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Introduction to Subsea Engineering

Presented by

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Chess Subsea Engineering

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Part 3 : Flow Assurance and Systems Engineering

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Flow Assurance and System Engineering

System engineering discipline activities are broadly classified into three primary service areas:

- ✓ Production system design;
- ✓ System integration;
- ✓ Equipment application and development;

Classification of System Engineering

SYSTEMS ENGINEERING

Production System Design

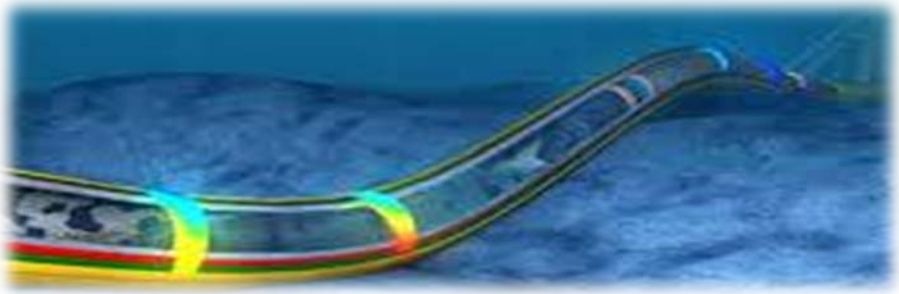
- Line Sizing and Configuration
- Thermal Hydraulic Design
- Fluid Behavior
- Artificial Lift
- Solid Prevention & Control
- Production Chemicals
- Chemical Injection
- Operating Envelopes
- Operating Strategies
- Operating Philosophies
- Operating Manual
- Reservoir Interfaces
- Processing Facilities Interfaces
- Production Simulators

Systems Integration

- Development Concepts and Layout
- Project Wide Design Basis
- PIDs & PFDs
- Functional Specifications
- Functional Interfaces
- Design Reviews
- Cost and Economics
- Risk and Reliability Assessment
- Hazops & HAZID

Equipment Application and Development

- Electric Flowline Heating
- Subsea Processing
- Subsea Chemical Distribution
- Multiphase Metering
- Multiphase Pumping and
- Single Phase Pumping and Compression
- Control / Service / Power Bouy
- Long Distance Communication
- Subsea Power Distribution
- Subsea Power Generation



Subsea Operations

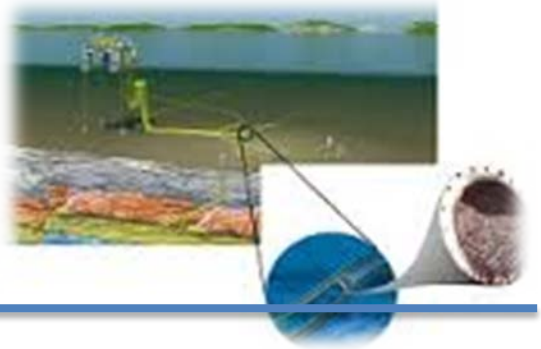
After the production system has been installed, numerous operations are in place to ensure safe and pollution-free operations and support the continued flow of hydrocarbon. The following are typical post installation operations:

- Commissioning and start-up (start-up could be “cold” or “hot”);
- Normal operations;
- Production processing;
- Chemical injection;
- Routine testing

Subsea Operations

- Maintenance and repairs (remotely operated vehicle [ROV], routine surface);
- Emergency shutdown;
- Securing facilities (e.g., from extreme weather events);
- Intervention.

- In many cases the technology and techniques applied to support production activities in deepwater are similar in scope to developments in shallow water.



Subsea Operations

- Deep water does add a level of complexity to the project, particularly subsea developments.

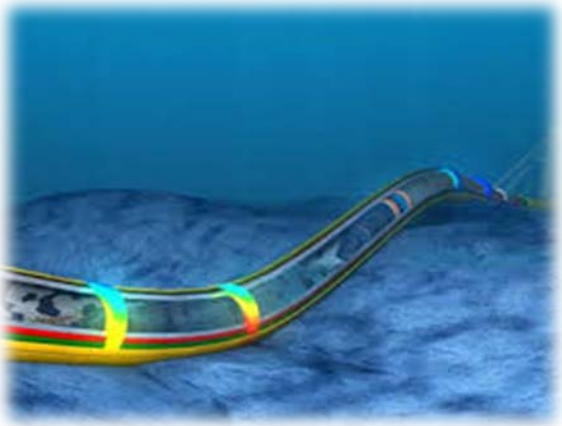
- A significant amount of work is necessary for **proper planning**, **simulations (steady-state and transient),design, testing,** and **system integration** before the deepwater development moves forward.

