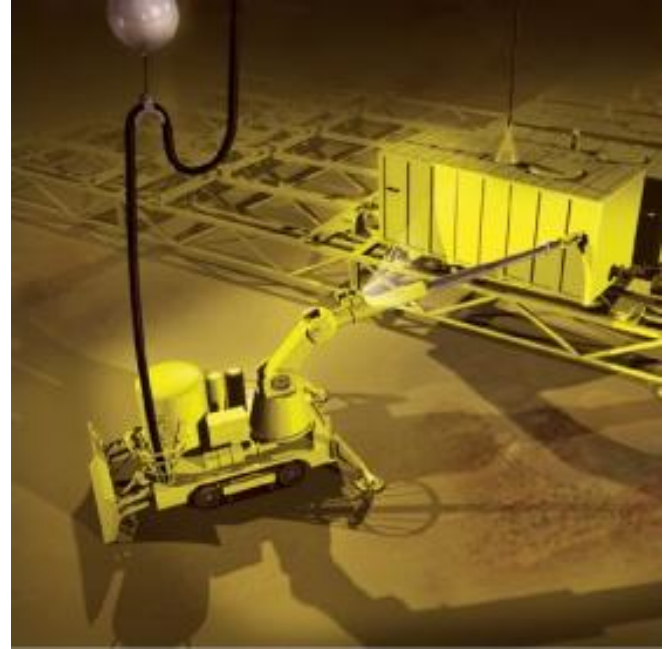


Hoe diep wil je gaan?.....

.....Bosch Rexroth legt de lat op 6000 meter!



Deep Water Hydraulics – Challenges and Solutions

Johannes Schunder / Gérard Swagten

Starting point

- Co-development with OEM, sponsored by German Government
- Development of Hydraulic Drive & Control for subsea Crawler
- Use of standard product portfolio with minor modifications
- Use of available technologies

Deep Water Hydraulics – Challenges and Solutions

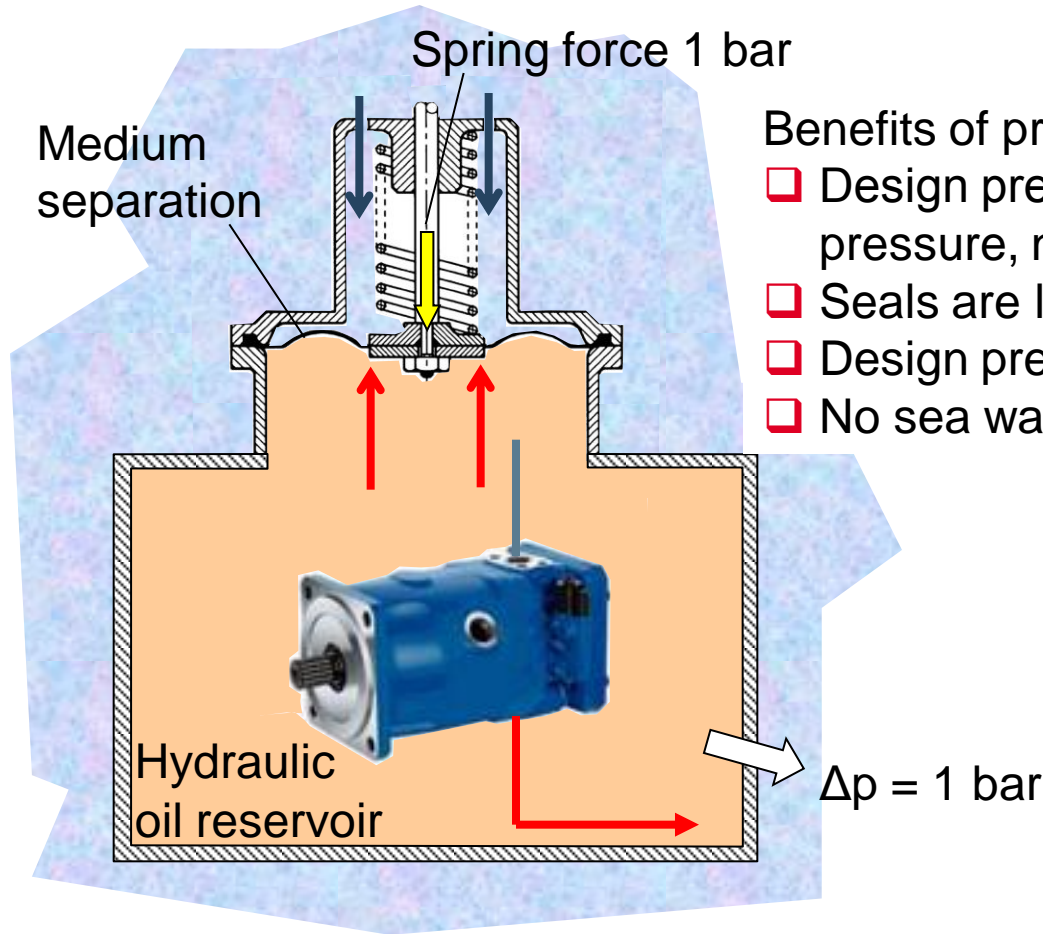
- 23 Control manifolds
- 27 Cylinder axes
- 7 Hydraulic motors



