2oo3*plus* – A New Design of Electro-hydraulic Safety Controls for Critical Applications

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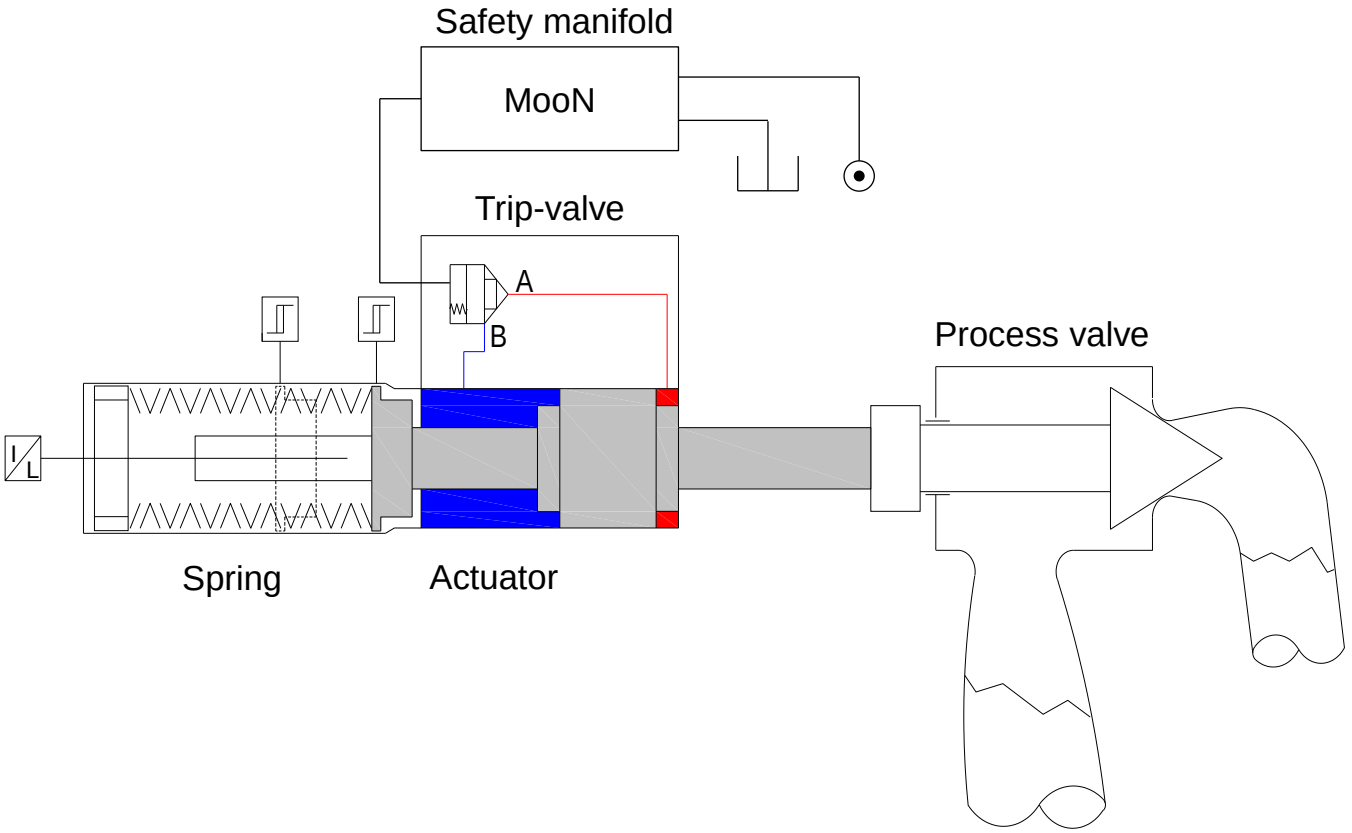
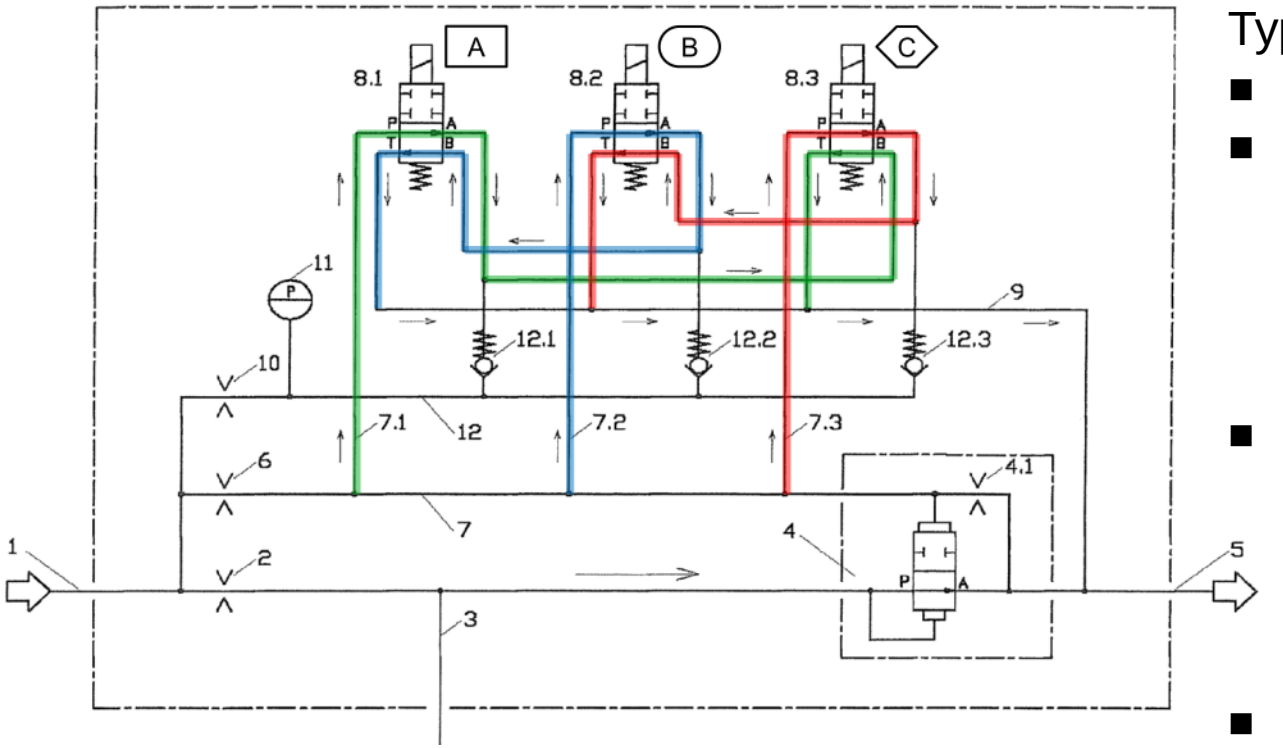
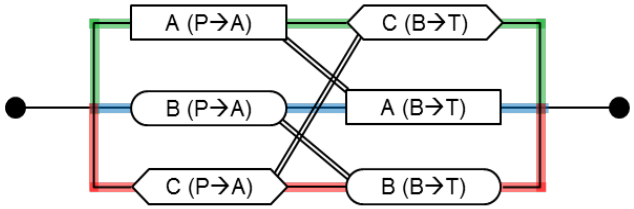
MooN-Safetycontrol – Application



