SEMPELL - MAIN FEEDWATER DAMPED CHECK VALVE

SERIES MFDCV

Developed to protect the piping system after a pipe break in the feedwater line of a nuclear power plant

GENERAL APPLICATION

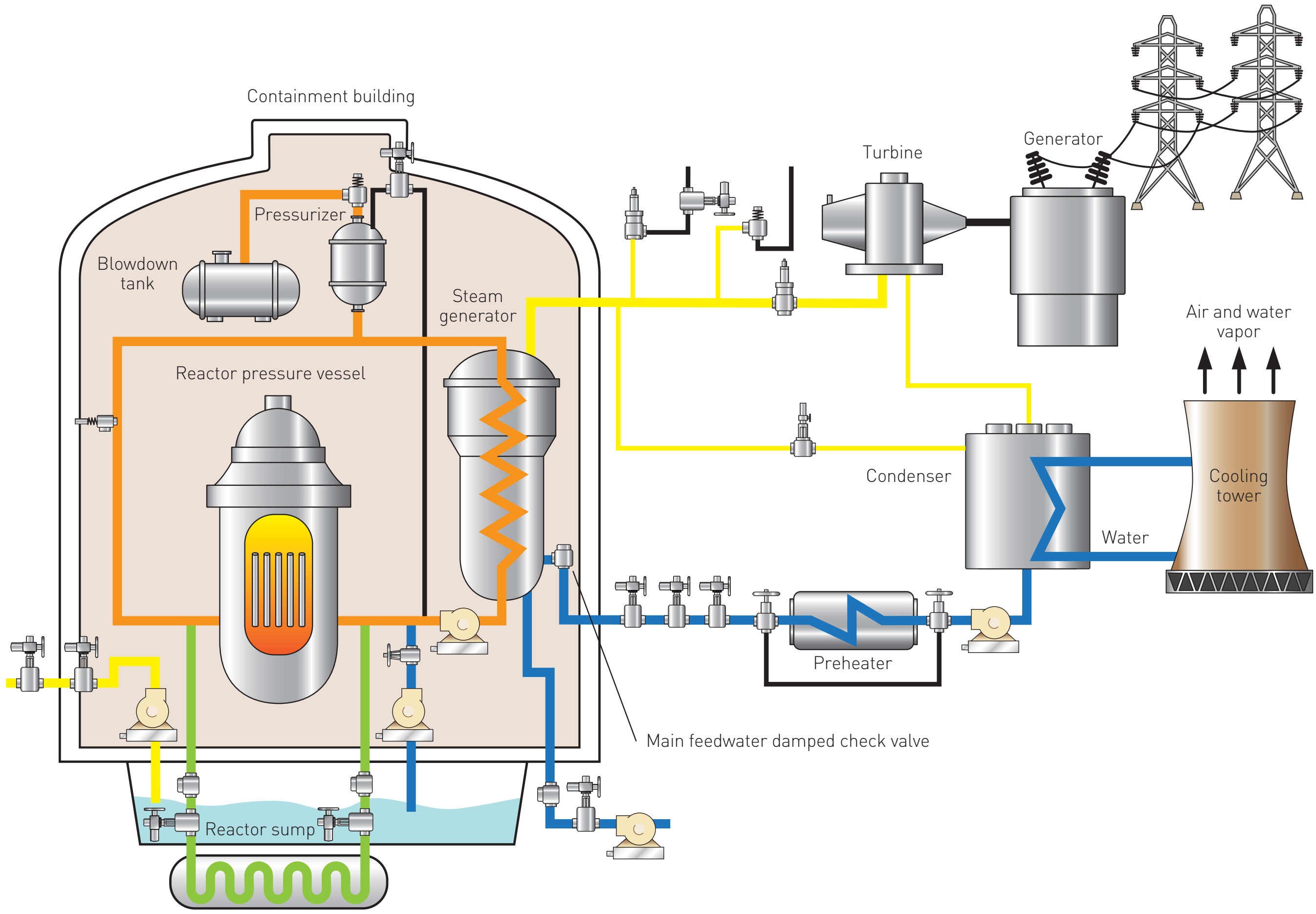
Rapid changes in mass flows in high-pressure lines can cause pressure surges and forces which exceed the permissible material strength limits. Consequently, particular importance is placed on the closing behavior of check valves after a break has occurred in high pressure pipes. Our qualified damped valve is equipped with a piston, which slows the closing movement to eliminate the water-hammer effect. These valves are specially engineered to customer specifications.
The design ensures a slowdown of the valve closing by damping as much as necessary in order to keep the fluid dynamic loads from pressure waves within limits and not to endanger pipe integrity. On the other hand the valve closes as quickly as possible to reduce the loss of feedwater to a minimum.

