Engineering Letter
Pump Protection
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Notes
Introduction

Owing to necessary cost reductions, a higher system efficiency and risk management, a reliable system to ensure a minimum flow through the pump is a prime 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 and back to the tank.

Much consideration is given to the materials to be used for the valves, in order to minimise corrosion and erosion under high velocity conditions, or special medium applications.

Important advice
In general, and especially for high pressure applications, all equipment including the valves should fulfil the following requirements:

Reliable operation
Production stops are very costly and it pays to accept higher first investments rather than go for the cheapest solution (cheap can be very expensive!).

Ease of maintenance, good serviceability
Although platform personnel includes highly trained technicians, the equipment should be maintenance free or require little maintenance by the platform engineers. Time is scarce, and time 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!
1.1 What 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, which 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 which 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 m$^3$/h (per pump), the bypass flow required is minimal 125 m$^3$/h (usually 150-200 m$^3$/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 in the region of $ 200,000.

This system is therefore very costly and it is bad engineering practice.
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 considered. 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.
1.1.3 Automatic Recirculation Valves

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

The SCHROEDAHIL ARV is distinguished by:

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

Which 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 SCHROEDAHIL valves are most reliable valves providing minimum flow through a pump. They have many advantages over other systems and are low in first costs (approx. 60 - 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 SCHROEDAHIL.
**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 and 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.
2.2 ARV Installation Recommendations

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 x DN (no elbows at the inlet).
- Downstream of the bypass should be in a straight pipe run of 3 x DN (no elbows).
- Standard filter mesh size should be 0.3 to 0.5 mm (pump suction side). For commissioning we recommend to use a smaller mesh size (of 0.1 mm).
- Bypass Back Pressure:
  For applications where the differential pressure is more than 120 bar, the recommended bypass back pressure is about 4.0 bar higher than the saturation condition (approximate figures).
2.3 Schroedahl ARV Types

**SUL Type**
- Max. PN 300 lbs/PN 64
- Cast Body
- Economic and Efficient Design

**TDL Type**
- Max. PN 300 lbs/PN 64
- Forged Body
- Check Valve in the Bypass
- Venturi Ring Design

**TDM Type**
- Max. PN 1500/2500 lbs/PN 250/400
- Forged Body
- High Pressure Reduction Bypass Device (up to 5 Stages)
- Non return Function in Bypass

**MRM/MRK Type**
- Max. PN 4500 lbs/PN 640
- Forged Body
- High Pressure Reduction Bypass System for Pressure Reduction up to 500 bar.
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.

Example curve with design conditions:

\[ Q_{100\%} = 100 \, \text{m}^3/\text{h} \]
\[ Q_{\text{min}} = 30 \, \text{m}^3/\text{h} \]

Valve switch point (SP)
For normal operation conditions with TDM-Valves, where the bypass flow is not higher than about 30 % of the rated pump flow, the valve switch point is about 25 % higher than the specified minimum flow:

\[ \text{SP} \approx Q_m \times 1.25 \]

This very low switch point is one of the advantages of SCHROEDAHL valves!
2.5 ARV Operation on Pump Curve

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

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

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.

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

Operation Range of Pump Protection
HP applications, which should operate from 0 % to 100 % process flow, requires detailed engineering and have to be confirmed before order processing.
2.6. ARV Application with Speed Operated 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 its 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!

Note:
Please also inform us about the load data if a booster pump with constant speed is installed.
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 0.1mm.

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.
## Automatic Recirculation Valve RFQ Datasheet

<table>
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<th>Client:</th>
<th>TAG No.:</th>
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<tbody>
<tr>
<td>Customer Ref.:</td>
<td>Qty.:</td>
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<tr>
<td>Project:</td>
<td></td>
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<tr>
<td>System Description:</td>
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### Valve Inlet
- DN
- PN
- Flange Standard (DIN EN/ASME...):

### Valve Outlet
- DN
- Installation: (vertical = standard)

### Bypass
- DN
- Painting: (Stand./Spec.)

### Manual Start-Up (if req.)
- DN

### Certificates: (e.g. EN 10204 / 3.1,...)

### Specification/ Specials/ NDT Requirements:

### Carbon Steel, Stainless Steel, Duplex, others:

### Housing Material:

<table>
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<tr>
<th>Medium:</th>
<th>in kg/dm³, t/m³</th>
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<tr>
<td>S.G.:</td>
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<table>
<thead>
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<th>( Q_{100} )</th>
<th>m³/h</th>
<th>( H_{100} )</th>
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<td>( Q_{M} )</td>
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<tr>
<td>( Q_{A} )</td>
<td>m³/h</td>
<td>( H_{A} )</td>
<td>m</td>
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</table>

### Operating Temperature: °C

### Design Temperature: °C

### Design Pressure: bar g

### Suction Pressure \( p_v \): bar g

### Back Pressure Bypass \( p_n \): bar g

### Back Pressure Start-up \( p_A \): bar g
2.9 Signal Exchange of the Minimum Flow Control System

**Note:**
The SCHROEDAHL unit excludes wiring between valve, orifice and control room!

**Scope of supply, to be clarified for an order:**

1. **Minimum Flow Control Valve with actuator**
2. **Type of valve actuator; pneumatic, electric, hydraulic**
3. **Transducer / controller; special requirements, or already existing in the pump package.**
4. **Flow measurement requirement; orifice or venturi nozzle on pump suction or discharge side.**

**Signal exchange, to be clarified for an order:**

1) Analogue signal from DCS system:
   a) Normal operation, b) Emergency; Valve open, ....

2) Analogue signal from valve / control room:
   a) Limit switch open/close, b) 4-20 mA position feedback, c) Emergency; Valve open, ....
3.0 Schematic Arrangement for CV Solution with Venturi Nozzle at Pump Discharge and Signal Controlled Pump Speed

Remark: the system reliability is related to each component of the pump protection package!

All activities must be specified in the programme flow chart for the controller, as well as any signal loss between the components and the DCS system (control room).
SCHROEDAHL
we protect your business

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