Standard 2oo3



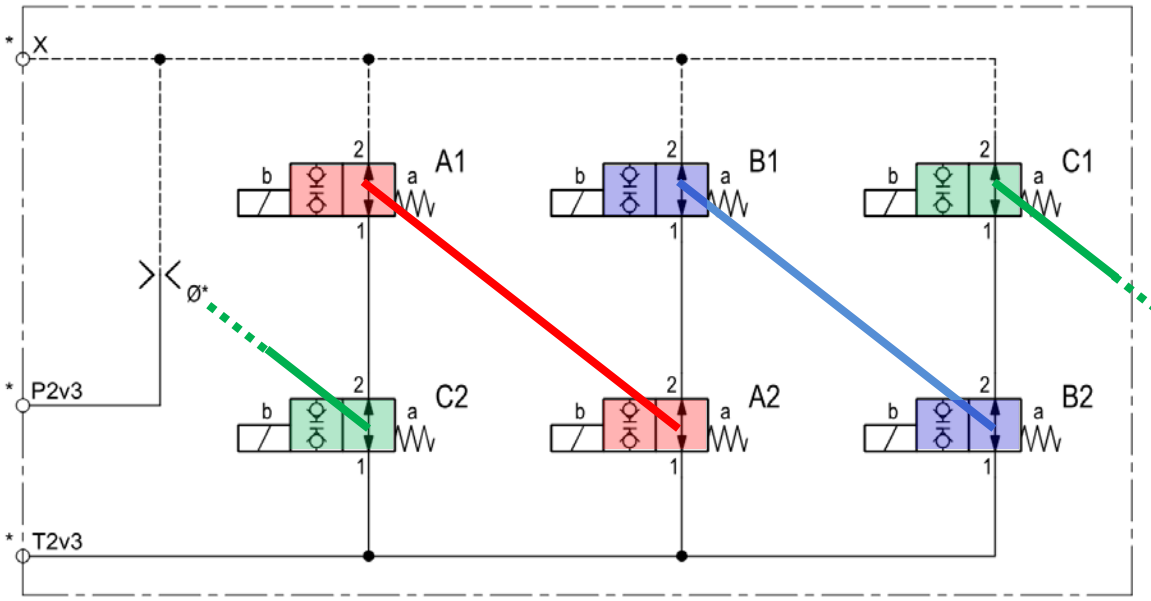


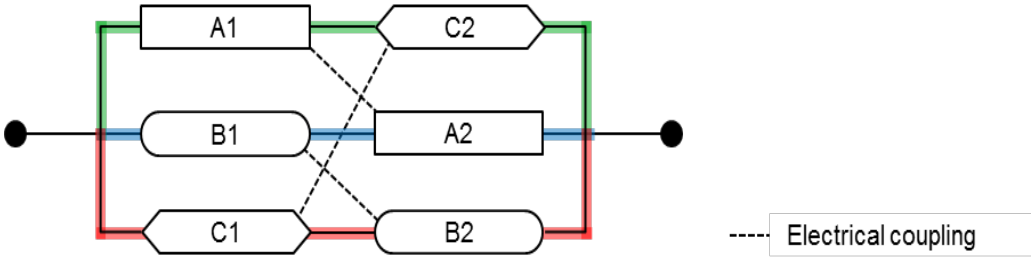
Mechanical coupling

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

Enhanced concept 2oo3*plus*





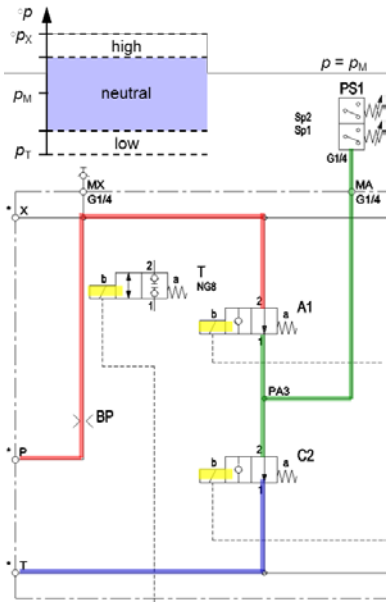
- Eliminate the mechanical couplings of the control openings by the use of six individual 2/2-way poppet valves
- Valves controlled electrically in pairs in different hydraulic channels
- One failure results in the failure of only one hydraulic channel

