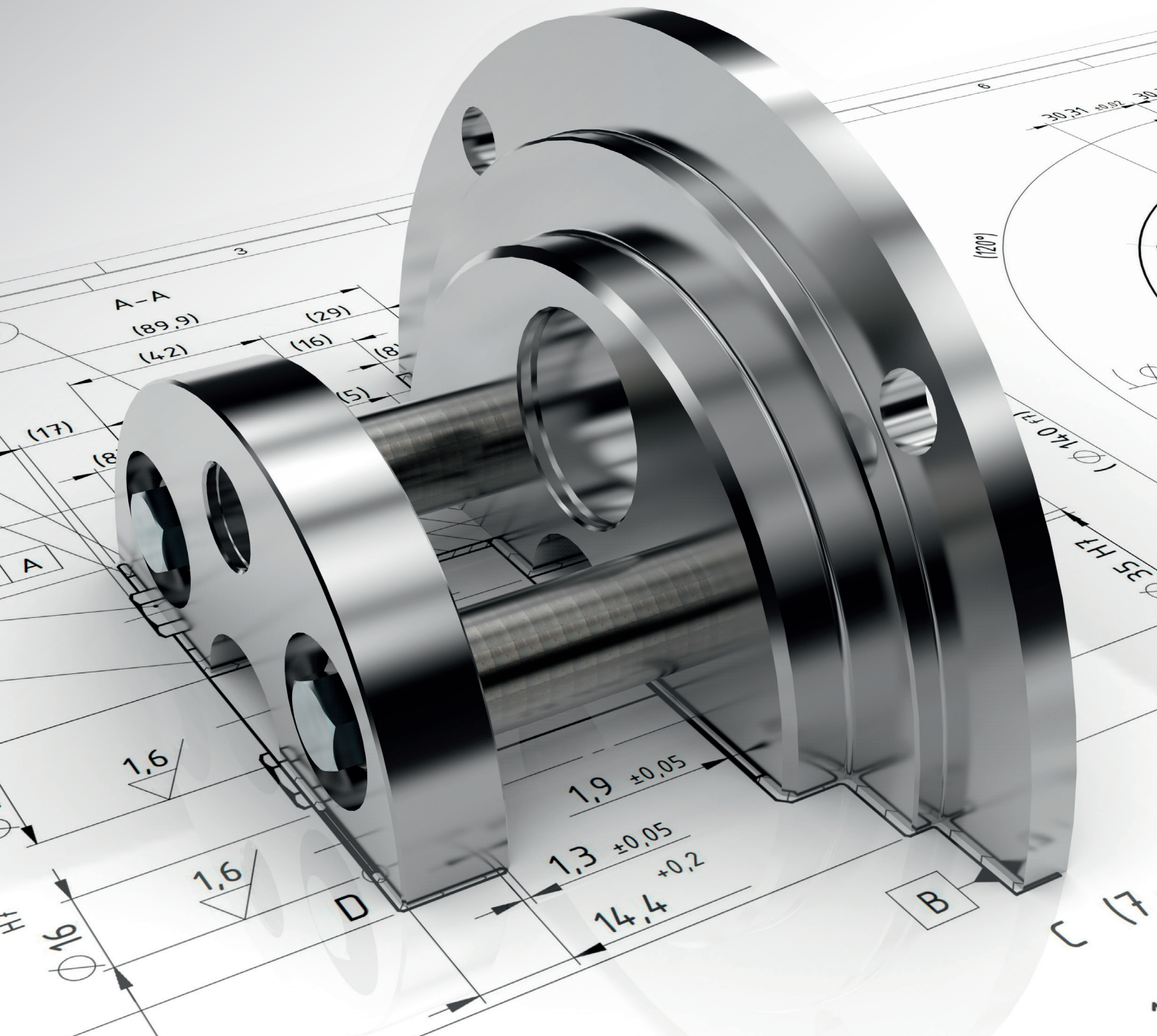


ENGINEERING LETTER

Pump Protection

Excellence in Flow Control



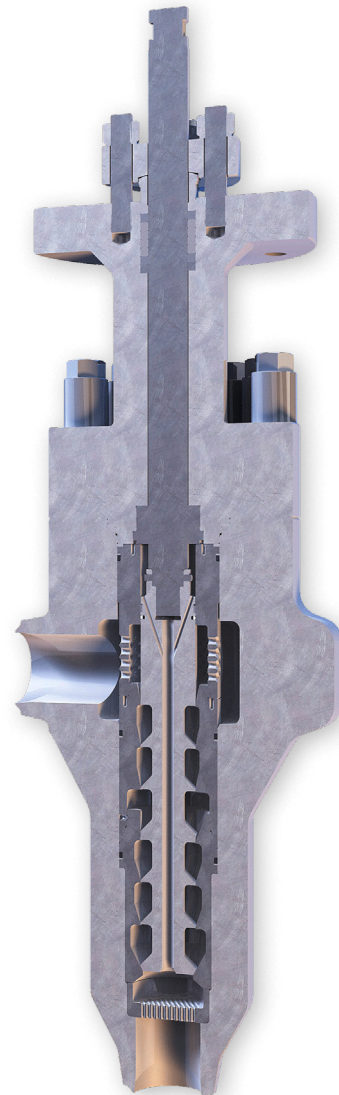
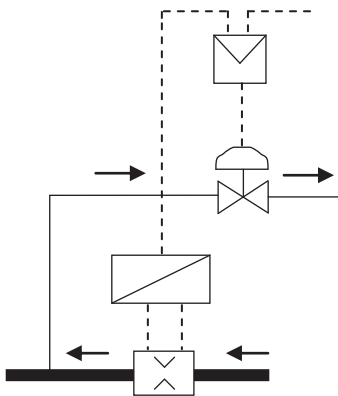
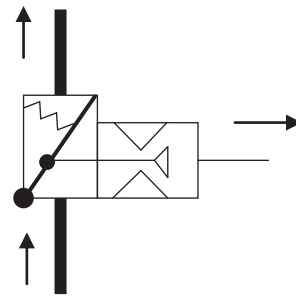
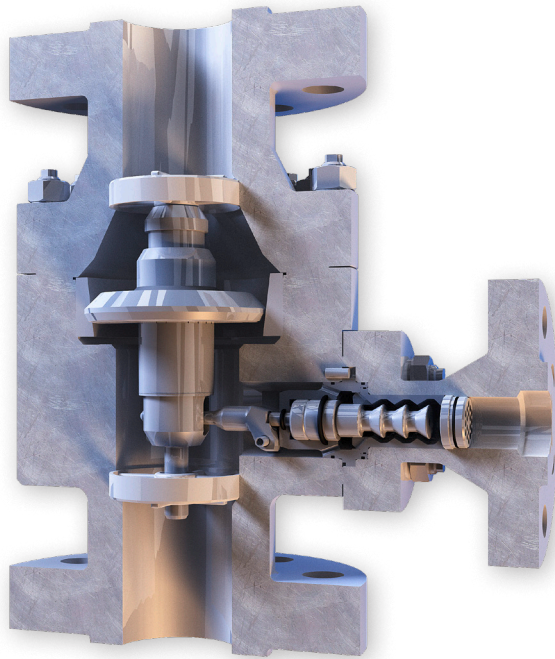
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Introduction