Challenges

- Ambient pressure 1 bar per 10 m water depth -> **600bar!!**
- Equipment located in salt water
 - Corrosion protection is indispensable
 - Electro hydraulics does not work in salt water
 - Avoid water penetration at all costs
- Diagnosis of operating conditions

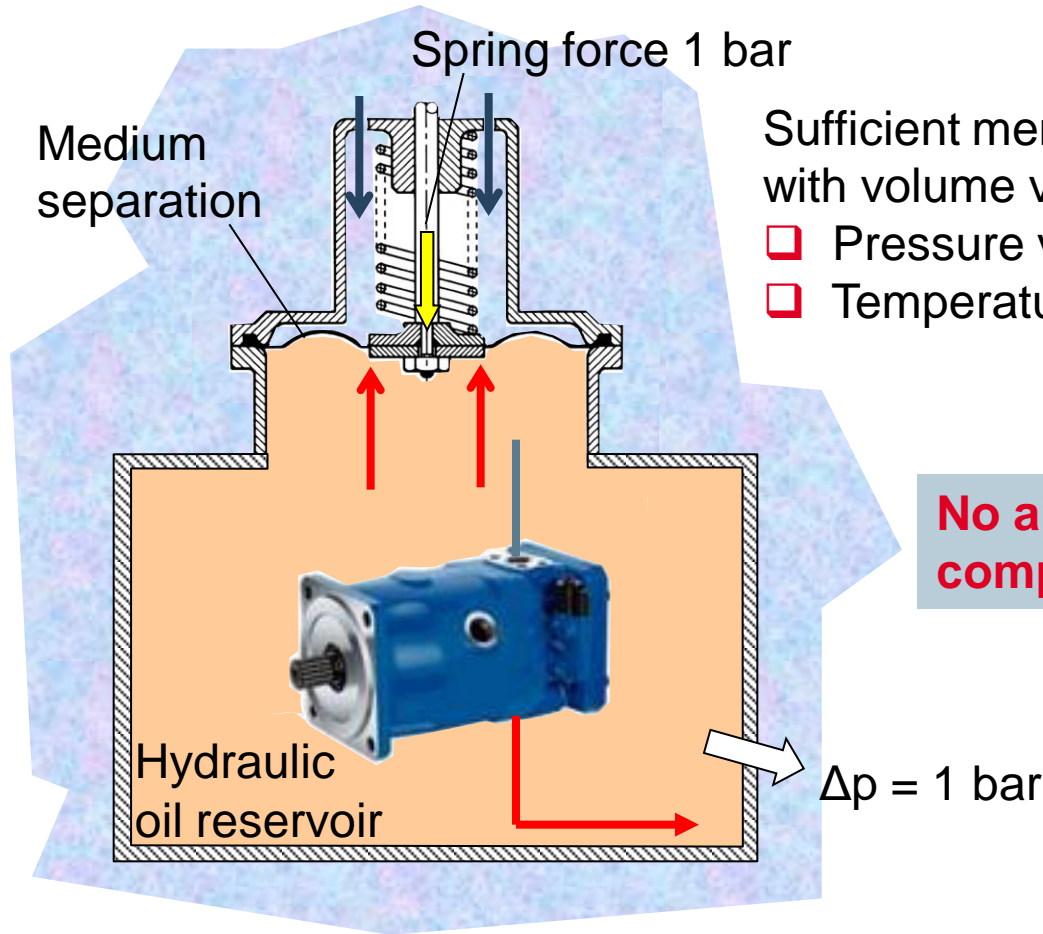
Solutions – Pressure compensator



Benefits of pressure compensation:

- Design pressure is “only” the hydraulic pressure, not the static pressure
- Seals are less complicated
- Design pressure enclosures = 1 bar
- No sea water ingress

