRF cavities and the SM modules are so different. The SRF cavities ask the pressure fluctuation must be less than 3 mbar and the level fluctuation must be less than 1% in its liquid helium vessel. The SM modules ask the pressure as low as possible, but do not care for the fluctuation of pressure and level. Besides, the SM modules will sometimes quench and release huge quantity of helium gas in short time. Therefore, the SRF cavities and the SM modules can't be supplied by one cryogenic plant, and in our design the two cryogenic plants must normally operate independently. However, only several beam-lines will shut down if the SM modules shut down, but the storage ring will shut down if the SRF cavities shut down, i.e., about thirty beam-lines will shut down. Hence, we ask the MCP2 can be transferred to supply the SRF cavities when the MCP1 shuts down, and we design a distribution valve box to carry out this transformation.

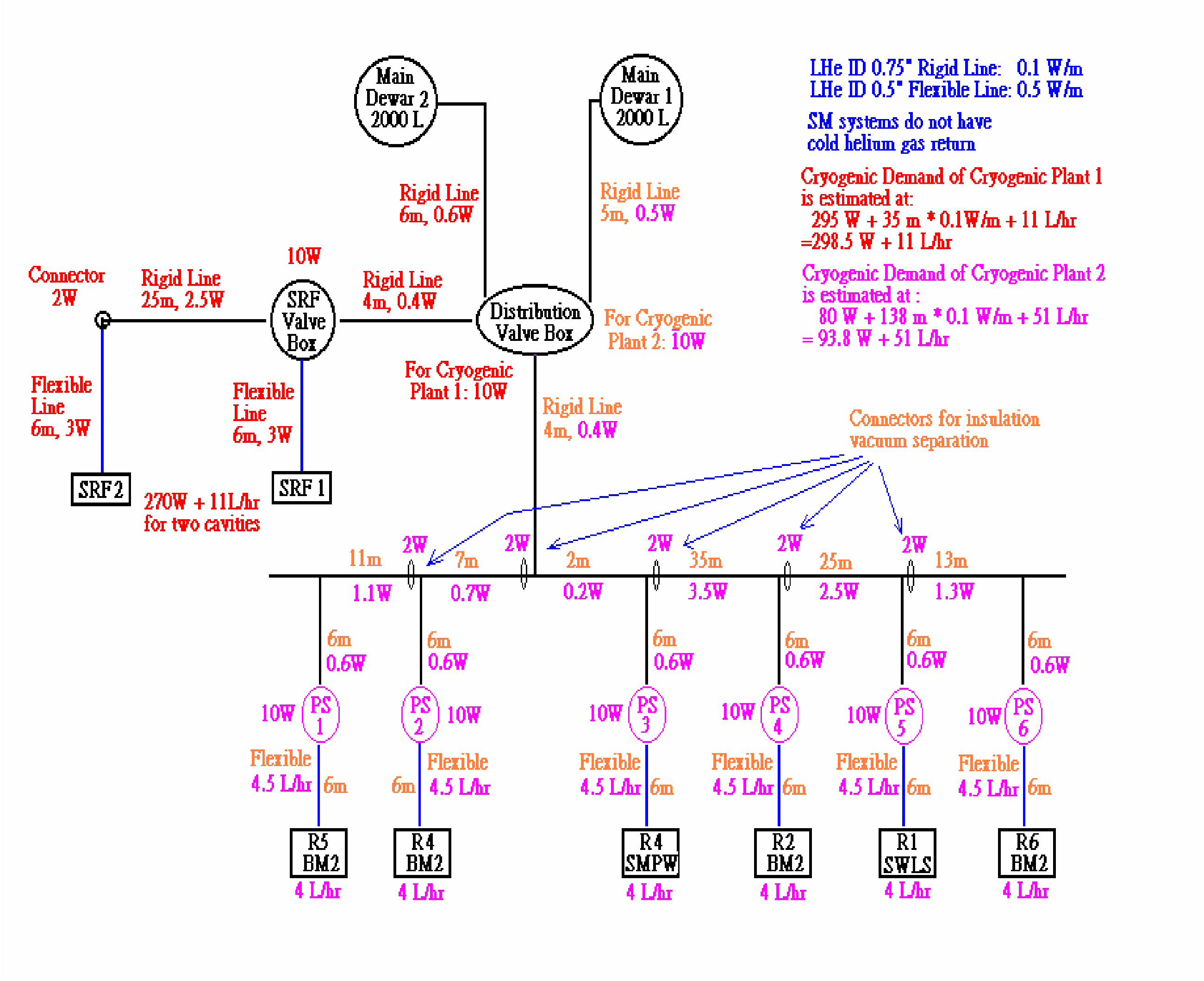

Figure 2: Estimated heat leak of SRF cavities, SM module, and associated valve boxes and piping.