Because of necessary cost reductions and a higher degree of system efficiency and risk management, a reliable system that ensures a minimum flow through the pump is an essential requirement, especially for high pressure applications.

Besides protecting the pump against overheating, a well-engineered, modulating, controlled bypass system improves the stable operation of the complete system. The system itself is usually a closed loop application and therefore consists of a suction and recirculation line from the tank and back to the tank. The materials used for the valves are carefully chosen in order to minimise corrosion and erosion under high velocity conditions or special medium applications.

Important note

Especially for high pressure applications, all equipment including the valves should fulfil the following requirements:

Reliable operation

Production stops are very costly. A higher initial investment will pay off in the long run than opting for the most inexpensive solution (inexpensive can be very expensive!).

Ease of maintenance, good serviceability

Although highly trained technicians are among the platform personnel, the equipment should be maintenance-free or require little maintenance by the platform engineers. Time is scarce and costs money especially on platforms.

Long life of the valve and its trim parts

In order to prevent production loss or unnecessary doubling of control systems. Again, a cost factor!

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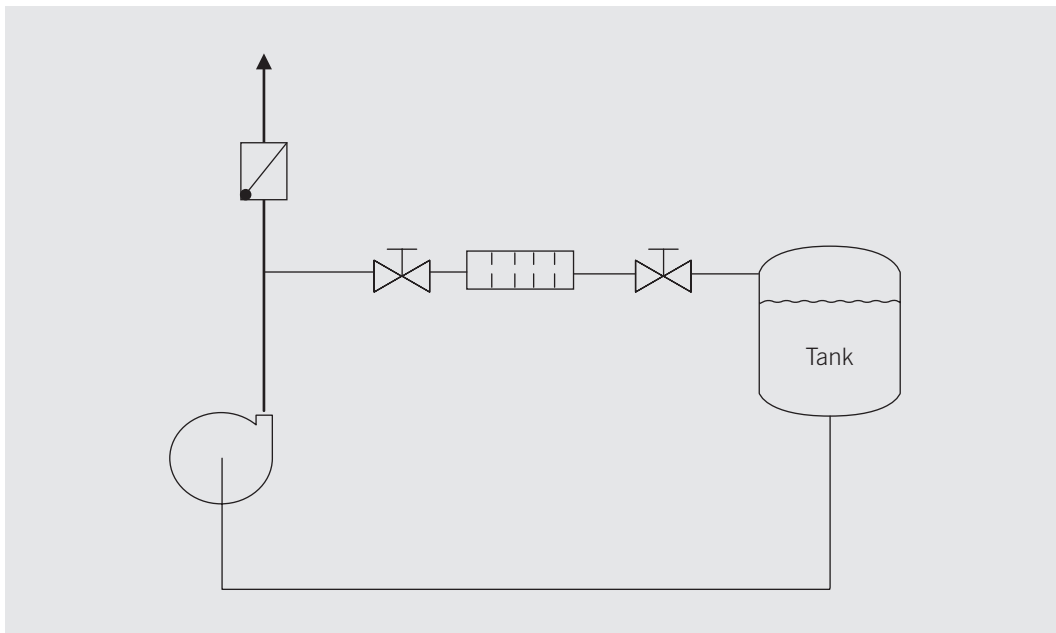
Pump Protection

1.1 Which systems are available to ensure the minimum flow through the pump at all times?

1.1.1 Continuous Bypass System

These systems continuously bypass the flow that is required as a minimum to prevent overheating of the high pressure injection pumps. Minimum flow is usually approx. 30% of the normal flow. The pressure at which the water is

injected causes a tremendous loss of energy. Therefore, the pump to be selected should be larger in size as well as the installed capacity of the driver (130%).



Also, a pressure reduction system has to be provided with orifice plates that are subject to cavitation and wear.

An additional check valve is needed!

Pay attention to saving costs for high pressure applications!

In a typical high pressure injection system with a normal flow of 625 m³/h (per pump), the bypass flow required is a minimum of 125 m³/h (usually

150-200 m³/h). At a pump head of 2150 m the extra power consumption of the larger pumps would be 950 kW per hour.

In continuous operation (say 300 days per year) and energy costs of 3 cents per kW/h, the extra energy costs would be roughly \$200,000.

This system is therefore very costly and it is bad engineering practice.