Solutions – Pressure compensator



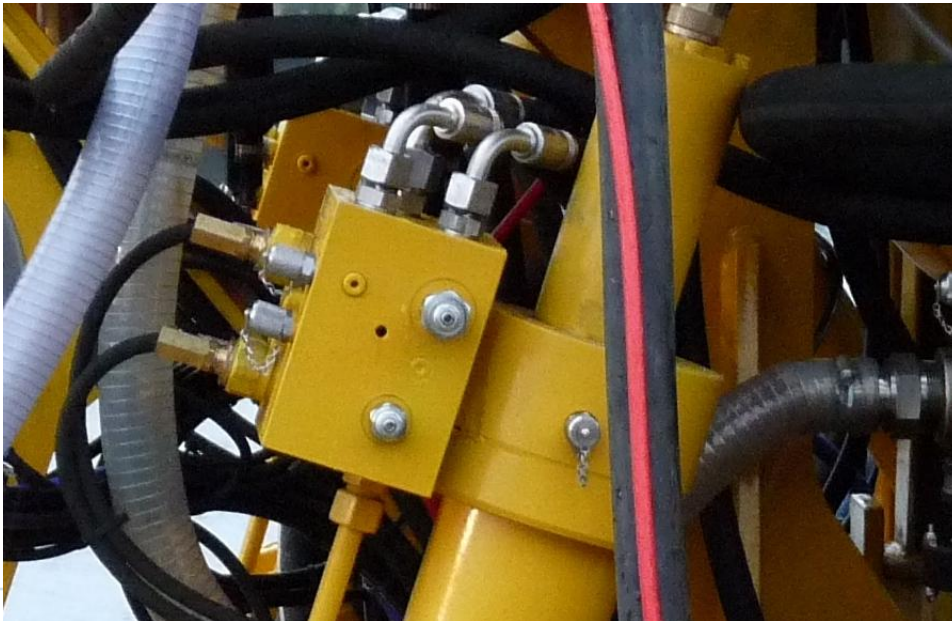
Sufficient membrane displacement to cope with volume variations due to:

- Pressure variations (compressibility)
- Temperature variations (expansion)

No air allowed inside pressure compensated rooms!

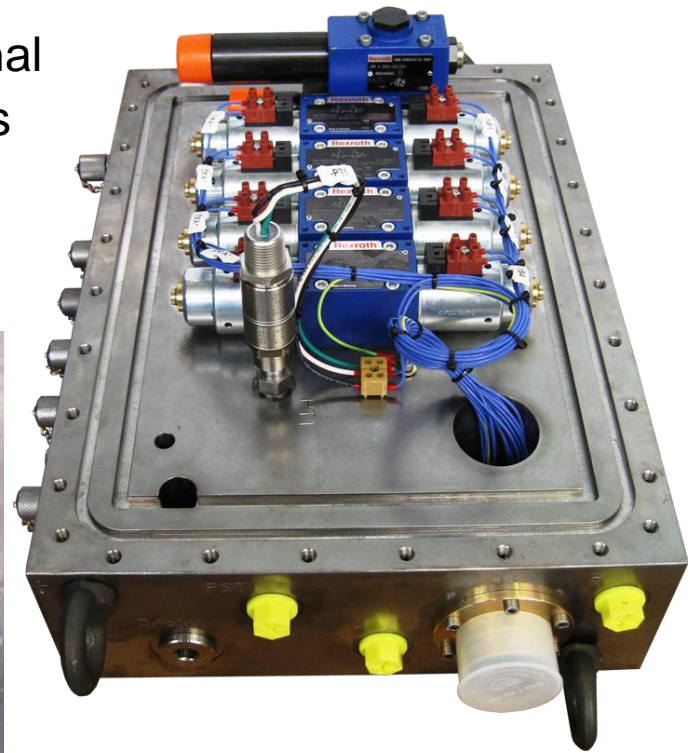
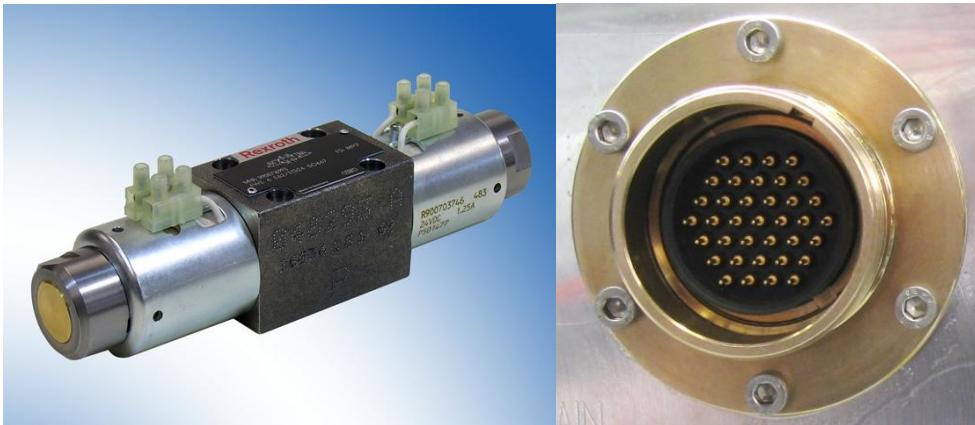
Solutions – Corrosion Protection