Commissioning and Start-Up

- Operations typically begin with systems integration testing (SIT) at a shore base or vendor or manufacturer's facility.
- Mobilization to and the start-up of installation at the offshore location can involve a large number of vessels, including:
  - ✓ drilling unit, support boats, derrick barge, transport barges and tugs, pipelay vessels, ROVs, and divers.
- Production from the well at this point will include completion fluids and reservoir fluids.

Commissioning and Start-Up

- These may be flared/burned, treated, and discharged overboard, or transported to shore for disposal at an approved location.
- The cleanup phase of bringing a well / field on line typically last 2 to 5 days.

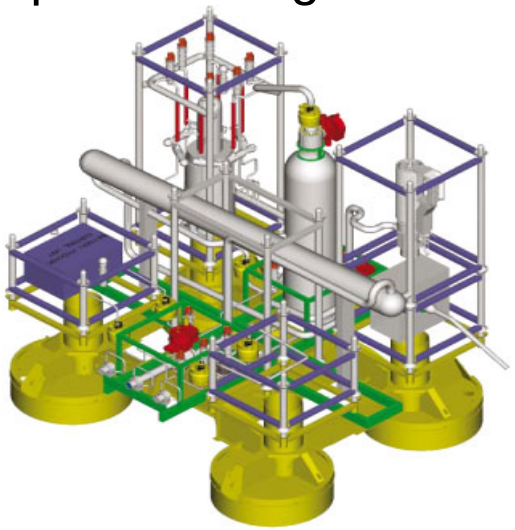


Production Processing

- Production processing equipment is generally the same for both shallow and deepwater developments.
- The production system may involve several separators, a series of safety valves, treaters, compressors, pumps, and associated piping.
- For deepwater facilities, the production system may be designed to process higher rates of flow.
- These could include production from multiple developments commingled at a common host facility.

Production Processing

- The main surface production processing system components might involve:
  - ✓ crude oil separation,
  - ✓ water injection equipment,
  - ✓ gas compression,
  - ✓ chemical injection,
  - ✓ control systems for subsea
  - ✓production equipment, and
  - ✓ associated piping.



Production Processing

- One area that does differ is the need to account for vessel motion that can be induced by environmental forces on these floating production facilities.
- In these conditions, production separators require specialized designs.

Chemicals Injection

Fluid problems in deepwater are critical issues i.e.

- ✓ colder seabed,
- ✓ produced water,
- ✓ cold temperatures,
- ✓ condensates,
- ✓ paraffin, and
- ✓ asphaltenes contents in the oil.

All these can compromise the viability of a development project.

Chemicals Injection

The use of chemicals in offshore oil production processes is not a new approach.

Some of the chemicals used are:

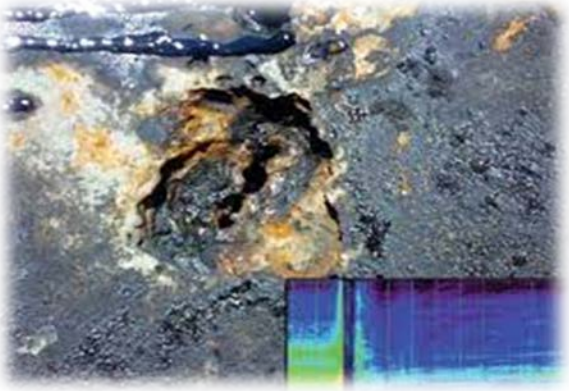
- ✓ corrosion inhibitors,
- ✓ workover / packer fluids (weighted clear fluids, bromides, chlorides, etc.),
- ✓ hydrate and paraffin inhibitors,
- ✓ defoamers,
- ✓ solvents (soaps, acids),
- ✓ glycol, and diesel.

Chemicals Injection

- These chemicals are typically used for batch treatment i.e. small-volume continuous injections or remedial treatments such as workover operations.
- Material safety data sheets are required for all chemicals used offshore.
- Carbon-steel components of the production system that are wetted by the produced fluid are protected by corrosion inhibitors.
- Material selection is a critical factor in the proper design of a production system.

Chemicals Injection

- Thus, material selection requires information about the composition of the produced fluid.



Hydrate Inhibition

- Hydrate inhibition is normally associated with batch treatments for the processes of start-up and shut-down (planned or unplanned).
- Continuous injection also occurs when there is induced cooling likely due to chokes.
- Also the natural cooling of pipelines by the cold ambient temperatures of the seabed.



Hydrate Inhibition

- Methanol is one of the most common hydrate inhibitors used, particularly for subsea wells and in arctic regions where rapid cooling of the produced fluid flow (gas and water) can cause hydrate formation.

- Methanol is injected into the tree and sometimes downhole just above the subsurface safety valve while the fluids are hot.

