EMAS CHIYODA Subsea

Evolution and Trends of the Design and installation of Subsea Systems

Ng Eng Bin
Regional Director - Engineering

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Agenda

- Brief history
- Evolution in Design of Production Facilities
- Changes in Design Codes to Cope with Increasing Demands
- Evolution of Offshore Installation Methodologies
  - Evolution in pipelaying methodology
  - Evolution in platform installation
  - Evolution in pipeline repairs
- Short-term & Long-term Trend
- Gaps & Opportunities for Development

Agenda

- ❑ **Brief history**

Brief history of the Oil and Gas Industry

- Oil seeps in Baku flowed freely for many centuries BC
- First oil well was drilled by the Chinese in 347 AD
- Onshore wells were developed from 1840s till now
- Increasing demand for oil and gas led to exploitation of offshore reserves
- Subsea completions can be traced back to 1943 with the Lake Erie completion at a 35-ft water depth
- The first commercial offshore oil well drilled by a "mobile" rig out of sight of land was completed in 1947.
- Shell completed its first subsea well in the Gulf of Mexico in 1961

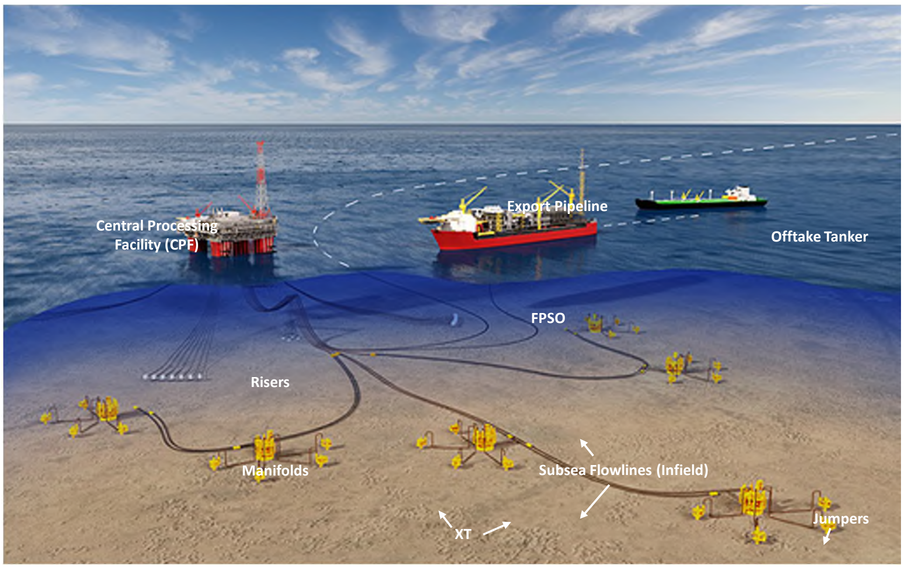
Agenda

- ❑ **Evolution in Design of Production Facilities**

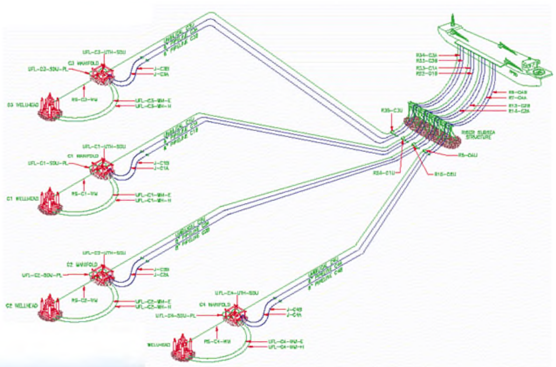
Production Systems for varying Depths

1, 2) conventional fixed platforms; 3) compliant tower; 4, 5) tension leg and mini-tension leg platform; 6) Spar ; 7,8) Semi-submersibles ; 9) Floating production, storage, and offloading facility; 10) sub-sea completion and tie-back to host facility

Schematic Subsea Field Development (typical)