- Use of sea water protected components
- Stainless steel fittings and minimess
- Special paint:
 - 1st layer = Amerlock 400 Aluminum 100-120 μ
 - 2nd layer = Amerlock 400 Color 100-120 μ



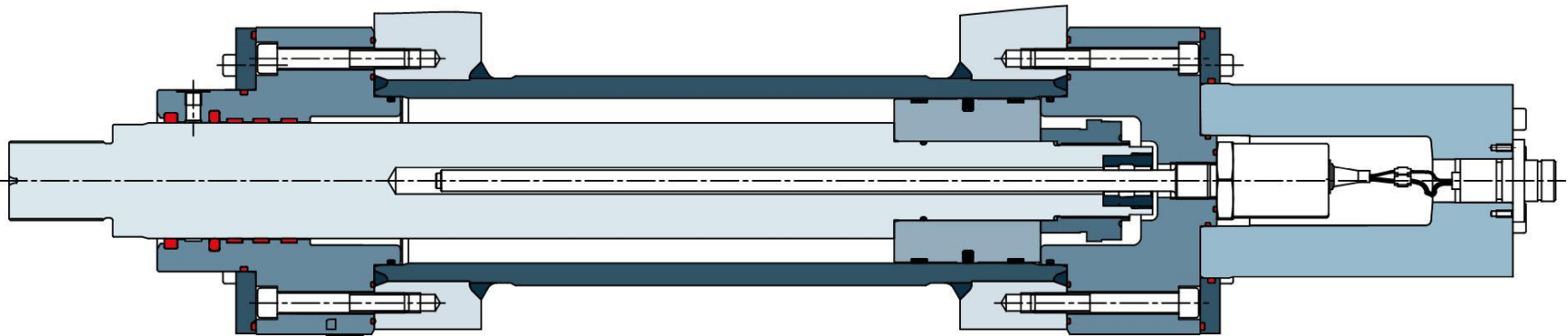
Solutions – Electro Hydraulics

- Encapsulated manifold, oil filled and pressure compensated
- Sea water resistant seal for cover
- Air has to be vented completely
- Specially developed on-off and proportional valves with modified solenoids, pole tubes and terminal strips
- Sub sea electrical connector (penetrator)