TECHNICAL DATA

Sizes NPS (DN):	Up to 18 (450)
Pressure:	class 1500 / PN250
Temperature:	up to 300 °C
Body material:	A105 (1.0460) and S/S

FEATURES

- One-piece, compact block design with forged or cast body thus not presenting any seismological safety problem. The connection of the damping chamber with the main valve body is integrated into the cylinder, thus no external equalizing or balancing pipe is necessary.
- Simple, robust design with only a few moving parts, which leads to low maintenance requirements and a small stock of spares. Internal components can be removed from the body as a single unit.
- Guiding of the piston and the disc can be replaced, while the valve body remains in the pipeline and is not subject to any maintenance.
- The internal design of the valve is flexible, optional fixed closing time or customized closing behavior is possible. The damping of piston ensures that the high pressure transients in feedwater lines are eliminated as required by specifications of the specific reactor design.
- Optimized disc design for stable open position at low flows to ensure plant operation within a wide load range.
- Cobalt-free hardfacing for applications in contact with primary circuit media on request, since the radioactivity in nuclear power stations is primarily caused by the Co-58 and Co-60 cobalt isotopes.
- Inductive position indicator on request available, thus not requiring penetration of the pressure retaining boundary.
- Optimized for low pressure loss to ensure plant efficiency.
- Full scale tests executed in test loop HDR Kahl DN 350 for verification of fluid dynamic behavior.
- Seismic shake table test acc. to IEEE 344 executed for different designs.

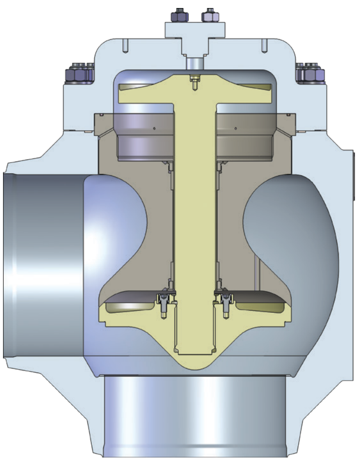


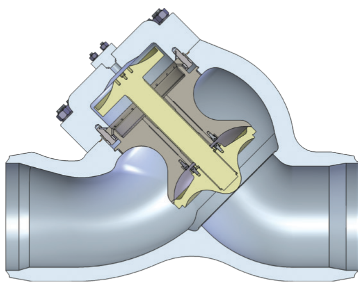
INTRODUCTION

The development of a damped closing check valve was determined by a discussion on pressure surge problems resulting from double-end fractures in feed water lines in nuclear power plants and the need to control this accident using suitable check valves without consequential damage of the shut-off system. To solve this problem, Sempell designed and qualified a damped check valve, which is used in many different NPPs since the 1970s, see also the attached reference list. The damping is variable thereto the valve is a customized design adapted to the respective conditions.

VARIATIONS OF DESIGN

- Angle type
- Straight way with vertical stem
- Straight way with inclined stem
- Material according to piping specification





DESIGN AND FUNCTION

The damped check valve is medium-operated and responds to the pressure differences inside the valve only. In normal operation the disc is pressed to the open position by the flowing feedwater from inlet A to outlet B. When the flow stops, the disc closes. The closing is damped to avoid pressure surges in the pipe.

The example shown is an angle-type, damped feedwater check valve. The body (1) is a one-piece block. The form of the body has no significance in terms of the basic functioning of the valve. Straight-way bodies could be used with equal success.