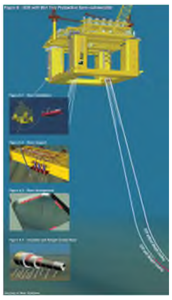


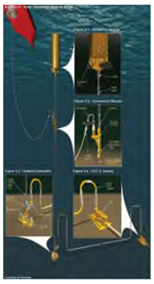
Trend - Subsea Tie-backs

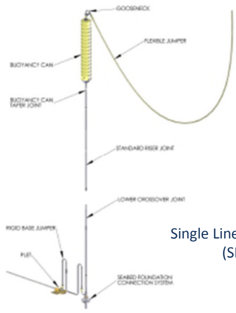


Evolution in Subsea Riser Systems

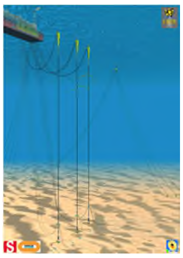

Steel Catenary Riser


Steel Catenary Riser

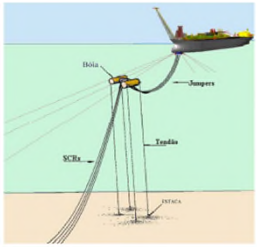

Free Standing Riser


Single Line offset Riser (SLOR)

Hybrid Riser Tower



Buoy supported riser



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- ❑ **Changes in Design Codes to Cope with Increasing Demands**

Evolution of Installation Codes for Offshore Installation (Example on Pipelines)

Example below on "pipelines" shows how codes have been evolved:

- Prior to 2000, pipelines were traditionally installed based on specified allowable stress criteria, such as following based on DNV 1976 and DNV 1981:
  - 85% SMYS for overbend
  - 72% SMYS for sagbend
- In 1996, DNV introduced the limit state design method. The new code was a complete revision of the DNV 1981.
- DNV 1996 adopted latest research achievements and practical experience gained through most challenging pipeline projects executed (Ref. 1).
- DNV 1996 code was subsequently & regularly updated and renamed DNV-OS-F101.

Ref. 1: OTC8671 - Limit State Design in DNV96 Rules for Submarine Pipeline Systems: Background and Project Experience

Evolution of Installation Codes for Offshore Installation (Con'td)

- In the limit state design approach, the different failure modes are identified for all phases and scenarios the pipeline will be subjected to, and specific design checks are done to ensure structural integrity.
- Pipeline capacity is characterized by actual capacity for each individual failure mode.

For installation condition, the failure mode includes:

- fatigue (cyclic load)
- fracture on the pipeline girth welds
- local buckling - collapse of pipe wall due to external hydrostatic pressure
- propagation buckling
- local buckling - combined loading
- ovalisation

Evolution of Installation Codes for Offshore Installation (Con'td)

- For most pipeline installation, the governing limit state is usually the local buckling failure due to combined loading. For this scenario, the DNV-OS-F101 Load Controlled Condition (LCC) equation can give higher allowable bending moment load compared to typical stress limit of 85% and 72% SMYS applied on overbend and sagbend.
- The advantage reduces with the increase in D/t ratio, i.e. relatively thinner wall.
- Impacts of the new codes are:
  - Rigid pipelines can be laid to much deeper water depths using S-lay method.
  - Rigid pipelines can be plasticised and laid by the reel-lay method.

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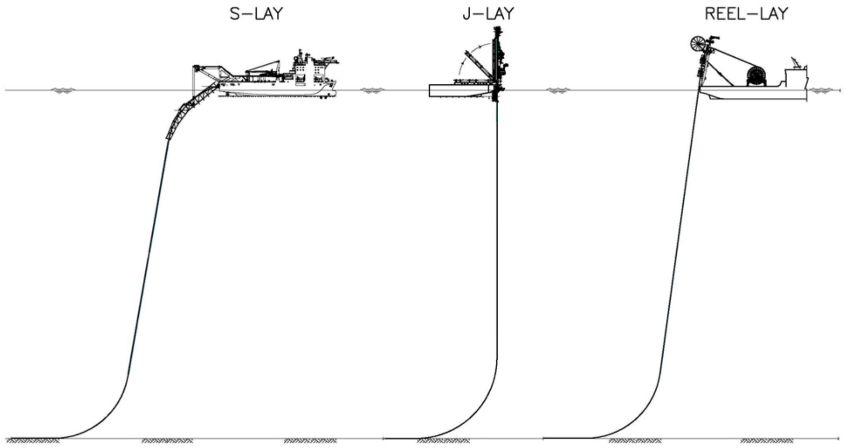
- **Evolution of Offshore Installation Methodologies**
  - **Evolution in pipelaying methodology**
  - **Evolution in platform installation**
  - **Evolution in pipeline repairs**

Agenda

- ❑ **Evolution of Offshore Installation Methodologies**
  - o **Evolution in pipelaying methodology**