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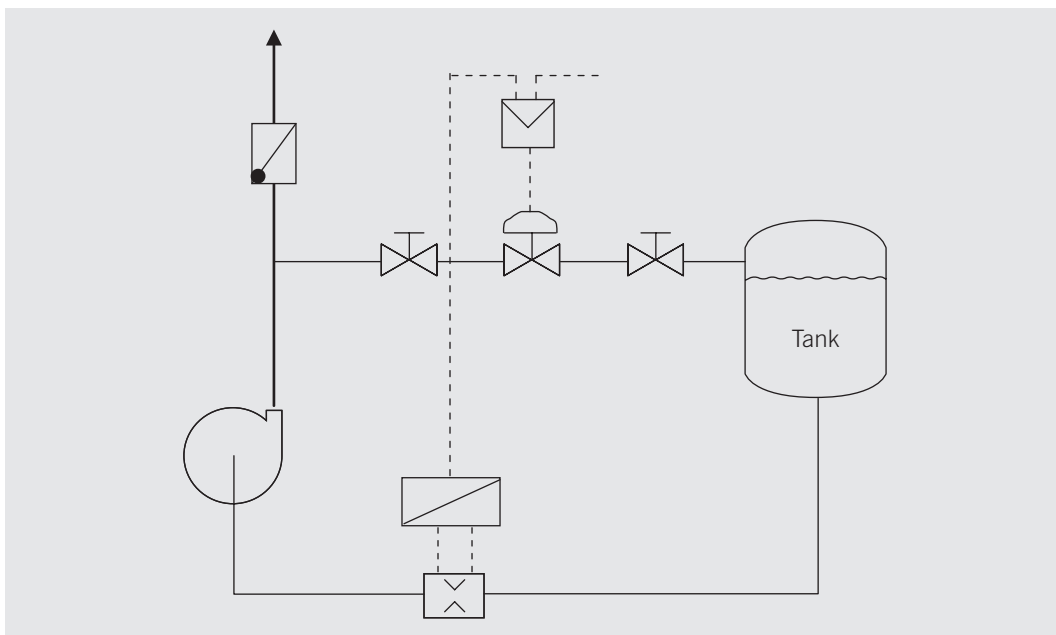
Pump Protection

1.1.2 Controlled Bypass System

This system consists of:

A control valve in the bypass. This control valve should be designed for high pressure reduction (e. g. from 200 bar down to 5 bar or lower). Usually, a four-stage trim (or more, depending on

the make) is required, and it should be equipped with an actuator to provide modulating control. It should also be available in the materials as required.



A flow sensor in the suction line, which senses the low flow conditions to the pump. Also available in a material as specified.

A control loop which transmits the signal from the flow sensor to the control valve actuator. This requires an air or electrical supply system and requires regular maintenance and calibration.

An additional check valve is needed!

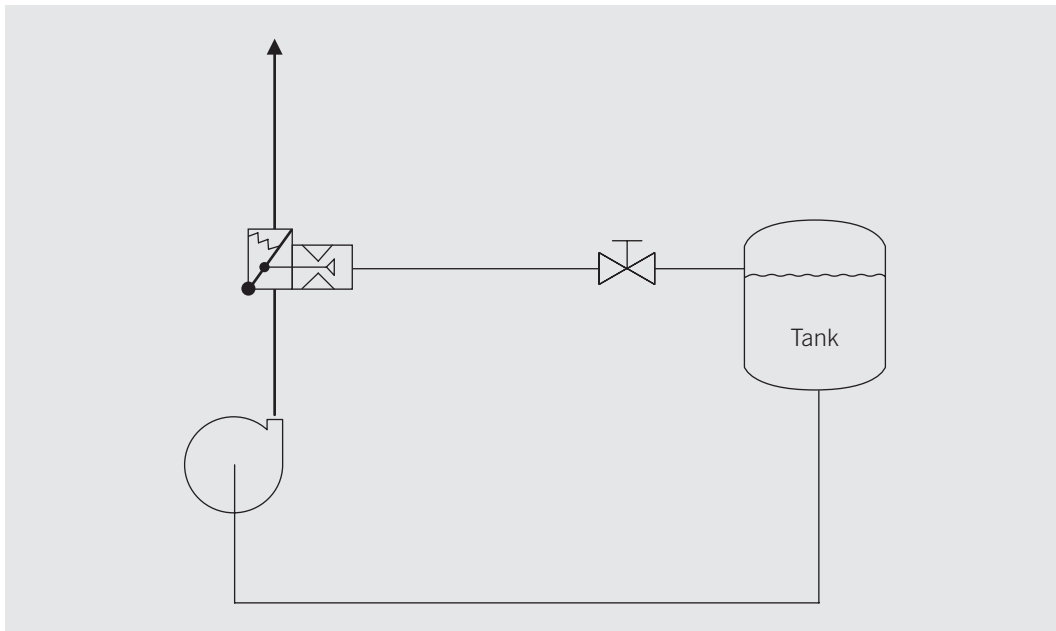
The check valve is located on the pump outlet to prevent back flow if the pump is not running. Again, the availability of the correct material for this check valve should be taken into consideration. This system has been applied (and still is) in many high pressure systems. It offers a good control of the bypass flow but has some drawbacks when compared to the system of an Automatic Recirculation Valve.

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1.1.3 Automatic Recirculation Valves

The Automatic Recirculation Valve, manufactured and marketed by SCHROEDAHL for almost 50 years, combines the 4 functions as outlined earlier in one simple unit (see below).



The SCHROEDAHL ARV features:

1. Flow sensing and modulating function
2. Check valve
3. Automatic bypass end connection
4. Pressure reduction of the bypass flow without cavitation

This results in the following advantages compared to conventional systems:

One self-operated unit only, which can be mounted directly on the pump outlet. No external energy required. Reliable, direct operation with little hysteresis. No special maintenance required; the unit is self-lubricating (pump fluid).

Conclusion:

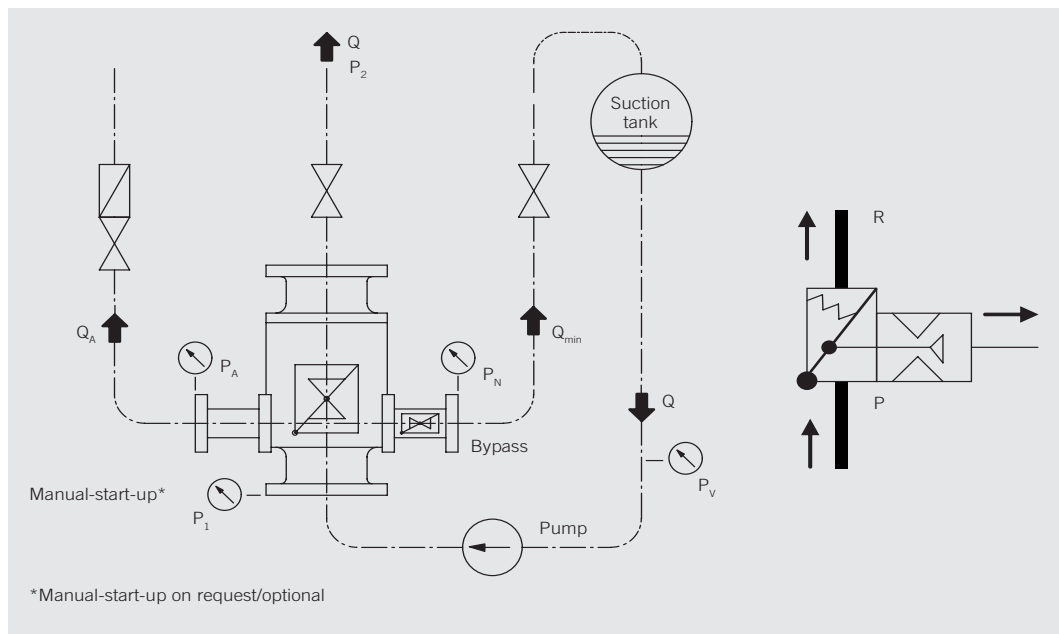
The SCHROEDAHL valves are the most reliable valves providing minimum flow through a pump. They have many advantages over other systems and are low in initial cost (approx. 70% of a conventional system). The valves are based on the latest technology, and SCHROEDAHL has nearly 50 years of experience since the valve was invented by Mr. Odendahl of SCHROEDAHL.

