Commissioning of Subsea Hydraulic Systems

Life of Asset Solutions

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SUBSEA CONTROL SYSTEMS

With the exception of a few all electric subsea trees subsea infrastructure and associated safety critical systems are generally hydraulically operated in one way or another.

Poor commissioning / start up preparation and processes can result in damage to hydraulic components through;

- Cavitation
- Aeration
- Inadequate lubrication
- Fluid contamination

Resulting in reduced life cycle and compromised operability.

Start-up damage can be prevented by ensuring;

- Appropriate design methodologies
- Hygienic component manufacture
- Hygienic subsystem assembly
- Fluid Cleanliness & Compatibility
- Developing equipment specific pre-commissioning and commissioning procedures
- Utilising competent personnel at every stage
Fluid cleanliness is the single most critical aspect when commissioning hydraulic systems

**Flushing**

- Hygienic assembly practices significantly reduce flushing time.
- Flushing any hydraulic system should be done at sufficient a pressure and flow rate to ensure turbulent flow is achieved.
- Replacing fluid is insufficient; it should be flushed completely with clean fluid or circulated through and appropriate filter until desired cleanliness is achieved.
- Replenishing a fluid reservoir with pre-filtered fluid and by using a filter pump that has at least the same separation capacity as the system in use.
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Testing

- Confirm fluid cleanliness via patch test kit (or in line particle counter).
- Consider permanently installed particle and moisture sensors
  - Some OEM’s do not approve particle counters
  - Emulsification can mask particles
  - ie light obscuration methods
  - Alleviated by installing check valve downstream of test point to pressurise sample
- Other testing considerations;
  - Remove sensitive equipment prior to flushing
  - Loop hoses to reduce flushing time
    - Whilst limiting the number of reconnections
  - Use non-bypass filters
NAS 1638
- Developed by the aerospace industry in the US
- Single figure representing Max’ particle count for designated size range per 100ml
- 5 size ranges are examined (5-15-25-50-100>100μm)
- Single figure therefore represents worst case
FLUID CLEANLINESS STANDARDS

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• Society of Automotive Engineers Aerospace Standard
• Extension of NAS1638
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• Differentiates – Particles projected area vs longest dimension
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• Quantifies particulate contamination per ml at 3 sizes
• Size range ranges defined as >4µm >6µm and >14µm respectively
• Range code from 6 – 24, each increment indicating a doubling in quantity
  • Ie code 0 – 28 representing particles per ml count of 0 – 250,000
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**GOST 17216-2001**
- Russian Governments Technical Committee of Standardisation

**NAV AIR 10-1A-17**
- Navy Standard for aircraft hydraulic systems
OTHER FLUID CONSIDERATIONS

Fluid Compatibility

- Multiple subsystems
  - Tested separately
  - Preservation fluids vs. Operational fluids

- Component material
  - Aluminium pump body vs glycol based fluids
  - Do fluids have corrosion inhibitors

- Seal material
  - Viton not suitable for high ph fluids (9.2 – 9.5 for std fluids, in particular HW443)

- Operating conditions
  - Temperature cycles
  - Time in service – volume transfer

Fluid Contamination

- Closed systems susceptible to bacteria growth is static for long periods
- Mineral oil in Water/Gycol – organic, promotes algae growth
- Gas migration / contamination - emulsification
- Moisture contamination – humidity – emulsification
COMPONENT CONSIDERATIONS

Manufacture and Assembly
• ‘Clean’ environment
• Appropriate tooling
• Do not rely on flushing after manufacture

Pipework
• Cleanliness during manufacture is critical
• Tube ends must be deburred
• All pipes pigged and hot washed
• Ends capped
  • Stainless caps (in preference to plastic)
  • No tape or rags!!!