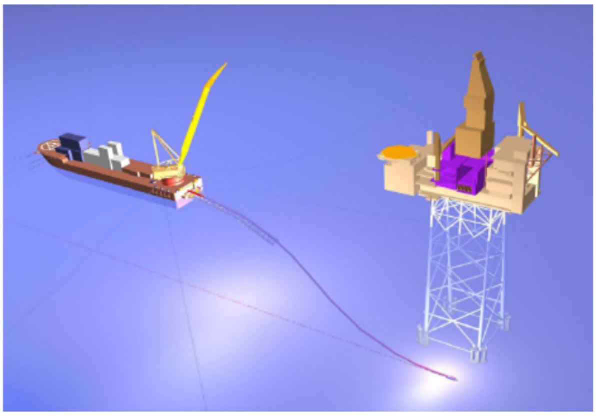
Types of Pipeline Installation (Conventional)

Typically, submarine pipelines are installed by 3 methods: S-Lay, J-Lay and Reel-Lay

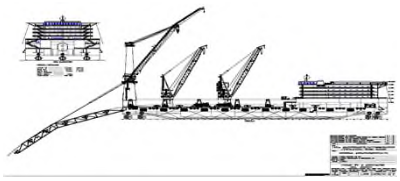


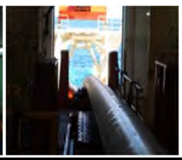
S-Lay Method of Pipeline Installation (Illustration)

S-LAY INSTALLATION



Typical Shallow – Medium Water Depth Lay Barge (ECS's Lewek Champion)

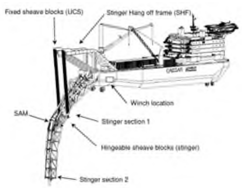




Evolution of Laybarges to Install Deep-water Pipelines

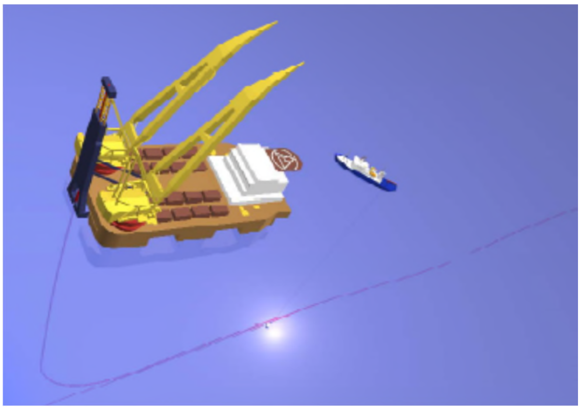
- Top tensions increasing, new equipment designed all the time.
- 600 mT tensioner not uncommon when compared with coventional 50 - 200 mT. Exceptional cases include ECS's Lewek Constellation with 800mT.
- Short stinger radius for 'vertical' lift off (to enable deep water pipelaying at minimal tension)
- Advanced welding & NDT equipment.
- Capable of laying to 2000m water depth
- An offshore factory: scale and production efficiency rules: welding, coating are key technologies.

Example of Mid/Deep Water Pipelay Vessel (ECS's Lewek Centurion)



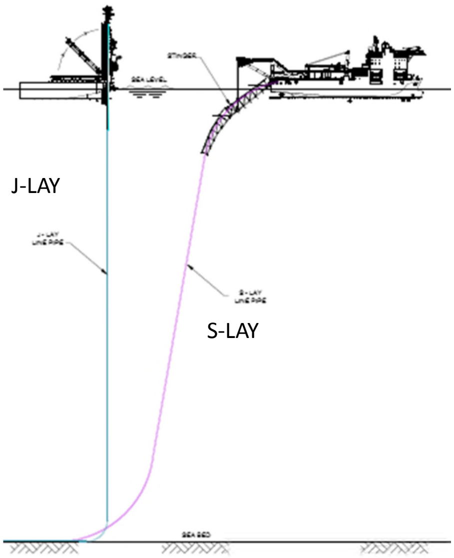
J-Lay Method of Pipeline Installation (Illustration)

J-LAY INSTALLATION

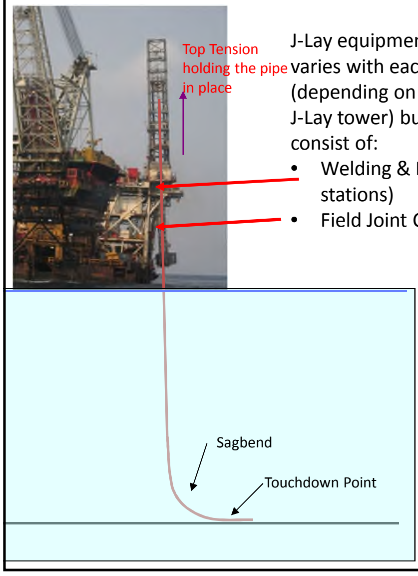


Evolution of J-lay

- Overbend region is problematic in S-lay as water depth increases due to increased pipe strain/ovality
- J-lay methodology was developed to eliminate the 'overbend', thereby allowing pipelines to be laid in ultra-deep waters