SCHROEDAHL Pump Protection

Engineering Letter

The Automatic Recirculation Valve Application – DETAILS

2.1 General ARV Information



Explanation

The Automatic Recirculation Valve (ARV) protects centrifugal pumps against overheating and cavitation problems by automatically maintaining a minimum flow when the system flow is in low load condition. The application itself is usually a closed loop application and consists of a suction and recirculation line from the tank and back to the tank. Typically the ARV is directly mounted on the pump discharge flange.

The valve system comprises a high quality check valve in the main line (see symbol above right)

and a special control device for the minimum flow recirculation (the bypass control system). The general valve functioning is related to the process flow quantity – all SCHROEDAHL ARVs are flow sensitive.

Simplified function explanation: An increasing process flow will automatically reduce the bypass flow. At a certain level of process flow (the valve switch point), the recirculating bypass is closed.

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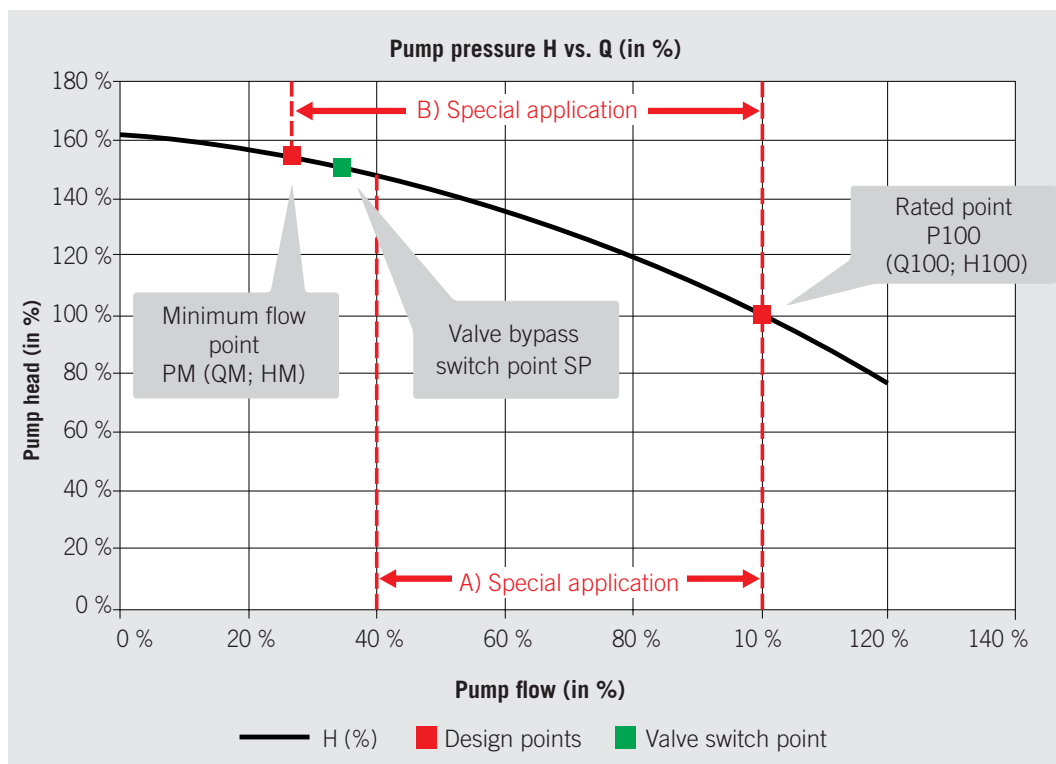
2.1 General ARV Information

ARV-Valve Function Description and Options

The ARV comprises a high quality check valve in the main line and a special modulating control device for the minimum flow recirculation (bypass system). The general valve functioning is related to the process flow quantity – **all SCHROEDAHL ARVs are flow sensitive.**

Definitions:

- Q100 - (m³/h, US GPM) Rated process flow (for ARV valve design)
- QM - (m³/h, US GPM) Pump minimum flow (for ARV bypass design)
- HM - (m, feed) Pump differential pressure at minimum flow
- Pv - (bar g, psi g) Pump suction pressure
- Pn - (bar g, psi g) Bypass back pressure (at bypass flange of ARV)



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Pump Protection

Normal or Special Operation Range Definition and Bypass Back Pressure

The pump operation data is the basic design data for the automatic pump protection valve and has therefore an influence on the valve design. The relation between the normal rated flow and the pump minimum flow is also important. Normally the pump minimum flow is not more than 30% of rated flow. The following pump curve example should explain the ARV functioning with the minimum

flow point and the rated process flow point. Please note: At the minimum flow point, the ARV bypass is completely open, and at the rated point, the full pump flow is going to the system. An optimal valve design can only be achieved when the operation data are complete. Therefore the pump protection has to be split into NORMAL and SPECIAL.

A) Normal Application is defined when the process flow is typically **not below 40%** of the rated flow (beside short start-up phases).

B) Special Application is defined when the system flow range is from **0% to 100%** of the range specified. If the pump pressure is also greater than 120 bar / 1740 psi, then a Back Pressure Valve (BPV) is required, as a simple orifice cannot ensure that the **back pressure Pn will be a minimum of 4 bar / 58 psi** higher than the saturation pressure (guide value, value range is 4 to 10 bar / 58 to 145 psi).

