Main Steam Isolation Valves (MSIV) in Nuclear Power Plants with PWR
Introduction

As isolating valve in the main steam line of nuclear power stations different designs are known. Beside the kind of actuators, hydraulic, spring-supported or medium controlled, an essential difference is in the choice of the valve type.

The engineer must decide between a gate valve with small pressure loss and a globe valve (designed as angle type or y-pattern type). The valve with medium control is easy and more reliable in function but has the disadvantage of a higher pressure loss. Beyond this consideration such factors as accessibility, simple maintenance and economy decide about the choice of a globe valve for quick pipe-isolation.

In Sweden and Germany i.e. the decision was made for valves with medium control in the 70ies and 80ies.

Design

Picture 1 shows a Sempell main steam isolation valve of type EBS32, the shown modern version has been used in several reactor plants. It represents a further development of the main steam quick closing valves supplied to Sweden.

Body (1) and cover (2) are forged and linked together by means of necked-down bolts (8). A spiral wound gasket (7) inserted between the cover and body provides a seal to the atmosphere. Cylinder (5) in which piston (4) travels is secured to cover (2) by means of bolts and nuts (9), (10). All guide and sealing surfaces are hardfaced. Piston rings (11) act as a seal between the upper and lower actuating chambers.

Disc (3) is movably secured to piston (4) with a trapezoidal thread cut with play. Cogging prevents rotation between disc (3) and piston (4).

A pneumatic drive is mounted on cover (2) of the valve and is linked to the moving parts - disc (3) and piston (4) - via rod (6). This drive makes it possible to actuate the valve even when the system is not under pressure and to keep it open during operation.

The chamber above the piston is connected to the inlet and outlet side of the valve via check valve selective controls X and Y. Thus the selective controls guarantee the filling of the piston’s upper chamber important for the function regardless whether the break of the pipe occurs before or behind the valve.

As an optional extra, the design shown in the figure contains a position indicator which has been mounted on the pneumatic drive.

The angle-type version of the main steam isolation valve is advantageous for keeping pressure losses to a minimum (picture 1). Pressure loss coefficients $\zeta = 1$ have been
achieved in Sempell's fluid mechanics laboratory by optimising the inner contour of
the body.

The form of the body does not affect the basic mode of operation of the valve. As the
various design examples in picture 2 show, bodies can be designed equally well as
straight-way versions, pipe fittings or slanted seat versions.

Function

During normal operation, the main steam isolation valve EBS32 is held open with the
pneumatic drive (picture 3). The two redundant pilot valves connected in parallel to
the control bore "S" are closed. Steam flows through the valve from "A" to "B". All
inner chambers of the valve are under pressure and temperature via the charging
bores and slots.

If a leak occurs in the main steam line on the inlet side "A" or outlet side "B" of the
valve, or if the main steam line fractures, the pilot valves connected to bore "S" open.
(picture 4 shows the circumstances for a leak on side "B"). The pressure in chambers
C and D (connected to C via bypass "F") is reduced. At the same time, the pneumatic
drive is also depressurised. Chamber "E" above the piston is refilled via the open
check valves DN 15 (selective control Y), the connection between "E" and "B" is
blocked by the check valves DN 30 (selective control Y). The valve closes due to the
difference in the pressure above and below the piston. After a partial lift, the bypass
bore "F" moves into the lower section of the cylinder and the connection cross-section
between "C" and "D" is throttled. The volume of steam contained in chamber "D" must
be relieved via smaller cross-sections; the closing speed of the valve is decelerated.
The full actuating force reserve is also available in the lower lift section by reason of
the intermediate extraction "C" between the upper piston rings.

Due to the difference in the pressures above and below the disc, the valve remains
closed even if the pilot valves at relief bore "S" are closed again. Only when the
pressures between the valve inlet and outlet are approximately balanced can the
valve be opened again with the pneumatic drive.

The valve closing function is fundamentally the same when a leak occurs on the inlet
side "A". Picture 5 shows that, in this case, the check valves DN 30 are open while the
check valves DN 15 block the passage between chamber "E" and side "A".
Furthermore, the pilot valves at the control bore "S" must remain open for as long as
the main steam isolation valve is to remain closed against the pressure.

Picture 6 shows the closing behaviour of Sempell's main steam isolation valve EBS32
in the event of a pipe break on turbine side B. The picture shows the results of a test
at a scale of 1 :1 in which the guillotine break of a main steam line was simulated.
Also entered in the diagram for comparison purposes are the results of a pre-
calculation performed with one of Sempell's computer programs. As the diagram
shows, there is a close correspondence between the figures calculated and those actually measured.

Starting from time 0 (pipe break), 2.5 seconds pass until the valve has closed fully.

