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FABRICATION AND INSTALLATION OF NEWLY DESIGNED CRYOSTATS AND TOP FLANGES FOR THE VERTICAL TEST OF RISP*

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Abstract

Rare Isotope Science Project (RISP) in the Institute of Basic Science (IBS), South Korea, is now operating SRF test facility in Sindong, Daejeon. Sindong SRF test facility has three vertical test pits and three horizontal test bunkers, 900W cryogenic system, RF power system, and radiation protection system. This paper explains about detail procedures of constructing cryostats and top flanges for the vertical test of RISP, Installed cryostats and top flanges have insulation vacuum layer, magnetic and thermal shield, 4K/2K reservoir, heat exchanger, cryogenic valves for supplying liquid helium, vacuum lines, and electrical instrumentations for the superconducting cavity tests.

INTRODUCTION

RISP is making and installing many devices such as ion source, superconducting (SC) linac, low and high energy experimental systems, cryogenic systems, RF powers and control system for RAON since 2012 [1]. And for the vertical test (VT) of SC cavity, RISP constructed and operated Munji SRF test facility from 2016 and larger SRF test facility at Sindong site from 2018. VT for SC cavity should be proceeded under same conditions as cryomodule such as 4K and 2K liquid helium (LHe) supply, thermal/magnetic shielding and ultra-high vacuum (UHV). This paper explains about whole process of constructing cryostat and top flange from design to installation.

CRYOSTAT AND TOP FLANGE DESIGN

Previous cryostat and top flange were conventional type, shown as figure 1 and 2, which had liquid nitrogen reservoir inside of cryostat walls for pre-cooling and thermal insulation and LHe reservoir at the cryostat inside. LHe reservoir was sealed with top flange so that UHV conditions was maintained, and LHe was filled within this reservoir so that SC cavity temperature was decreased to 4K/2K. Electrical instrumentation was connected through top flange feedthrough and magnetic shield was installed inside LHe reservoir. However, previous cryostat and top flange have a large heat load for cooling and warm-up because LHe reservoir was too large so that we should supply so much LHe for VT. Also, RISP should increase the VT capability for satisfying test and tunnel installation schedules. To increase the VT capability at Sindong SRF site, RISP decided to make a new

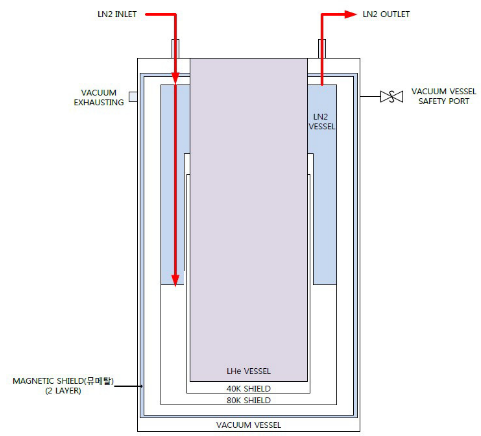

Figure 1: Conventional Cryostat PnID.

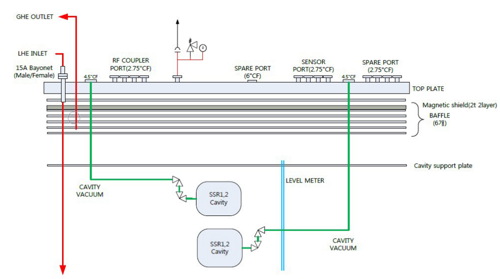

Figure 2: Conventional Top Flange PnID.

cryostats and top flanges which has similar cooling scheme with cryomodule and larger test capability, capable of 3 cavities simultaneously tested for QWR/HWR and 2 cavities for SSR1/2. Figures 3 and 4 shows the piping and instrumentation diagram (PnID) of newly designed cryostat and top flange for Sindong SRF site. Inner diameter of cryostat is increased up to 1200mm for installation three QWR/HWR cavities and two SSR1/2 cavities. And to decrease LHe supply, we decided to proceed VT with dressed cavity so that LHe is supplied only inside of LHe jacket. Following this decision, top flange design is changed almost same as cryomodule. LHe supply is controlled by cryogenic valves, supply and return lines are connected directly to LHe jacket so that the total LHe quantity is reduced. And likewise cryomodule, 4K/2K LHe reservoirs, heat exchanger and another cryogenic valve are installed inside of top flange for maintaining LHe level and stabilizing LHe pressure.