Hoses
• Pig hoses before end fittings are applied
• Flush and tested
• Ends capped
• Installation is critical (abrasion / kinking / environmental issues)
Accumulators

- Store with partial fill and pre-charge
  - Avoid bladder drying out or adhering to cylinder
- Charge gas slowly
  - to avoid brittle failure at low temperature
  - Over charge, allow to cool then bleed excess off
- Refer to pre-charge chart
  - 10-45°C ambient delta ~ 20 bar delta pre-charge

Pumps & Motors

- Pre-charge/bleed piston pumps to provide adequate lubrication to cylinders and bearings
- Ensure motor case is full – bearing lubrication
- Mineral oil systems can cavitate on cold start – viscosity
- Perform rotation checks
  - No load
    - Suction line open and full
  - Consider pressurising inlet to purge pump
- Always start-up at low pressure
COMPONENT CONSIDERATIONS

Cylinders
- Ensure system is fully bled and lubricated prior to start up to prevent seal damage
- Mineral Oil systems could experience “dieseling” if not bled properly

“Dieseling” refers to the combustion process in a diesel engine. Dieseling occurs in a hydraulic cylinder when free air mixes with the hydraulic fluid and combusts when pressurized. Dieseling can destroy the cylinder’s seals and in extreme cases, the cylinder itself. This is limited to mineral oil systems.

Regulators
- Screw down to near maximum pressure
- Fully prime at low pressure
- Wind back out
- Cycle to check repeatability of set point

Pressure Relief Valves
- Often removed from systems during flushing and testing
  - Ensure replaced prior to start-up
- Generally set and forget
  - Check design pressure ref operating pressure
START-UP RISK REDUCTION

Initial build cleanliness

- Ensure every item has been flushed

Factory Acceptance Testing (FAT)

- Each individual component or subsystem is tested and documented

System Integrity Testing (SIT)

- Where possible full stack up testing is performed
  - All functions are cycled
  - Interfaces are tested

Pre Commissioning

- Checks on all components off line
  - Fittings are secure
  - Fluids are clean
  - Components are purged/bled
  - Correct fluid is present
- Test/monitoring equipment is installed
Commissioning Procedures

Detailed procedures and check lists should be developed in consultation with the OEM’s for each system and subsystem.

Staged commissioning plans allow critical components to be tested sequentially during start-up.

Consideration for the following should be made prior to start-up;

- Install test gauges where possible
- Filter and Flush all fluids
- Pre-charge where required
- Prime to expel air
- Check levels are full
- Initial start up unloaded
- Check valves, regulators and control valves wound back where possible
- Run unloaded whilst venting pilot lines
- Observe – vibration, leaks, high temperatures, fluid levels
- Once warmed up
  - Set regulators, control valves etc
  - Function test without load where possible
- Shut down and inspect, remove test gauges
- Replace filters and inspect bowls for o-ring debris etc
POST START-UP

After Initial Start up

• Inspect system during initial running period
• Observe for; Leaks, Vibration, Heat build up
• In HPU’s benchmark pump cycle times

Shut Down

• Check & replenish fluid levels
• Change filter assemblies after run in period
• Inspect filter bowls for debris

Ongoing Monitoring

• Design and Monitoring is the key to preventing premature failure of a hydraulic system;
  • Record pump cycle times
  • Utilise multiple test points and fluid monitoring systems
  • Regular maintenance of filtration systems
  • Apply appropriate planned maintenance programs
    • Flush
    • Test
    • Flush again
SAFETY

Final Note

- During start up parts of protection systems and PLC control systems may be inhibited
  - Risk of over pressuring elements of the system is high
  - Start at low pressure, staged build up
  - Follow detailed start-up procedures

- Competent Personnel

- Fluid Cleanliness is the key to success
THE FUTURE

Subsea Factory
• Remote Processing
• Extended life between shutdowns
• Even more critical commissioning processes
Q&A

We would like to acknowledge and thank the following for contributing to this presentation:

FMC
Parker
Aker
Woodside
Statoil
Norsk Hydro
HYDAC
SKWS

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