2oo3plus – A New Design of Electro-hydraulic Safety Controls for Critical Applications

Weishaupt, Edgar
MooN-Safetycontrol – Application

- **Safety manifold**
- **MooN**
- **Trip-valve**
- **Process valve**
- **Spring**
- **Actuator**
Typical 2oo3-Block

- 4/2-way spool valve
- Each valve has 4 connections and 2 parallel hydraulic channels, connected mechanically
- Each hydraulic channel has 2 valves connected in series in different flow paths (P → A and B → T)
- One failure results in a 2oo2 voting architecture
Eliminate the mechanical couplings of the control openings by the use of six individual 2/2-way poppet valves
- Valves controlled electrically in pairs in different hydraulic channels
- One failure results in the failure of only one hydraulic channel
Enhanced concept 2003plus

Advantages

- Fast switching times support rapid actuator discharging
- Poppet design effectively prevents leakage during normal operation; suitable for accumulator-based applications
- Increased range of flow rates combined with solenoid operation; may eliminate the need for piloted slip-in cartridge valves in some cases
- Compact and light-weight manifold design
- Reduced component costs
- Minimised internal cavity volume prevents pressure collapse; suitable for large operating pressure range from as low as 6 bar up to 250 bar
- Wide ambient temperature range (-20..60 °C, with special measures up to 80 °C)
- Robust against oil contamination, moderate cleanliness requirements (20/18/15 acc. to ISO 4406)
- No requirements on installation position/orientation
Testing procedure

- Enable testing set-up
- Check standby state

- De-energise one logic channel (e.g. valve pair A1/A2)
- Check valve states
- Re-energise that channel
- Check standby state again
Interface-Box adapts the manifold to standard 2oo3 controller

- Includes evaluation logic
- Adapts the inputs and outputs to match conventional 2oo3 set-up
- Simple and robust design
- Optimized for maximum reliability
- No software or other complex elements
- Easy exchange of diagnostic module during operation
Modular manifold design

- Components
  - Standard poppet valves WS(M) in scaled sizes DN6..DN20
  - Pressure switch EDS 4448

- Modular design
  - Each hydraulic channel in one valve plate

- Easy adaptation to installation requirements
  - Direct flange mounting
  - Piping connection

- Easy addition of secondary functions

- Possibility of different voting architectures
### Possible MooN voting configurations

<table>
<thead>
<tr>
<th>MooN voting</th>
<th>No. of slabs x valves</th>
<th>Valve set-up</th>
<th>HFT (d)¹</th>
<th>HFT (s)¹</th>
<th>Valve diagnostic test</th>
<th>Annotations on valve diagnostic test</th>
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</thead>
<tbody>
<tr>
<td>1oo1</td>
<td>1 x 1</td>
<td>A1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1oo1plus (1oo1 x 2oo2)</td>
<td>1 x 2</td>
<td>A1, A2</td>
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<tr>
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<tr>
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<td>deenergising of valve pairs</td>
</tr>
</tbody>
</table>

¹ Hardware Fault Tolerance of hydraulic part towards dangerous (d) or safe (s) failures, respectively
² if valves are operated accordingly during test, deviating from normal operation
Additional functionality

- Additional module on port plate
- Poppet valves
- Valves normally closed
- Isolation of port P
- Partial stroke test
  - 1 or 2 solenoid operated valves
- Speed adjustable via throttle valve
 Explosion proof version

- Explosion protection class \( \text{Ex II 2G Ex h IIC T4 Gb} \)
- Ex-proof solenoids on the basis of HYDAC EX-1516 (increased safety)
- Ambient temperature range -20..+60 °C
System performance

- Possibility to cover a wide range of flow rates
- High response time
- Fast manifold discharge behavior because of low hydraulic capacity
Evaluation of functional safety

- Calculation based on methods of IEC 61508
- Contribution of common cause failure (CCF) dominant because two valves won’t fail independently at the same time
- Combines the advantages of the 1oo3 architecture and of the 2oo3 architecture
- Combines advantages of increased Hardware Fault Tolerance (HFT) and diagnostic testing
- HFT at least 2
Advantages – increased reliability

- Proven and reliable poppet valve technology $\rightarrow$ lower sensitivity to contamination and susceptibility to failure as spool valves
- Suitability for SIL 3, certified by TÜV Rheinland
- Better PFD values despite larger number of components
- Higher hardware fault tolerance than conventional 2oo3 systems, both in terms of dangerous (security) and safe (availability) errors. Lower susceptibility to common cause errors.

- 2 to 4 dangerous faults permitted, depending on the position of the failures
- 1 to 3 safe errors allowed; with 2 valve failures still 80% availability
Thank you for your attention!

Contact:

• Dr. Edgar Weishaupt
  Hydac Systems & Services GmbH
  Edgar.Weishaupt@hydac.com