Proportional pressure reducing valves with intrinsic fail safe function

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1 Introduction and Motivation
2 PPRVs as pilot valves for sectional valves
3 Functional principle of Fail Safe versions
4 Limits and Restrictions
5 Influence on functional safety ratings
6 Summary
THOMAS Mobilhydraulic history:
First cartridge valve development in 1996

PPRV: 3/2-way proportional pressure reducing valve

PPCD04
Proportional Pressure Control
Direct operated
04 = flow capacity
Introduction and Motivation

What to do for continuous improvements?

1) Higher performance and/or more compact and/or more cost efficient design

Standard PPRV  \[\rightarrow\]  High Performance Valve  \[\rightarrow\]  New Generation

2006  \[\rightarrow\]  2017
What to do for continuous improvements?

2) Integration of more functionality

2017

Standard PPCD04

Fail Safe version
PPRVs as pilot valves for sectional valves

Functional principle of a PPCD04
PPRVs as pilot valves for sectional valves

Functional principle of a PPCD06

![Diagram of PPCD06](image)
PPRVs as pilot valves for sectional valves

Safe situation for implement functions with electrohydraulically driven sectional valve

\[ P_C < P_{SF} \rightarrow \text{Safe Situation} \]
Functional principle of Fail Safe versions

PPCD04

\[ P_p \]

\[ P_C < P_{SF} \]

Tank

armature bar
Functional principle of Fail Safe versions

PPCD06

$P_C < P_{SF}$

$P_P$

Tank

pressure pin
Functional principle of Fail Safe versions

- Spool stuck open (125 μm thick wire)

- Current
- Control Pressure
- Supply Pressure

Time [sec]
Current [mA]
Pressure [bar]
Functional principle of Fail Safe versions

First Design

Filter: mesh width of 125 μm

Final Design

Flow restricting bore
Limits and Restrictions

Remaining control pressure depending on pump pressure and orifice-Ø

PPCD04

\[ P_C [\text{bar}] \]

\[ P_P [\text{bar}] \]

orifice- Ø [mm]

- 0-4
- 4-8
- 8-12
- 12-16
- 16-20
Limits and Restrictions

Dynamic limitation by pump port orifice

**PPCD04**

<table>
<thead>
<tr>
<th>orifice-Ø in P-Port [mm]</th>
<th>filling time [ms]</th>
</tr>
</thead>
<tbody>
<tr>
<td>no orifice</td>
<td>Vol. = 6 ml</td>
</tr>
<tr>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

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Limits and Restrictions

Dynamic limitation and residual pressure

- Filling time PPCD06
- Filling time PPCD04
- Residual pressure PPCD06
- Residual pressure PPCD04

Vol. = 6 ml

Orifice-Ø in P-Port [mm]
Influence on functional safety ratings

Electrohydraulic Actuator

- CAN Signal as input command
- Position feedback signal by hall sensor
- Rated according to ISO13849

MTTFd = 150 year
Influence on functional safety ratings

Reliability model for the main Safety Function:
Both pilot valves are generating a pilot pressure below \( P_{SF} \) if neutral position is commanded
Influence on functional safety ratings

Possible failure modes due to table C.6 in ISO 13849

Detectable and EHA can be brought into safe state

MTTF_D = \sum \frac{1}{MTTF_Dj} = \sum \frac{\eta_j}{MTTF_Dj}

DC_avg = \sum DC_j * MTTF_D_j / MTTF_D

DC_avg 84 %

MTTF_D 29,1 years

Pilot Valve

150 years

67%

Pilot Valve 2x

Safety and Protection Transducer

PLC

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Summary

Introduction of valves with fail safe function

Discussion of limits and restrictions

Positive effects on functional rating of systems with integrated fail safe valves
Thank you for your attention!

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