Commissioning of Subsea Hydraulic Systems

Life of Asset Solutions

PRESSURE DYNAMICS

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SUBSEA CONTROL SYSTEMS

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

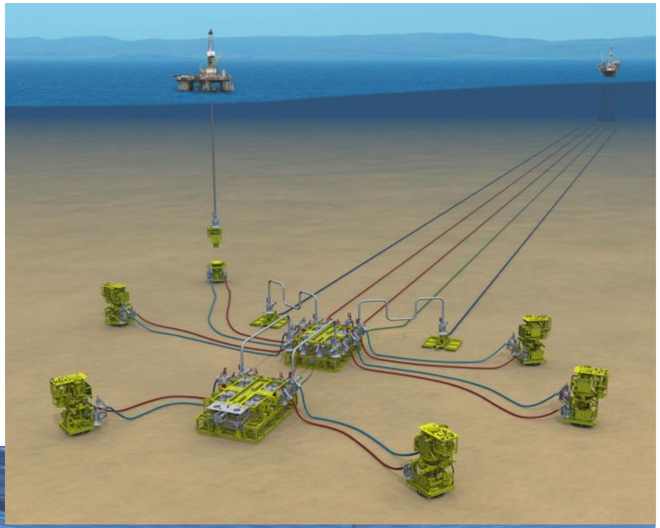
Poor commissioning / start up preparation and processes can result in damage to hydraulic components through;

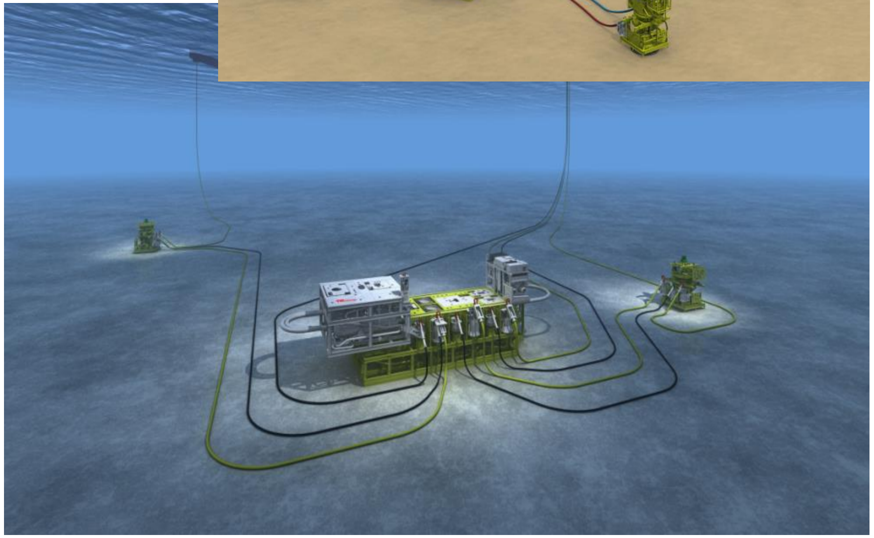
- Cavitation
- Aeration
- Inadequate lubrication
- Fluid contamination

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

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

FLUID CLEANLINESS STANDARDS

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

NAS classes (based on maximum contamination limits, particles per 100ml)	Size range	5–15 µm	15–25 µm	25–50 µm	50–100 µm	>100 µm
	00	125	22	4	1	0
	0	250	44	8	2	0
	1	500	89	16	3	1
	2	1 000	178	32	6	1
	3	2 000	356	63	11	2
	4	4 000	712	126	22	4
	5	8 000	1 425	253	45	8
	6	16 000	2 850	506	90	16
	7	32 000	5 700	1 012	180	32
	8	64 000	11 400	2 025	360	64
	9	128 000	22 800	4 050	720	128
	10	256 000	45 600	8 100	1 440	256
	11	512 000	91 000	16 200	2 880	512
	12	102 4000	182 400	32 400	5 760	1 024