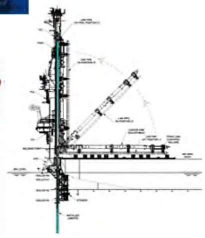


Typical J-lay Barges & Equipment Layout



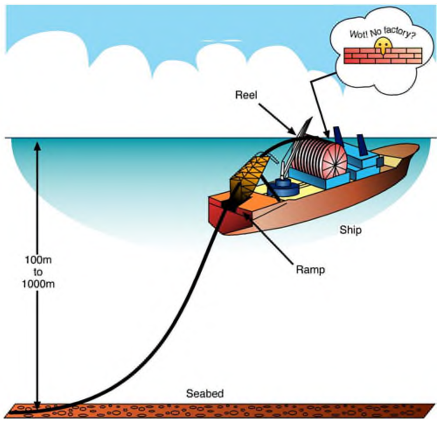
J-Lay equipment layout varies with each vessel (depending on design of J-Lay tower) but typically consist of:

- Welding & NDT (1-2 stations)
- Field Joint Coating



- A complex handling system lift the stalks from horizontal position into J-lay tower
- Once in the tower, pipe stalk is aligned with preceding pipe string
- Weld connection & NDT
- Apply field joint coating
- Move vessel forward
- Pay out tensioner

Reel-Lay Method of Pipeline Installation (Illustration)



- Reel-lay is the process where rigid (or flexible) pipe is un-spooled from a drum, straightened, tension applied, and then laid over a ramp to the seabed.
- Essentially, the pipe is fabricated onshore and reeled onto a large drum (on the laybarge).
- The pipe is unreeled, straightened, then passed through a tensioner prior to leaving the vessel.
- Majority of vessels have the reel positioned such that the pipeline unwinds in the vertical plane.
- Benefits of reeling as installation method:
  - ➢ Onshore welding and fabrication
  - ➢ Enables greater assurance of welds as they can be tested onshore
  - ➢ Minimize offshore welding and, hence, installation time, resulting in overall increase of lay rate in comparison with S-lay and J-lay techniques
- Often most economical method for pipeline up to 16" OD

Typical Reel Lay Vessel – ECS's Lewek Express

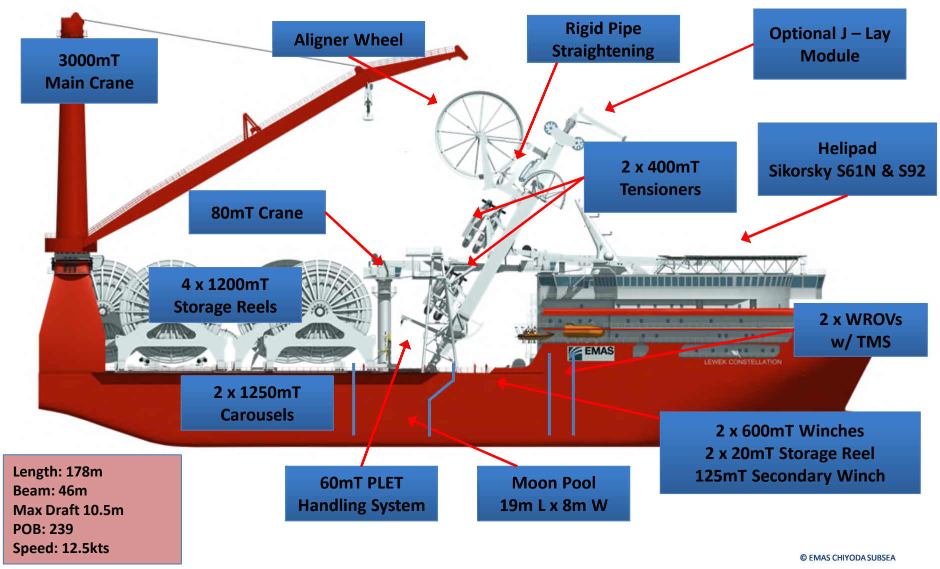
Express - Multi-service Vessel
Express is reel pipeline construction vessel having 2 reels capable of holding 3,000 tons of pipe up to 14 inches in diameter.