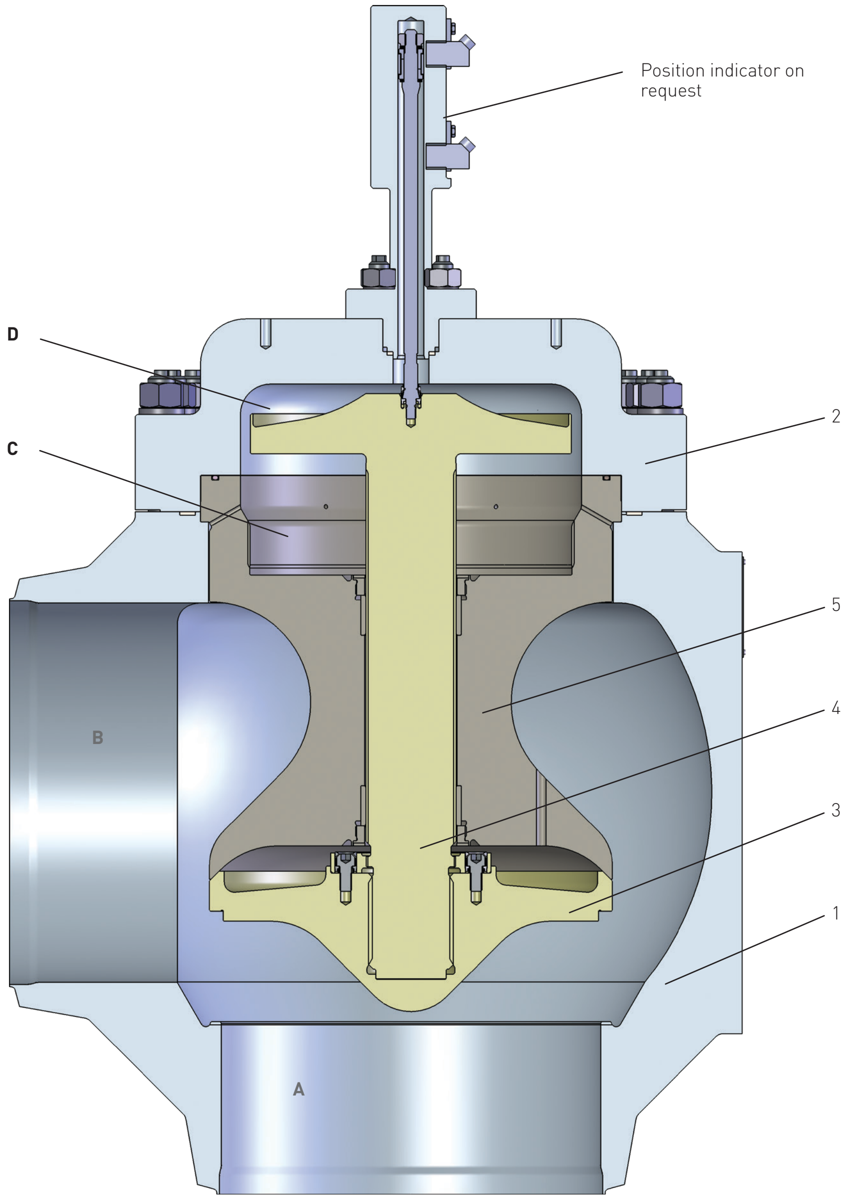
The moving parts of the valve are the shut-off disc (3) and the stem with damping piston (4). Particularly distinctive are the shape of the shut-off disc which has been profiled similar to a control disc, and the relatively large lift.

The stem with damping piston (4) is double guided in a small-diameter bore hole in cylinder (5). The ratio of the length to the diameter of the guide is large, thereby preventing jamming or excessive friction of the stem. The contacting slide surfaces are hardfaced to attain optimum running behavior.

The damping piston (4) runs contact-free in cylinder (5) over the entire closing path of the valve. The gap between the piston and the cylinder during the first part of the lift is large enough for the medium to pass from chamber C to D with virtually no loss. The gap is small over the second part of the closing path - being a few tenths of a millimeter wide - so as to keep the overflow resistance from C to D as high as possible. However, it is sufficiently large to ensure that the damping piston can move without contact.

Cylinder (5) is secured with clearance to cover (2) of body (1). This means that even extremely large body deformations have no effect on the freedom of movement of the shut-off units. The design described has no gland leading to the outside, this fact being essential to ensure easy running. A bore located in the center of the cover is used for mounting a non-contact position indicator or diagnostic systems which can be used during repeat tests for checking the damping mechanism of the valve for easy running.