Note:

A) Differentiation between Normal and Special:

Normal: An application will be classified as Normal (A), when no operation range information is given.

Special: The **Special Application (B)** (> 120 bar / > 1740 psi) needs information about the static and dynamic bypass back pressure Pn (stat. / dyn.) as well as a check about the correct bypass piping system with incorporation of the medium temperature rise at minimum flow.

B) High Pressure Applications

For applications with ≥ 120 bar / > 1740 psi differential pressure, a Back Pressure Valve (BPV) is recommended. The BPV should be installed directly before the inlet into the tank to keep the pressure in the recirculation line (Pn) at a minimum of 4 bar / 58 psi higher (rough thermodynamic safety margin, maximum up to 10 bar / 145 psi possible and confirmed by SCHROEDAHL).

Medium Temperature Rise

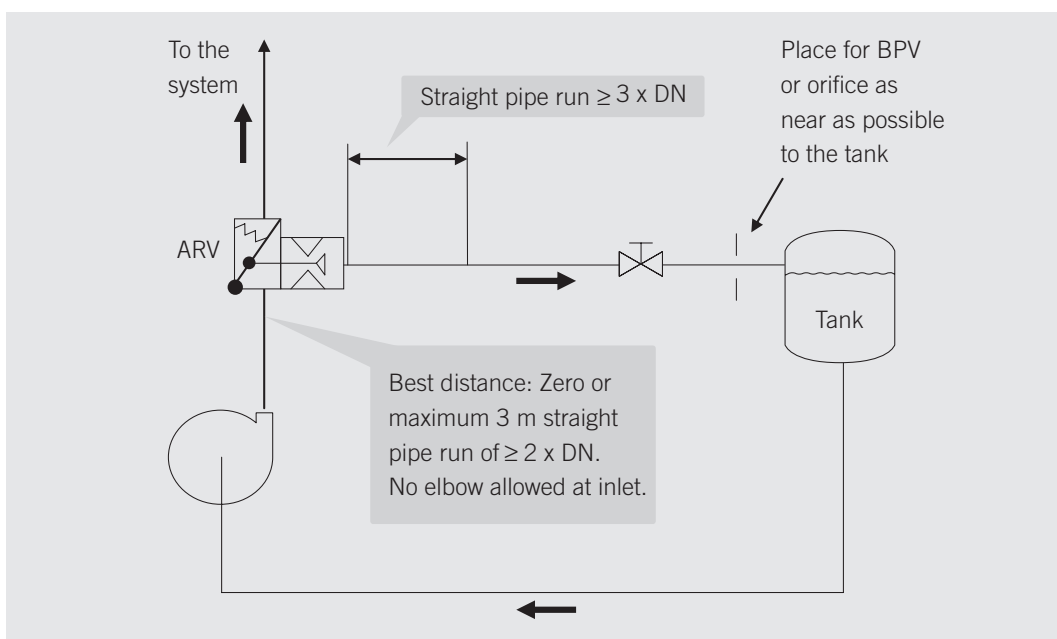
Based on thermodynamic rules due to the pressure increase and decrease, plus friction losses, the temperature of the medium rises within the pump (refer to I. J. Karassik) and ARV bypass system. With typical low efficiency of the pump at mini-

mum flow, the temperature **rises between 10 °C and 20 °C** (for HP feed water applications). Please take this into consideration for the recirculation system up to the inlet of the deaerator / feed water tank (flashing and choked flow collapse).

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2.2 ARV Installation Recommendations



> **Note:** Vertical installation of the ARV directly on the pump discharge is best!

Back Pressure Valve Information

If a Back Pressure Valve (BPV) or Anti-flashing Device is requested, it should be installed as near as possible to the tank and the downstream pipe

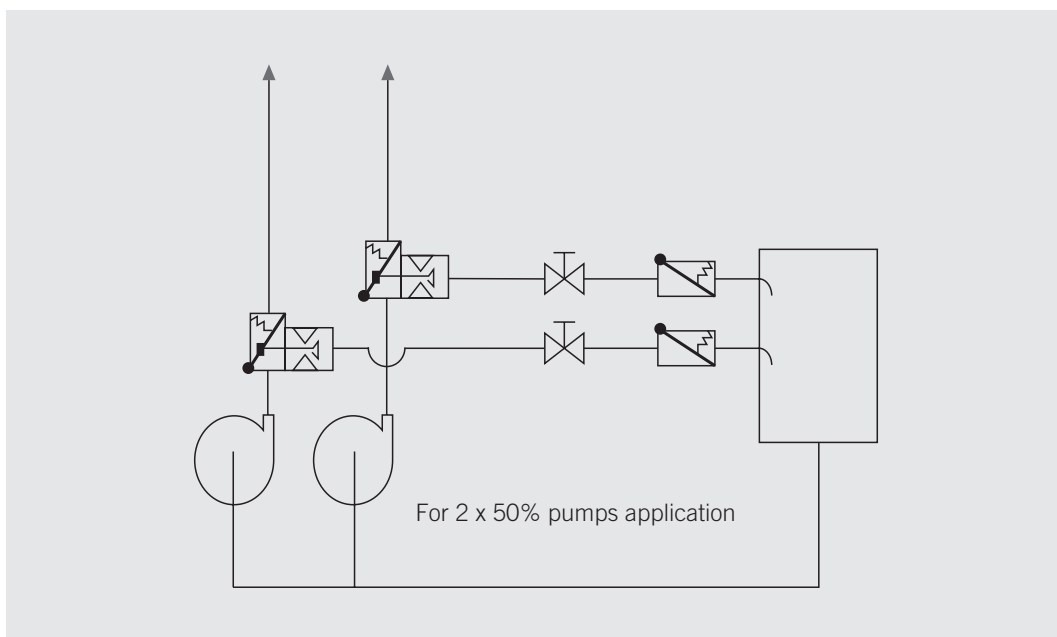
size should be preferably 1 size larger – due to flashing!