ECS's INGLESIDE SPOOL BASE, TEXAS, USA

Introducing Latest Generation Multi-purpose Reel-Lay Barge

Multipurpose Installation Vessel Capable of Various Installation Modes

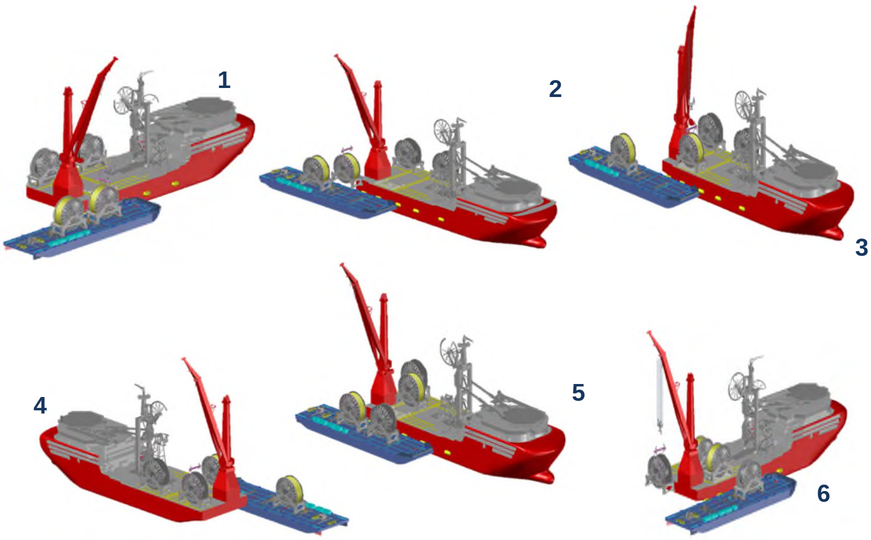
EMAS CHIYODA SUBSEA's Lewek Constellation



ECS's Innovative Reel Lay Concept – Dedicated Reeling Vessel cum Transport Barge

Reeling of pipe strings at ECS's Ingleside spool base

ECS's concept for reel change at installation site



ECS's Lewek Constellation on Platform Installation & Flexlay Modes

Constellation can be configured for:

- Multi-reel pipelaying
- J-lay pipelaying (planned)
- Flexible pipe, umbilical & cable installation
- Platform installation (jacket & deck)
- Other types of offshore lifts

Flexlay mode

Advantages of Newly Evolved Installation Vessel

- Reeled pipe lay method has normally been utilized in offshore fields with close proximity to onshore support, onshore logistics and short transit distance to onshore spool bases.
- This is often on critical path of the overall pipe laying activities
- *By using the portable reel concept, Lewek Constellation* has become a 'game-changer' because:
  - Possible to decrease the overall project cost by minimizing the amount of time a pipelay vessel is on hire.
  - Construction can be accelerated because spooling operations can be done off critical path, allowing the vessel to stay in field working on installation and commissioning activities.
  - With the heavy lift crane and multi lay system, *Lewek* Constellation is a "one stop shop".
  - Vessel's ability to reconfigure from pipelay to flexible and umbilical lay mode allows for the installation of field developments with multiple flow lines and umbilical products.
  - Vessel can reconfigure to heavy lift mode to install large manifolds, subsea pump stations and fixed platforms.
  - By using such vessel to install an entire field development, the need for additional vessels is minimized thereby reducing the chance of a schedule slip and cost associated with multiple mobilizations and transits to remote locations.

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- ❑ **Evolution of Offshore Installation Methodologies**
  - **Evolution in platform installation**

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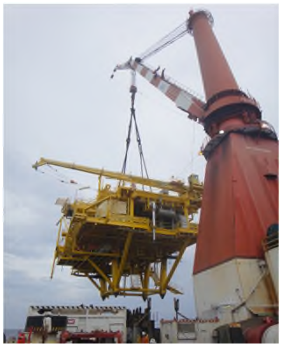
Conventional Platform Lift



Platform lift using ECS's Lewek Champion in Thailand

Platform Installation by Float-over Method

The float-over method eliminates the need for a heavy lift vessel and allows for very heavy decks to be installed

Agenda

- ❑ **Evolution of Offshore Installation Methodologies**
  - o **Evolution in pipeline repairs**

Evolution of Repair Clamps/sleeves

- If pipeline damage is limited to small area and the line is not severed, a permanent repair can be made by installing a repair clamp.
- In the early days, repair clamps were installed by divers (such as those by Plidco)
- Repair clamps have since evolved and 2 types are typically available:
  - For shallow water, the clamps can be either diver or ROV installed
  - For deep water, these are ROV installed.