The connection of the damping chamber with the main valve body is integrated into the cylinder. No external equalizing / balancing pipe is necessary. Thus a qualified damping characteristic is achieved without welded joints in the pressure retaining boundary subject to in-service inspection.



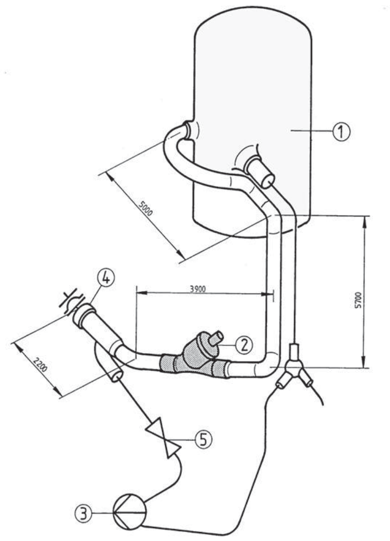
DAMPED CHECK VALVE COMPARED TO SWING CHECK VALVE

The qualified Sempell design of main feedwater damped check valves was developed due to the pressure surge problems resulting from double-end fractures in the feedwater lines of nuclear power plants and the need to be able to control this accident using suitable check valves without consequential damage to the shut-off piping system.

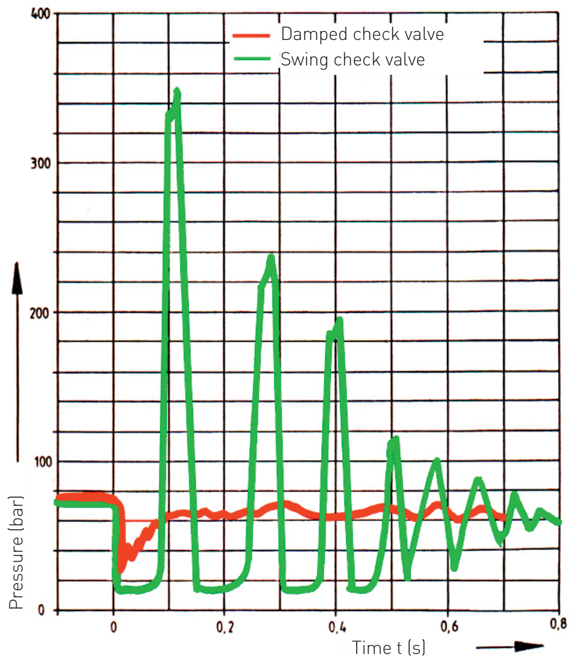
QUALIFICATION

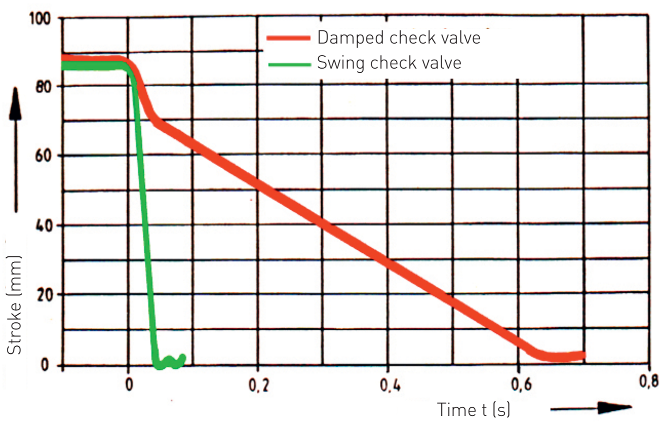
To demonstrate that damped check valves constitute a suitable pipe-break protection in feedwater lines the full scaled blowdown tests were performed with a DN 350 valve at the experimental reactor HDR Kahl (Germany). During these tests, a double-end pipe break was realistically simulated. The test setup is shown in the picture. The double-ended pipe-break was simulated by destroying the burst protection at rupture disc (4).