For increasing inner volume of cryostat and reducing heat load, liquid nitrogen (LN2) reservoir is substituted with thermal shield of cryostat. With this modifications, RISP con-

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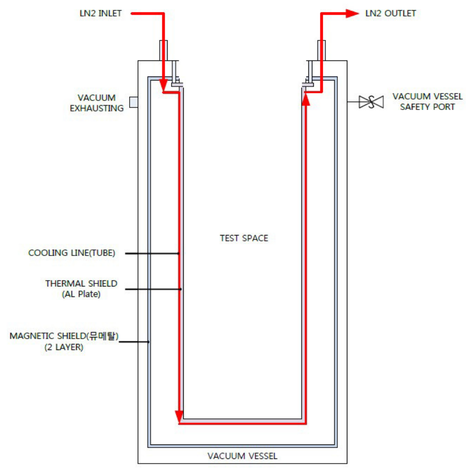

Figure 3: Newly designed Cryostat PnID.

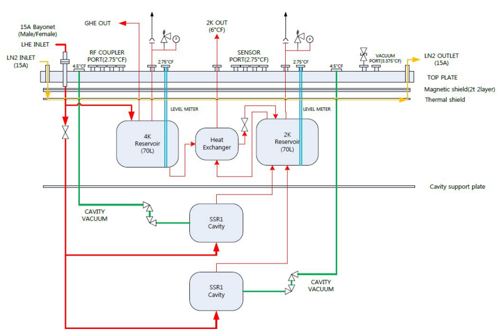

Figure 4: Newly designed Top Flange PnID.

tracted with domestic company for making 3 cryostats (1 for bare cavity test, 2 for dressed cavity test) and 5 top flanges (1 for bare cavity test, 2 for QWR/HWR dressed cavity test, 2 for SSR1/2 dressed cavity test). As written in Table 1 and 2, total heat load of conventional cryostat and top flange assembly is estimated 13.76W, and total heat load of newly designed cryostat and top flange assembly is 5.57W so that our new cryostat and top flange have lower heat load than conventional type [2].

Table 1: Heat Load for Conventional Cryostat/Top Flange

Components (300 to 4K)	Load*Q'ty	Heat Load
Mounting Plate Support	0.122 * 6	0.732
Cavity Vacuum Line	0.116 * 2	0.232
LHe Bayonet	0.583 * 1	0.583
LHe Vessel Conduction	1.67 * 1	1.67
LHe Vessel Radiation	1.15 * 1	1.15
LHe Vessel Top	9.39 * 1	9.39
Total Heat Load Sum	-	13.76

Table 2: Heat Load for Newly Designed Cryostat/Top Flange

Components (300 to 4K)	Load*Q'ty	Heat load
Mounting Plate Support	0.078 * 6	0.468
4K Reservoir Support	0.188 * 3	0.564
4K Return Line	0.289 * 1	0.289
4K Safety and Level Meter	0.082 * 2	0.164
LHe Bayonet	0.583 * 1	0.583
Cryogenic Valve	0.072 * 2	0.144
Cavity Vacuum Line	0.133 * 2	0.266
2K Reservoir Support	0.188 * 3	0.564
Heat Exchanger Support	0.088 * 4	0.352
2K Return Line	0.082 * 1	0.082
2K Safety and Level Meter	0.082 * 2	0.164
Cavity (SSR basis)	0.204 * 2	0.408
4K Reservoir	0.761 * 1	0.761
2K Reservoir	0.761 * 1	0.761
Total Heat Load Sum	-	5.57

FABRICATION AND SUB-COMPONENTS TEST

For installing 4K/2K LHe reservoirs and operating LHe supply/return pipelines, Korean Gas Safety (KGS) certification is necessary so that water pressure test is proceeded during fabrication. Figure 5 shows the water pressure test for 4K/2K reservoir with KGS inspector at factory [3]. Figure 6 shows the fabrication of cryostat and top flange, and Fig. 7 shows the fabrication process of thermal shield. Figure 8 shows the magnetic flux measurement results. All cryostat should satisfy the criteria, maximum 15mG inner magnetic flux, and all three cryostats meet this criteria. However, during inspection, some outside weldments of 1 cryostat has a very high magnetic flux over 1G. We assumed that this phenomenon comes from crystal lattice structure change during gas tungsten arc welding (GTAW) process, and therefore we should measure inner magnetic flux of cryostat periodically for finding the affect of this phenomenon.