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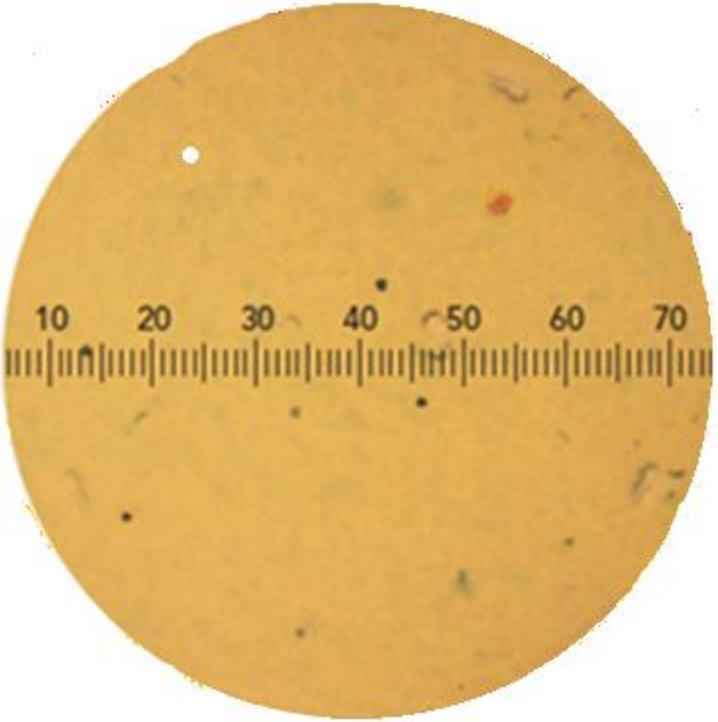
SAE AS4059 rev E

- Society of Automotive Engineers Aerospace Standard
- Extension of NAS1638
- Counts particles per 100ml using revised size ranges
- Differentiates – Particles projected area vs longest dimension



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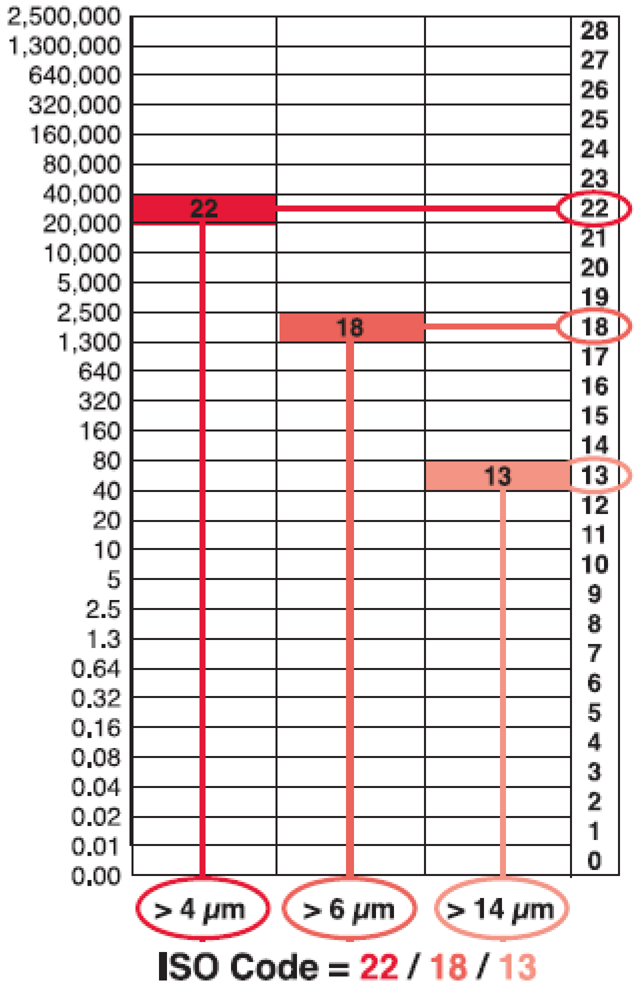
ISO (ISO4406-1999)