Installation Conditions

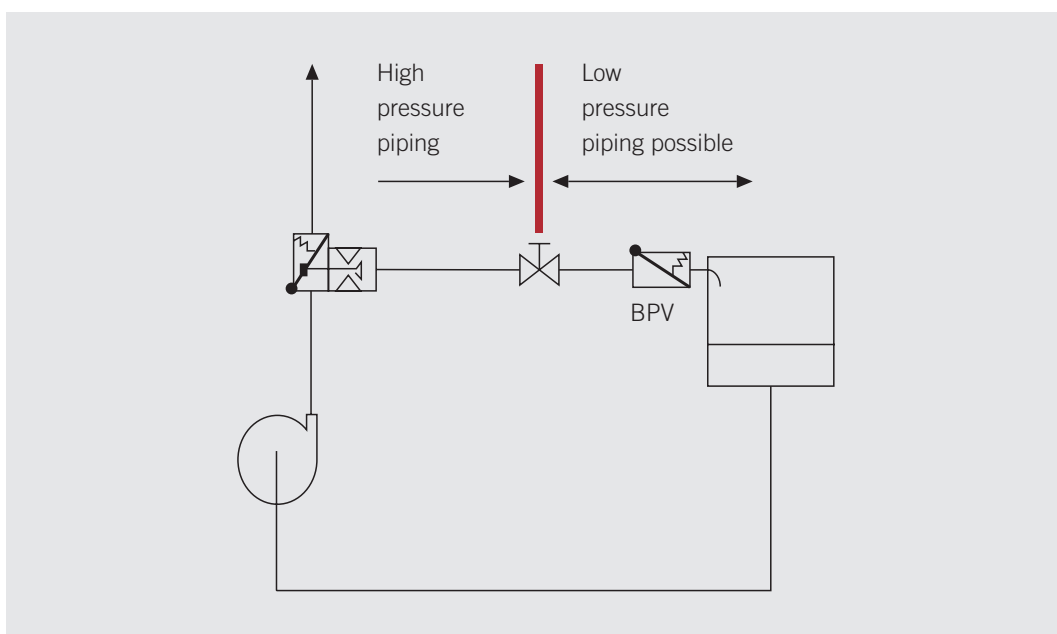
- Vertical installation is preferred, horizontal on request.
- Preferred installation is **directly on the pump discharge flange**. Otherwise, if possible, no farther downstream than about 3 metres after the pump (depends on the application).
- The recommended **straight pipe run at the inlet** should then be at least $2 \times DN$ (no elbows at the inlet).
- Downstream of the bypass should be in a straight pipe run of $3 \times DN$ (no elbows).
- Standard **filter mesh size should be 0.3 to 0.5 mm** (pump suction side). For commissioning we recommend using a smaller mesh size (of 0.1 mm).
- After commissioning a valve inspection is recommended.

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> Recommended individual bypass line for 2 x 50% pumps.



> Possibility for rating step down.

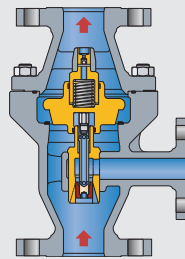
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Pump Protection

2.3 SCHROEDAHL ARV Types

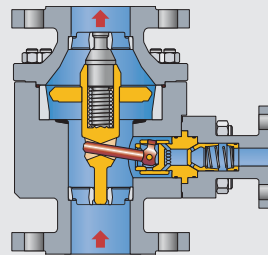
SUL

- Max. class 300 / PN 63
- Cast body
- Economic and efficient design



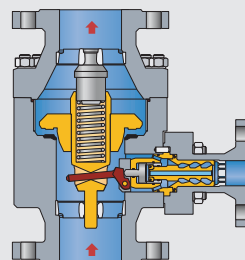
TDL

- Max. class 900 / PN 160
- Forged body
- Check valve in the bypass
- Venturi ring design



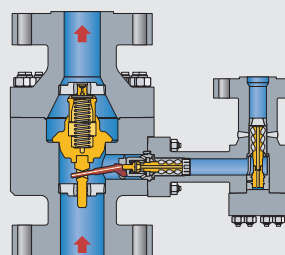
TDM

- Max. class 2500 / PN 400
- Forged body
- High pressure reduction bypas device (up to 5 stages)
- Non-return function in bypass



MRK

- Max. class 4500 / PN 640
- Forged body
- High pressure reduction bypas system for pressure reduction up to 500 bar.



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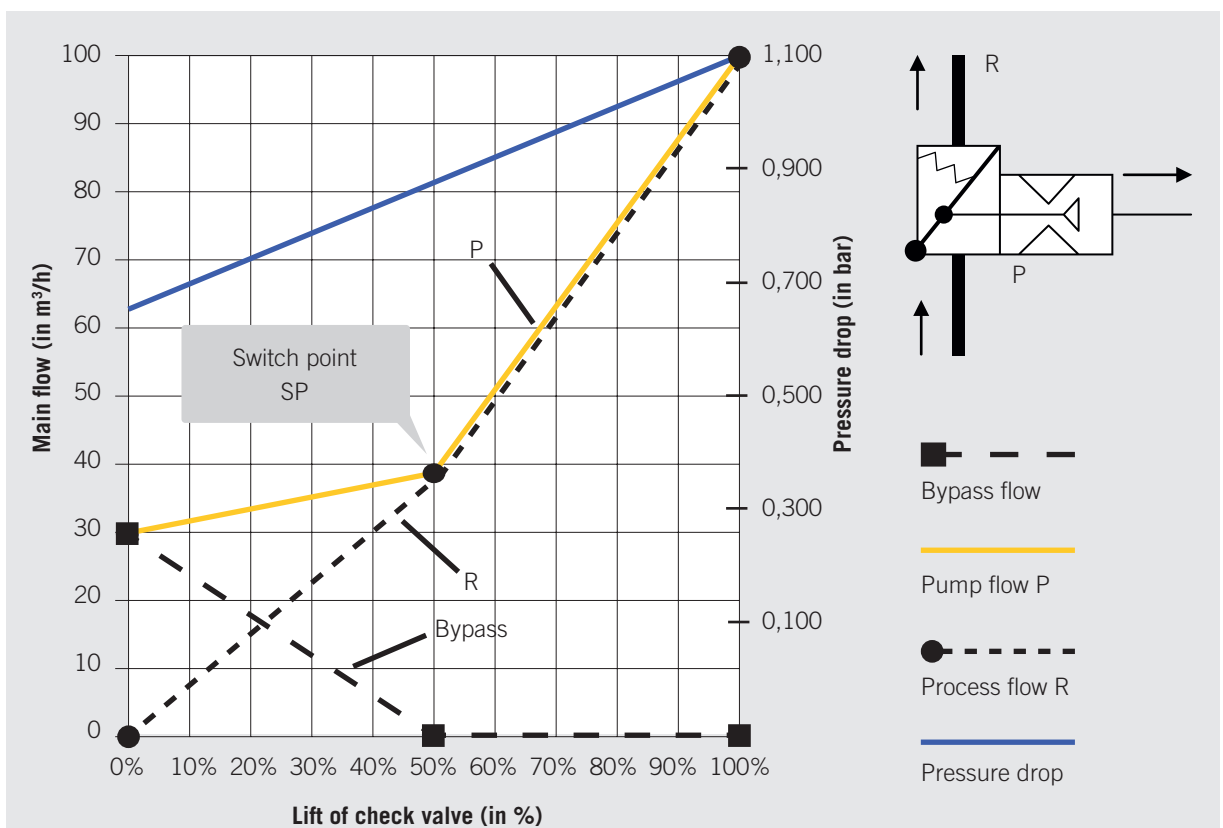
Pump Protection