Figure 5: 4K/2K LHe reservoir pressure test with KGS.

INSTALLATION AT VERTICAL TEST PITS

Fabricated and inspected cryostats and top flanges are transferred to Sindong SRF and installed to vertical test pits.

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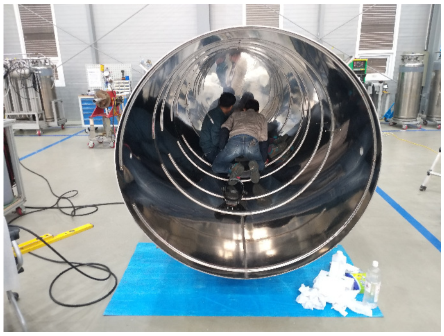

Figure 6: Cryostat fabrication - GTAW process.

Figure 7: Cryostat thermal shield fabrication.

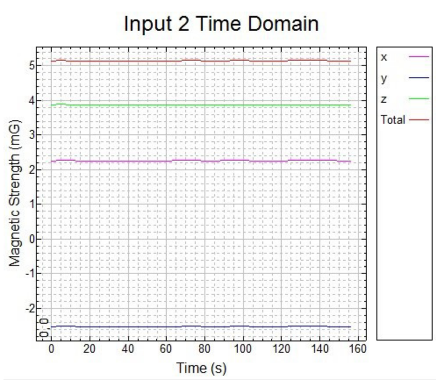

Figure 8: Magnetic shield measurement.

Figure 9: Cryostat, top flange, and connection installation.

Figure 10: HWR dressed cavity installation for VT.

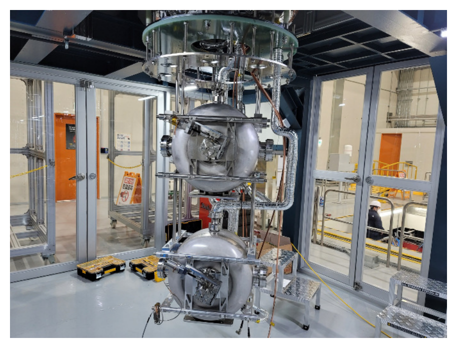

Figure 11: SSR1 dressed cavity installation for VT.

Cryostat and top flange assembly is about 3.3m height and 1.8m diameter. Test pit is 4.5m depth and 2.2m x 2.2m square, so we installed pit stand and stair to each pit for safety. Test pit and sliding cover is designed and constructed with radiation shielding consideration. Furthermore, LHe and LN2 supply/return connections are also fabricated and installed simultaneously. Figure 9 shows the installation of cryostat, top flange, and cryogenic connections. Figure 10 and 11 shows the VT preparation status of three HWR dressed cavities and two SSR1 dressed cavities hanging at the top flange.

CONCLUSIONS AND FUTURE WORKS

Whole process started from October 2018 and finished by June 2019, and all cryostats and top flanges were used for QWR/HWR/SSR1 cavity cold tests since 2019. After installation of new cryostats and top flanges, the cold test capability is increased so that over 70 HWR cavities and all SSR1 prototypes are tested in Sindong SRF test facility. However, for maintaining this test capability, we should check every operating and measuring devices such as vacuum gauges, pumps, periodically. Maintenance of Sindong SRF test facility is mandatory and should be prepared.

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REFERENCES

[1] D. Jeon *et al.*, "Design of the RAON Accelerator Systems" in *Journal of Korean Physical Society*, vol. 65, no. 7, Oct. 2014, pp.1010-1019.

[2] Design Report for SRF Cryostat and Top Flange, CVE, Dec. 2019.

[3] KGS Pressure Vessel Code, AC-111 (ASME Section VIII), Jan. 2021.