- 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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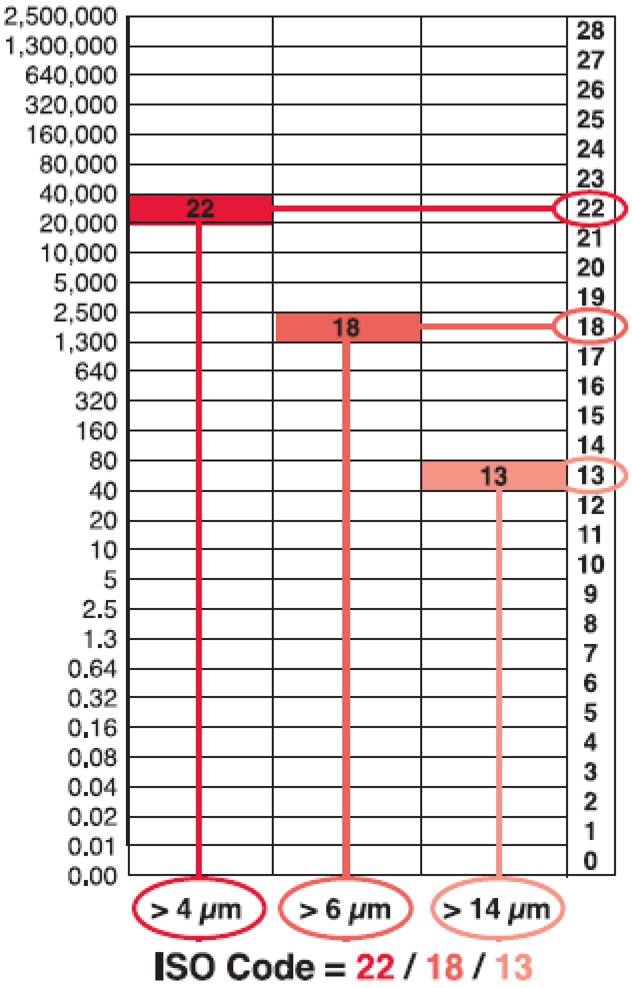
GOST 17216-2001
- Russian Governments Technical Committee of Standardisation

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

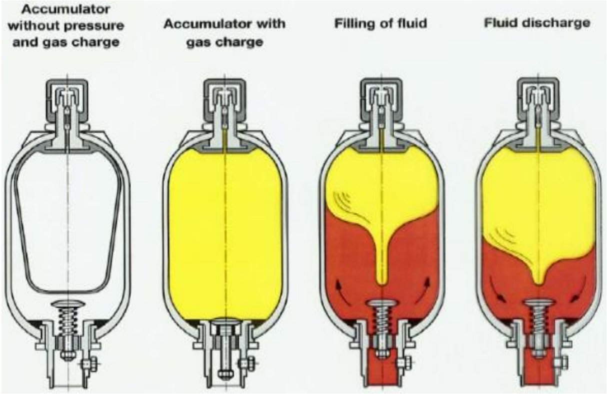
Pipework

- 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)

COMPONENT CONSIDERATIONS



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
  - 10-45C ambient delta ~ 20bar 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)

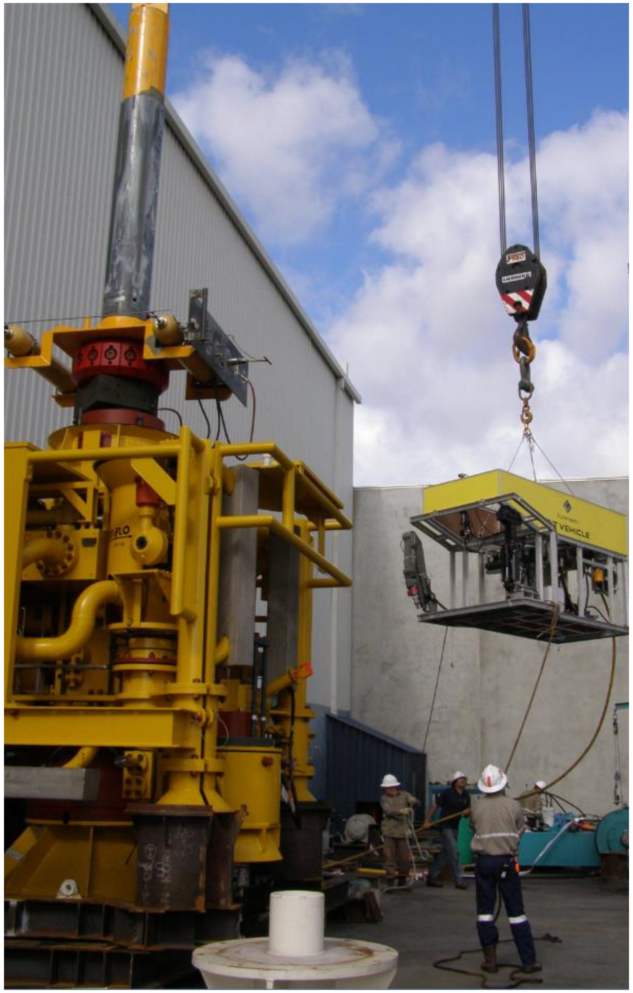
- Each individual component or subsystem is tested and documented

