Introduction of Alarm System for STELLA-1

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1. Introduction

To support the design of Prototype Gen IV Sodium-cooled Fast Reactor(SFR) under development by KAERI substantial safety system research is ongoing. The high reactivity of sodium, especially with water and oxygen, can cause serious accidents. Thus, large sodium facility needs well developed alarm system to prevent various incidents.

In this paper, the alarm system for safe operation of Sodium Integral Effect Test Loop for Safety Simulation and Assessment(STELLA-1) is introduced.

2. Alarm System

The alarm system of STELLA-1 includes 1,508 items in total. The list can be divided into two groups in on its purpose, which are the alarm for equipment management and safety. First, there are 5 kinds of equipment maintenance alarms which are temperature, level of sodium, pressure, heaters and pumps deviation control and power fault alarm. Second, safety alarm includes solidification, leak detection and fire detection alert. These alarms have limit values to protect equipment and safety. The values are set conservatively to give time to rectify problems for operators.

2.1 Temperature Alarm

For the facility using liquid sodium, temperature is very important value to protect equipment. When the temperature of sodium inside the loop reaches its melting point(i.e. 98℃), the sodium starts to solidify and stick to pipe line and valve. To prevent this situation, low temperature alarm is required.

On the other hand, high temperature alarm is for flow meter and pressure gauge. The facility of STELLA-1 has coriolis flow meters and there is a possibility to break down at the temperature over allowed condition.

Therefore the limit value of temperature alarm should leave the margin about 20~30℃ considering the characteristics of equipment and response time.

2.2 Level Alarm

To keep the level of STELLA-1 Tank usual operating state, level alarm is necessary. The tank always needs to fill Ar as cover gas and the gas supply pipe is located at the top of the tank. There is possibility to flow liquid into gas supply pipe. So operators keep attention level alerts to check uniform value. Additionally, since quantity of sodium is estimated by the level alarm, the alert also acts as a leak detection.

2.3 Pressure Alarm

STELLA-1 is designed to store the sodium generally in the underground storage tank for safety then to conduct an experiment by filling the loop with sodium. Ar gas, which has little reactivity with sodium, is used to fill up equipment and pipes from the underground tank. Pressure alarm is necessary to avoid sodium-oxygen reaction for inflowing air under lower pressure than atmospheric pressure. In addition, high pressure alert is for preventing over pressure.

2.4 Deviation and Panel Power Fault Alarm

Deviation alarm means the percentage limit of the gap between previous and present setting values. The role of heater and pump deviation alarm is for avoiding excessive load on the system. The alarm makes engineers notice that the devices run by excessive power though there is no order. And even the output is under the setting value, operators notice the malfunction. STELLA-1 set the limit value for deviation by 20% and it is conservative range to minimize repair due to the characteristic of the sodium facility.

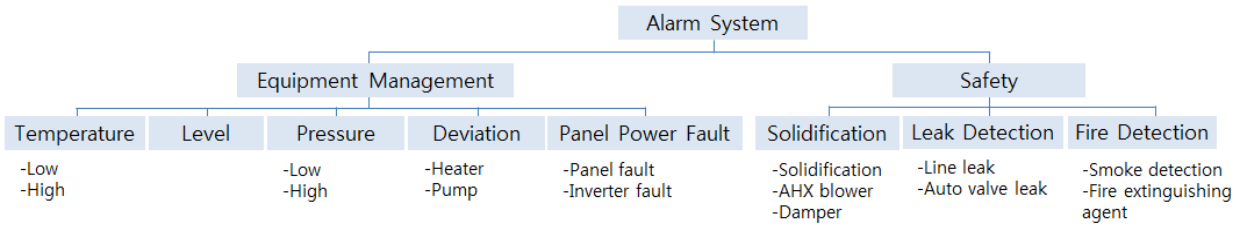

Fig.1. Alarm system for STELLA-1

Most of devices in large system equipment are controlled by electronic signal. Thus before starting an experiment, operators should check the panel power fault alarm whether the devices are activated by proper power supply or some of them are shut down by trip logic to protect themselves from an overcurrent.

2.5 Solidification Alarm

STELLA-1 facility has two kinds of heat exchanger which are AHX(Air-to-sodium Heat Exchanger) and DHX(Decay Heat Exchanger). Especially the AHX can cause sodium solidification at a low temperature experiment. It is desirable that the low limit of the AHX tube side to prevent sodium solidification is set as an alarm. The solidification alert is linked to damper and AHX blower by a connective movement. It closes the damper at the limit temperature and avert solidification by blocking the air flow.

2.6 Leak Detection Alarm

Although all pipe lines flowing liquid sodium were installed by welding, leak problem can occur at lines and valves by vibration of equipment or stress fatigue. Therefore leak detection alarm is essential for sodium facility. In STELLA-1, total 213 alarms compose for leak detection. Leak detectors are installed in every pipeline and they transmit a True/False signal to the Digital Control System (DCS).

2.7 Fire Detection Alarm

The fire detection alarm is the most important alert in safety sections. The white aerosol from the sodium fire is toxic enough to stifle operators with smoke. The detector located at the top of AHX shell side is representative. When sodium leaks to the outside of AHX tube, the high temperature sodium burns with oxygen inside of the AHX shell. But operators are not easy to recognize it because of the location of fire. 5 fire detectors are installed in STELLA-1 facility. The alarm is connected with sodium fire extinguishing agent.

3. Conclusions

In this paper, the alarm system for STELLA-1 as a large sodium experiment facility is introduced; the equipment management and the safety.

-Equipment management alarm comprises 5 kinds of alarm; temperature, level, pressure, deviation and panel power fault.
-Safety alarm comprises 3 kinds of alarm; solidification, leak detection and fire detection.

Especially the limit value of solidification is set conservatively due to high temperature liquid metal experiment. Thus, some conservative setting values in STELLA-1 facility restrict experimental region in a particular condition. For safe operation of the liquid sodium utility, it is important to determine appropriate values for alarm limit. Operators should know the critical alarm and its limit value to prevent hazardous situation. Therefore, it is tentatively supposed that the experimental studies about finding appropriate limit value with satisfying the equipment management and safety should be conducted as a future work.

4. Acknowledgement

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REFERENCES

[1] Japanese Nuclear Cycle Development Institute, Sodium Technology Handbook, 2005., pp1-1~19
[2] Tae-Ho Lee, Design Report of STELLA-1, KAERI Fast Reactor Technology Development Division, KAERI/TR-4295/2011
[3] J.H. EOH, H.Y. LEE, T.J. KIM, J. Y. JEONG, Y. B. LEE, Design features of a large-scale sodium thermal-hydraulic test facility: STELLA, Vol. 10, p.1