Traditional Diver-Installed Clamp by Plidco

Oil States' (L) Diver-Assisted Clamp

ROV-operated Repair Clamp by Oceaneering

Surface method of pipeline tie-in or repair (traditional)

- Where the damaged section of the pipeline needs to be replaced, this can be done by cutting the pipeline underwater and bringing the 2 section ends to surface and a new pup piece welded to the 2 ends.
- This is generally possible in swallow waters

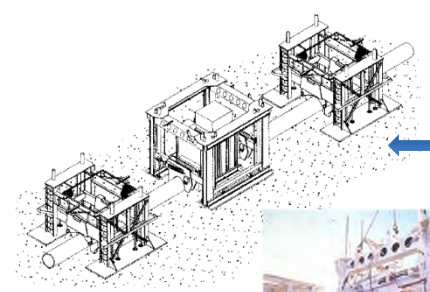
Hyperbaric repair of pipelines

- Where it is not feasible to repair the pipeline above water surface, underwater repair, such as hyperbaric welding can be considered.
- Hyperbaric welding refers to welding works carried out under water but in a dry habitat by a specialised subsea contractor using highly skilled diver welders.
- This process is used for underwater repair of pipeline where a permanent repair is required. This method is also classified as horizontal spool repair.
- Hyperbaric welding is carried out under water and in a dry atmosphere created by the welding habitat. The habitat atmosphere is a breathable mix of helium and oxygen gases.
- Diver welders are deployed from the pressurised chamber on board the vessel and then swim from the diving bell to the welding habitat, remove their diving equipment and dress in fireproof coveralls for welding and related activities.
- The welding habitat is set up inside as a welding station allowing two diver welders to work at the same time in a dry environment.

Hyperbaric Welding Repair of Pipeline

A typical hyperbaric system comprises the following components:

- One unit of Combined Habitat & Alignment System (CHAS)
- Two units of Pipe Handling Frames (PHFs)
- One unit of Welding & Diving Station (WADS)
- A series of umbilicals and winches to service the CHAS.



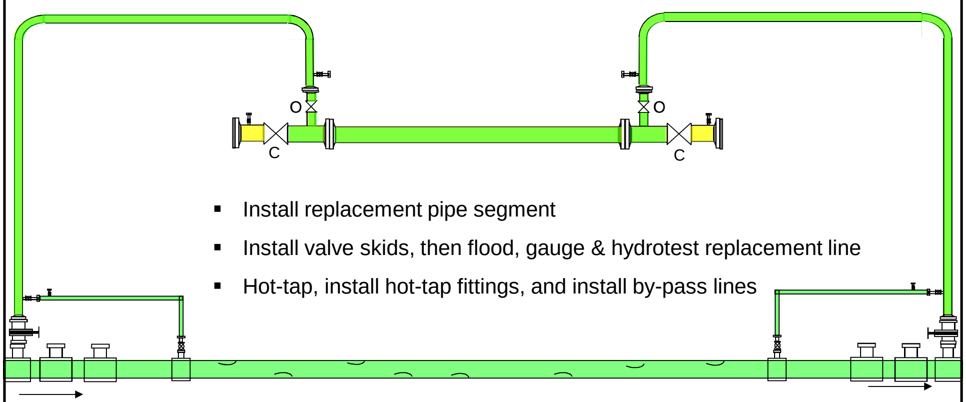
Typical Seabed Arrangement for PHFs and CHAS for Hyperbaric Operation

Hot-tap Repair Method

- Repair by 'hot tapping' has been used for pipelines that have not ruptured and where the Operator requires the pipeline to be repaired in 'live' condition.
- The operating pressure of the pipeline may need to be reduced during the hot-tap operation.
- Typically, the hot tapping solution package includes hot taps, plugs (e.g. TDWilliamson's STOPPLE plugs) and associated accessories.

