Dealing with Un-Inspectable Equipment in the Life Extension of Subsea Facilities

John Upchurch, Director – Subsea
and
Alan Yu, Director - SURF

Design Life and History

- Onshore Production
  - <100 years
- Offshore Production
  - ~75 years
- Subsea Production
  - ~50 years
  - Deepwater Production *
    - First GOM Deepwater Subsea Production
      - Placid Oil GC 29 – 1st Production 1988 - P&A
    - Oldest Active Subsea Field
      - Shell / W&T Tahoe – 1st Production - January 1994

* Per BSEE Database

Subsea Equipment Life

- Standard Subsea Development
  - Trees
    - Static environment, so fatigue usually is not an issue
    - Most issues are related to corrosion and erosion
  - Jumpers and Manifold
    - Similar to trees
  - Flowlines
    - Static design - but can experience thermal fatigue and spanning issues
  - Risers
    - Dynamic design with fatigue issues, in addition to pitting/corrosion, installation damage, & contact wear issues
- Design Life
  - 20 years design (30 years and even 35 years nowadays)
  - Well life vs field life

Subsea Equipment – refurbish then re-deploy

- Refurbish and redeploy
  - Trees & jumpers
    - Retrieved, cleaned and inspected
    - Soft goods replaced (for example elastomer & metal seals, etc.)
  - Top Tensioned Risers (TTRs)
    - High pressure drilling riser joints – refurbished, and reused
    - High pressure production outer riser – similar to trees process
    - Tensioner system – refurbished and reused
  - 20 years design
  - Retrieve, refurbish (clean & replace soft goods), storage, or deploy
- Long term / non-retrievable
  - Manifolds
  - Pipelines
  - Steel Catenary Risers (SCRs)

Consumption and Safety Factor

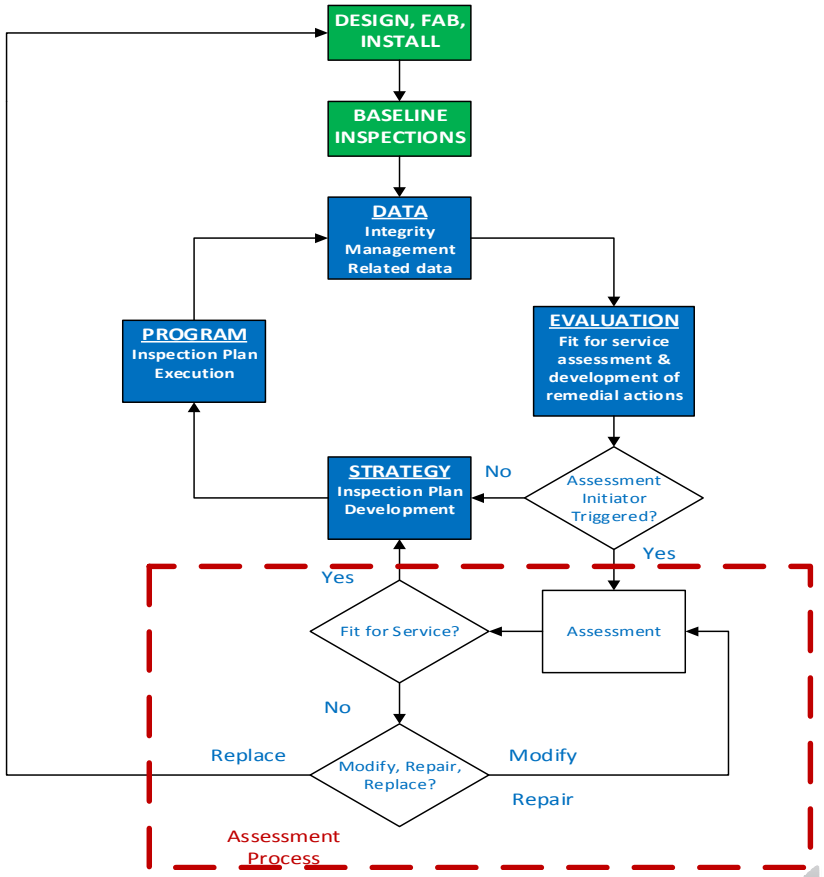
Conventional S.F. = 10

Design Life	20 years * 10 = 200 years
Actual Life	20 year
Remaining Life	180 year
Safety Factor	/10
Remaining Design Life	18 years

Regulators will not accept this approach

Inspect - Review

- Use Field Measurement Data
  - Recorded operational data
    - Production data (flow rate, pressure, temperature, etc.)
    - Chemical injection, inhibitor, Meg, water injection, etc.
    - Start up/down cycles
  - Vessel motion response
    - Vessel extreme offset & set down (strength issue)
    - Figure 8 vs elliptical loop
    - Drilling rig vs no drilling rig
    - Offset and set down design/measured differences, etc.
- Establish Baseline (Visual) Inspection
  - Riser
    - Hang-off condition
    - Strake length
    - Touch down point & vicinity
    - External damages



Analysis

- Refine Analysis Methodology and Use of Modern Tools
  - Vessel motion response – time domain vs RAOs
    - Vessel extreme offset & set down (strength issue)
    - Figure 8 vs elliptical loop
    - Drilling rig vs no drilling rig
    - Offset and set down design/measured differences, etc.
  - Time domain vs frequency domain riser analysis program and methodology
  - Vessel directionalities vs Omni-directional
  - Full scale fatigue testing for a better fatigue curves and SCFs

Life Extension

- What Do You Want/Need to Accomplish?
  - How much additional life do you want / need?