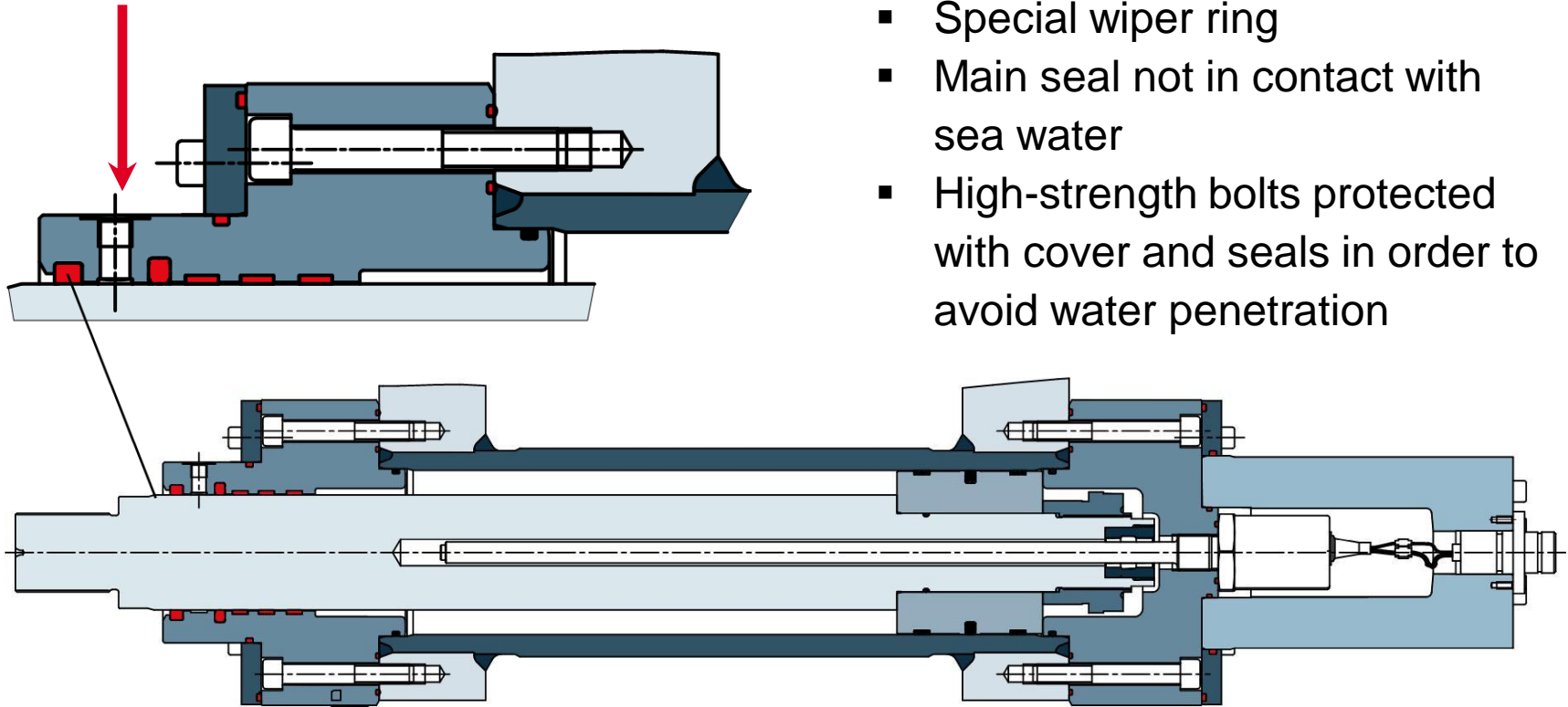
Solutions – Deep Water Cylinder

- Welded instead of threaded design to avoid water penetration
- High pressure position transducer, encapsulated
- Extra heavy design for cylinder bottom and thread for position encoder (600 bar at bottom and thread)
- Sub sea electrical connector (penetrator)
- Special paint