Schematic showing typical hot-tapping operation

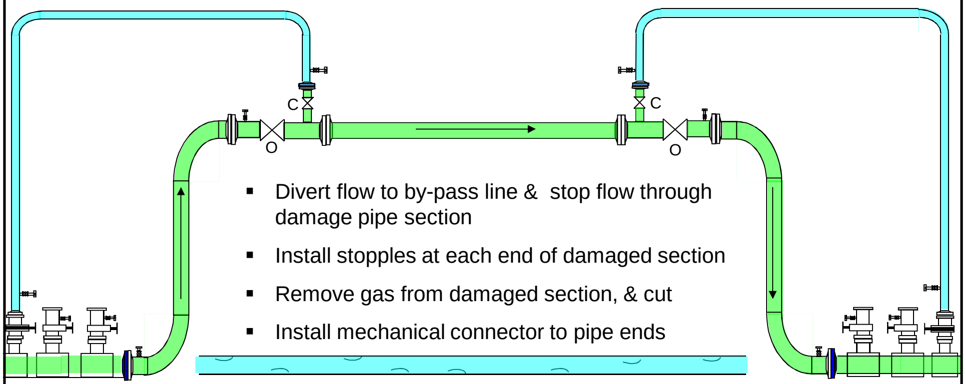
Note: Below is a simplified version – actual is much more complicated



- Install replacement pipe segment
- Install valve skids, then flood, gauge & hydrotest replacement line
- Hot-tap, install hot-tap fittings, and install by-pass lines

Schematic showing typical hot-tapping operation (Cont'd)

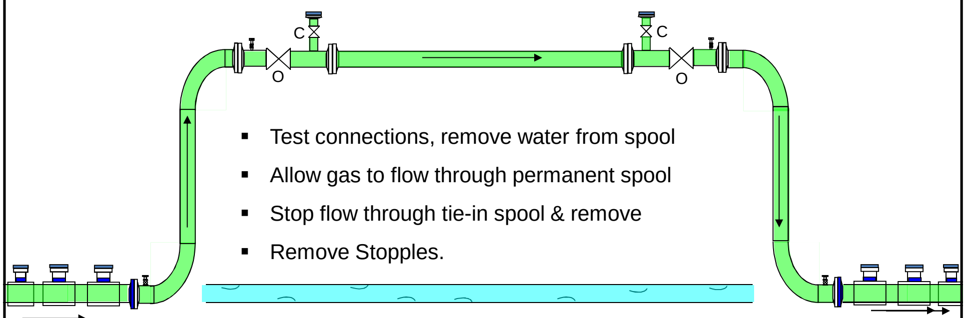
Note: Below is a simplified version – actual is much more complicated



- Divert flow to by-pass line & stop flow through damage pipe section
- Install stopples at each end of damaged section
- Remove gas from damaged section, & cut
- Install mechanical connector to pipe ends
- Install spool to connect old pipeline segments to replacement line

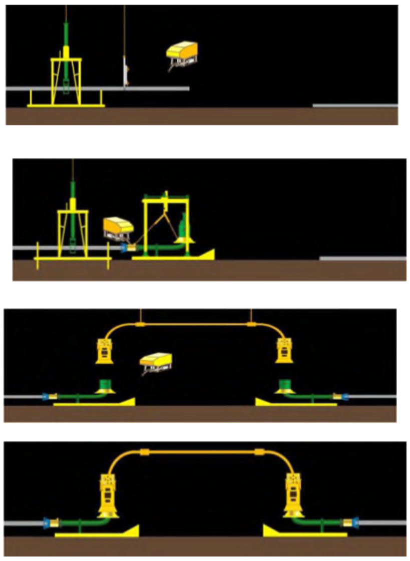
Schematic showing typical hot-tapping operation (Cont'd)

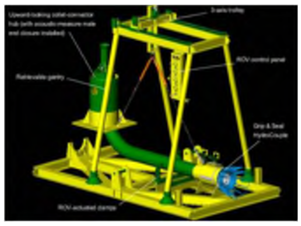
Note: Below is a simplified version – actual is much more complicated



- Test connections, remove water from spool
- Allow gas to flow through permanent spool
- Stop flow through tie-in spool & remove
- Remove Stopples.
- Pipeline Repair Completed!!!

Evolution in pipeline repair – vertical spool system





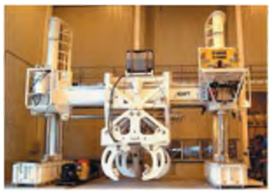
- In the vertical spool repair system, the replacement spool is orientated in the vertical direction.
- This repair system is used mainly for pipeline repair where use of divers is not preferred.
- The connection of the vertical spool is achieved with vertical collet connectors consisting of a female collect attached to the spool and a male hub attached to the pipeline under repair.