- Original Design Life?
  - Do you have or can you get the original calculations?
  - What was it based on?
    - Temperature/pressure
    - Product
      - Sweet
      - Sour
      - Water
      - H_2S/CO_2

Design, Fabrication and Installation

- Design, Fabrication and Installation
  - Design criteria
    - Working stress versus
    - Limit State or Load Resistance Factor (LSD or LFRD)
  - Testing & inspection records
    - Reports
      - Full scale fatigue testing
      - FAT
      - SIT
    - Photographs
    - Video

Baseline Inspection

- Post Installation Inspection
  - Top hang off region survey
    - Unusual wear and tear
    - Hang off elastomer anomaly (may require tools to clean then visual inspect)
    - Marine growth
    - Anode/CP consumption or damage
  - Through water column survey
    - Marine growth
    - Strake/fairing condition
    - Anode/CP consumption or damage
    - Obvious external damages/leaks
  - On-bottom survey
    - Location
    - Obstructions
    - Spanning

Data Gathering

- Production Data
  - Products contents change or pressure trending
  - Temperature range changes or trending
  - Start up/shut down cycling
- Met-ocean Data
  - Recorded storms passing fields
  - Recorded currents around the field
- External Events
  - Damage
  - Inhibition lapses/failure

Evaluation

What was the original design life and how much has been consumed?

- Recalculate Design Life
  - Actual conditions
  - Forecasted conditions
- Strength Check
  - API 1111 computed burst capacity. If the corroded parts (as computed not measured) based on the original assumption of 0.0x”/year
- No Change to Safety Factor
  - Regulatory may accept a lower safety factor if the life extension program requires more frequent offshore inspection, for example

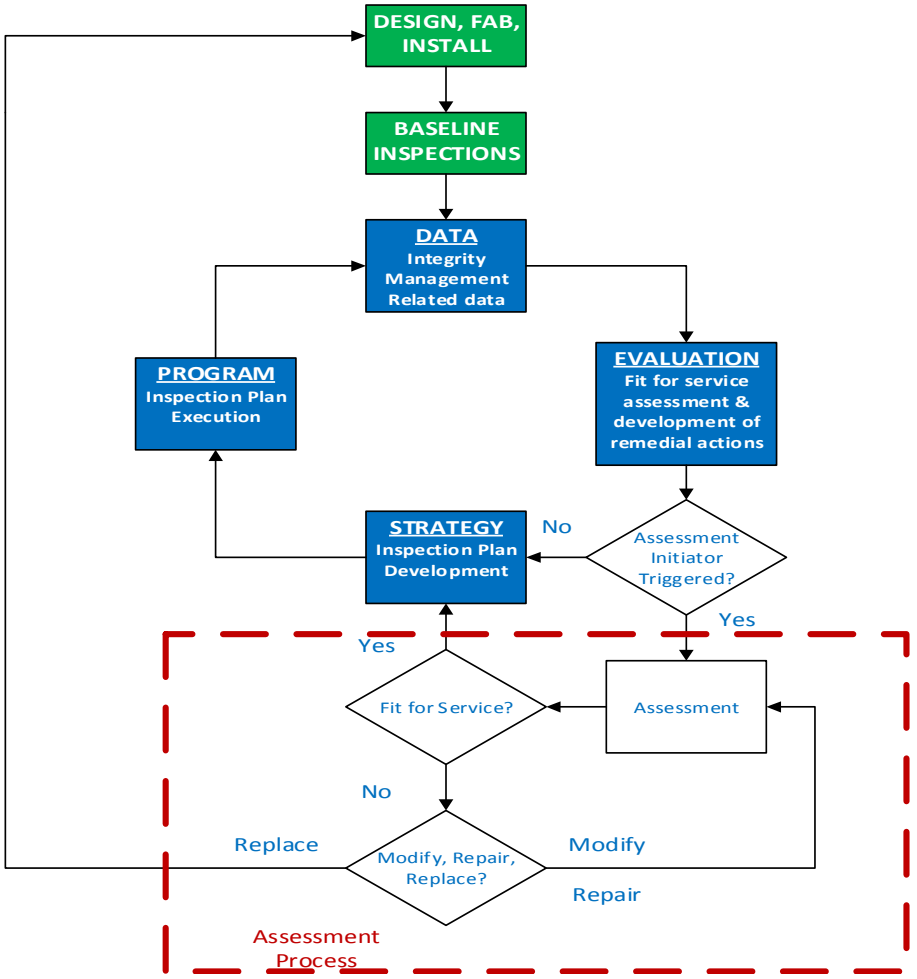
Develop Remaining Life Strategy and Execute

- Strategy & Execution
  - Recalculate design life
    - Actual conditions
      - How did the actual compare to design assumptions
    - Forecasted conditions
      - Regardless or the original plan – what is expected
- Inspection & Testing Strategy
  - If the original safety factor can be maintained for the desired extended life and no known operational anomalies then carry on the original measurement and inspection plan, however,
  - If the original safety factor can not be maintained then more frequent inspection and more rigorous measurement shall be established and recommended for approval.

Life Extension Flow Chart

The flowchart has three major elements:

- Integrity management – data collection is to be early and thorough
- Assessment – fit for service assessment is to be experience based
- Recommendation – practical and remember you can always recommend shut in wells



Thank you

Contact

John Upchurch Jupchurch@eagle.org
Alan Yu AlanYu@eagle.org