Ensuring alternative air supplies for safety relief valves (SRV) in the event of a station blackout (SBO) at a Nuclear Power Plant (NPP).

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ABSTRACT

In the event of a long-term station blackout (SBO) at BWR, Safety Relief Valve (SRV) would cease to operate through loss of electric current and/or loss of air supply. However, SRV need to continue to be operated to ensure the safe shut-down of the nuclear power plant in question. In order to solve this problem, it is necessary to devise effective strategies.

Followings show our counter measure for this problem.

Two sets of valves are connected to the exhaust line of the air supply solenoid valve by a three-way air valve which switches the flow path by internal pressure. This valve has three connection ports called the pressure port, the exhaust port, and the cylinder port. The valves facilitate the air flow through the actuator by receiving pressure from the pressure port. Valve disks can switch closed port from the pressure port to the exhaust port. By the use of a valve at the exhaust line of a solenoid valve of SRV, it is possible to:

1. Maintain the exhaust line from the actuator port during operation/standby time.
2. Activate the air-operated valve by receiving pressure from the exhaust port through solenoid valve in the event of SBO.

This enables SRVs to be operated, even in the event of an unexpected and severe accident caused by a prolonged station blackout.
INTRODUCTION

In this paper, we reported means of operating main steam safety relief valve (SRV) without electric current and/or loss of existing air supply at nuclear power plant (NPP).

Overview

In the event of a long-term station blackout (SBO) at BWR, all the air-operated valves including SRV would cease to operate through loss of electric current and/or loss of air supply. However, SRV need to continue to be operated to ensure the safe shut-down of the nuclear power plant in question. Also, NRC has been requested to allow water injection by actuating the SRV from outside of the pressure containment vessel to depressurize the reactor pressure vessel in NEI-06-12.

Background

The SRV fulfills the overpressure safety requirements of boiling water reactor primary loops. The valve will pop automatically at the set pressure or may be opened by means of an electrical signal to one, two or three solenoid valves that actuate the air cylinder on the SRV. A solenoid valve which mounted SRV has three connection ports called the air supply port, the exhaust port, and the actuator port (Figure 1). Function of SRV is as follows;

1) Be actuated directly by steam pressure (pressure mode)

2) Be actuated remotely by manual operation of a switch an electrical signal (actuation mode)

3) Be actuated remotely as part of the automatic depressurization system (actuation mode)

In the actuation mode of operation, solenoid valves couldn’t be operated through loss of electric current and/or loss of air supply. In other words, a solenoid valve on the SRV would not be worked in the situation of prolonged station blackout. In order to solve this problem, it is necessary to devise effective strategies.
METHOD

Followings show our countermeasure for this problem. Two sets of valves are connected to the exhaust line of the air supply solenoid valve by a three-way air valve which switches the flow path by internal pressure (Figure 2). The valves facilitate the air flow through the actuator by receiving pressure from the pressure port. Valve disks can switch closed port from the pressure port to the exhaust port. By the use of a valve at the exhaust line of the solenoid valve of SRV, it is possible to;

(1) Maintain the exhaust line from the cylinder port during operation/standby time.

(2) Activate the air-operated valve by receiving pressure from the exhaust port through solenoid valve in the event of SBO(alternative mode).
**Method of actuation mode at basic operations**

In the actuation mode of operation, air pressure is supplied to the cylinder by energizing the solenoid valve. When the solenoid valve is energized, the pressure port is connected to the cylinder port and the exhaust port is closed. Then the SRV cylinder is actuated to open the SRV (Figure 3). When the solenoid valve is de-energized, the pressure port is closed and the cylinder port is connected to the exhaust port. Then the SRV cylinder is depressurized. The SRV is closed by depressurizing the reactor (Figure 4).
Figure 3. Basic operation of actuation mode (Opening movement)

Figure 4. Basic operation of actuation mode (Closing movement)
Method of alternative mode at severe operations

In the alternative mode of operation, the solenoid valve is de-energized, the pressure port is closed and the cylinder port is connected to the exhaust port. Air pressure is supplied to the cylinder by pressurizing the three-way valve (Figure 5). When the SRV cylinder is depressurized, unless the three-way valve is depressurized, the pressure port is connected to the cylinder port and the exhaust port is closed (Figure 6). When the three-way valve is de-pressurized at the pressure port is closed and the cylinder port is connected to the exhaust port. The SRV is closed by depressurizing the reactor (Figure 7).

![Figure 5. Operation of alternative mode (Opening movement)](image1)

![Figure 6. Operation of alternative mode (Beginning of closing movement)](image2)
Features of the three-way air valve which switches the flow path by internal pressure

The pressure port is closed by the valve disk at the basic operation. The disk is pushed below by a spring and gravity (Figure 8). The disk and the body are made by stainless steel because of operating environment especially temperature. The valve seat is made by graphite to use it even under severe accident conditions in BWR environment. Materials of the valve parts are listed in. In addition to the environmental condition of the valve is listed in Table 2.
Table 1: Materials of the valve parts

<table>
<thead>
<tr>
<th>Material of valve body and disk</th>
<th>Stainless steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material of spring</td>
<td>INCONEL</td>
</tr>
<tr>
<td>Material of valve seat</td>
<td>Graphite</td>
</tr>
</tbody>
</table>

Table 2. Environmental conditions

<table>
<thead>
<tr>
<th>Temperature (maximum)</th>
<th>300°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (external)</td>
<td>0.84 MPa</td>
</tr>
<tr>
<td>Pressure (internal)</td>
<td>1.13～1.77 MPa</td>
</tr>
</tbody>
</table>

**CONCLUSION**

In conclusion, in the event of a long-term SBO at BWR, SRV would cease to operate through loss of electric current and/or loss of air supply. By the use of alternative mode, it is possible to supply air pressure for the cylinder of SRV. This enables SRV to be operated, even in the event of an unexpected and severe accident caused by a prolonged station blackout.