Solutions – Deep Water Cylinder

Pressure compensation



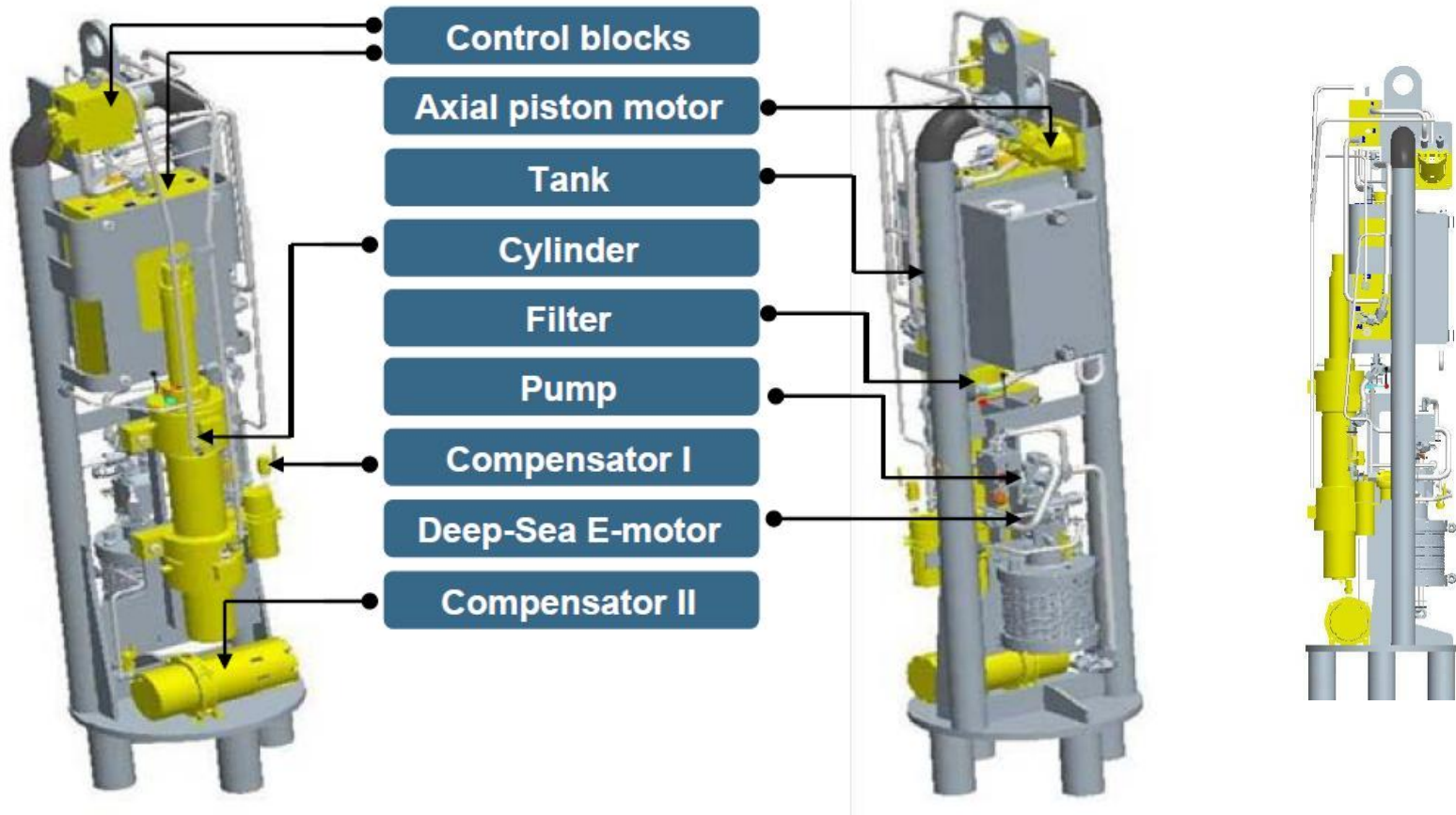
- Rod seals pressure compensated
- Special wiper ring
- Main seal not in contact with sea water
- High-strength bolts protected with cover and seals in order to avoid water penetration

Solutions – Diagnosis of hydraulic system

- All cylinders equipped either with proximity switches or position encoders
- Main pump fitted with swivel angle transducer
- Speed sensors for track drive motors
- Clogging indicator for pressure and return filters
- Particle counter in return line
- Special sub sea pressure sensors for all main functions
- Compensators equipped with level indicators
- Oil reservoir with water ingress and temperature sensors



Deep Sea Power Unit



Deep Sea Power Unit – Test in pressure chamber

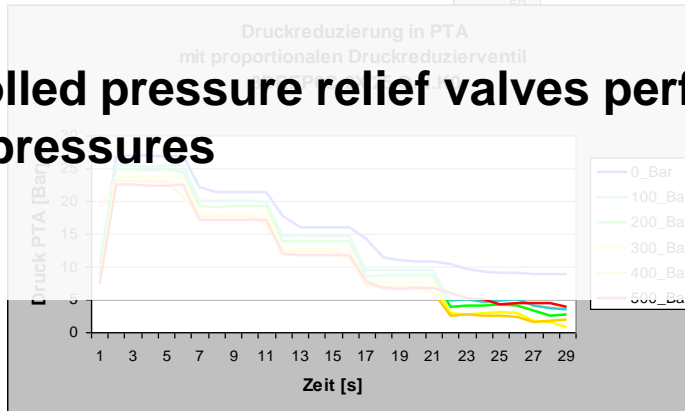


- Tests up to 1000 bar (ambient temperature) have been successful



Test results

- ❑ Control valves (flow and pressure) function properly at water pressures up to 600 bar
- ❑ Flow control valves cause cylinders to move slower at higher water pressures: 1 sec per 100 bar.
- ❑ Controlled pressure reducing valves vary slightly with increasing water pressures: 1 bar per 100 bar water pressure
- ❑ Controlled pressure relief valves perform independently of applied water pressures



Summary and prospects

- ❑ **Deep water hydraulics is feasible but (currently) expensive**
- ❑ **Breakthrough for the profitability is not far away**
- ❑ **Raising energy costs and increasing consumption are driving the need for sub sea solutions**
- ❑ **But there are still some open points:**
 - ❑ **Electric energy supply in great water depths**
 - ❑ **Maintenance of filters and pressure medium**
 - ❑ **Long service life**



Deep Water Hydraulics – Challenges and Solutions



Thank you, for your attention....