Characteristics and formation of hydrates in subsea production systems are detailed in the hydrate modules. The solution methodology and hydrate control designs are summarized.

Paraffin Inhibition

- Paraffin inhibitors are used to protect the wellbore, production tree, and subsea pipelines/flowlines from plugging.
- The injection of these chemical inhibitors is dependent on the composition of the produced fluids.
- Injection can occur continuously at the tree, pipeline, manifold, and other critical areas while the production flow is hot, and to batch treatments at production start-up and shut-down processes.

Paraffin Inhibition

- The wax content, pour point, and other factors are determined prior to beginning production to determine the chemical(s) needed, if any, and the best method for treatment.



Asphaltene Inhibitions

- Asphaltene inhibitors are injected in the same manner as other inhibitors, but on a continuous basis.
- They form in the production system as the pressure declines to near the bubble point.
- Most development projects require one or all of these chemical inhibitors to avoid produced fluid problems.
- Efforts are under way to improve the performance of the inhibiting chemicals and to reduce the toxicity of the chemicals.

Well Testing

- Flow testing is done to confirm the producibility of the reservoir and to locate any boundary effects that could limit long-term production.
- An extended well test may be necessary to confirm the development potential.
- A well test could last for several days to a month.
- Significant data are gathered about the system from the pressure build-up stage of a well test.

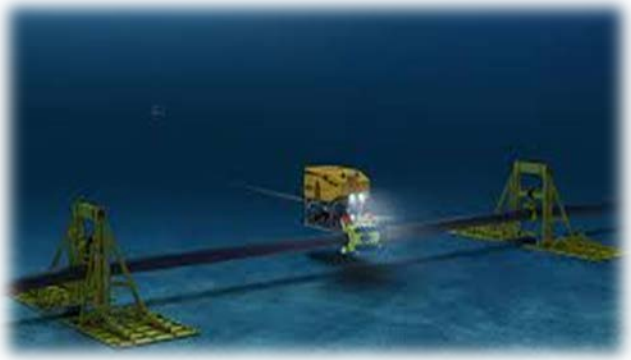
Well Testing

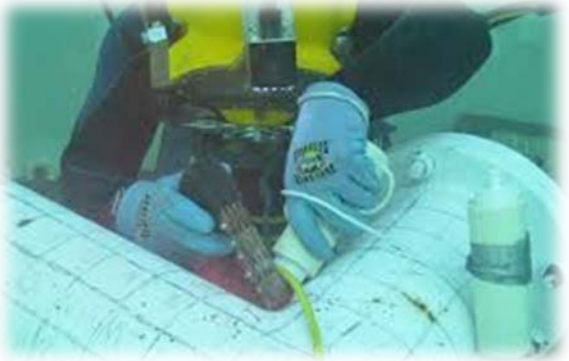
Oil recovered as part of the well test will be stored and reinjected, burned, or transported to shore for sales or disposal; gas is normally flared during the test.



Subsea Systems Inspection and Maintenance

- Facilities and pipelines require periodic inspections to ensure that no external damage or hazards are present that will affect the system's integrity.
- Unlike the shallow-water platform and subsea completions where diver access is possible, a deepwater system requires the use of ROVs for surveys and some repairs.





Subsea Systems Inspection and Maintenance

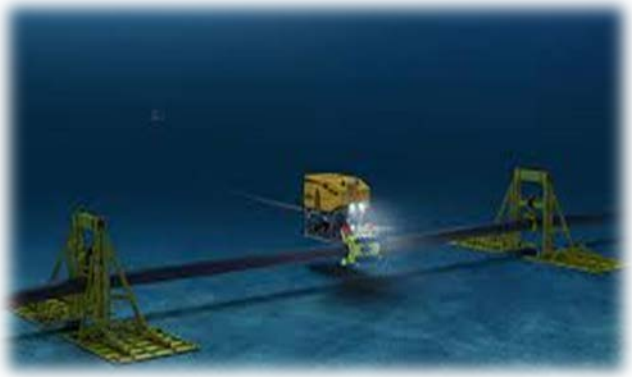
- For floating systems such as the TLP (Tension Leg Platform), the survey would examine the tendons as well as the hull and production riser.

- Inspections of other systems would investigate the mooring system components as well as the production components (trees if subsea, pipelines, risers, umbilical, manifold, etc.).

- Many of the components of subsea equipment are modular, with built-in redundancy to expedite retrievals in the event of a failure.

Subsea Systems Inspection and Maintenance

- Mobilization of a drilling rig or specialized intervention vessel would be required for intervention into any of the subsea systems.
- If the production equipment is surface based, the maintenance, retrieval, and repair would be similar in scope to the conventional fixed platforms.



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