Parallel to the simulated accident, calculations with special software programs were conducted. Measurement and calculations show close correspondence. The global target of the HDR tests consists in the proof of the correctness and the strengthening of the available calculation methods (codes, handling input parameters) on the basis of a comparison of calculation and measurement results.
Based on the obtained results proven calculation methods for determination of fluid dynamical loads in feed water systems with check valves are used for the engineering of damped check valves.



1 Reactor pressure vessel
2 Sempell test valve
3 Circulation pump
4 Rupture disc
5 Quick-closing valve





The diagrams illustrate the comparison of test results, showing the difference between damped check valve versus undamped swing check valve with respect to pressure surge.

EXAMPLE OF OPTIMIZATION

The goal of this customized solution compared to a standardized design is two-fold. On the one hand, it is designed to slow down the closing time of the valve by damping as much as necessary. This, in turn, keeps pressure waves after check valves closing within the limits, not to endanger the pipe. On the other hand it is designed to keep the closing time as short as possible, in order to limit the loss of feedwater to a minimum.

Due to the fact that new plants have to be operated within a wide load range, a stable, full open position is adapted to the minimum load cases. At the same time the valves are optimized in regard to the pressure loss.

Key advantages of Sempell design

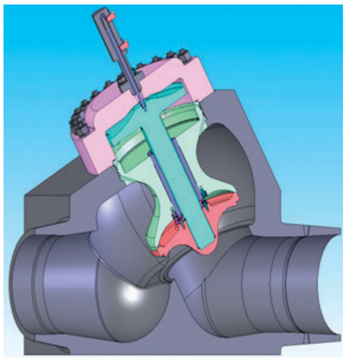
Required engineering and design features:

- Disc design in regard to profile and weight
  - Low peak pressure at pipe break
  - Stable open position during operation, therfore no wear
  - Minimum pressure loss
- Cylinder section design in regard to heights of the damping section
  - Low peak pressure at pipe break
  - No external equalizing pipe required, no welding at pressure boundary.
- Optimized bolt and cover design
  - No leakage during and after transients
  - Easy maintenance, no guiding surface directly in the body.

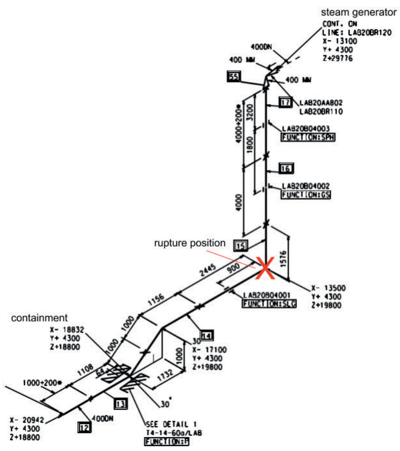
Technical data for the example project

Boundary conditions:

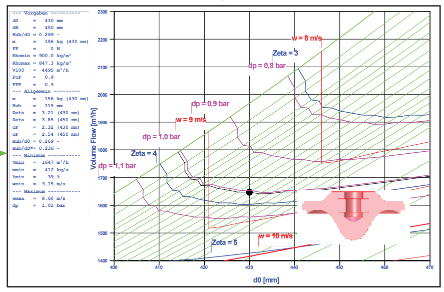
Design pressure:	84 barg
Design temperature:	300 °C
Bending moment pipe:	229 kNm
Tightening force bolts:	2160 kN
Material:	SA-182 F316LN
Yield strength:	(300 °C) 128 MPa