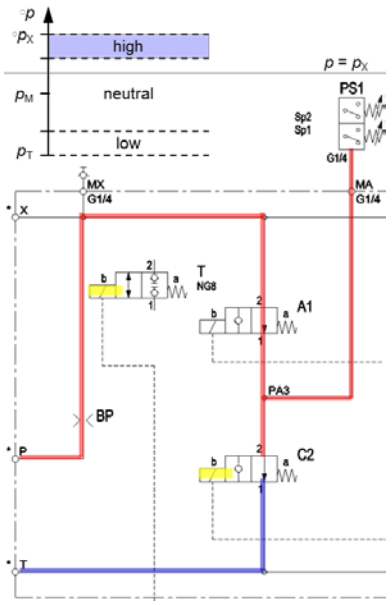
Enhanced concept 2oo3*plus*

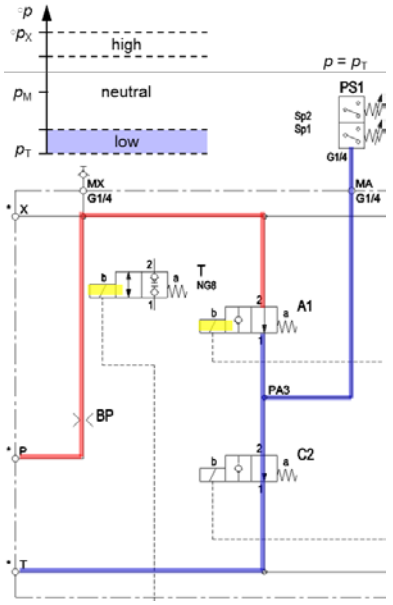
Advantages

- 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



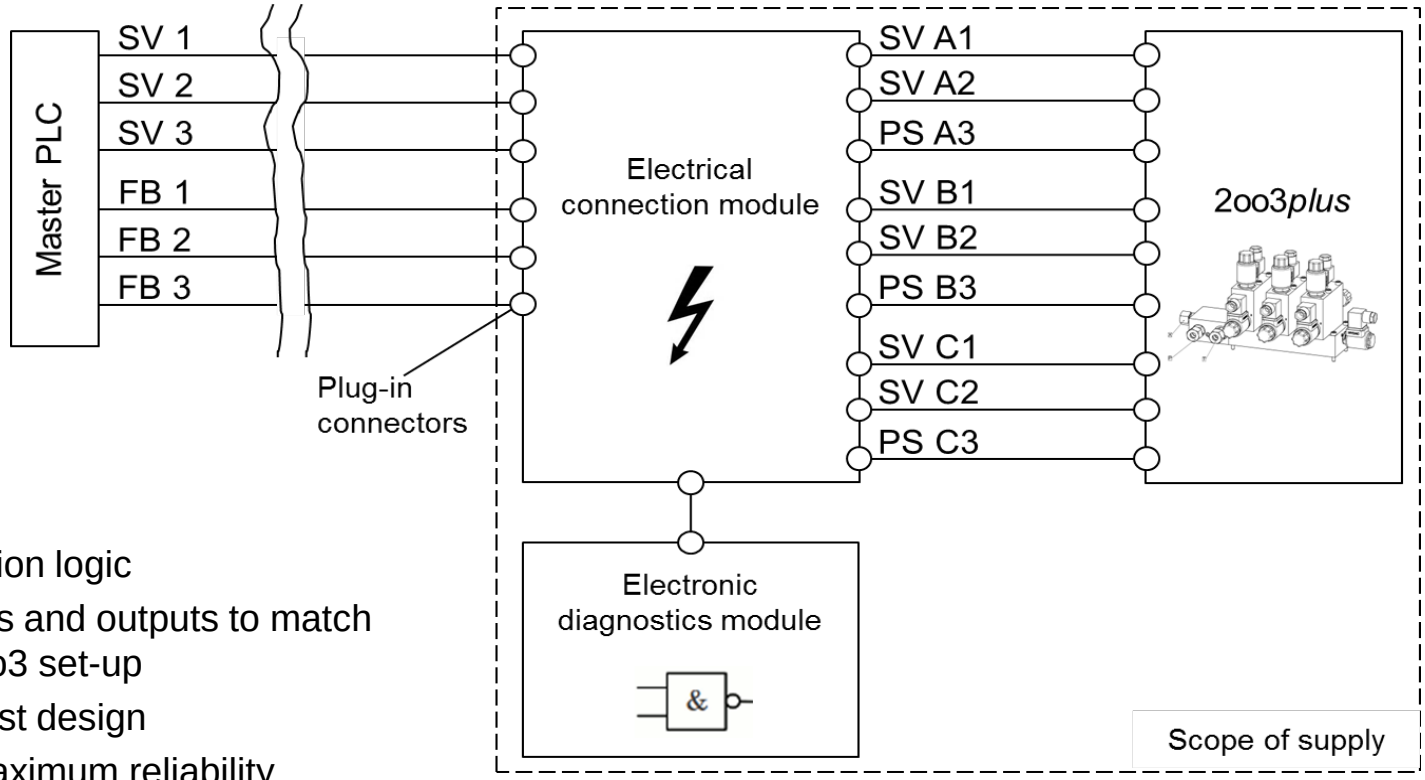




- Enable testing set-up
- Check standby state

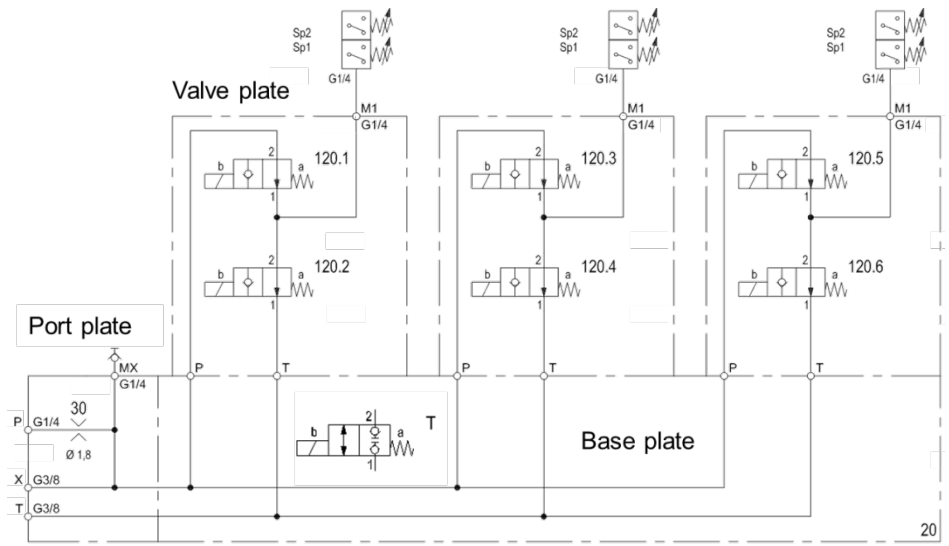
- De-energise one logic channel (e.g. valve pair A1/A2)
- Check valve states
- Re-energise that channel
- Check standby state again

