Role of Engineering Analysis
Role of Engineering Analysis

Engineering analysis has a key role in design development and subsea field development design is no exception to this rule.

- Many of the essential steps in subsea development design require analysis. Some examples are:
  - Structural loading
  - Stress and fatigue analysis
  - Pipe bend collapse
  - Pipe expansion analysis
  - Lateral buckling analysis
  - Wall Thickness calculation
  - Cathodic projection analysis
  - Span analysis

- Two of the most critical areas of analysis are Flow Assurance and Riser Motion Analysis
  - Flow Assurance is essential to the fundamental operation of a system design
  - Riser analysis is critical to assurance of the pipeline delivery system
Flow Assurance
Flow Assurance Overview

- What is Flow Assurance?
- What is its importance?
- What are the challenges?
- How do we determine the impact of these challenges?
- How do we mitigate these challenges?
Flow Assurance can be characterized as:

- The ability to produce fluids \textbf{reliably} & economically from the reservoir to a production facility over life of the field in any environment.
- Assurance that well fluids can be delivered from the wellhead to the final production facility under all operating conditions.
- Also the ability to deliver produced fluids via export lines, trunklines or transportation lines to process facilities.

This ability is influenced by:

- Pressure
- Temperature
- Fluid composition
- Distance
- Environmental conditions
- Operating conditions

We really mean: “Flow Assurance and Operability”
What really comes out of the ground? Mixtures of:

- Gas
- Hydrocarbon liquid – oil or condensate
- Water – liquid, vapor
- Solids
- ???

Reservoir Fluids
What are the Challenges to Flow Assurance?

- Hydraulics (available pressure)
- Slugging / Liquid Management
- Hydrates
- Paraffin (Wax) / Asphaltenes
- Corrosion
- Sand / Erosion
- Scale
- Emulsion / Foam
What are Hydrates?

- “Flammable Ice”
- Guest molecule stabilizes H$_2$O crystal
- Form at T $\gg$ normal freezing
- Can block lines
- Challenging to remove

Small “guest molecule”, e.g., methane

Water molecules
What is wax?

- “Paraffin” and “wax” used interchangeably
- Wide range of high molecular weight paraffins (saturated hydrocarbons) – soluble in oil
- Solidifies primarily due to a temperature decrease
Thermal Management – Why Do We Care?

Wax

Viscosity

Hydrates
Other Solids & Concerns

- Asphaltenes
- Scale
- Sand
- Corrosion
- Emulsions
Flow Assurance Analyses

- How do we determine the deliverability of a system?

- How do we ascertain the impact of pressure, temperature and fluid composition?

- How do we establish the system performance under various operating scenarios?

- How do we know what to plan for in the different operating conditions?
Multiphase Flow Simulation

- **Multiphase Flow Modeling**
  - Flow pattern
  - Pressure drop
  - Liquid holdup
  - Line sizing
  - Deliverability
  - Slugging (size, frequency)

- **Analytical Tools:**
  - Pipesim (steady state)
  - OLGA – transient
  - MAXIMUS – steady state, life of field)
Flow Assurance is a very broad discipline

Flow Assurance AND OPERABILITY

Many technical and environmental challenges

Prevention and remediation are key design issues

Analysis is a key tool for developing a system design

Design must accommodate all:
- Field conditions (early, late life; rates; varying reservoir conditions)
- Operations (shutdown, cooldown, restart, etc.)
Riser Design
What is a riser?

- Vertical extension of a pipeline
- Allows fluid flow from seafloor to platform deck at the surface or vise versa
- May be platform supported or self supported
- Design integrity is influenced by:
  - Weight
  - Operational loads
  - Installation loads
  - Environmental loads: currents, waves, etc
Types of Risers

- Compliant risers
  - Steel catenary risers (SCRs)
  - Flexible risers

- FPS top-tensioned risers
  (TTRs or dry tree risers)
  - Drilling
  - Production

- Hybrid Risers

- Fluid Transfer Lines

- MODU risers
  - Marine drilling risers
  - Completion/ workover risers
Types of Production Risers

- Steel Catenary
- Flexible Risers
- Hybrid
- TTR (Top Tensioned Risers)
Types of Production Risers

Riser Joint

Riser System

Spider
Gimbal
Telescoping Joint
Riser Joint
Flex Joint
Lower Riser Adapter
Riser Configuration Design Drivers

- Water depth
- Host vessel motion characteristics
  - TLP
  - Spar
  - Semi-submersible
  - FPSO
- Host vessel access / hang-off location
- Field Layout
  - No. and type of riser
  - Mooring layout
- Environmental data
- Design pressures and sizes
Environment Design

- 100-Year Hurricane, 1000-Year Hurricane, Loop Currents
- Survival in 10,000 Year Storms is Considered in Some Projects
- Consequence of riser failure can be severe (damage to environment if there is oil spill)
Riser System Analysis and Design

- **Cross Section Design**
  - Design for hoop, buckle, collapse and combined stress
  - Steel Design codes: API RP2RD, API 1111, ASME B31.8 & 31.4, DNV F201
  - Flexible Design Codes API Spec 17J, API RP 17B

- **Wave-Induced Fatigue Design**
  - Major driver of fatigue damage accumulation in SCRs
  - Can influence hang-off angle, cross section design etc.

- **Vortex-Induced Vibrations (VIV) Design**
  - Major determinant of need for VIV suppression

- **Strength Design and Stress Checks**
  - Check dynamic riser stresses vs. allowable (RP2RD etc.)

- **VIM**
  - Vortex-induced vessel motion – function of current & mooring stiffness

- **Interference Design**
  - May influence azimuth and/or hang-off angle

- **Ancillary device design**
  - SCRs: flex-joints, stress joints, buoyancy, clamps, anchors, flanges

- **Installation Design**
  - Installation Fatigue – low cycle fatigue due to reeling & allowable hang-off duration
  - Seabed stability for all riser types
  - Ensures stresses and bend radii remain within allowable during installation
Riser System Analysis and Design

Software:

- Orcaflex – static and dynamic analysis
- Flexcom-3D – static and dynamic analysis
- RIFLEX – static and dynamic analysis, soil / pipe interaction
- Shear7, VIVA, MODE-3D – VIV analysis
- ABAQUS – Elastic Plastic Analysis
- ANSYS – FE stress and components design
- ANSYS – CFD analysis
Role of Engineering Analysis

Summary

- Analysis is critical to subsea system design
- Role of analysis essential to field development disciplines
  - Flow Assurance
  - Risers
  - Pipelines
  - Subsea Structures
  - Subsea Equipment
  - Installation
  - Construction
- Many software packages options available
- Analytical software is well established in the Oil & Gas industry
Role of Engineering Analysis

Questions?