2.4 The ARV Functioning / Flow Curve

Modulating Bypass Function

All SCHROEDAHL valves have a modulating function; they do not have a simple ON / OFF function. Therefore, with the modulating function, they can handle load cases between zero process flow and the minimum pump operating conditions without loss of energy.

During zero process flow, the bypass is completely open. The pump is running with the specified minimum flow. When increasing the process flow, the bypass flow will decrease accordingly.



> Above flow curve shows the valve behaviour for the flow reduction process (shut-down event).

Example curve with design conditions:

$Q_{100\%} = 100 \text{ m}^3/\text{h}$
 $Q_{\text{min}} = 30 \text{ m}^3/\text{h}$

30% of the rated pump flow, the valve switch point is about 25% higher than the specified minimum flow:

$$SP \sim Q_m \times 1,25$$

Valve switch point (SP)

For normal operation conditions with TDM-Valves, where the bypass flow is not higher than about

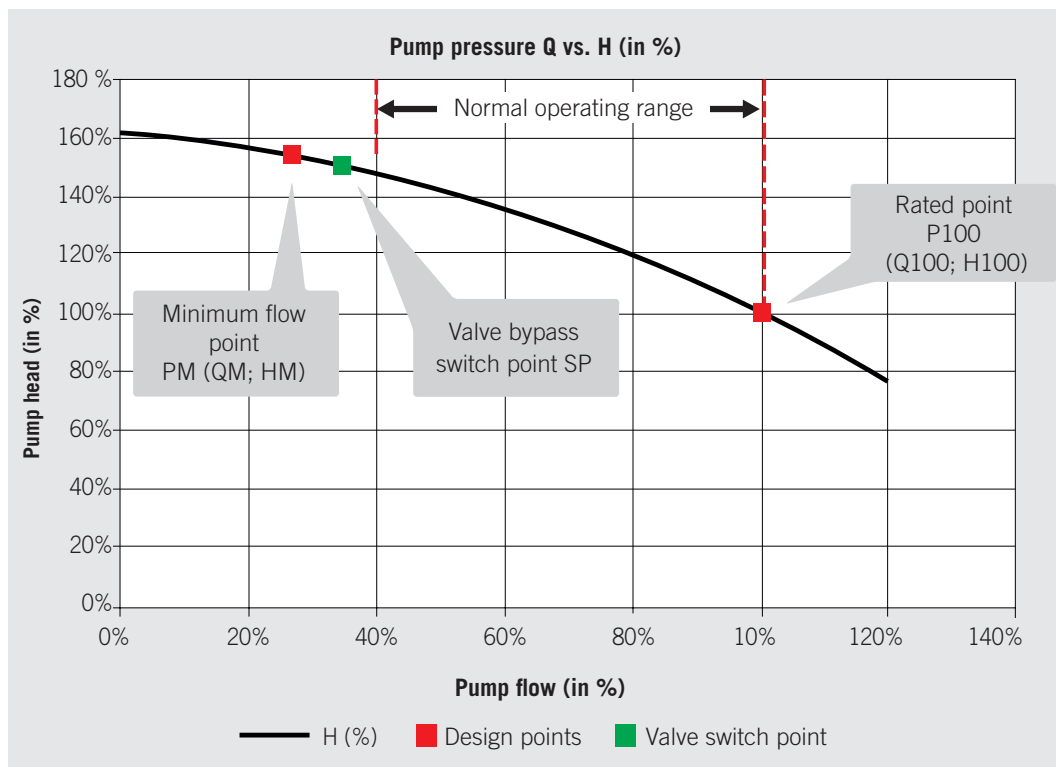
This very low switch point is one of the advantages of SCHROEDAHL valves!

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2.5 ARV Operation on Pump Curve

Please refer to the following principal pump curve according to the typical pump curve (pressure head over pump flow) to understand the characteristics of an ARV



Definition

For the curve, the normal operation point (rated point) is stated as the 100% case with H = 100% at Q = 100%

Usually, the system operation is between 40% to 100 % and therefore above the valve switch point (see graph above: normal operation).

Explanation

The bypass flow will decrease when the flow to the system (process flow) is increased. Therefore, the bypass flow reduces from the minimum flow point to the switch point. At the ARV switch point, the bypass flow is closed.

Operation Range of Pump Protection

HP applications, which should operate from 0% to 100% process flow, require detailed engineering and have to be confirmed before order processing (see section 2.1).