During the first 0.6 seconds, the valve closes relatively slowly, accelerates until a lift of approximately 100 mm remains and then decelerates again until the end of the lift at a speed of approximately 0.07 m/s. This decelerated closing motion is due to the damping effect caused when the bypass bore "F" passes into the lower section of the cylinder.

The evaluation of the test records shows that all pilot valves remain closed during the first 0.6 seconds but that the valve nevertheless begins to close. It was ascertained that Sempell quick closing valves still close with a mass throughput of 150 % of the nominal throughput, even if all pilot valves should fail. (The mass throughput would be 400 % the nominal throughput in the event of a complete pipe break).

**Control System**

To control the main steam quick closing valves with the presented medium control according to relief principle, several control valves can be used differing in regard of design.

Solenoid control valves are normally chosen according to the working current principle. It is possible to use single (picture 8) or double solenoid valves (picture 7).

The shown constructions are executed with pilot control, i.e. a pilot valve opens the real relief disc. This principle enables to manufacture compact solenoids with high forces and reduced power input.

Such solenoid valves have been qualified according to the IEEE standard. As alternative also angle type stop valves either with electrical actuator (picture 9) (provided that a secured contact rail exists) or with pneumatic actuator according to the „fail-safe-open“ principle (picture 10) are available.

Finally, picture 11 shows a valve station with a total of four medium-controlled main valves, the two most important being the main steam safety valve VS99 K and the quick closing valve EBS32. The valve station shown in picture 11 is incorporated into the piping system directly at the point where the safety sleeve enters the main steam line. The diagram shows the following valves from left to right

- the main steam quick closing valve EBS32
- the main steam isolation valve TBS34, connected upstream of the blow-off valve
- the main steam globe valve VBS34
- the main steam safety valve VS99 K.
This valve station represents the latest stage in our company's development of medium-controlled valves. We have so far supplied or have received commissions to supply valve stations of this type for 12 nuclear power plants.

The picture clearly shows the forged bodies which are designed as pipe fittings and are directly welded to each other. Double solenoid valves of type DMS are connected directly to the body via an adapter.

Instead of the intermediate pieces, lockable gate valves (DN 32) are used for most plants equipped with this station to enable individual control lines to be blocked for service and repair work.

The pneumatic drive can be clearly seen on the first three valves and the non-contact position indicator is also clearly visible on the safety valve.

It should be stressed that different plants which were originally equipped with gate valves were retrofitted with the medium-operated valves described.
Main Steam Isolation Valve EBS32

Detail X

Detail Y

1
2
3
4
5
6
7
8
9, 10
11

Detail X

Detail Y

A
B
Various Body Types of Main Steam Isolation Valves
Main Steam Isolation Valve EBS32

<table>
<thead>
<tr>
<th>Type</th>
<th>Valve Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type EBS 32</td>
<td>Open – Operating position</td>
</tr>
<tr>
<td>Check valves DN 30</td>
<td>Closed</td>
</tr>
<tr>
<td>Check valves DN 15</td>
<td>Closed</td>
</tr>
<tr>
<td>Connection pneumatics</td>
<td>Pressure below pneumatic piston</td>
</tr>
<tr>
<td>Type 2207</td>
<td>Open</td>
</tr>
<tr>
<td>Type 161</td>
<td>Principle „energized – solenoid valve open“</td>
</tr>
<tr>
<td></td>
<td>Closed, deenergized</td>
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Linear position indicator

Limit switch
1 x OPEN
1 x CLOSED

Additional dead volume

Connection pneumatics

RSVK DN 30
RSVK DN 15

Type 2207 Principle "energized – solenoid valve open"
Closed, deenergized
Main Steam Isolation Valve EBS32

- Linear position indicator
- Limit switch
  - 1 x OPEN
  - 1 x CLOSED
- Additional dead volume
- Connection pneumatics
  - RSVK DN 30
  - RSVK DN 15

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<td>Open</td>
</tr>
<tr>
<td>Connection pneumatics</td>
<td>Without pressure below pneumatic piston Open to the atmosphere</td>
</tr>
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**Linear position indicator**

- Limit switch
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- RSVK DN 30
- RSVK DN 15

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Main Steam Isolation Valve EBS32 – 2 Control Valves
Closing at 1 F Fracture at the Turbine Side
Comparison Test and Calculation
Double Solenoid Control Valve DMS

Solenoid

Outlet

From the main valve

A

B

C

1

2

3

4

5

6

7

8

9

PICTURE 7

12
Motor Operated Stop Valve

Electromotive actuator
High Pressure Stop Valve VA500
with pneumatic Actuator Type PC 420
Main Steam Isolation and Safety Valves

EBS 32
Main Steam Isolation Valve

TBS 34
Blowdown Isolation Valve

VBS 34
Globe Valve

VS99K
Safety Valve

Flexible Support

Solenoid Pilot Valve (Twin Body Type)