Construction of the LN_2 Supply & Control System of the Cryosorption pumps of the NB-TS at KAERI

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1. Introduction

Vacuum system of the neutral beam test stand (NB-TS) at KAERI has been enhanced of its performance by the expansion of the liquid nitrogen(LN_2) supply system for the cryosorption pumps from a mere 150L supply reservoir to 5000L field tank installed outside the facility building. The accompanying control system was fabricated and installed to comply with the control needs of the expanded LN_2 supply system. The newer LN_2 supply system with temperature and level control functions now works satisfactorily for the operation of the cryosorption pumps of the NB beam line.

2. Baffle temperature and LN_2 level control of the cryosorption pump operations

Small LN_2 supply capacity(150L) and thus the inconvenience of frequent replenishing of the depleted LN_2 of the old LN_2 supply system soon dictated a construction of a larger one(1). Thus a larger LN_2 supply tank(5000L) with more refined control of the LN_2 levels through many controlling valves and thermocouples have been constructed as schematically shown in Figure 1.

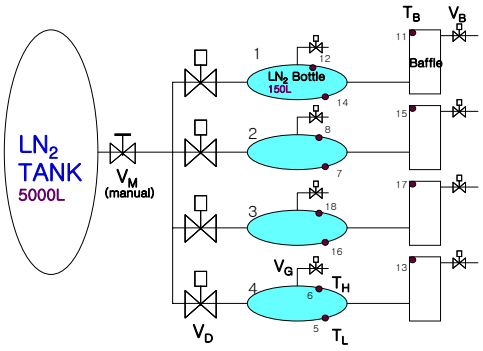

Figure 1. Schematic diagram of the newly constructed LN_2 supply system.

The existence of the two temperature measurement points(T_H and T_L) onto each of the LN_2 reservoir bottle is to control the operation of the replenishing valve V_D, and the existence of the T_B is to control the baffle temperature through the LN_2 level control. The controlling prerequisites are shown in Table 1. Mode #1 necessitates that when the temperature of the reservoir "low" goes higher than -190℃, valve V_D is opened, thus filling the reservoir with LN_2 and when the temperature goes lower than -190℃ at reservoir "high", valve V_D is closed. Thus the whole sequence of controlling the LN_2 level in the reservoir bottle can temporally be shown as in Figure 2.

LN_2 Control Mode

1. LN_2 Level Control
   Open V_D when T_L>−190°C
   Close V_D when T_H<−190°C

2. Baffle Temperature Control
   Open V_B and Close V_G when T_B>−185°C
   Close V_B and Open V_G when T_B<−185°C

3. Each valve must have a 「 manual 」 mode too

※110V for V_G & V_B, 220V for V_D
※2−functions/4−channels controller installed in 19" rack

Table 1. Prerequisite controlling parameters for each line of cryopumps.

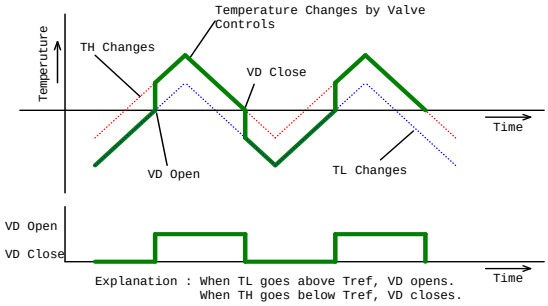

Figure 2. Schematic diagram showing the level control of the LN2 reservoir.

The resulting circuit related to the level controlling is designed as shown in Figure 3. For the case of the baffle temperature control, an apparent feature is that at any time one of the two

valves VB and VG should be open to prevent N_2 pressure accumulation inside the reservoir/baffle paths, thus resulting in a complementary actuation of the two valves. The designed circuit for the baffle temperature control is shown in Figure 4. A higher resolution temperature controller model(Chino, LT450) was utilized for a more refined control of the LN_2 levels in the reservoirs, whereas for the baffle case controller(Chino, LT230) temperature resolution requirement is less than the reservoir case.

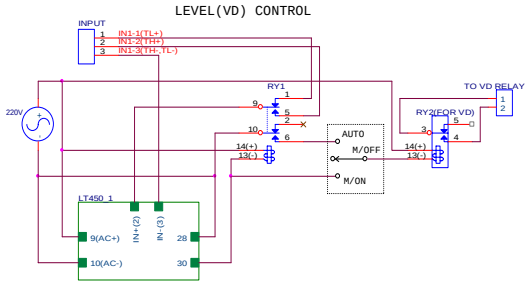

Figure 3. LN2 level control circuit diagram.

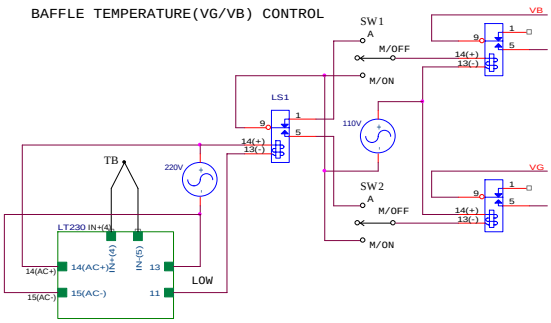

Figure 4. Baffle temperature control circuit diagram.

Care should be taken in operating the baffle temperature control circuits; i.e., when LN_2 is inside the reservoir, there should never be a chance when both of the two valves are closed. This possibility exists when one of the switches is in AUTO position and the other switch is in MANUAL position or when both of the switches are on the OFF position with the LN_2 in the reservoirs. In this state N_2 pressure in the reservoir-baffle path can become higher as time passes, leading to an unacceptably or even dangerous nitrogen pressure levels. The front panel appearance of the finally constructed LN_2 supply control module is shown in Picture 1.

Picture 1. The front view of the LN2 controlling module.

Conclusion

After the volume expansion works of the LN_2 supply line for the cryosorption pumps of the NB-TS have been completed, accompanying control circuits for the LN_2 level and the baffle temperature in the reservoirs have also been designed, fabricated and installed onto the relevant locations of the facility. As compared to the previous LN_2 supply system and its controlling circuits(1), the newly constructed system has much larger volume capacity(5000L vs. 150L) and the controlling mode is more refined. Operator can now be relieved from the intolerably frequent exchange works of the depleted LN_2 bottles during the cool-down process. Temperatures of the baffles and cryosorption panels and the LN_2 levels are now automatically regulated by the newly fabricated controller circuit without the need of frequent attendance of the operator. A cautious aspect of the controlling circuit is also discussed for the safe operation of the system.

References

(1) Ki-sok Jung, et al., “Fabrication and installment of the hard-wired I&C works for the Neutral Beam Injection system of the KSTAR Project”, Proceedings of the Korean Nuclear Society Spring Meeting, Gyeongju, Korea, May 2004, p. 260.