EMERGENCE OF EMERGENCY PIPELINE REPAIR SYSTEM

- Unexpected pipeline damage severely disrupts hydrocarbon production and operators' profitability.
- A few major operators (e.g. Statoil and Chevron) have some form of Emergency Pipeline Repair System (EPRS) scheme to minimise period to perform pipeline repair.
- The components of an EPRS typically comprise some or all of the following components:
  - Combined Habitat and Alignment System (CHAS)
  - Pipe Handling Frames (PHF, 2 nos.)
  - Welding and Diving Station (WADS)
  - Repair Couplings
  - Repair Coupling Installation Frame (CIF)
  - Concrete Removal Machine (CRM)
  - Pipeline Retrieval Tool (PRT)
  - Pipeline Isolation Plugs (2 nos.)
  - Launching Frame
  - Appurtenances and Spares

STATOIL EPRS SYSTEM FOR NORTH SEA

- STATOIL repair system is based on the longitudinal spool repair concept.



PHF

Launching Frame with Heave Compensator

Concrete Cutting Machine

CHAS

Agenda

- ❑ **Short-term & Long-term Trend**

Short-term Trend

As a result of low oil prices depressing the market, dire consequences have affected the industry, such as:

- Planned deep water and marginal field developments are put on hold or shelved.
- Operators, contractors , consultants and suppliers are reeling from the effect – some have gone bust and some have applied for judicial management (e.g. 3 major players in Singapore)
- Retrenchment of skilled personnel
- Expenses that do not immediately generate income are put on hold or eliminated, e.g. training, R&D etc.
- Majority of new developments are in shallow water, e.g. Saudi Arabia
- "Short-sightedness" in terms of planning for market upswing

Long-term Trend

- ❑ Increased competition with onshore shale gas due in part to fracking will continuously put pressure on Oil & Gas prices
- ❑ Tendency to go deeper and to remote sites (once oil prices revert to 'profitable' levels)
- ❑ Composite materials to replace traditional steel flowlines and risers
- ❑ Requirements for HPHT development
- ❑ FLNG and subsea processing
- ❑ Shift from greenfield to tie-backs to minimise development cost
- ❑ Building of specialised multi-functional installation vessel (e.g. EMAS CHIYODA's Lewek Constellation)
- ❑ Merger of established players (e.g. Subsea7 and Acergy; Technip and Global; EMAS, Chiyoda and NYK, etc.)
- ❑ Adoption of "One Stop Shop" approach, e.g. Technip-FMC, offering combined front end & detailed engineering, the production of entire subsea production equipment and installation of entire system.

Example of Evolution in Offshore Installation Methodology and Vessel by EMAS CHIYODA SUBSEA

Potential Trend for the Future

- Faster crane with deeper reach for subsea work
- Bigger vessel winches with higher degree of speed control
- Higher capacity vessel subsea cranes with active heave compensation & constant tension modes – with depth capability of +2000 m.
- More advances ROVs which can be launched in extreme weather, and equipped with long tethers for several hundred meters of horizontal excursion.
- Autonomous Operated Vehicles
- Quicker and more advanced method for offshore welding
- Installation vessels that can operate in both shallow and deep waters

Agenda

- ❑ **Gaps & Opportunities for Development**

Capability Gaps & Collaboration Opportunities with Suppliers

- ❑ New era of HP/HT (or ultra HP/HT) developments necessities new materials such as CRA, coating and welding which currently has certain limitations. For example
  - o Coating - currently technology on corrosion coating and field joint will soon not be sufficient if the temperature trends continue, so this gap needs to be plugged.
  - o Some projects require that internally coated pipeline need to have the field joint coated – development of internal coating machine that can be used during pipelaying and that does not slow down installation time still lacking.
- ❑ As petroleum exploration and production goes deeper, new technology is required to bridge the gap. This would include:
  - o Improvement in subsea processing technology, including subsea separation, pumping, compression, etc.
  - o More advanced welding and NDT technologies
  - o Development of composite materials to replace traditional steel pipelines, flowlines and risers
  - o More advanced subsea intervention equipment and methodologies
  - o More advance installation equipment (e.g. vessel such as Lewek Constellation)

Capability Gaps & Collaboration Opportunities with Suppliers

- People and experience challenges – every industry downturn creates skill and experience gaps, and Oil & Gas industry is not very good at bridging these.
  - A huge number of skilled personnel have been retrenched and many are possibly changing industry or retiring.
  - Existing companies are cutting down on recruitment & training of new graduates.
  - When the market picks up (upswing), I predict a huge shortage of skilled personnel (particularly, engineers). This will drive up personnel cost with little increase in supply.

Question & Answer

Thank you