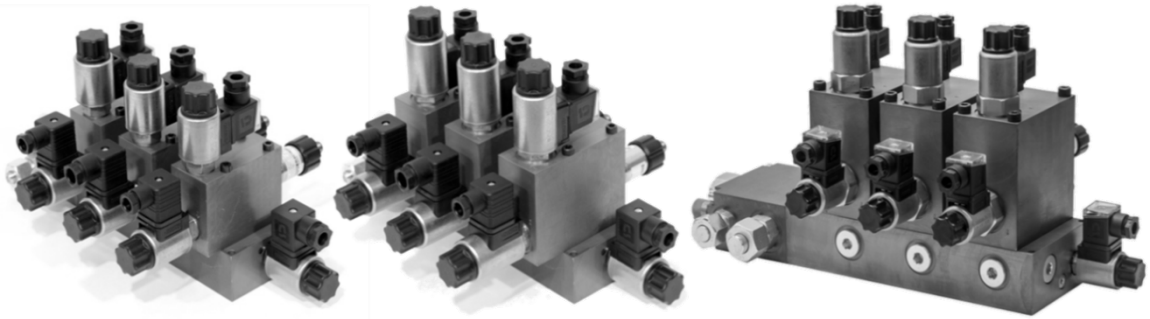
Interface-Box adapts the manifold to standard 2oo3 controller