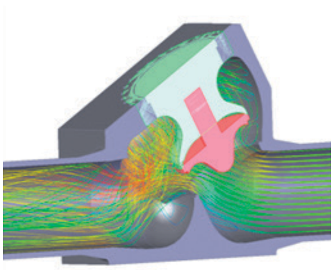


Model tests

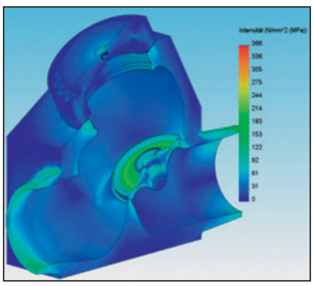


Pipebreak analyses





CFD analyses



Stress analyses

WORLDWIDE REFERENCES

Order year	Plant	Country	Reactor type	Capacity	Types
1974	Krümmel	DE	BWR	1300 MW	SBS33, EBS33
1976	Mülheim-Kärlich	DE	PWR	1300 MW	SBS33, SBS33
1976	Doel 3 + 4	BE	PWR	1000 MW	SBS33
1977	Grafenrheinfeld	DE	PWR	1300 MW	SSS30, ESS30
1977	Gundremmingen 2, B + C	DE	BWR	1300 MW	SBS33, EBS33
1978	Krümmel	DE	BWR	1300 MW	SBS33, EBS33
1978	Neckarwestheim 1	DE	PWR	840 MW	VBS30
1978	Philippsburg 2	DE	PWR	1400 MW	EBS30
1978	Würgassen	DE	BWR	640 MW	VBS33, EBS33
1979	Brunsbüttel	DE	BWR	800 MW	EBS30, VBS30, VBS33
1981	Stade	DE	PWR	700 MW	EBS30
1982	Biblis A	DE	PWR	1200 MW	EBS30
1982	Biblis B	DE	PWR	1300 MW	EBS30
1982	Philippsburg 2	DE	PWR	1400 MW	EBS30
1984	Atucha 2	AR	PHWR	700 MW	VBS30, EBS30, ZBS30
1984	Trillo	ES	PWR	1066 MW	EBS30, VBS30
1988	Brunsbüttel	DE	BWR	800 MW	VBS30
1990	Biblis A	DE	PWR	1200 MW	EBS33
1990	Biblis B	DE	PWR	1300 MW	EBS33
1990	Brunsbüttel	DE	BWR	800 MW	EBS30
1991	Gundremmingen 2, B + C	DE	BWR	1300 MW	EBS30
1993	Unterweser	DE	PWR	1350 MW	VBS30
1994	Oskarshamn 1	SE	BWR	465 MW	VBS30
1994	Oskarshamn 2	SE	BWR	630 MW	VBS30
1995	Borssele	NL	PWR	480 MW	VBS30
1996	Doel 3	BE	PWR	1000 MW	SBS33
1997	Oskarshamn 1	SE	BWR	465 MW	SBS33, SBS30
1997	Barsebäck 2	SE	BWR	615 MW	VBS30
2000	Tianwan 1 + 2	CN	WER	1000 MW	EBS30
2001	Barsebäck 2	SE	BWR	615 MW	SBS30
2005	Olkiluoto 3	FI	EPR	1600 MW	EBS30
2005	Tianwan 1 + 2	CN	WER	1000 MW	EBS30
2006	Oskarshamn 2	SE	BWR	1200 MW	EBS30
2006	Oskarshamn 3	SE	BWR	1200 MW	EBS30, SBS30
2007	Flamanville 3	FR	EPR	1600 MW	EBS30
2010	Taishan 1 + 2	CN	EPR	1600 MW	EBS30
2012	Tianwan 3 + 4	CN	WER	1000 MW	EBS30

QUALITY CERTIFICATIONS AND STANDARDS

ASME Section III N. NV. NPT certification
Rules for construction of nuclear valves for Class 1, 2, 3

ASME Section VIII UV certification
Rules for construction of pressure relief valves

RCC-M
Design and construction rules for mechanical components of PWR nuclear islands

KTA 1401
Nuclear Safety Standards Commission (KTA)
General requirements on quality assurance

KTA 3201.3
Nuclear Safety Standards Commission (KTA) Components of the reactor coolant pressure boundary of light water reactors

DIN EN ISO 3834-2
Quality requirements for fusion welding of metallic materials -
Part 2: Comprehensive quality requirements (ISO 3834-2:2005).

DIN EN ISO 9001:2008
Quality management systems - Requirements
(ISO 9001:2008)

ISO 14001:2004
Environmental management systems Requirements with guidance for use (ISO 14001:2004)

PED 2014/68/EU
Pressure Equipment Directive (Full Quality Assurance)

OHSAS 18001:1999
Certificate for an occupational health safety management system

CSEI
Manufacture License of Special Equipment People's Republic of China

SCCP
SGU-Management System in conformity with the standard SCCP petrochemistry

IAEA 50 CQ
Quality assurance for safety in Nuclear Power Plants

HAF 604
NNSA approval for design and manufacturing of valves class 1, 2, 3

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