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



START-UP

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

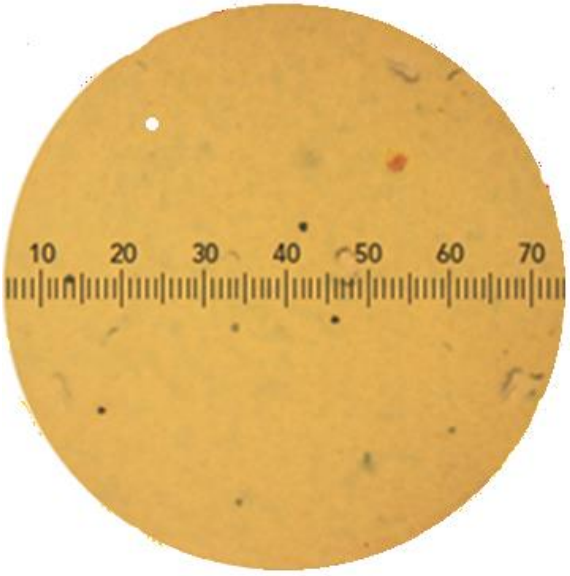
SAFETY

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

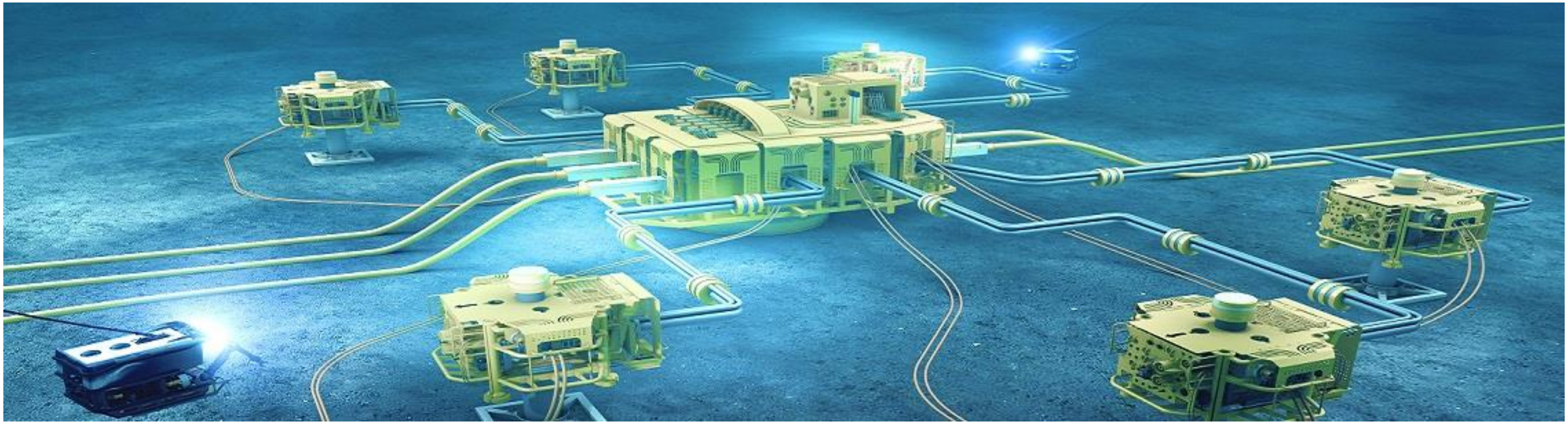
- Fluid Cleanliness is the key to success



THE FUTURE

Subsea Factory

- Remote Processing
- Extended life between shutdowns
- Even more critical commissioning processes



Curtesy – Statoil/Norsk Hydro

Q&A

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