- 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

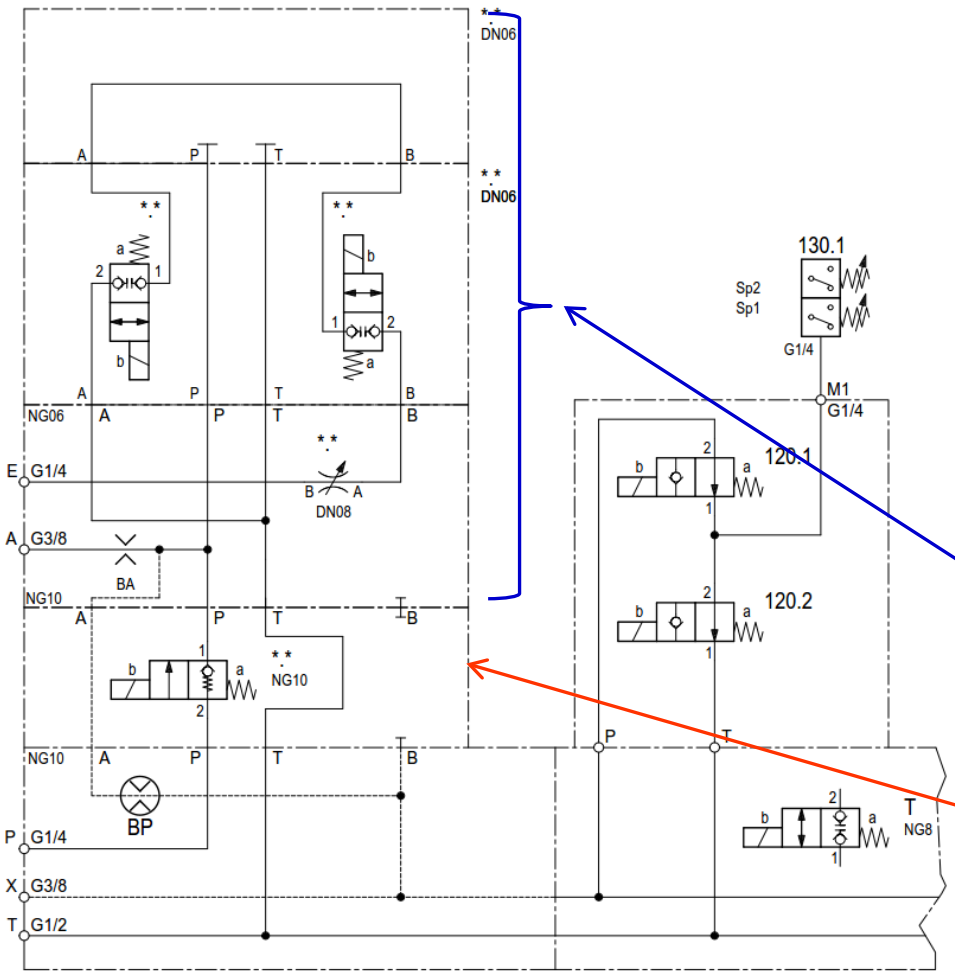
Possible MooN voting configurations

MooN voting	No. of slabs x valves	Valve set-up (Slab 1 | 2 | 3)	HFT (d)[1]	HFT (s)[1]	Valve diagnostic test	Annotations on valve diagnostic test
1oo1	1 x 1	A1	0	0	no	not available
1oo1*plus* (1oo1 x 2oo2)	1 x 2	A1 A2	0	1	yes[2]	deenergising of single valves for test only
1oo2	2 x 1	A1 B1	1	0	no	not available
1oo2*plus* (1oo2 x 2oo2)	2 x 2	A1 B1 A2 B2	1..2	1..2	yes[2]	deenergising of single valves for test only
2oo2	1 x 2	A1 B1	0	1	yes	deenergising of single valves
2oo2*plus* (2oo2 x 2oo2)	2 x 2	A1 B1 B2 A2	1..2	1..2	yes	deenergising of valve pairs
1oo3	3 x 1	A1 B1 C1	2	0	no	not available
1oo3*plus* (1oo3 x 2oo2)	3 x 2	A1 B1 C1 A2 B2 C2	2..4	2..4	yes[2]	deenergising of single valves for test only
2oo3*plus*	3 x 2	A1 B1 C1 C2 A2 B2	2..4	2..4	yes	deenergising of valve pairs

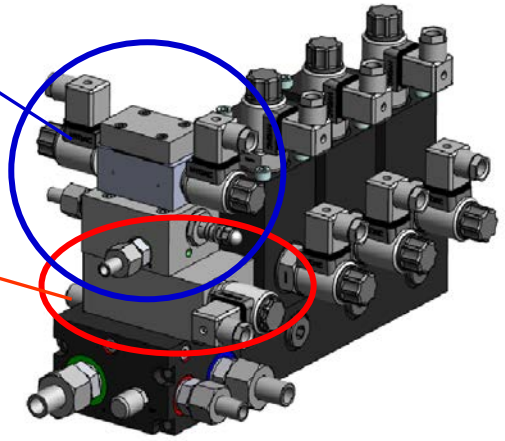
[1] Hardware Fault Tolerance of hydraulic part towards dangerous (d) or safe (s) failures, respectively

[2] if valves are operated accordingly during test, deviating from normal operation