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Pump Protection

2.6 ARV Application with Speed Operation Pumps

The ARV is flow sensitive

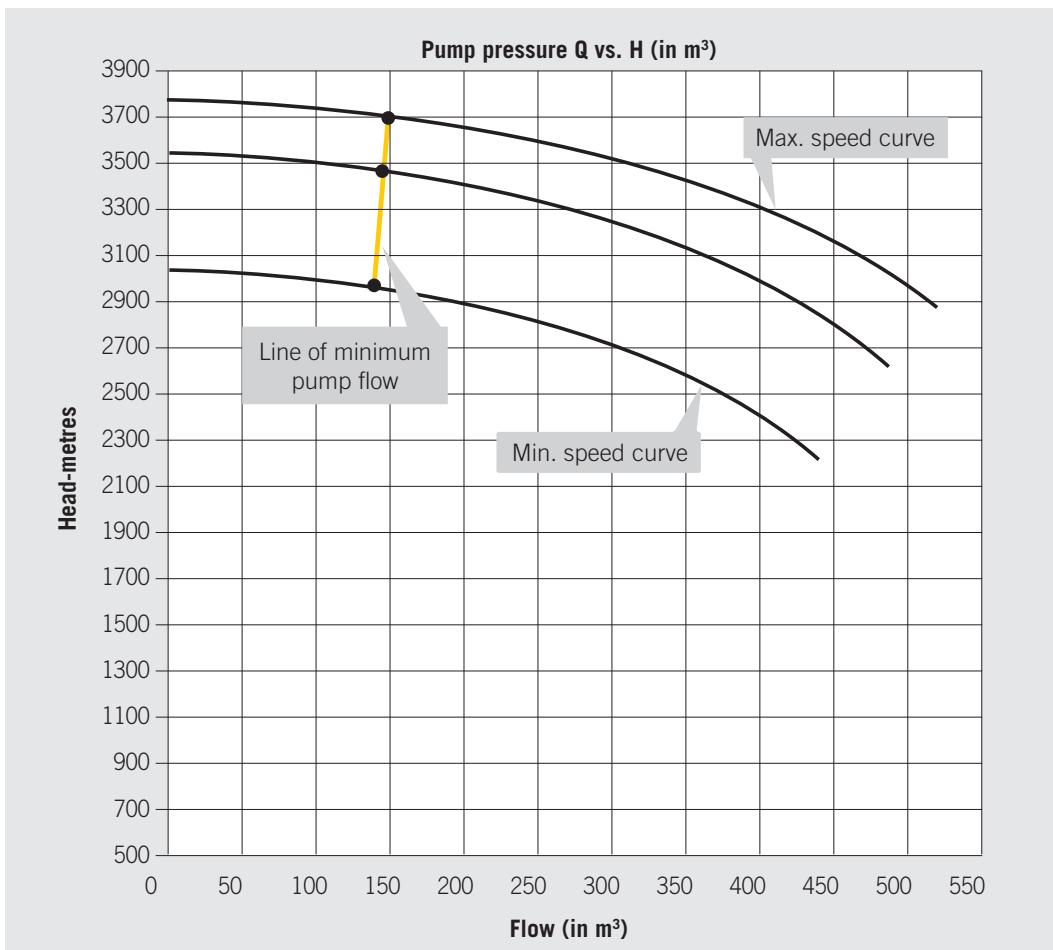
As the ARV functioning is related only to the process flow quantity, the valve will not have a problem when it must operate at lower pump speeds / lower pump pressures. This is a very big advantage of the ARV solution compared with a Control Valve system.

Valve calculation

For the valve design we calculate / incorporate all given speeds with the valve's minimum flow points and will ensure that all different operation points are covered (worst case scenario). The ARV pump protection will have a large and sufficient operational range.

The ARV is able to handle speed-operated pumps – easily!

> Typical Speed Operation Pump Curve



> **Note:** Please also inform us about the load data if a booster pump with constant speed is installed.

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Pump Protection

2.7 Engineering Guideline for ARV's

Materials

- Standard temperature range from -196 °C to +260 °C (LP up to +400 °C)
- Standard sealing material is EPDM, NBR, FKM, FFKM
- SUL valves are available in CS and SS housing material only (cast body)
- TD, MRM and MRK valves: CS, SS, LT, Duplex, Super Duplex
Special materials on request!

Differential Pressure at Rated Flow

- The differential pressure at rated flow (based on normal medium velocities of 4 to 5 m/s):
- **SUL approx. 0.3 bar**
- **TDL approx. 0.4 bar**
- **TDM approx. 1.0 bar** (approximate figures, depending on load conditions)

Installation Conditions

- **Preferred vertical**, horizontal on request.
- Preferred **installation is directly on pump discharge flange**, otherwise, if possible, no farther downstream than about 3 metres after the pump (depends on application).
- Standard **filter mesh size should be 0.3 to 0.5 mm** (pump suction side). For commissioning we recommend a smaller filter size of 0.1 mm.

Examinations, Tests and Certificates

- Standard certificates acc. EN 10204 / 3.1 and 97/23/EG (PED for CE marking for Europe).
- Leakage:
Main Check Valve: FCI 70.2 Class IV (all valves)
- Bypass: FCI 70.2 Class IV (only TDM / MRM valves); TDL and SUL are not tight closing (LP application).
- Witnessed inspection by customer or third party inspection.
- Non-destructive examinations on request for TD, MRM and MRK series (not for SUL type).
- Bypass Kv Value test certificate, on request.
- Flow curve for TDM, MRM and MRK series, on request.

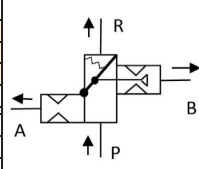
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CIRCOR | Schroedahl ARV Data Sheet

Customer	Rev.	prev. Order No.
		Data Sheet No.
		Quantity
Project		
Tag No. / KKS No.		
Type		

Valve Design						
	Connection	Size	Class	Standard	Schedule	Surface
P	Inlet					
R	Outlet					
B	Bypass					
A	Start-Up					



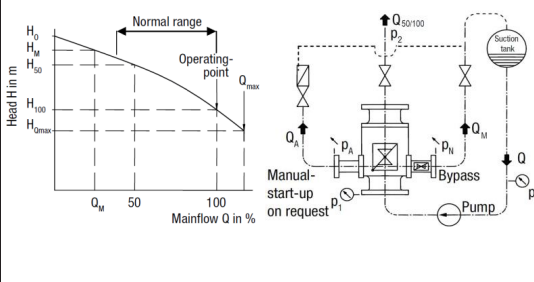
Installation P-R
Painting
Certificates

Design Data	
Design Temp.	Design Pressure

Material	
Body	Internals
	Gaskets

Medium	
Medium	
Operating Temp.	min. max.
S.G.	min. max.

Operating Data			
	Case 1	Case 2	Case 3
Q_M			
H_M			
Q_{100}			
H_{100}			
Q_{max}			
H_{max}			
H_0			
Q_A			
H_A			
p_v			
p_n			
Δp_{Bypass}			
$K_{v-Bypass}$			
RPM			



Remarks			

Revision	Date	Description	Name

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Pump Protection



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