CRYOGENIC SYSTEM

Our cryogenic system is shown in Fig. 3, where the distribution valve box is the key part in our design. In normal operation, the valves V102, VD01, VD02 close, and VD03, VD04, V101, V201 open. That is, the SRF cavities are supplied by MCP1, and the SM modules are supplied by MCP2. When the MCP1 shuts down but we still want the SRF cavities to operate, we close the valves V101 and VD03, and open the valves V102, VD01 and VD02. Then the SRF cavities get the liquid helium from MCP2, and return the cold and warm gas back to MCP2. In the same time, the thermal release helium gas from MCP1, the SM modules, and their phase separators will also goes back to the MCP2.

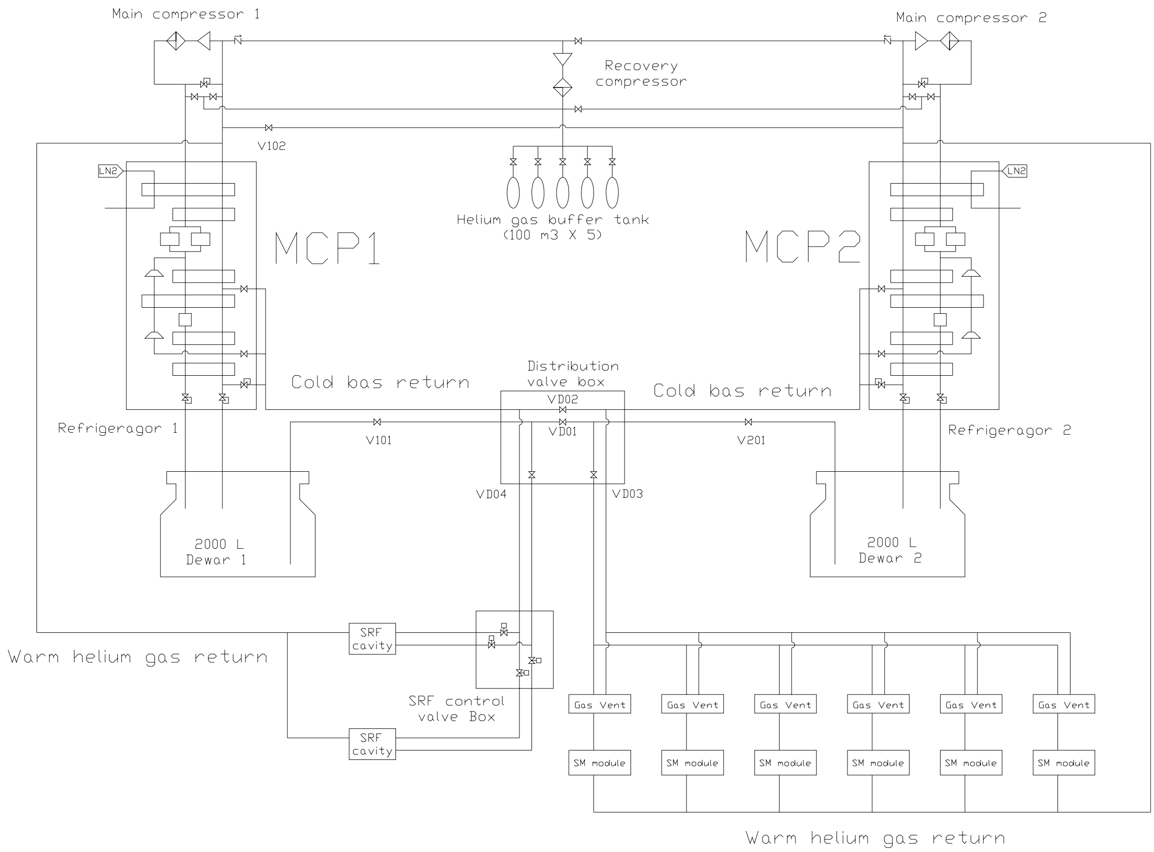

Figure 3: Cryogenic system of NSRRC.

Our design has some advantages. (1) The storage ring can operate if any one of the two cryogenic plants works. This point is very important for us because now our user time is crowded, and we have to avoid any unexpected storage ring shut down caused by the cryogenic system accidents. (2) The cryogenic system for the SRF cavities and the SM modules are isolated. If the SRF cavities and the SM modules are supplied by the same cryogenic plant, the quenches of the SM modules will disturb the pressure of the SRF cavities through the suction line, and the electron beam in the storage ring maybe will run trip. (3) Our design is the simplest way for that MCP2 is the backup of MCP1. Only the distribution valve box is the additional part for the backup function. The two cryogenic plants can be different capacities, operated by different control systems, and from different vendors. Of cause, our design has some weak points. (1) Two cryogenic plants are more expensive and complex than a large one with the same total capacity. (2) There is additional heat leak (estimated at 20W) form the distribution valve box.

SUMMARY

Now the user time in NSRRC is crowded, and we have to do our best to avoid any unexpected storage ring shut down and electron beam run trip caused by the cryogenic system accidents. The design of NSRRC cryogenic system is based on our special requirements.