Additional functionality

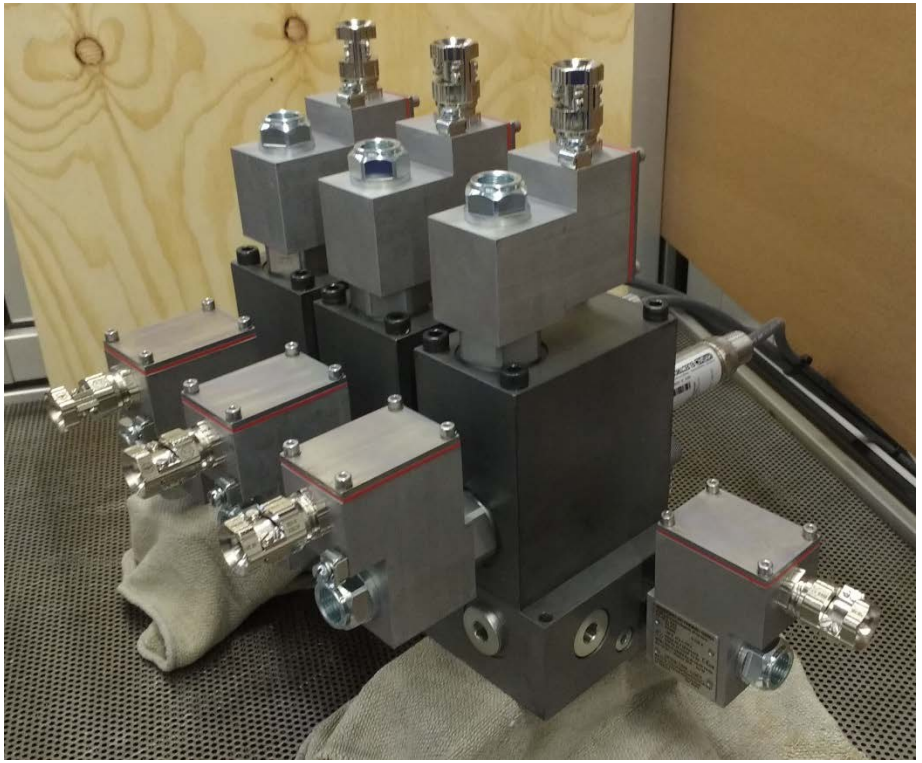


- Additional module on port plate
- Poppet valves
- Valves normally closed
- Isolation of port P
- Partial stroke test
  - 1 or 2 solenoid operated valves
- Speed adjustable via throttle valve

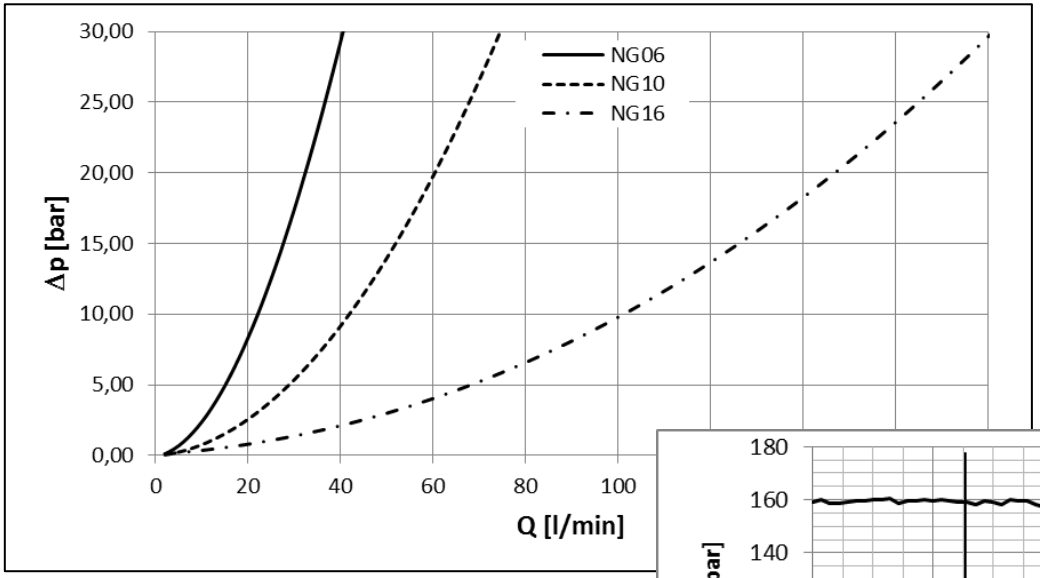


Explosion proof version

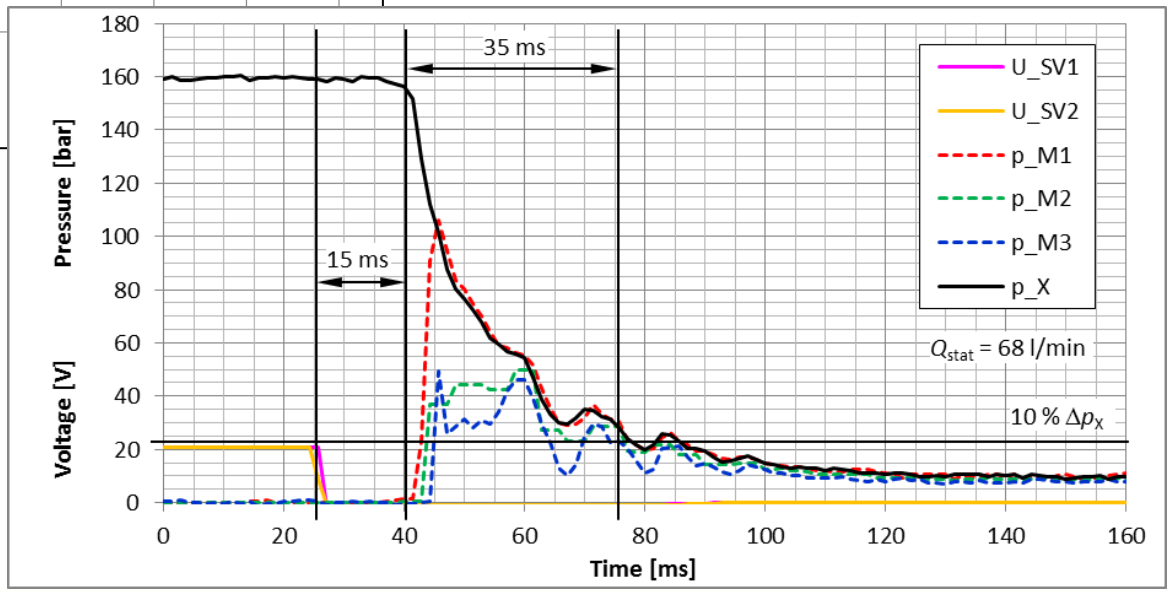
- Explosion protection class ⟨Ex⟩ II 2G Ex h IIC T4 Gb
- Ex-proof solenoids on the basis of HYDAC EX-1516 (increased safety)
- Ambient temperature range -20..+60 °C



