3. Great East Japan Earthquake

The Great East Japan Earthquake with a magnitude of 9.0 struck on March 11th, 2011, the cryogenic hydrogen system was operating at the rated condition.

- **Blackout occurred after 20 s.**
  - Instrument air failed after 3 min because the air supply piping burst was broken.
  - Facility building sank 1.5 ft.

- **Liquid nitrogen tank (20 m³) and the helium buffer tank (10 m³) were inclined by 0.8° and 2.1°.**
- **Part of the external supplying pipes were bent because of bending of the ground.**
  - However, there was no hydrogen leakage from the bent part.

4. Control valve malfunction

- **Hydrogen pressure abruptly decreased from 1.5 MPa to 0.4 MPa for 30 min during cryogenic operation (in February 2010).**
  - **No hydrogen leak** because there was no pressure rise in the inert gas blanket chamber, where the vales and part of the vent line were housed, decreased slightly during the cryogenic hydrogen discharge.
  - **No helium leak**
  - **Vibration and current of the pump increased suddenly at the hydrogen pressure of 0.4-0.4 MPa** for two phase-flow.
  - **Cause:** Contraction of the bellows connection because of the discharge of helium gas in them through the helium vent valve, which was installed in 2010 for protecting the bellows of the second accumulator as well as for protection against earthquakes, as mentioned above.

- **Measures:** Instrument air supply was cut off temporarily until the summer outage of 2015, when the electro-pneumatic positioner and the regulator will be exchanged.

It is still unknown why the valve opened abruptly although the opening was less than 0.1% of the total valve opening. The discharge valve has been unusable since December 2014 because it was exchanged for the third accumulator with a higher pressure tolerance of 2.0 MPa.

We were able to resume cryogenic operation 4 days after the failure in 2015.

CONCLUSIONS

Until now, we have considerable experiences and gained a lot of knowledge by facing several problems such as unstable operation of helium refrigerator because of impurities, leakage through the welded bellows of an accumulator, hydrogen pump impeller damage, and blackout and instrument air failure due to the Great East Japan Earthquake. We have confirmed through the problems that the cryogenic hydrogen system and its interlock system meet our design requirements.