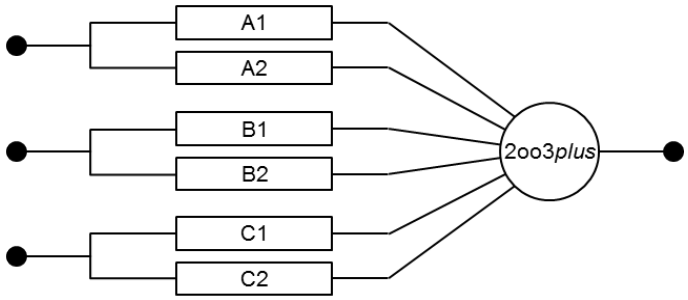
System performance

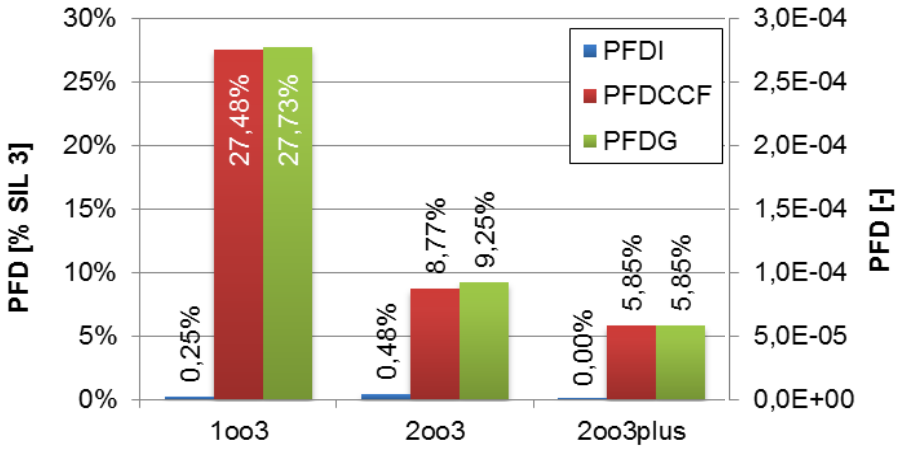


- Possibility to cover a wide range of flow rates
- High response time
- Fast manifold discharge behavior because of low hydraulic capacity



Evaluation of functional safety

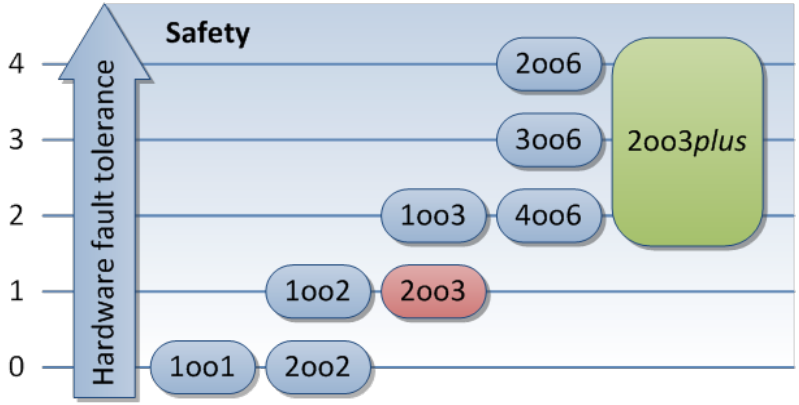




- Calculation based on methods of IEC 61508
- Contribution of common cause failure (CCF) dominant because two valves won't fail independently at the same time
- Combines the advantages of the 1oo3 architecture and of the 2oo3 architecture
- Combines advantages of increased Hardware Fault Tolerance (HFT)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

Advantages – increased reliability

- Proven and reliable poppet valve technology → 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!

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