Assessment and Analysis of Deepwater Pipeline Repair in the Gulf of Mexico

Sponsored by:
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Presented by:
Project Consulting Services, Inc.
The Need for Deepwater Pipeline Repair in the Gulf of Mexico

- 5 Trillion Cubic Feet of Gas per Year
- 500 Million Barrels of Oil per Year
1998 Gulf of Mexico Gas Production

Deep Water Gas Production 11%

Shallow Water Gas Production 89%
Anticipated 2000 Gulf of Mexico Gas Production

Deep Water Gas Production: 30%

Shallow Water Gas Production: 70%
Gulf of Mexico Gas Production Trends

- **Year**
  - 1993
  - 1994
  - 1995
  - 1996
  - 1997
  - 1998

- **Standard Cubic Feet of Gas (Billions)**
  - 0
  - 2000
  - 4000
  - 6000

- **Graph Legend**
  - Deep Water Gas Production
  - Total Gas Production
1998 Gulf of Mexico Oil Production

Deep Water Oil Production 36%

Shallow Water Oil Production 64%
Anticipated 2000 Gulf of Mexico Oil Production

Deep Water Oil Production 64%

Shallow Water Oil Production 36%
Gulf of Mexico Oil Production Trends

Barrels of Oil (Millions)

Year


Deep Water Oil Production
Total Oil Production
Deepwater Defined

- 1000+ Feet Sea Water
- Gulf of Mexico Bottoms Out at 15,000+ Feet Sea Water
Deep Water Discoveries

112 Deepwater Discoveries as of 1999
27 Deepwater Discoveries Producing at end of 1999
83 of the Current Deepwater Discoveries have Future Production Plans
Deep Water Discovery Trend

Year

Number of Discoveries Per Year

1999 Deep Water Production Start Ups

Water Depth (feet)

- Allegheny
- Angus
- Gemini
- Genesis
- Macaroni
- Marlin
- Ursa
Planned 2000 Deep Water Production Start Ups
Gulf of Mexico Transportation Methods to Bring Deepwater Production to Market

- Safe
- Pipelines
- Reliable
- Efficient
Hazards to Subsea Pipelines

- Natural Disasters
- Operational Error
- Physical Impacts from Fishing or Oil and Gas Activities
- Construction of the Pipeline
Purpose and Need For
Deepwater Pipeline Repair

Deepwater Pipeline Repair Capabilities are Essential to Provide Confidence in the Deepwater Oil and Gas Developments and to Ensure a Reliable Supply of Production from Deepwater Producing Fields
Gulf of Mexico Consortiums

- R.U.P.E. Co-Ownership Project
  - Began in 1977 by Tennessee Gas with 11 Participants
  - Today 22 World Wide Participants
Gulf of Mexico Consortiums

- DeepStar
  - Began in 1992 by Texaco
  - Conceptual Study of the Feasibility of Extended Reach Tie-Backs 40-60 miles
  - Has Expanded to Encourage the Production of Hydrocarbons from tracks in up to 10,000+ Feet Sea Water
Challenges of Deepwater

- Saturation Diving Limited to 1,200 Feet Sea Water
- Heavy Lift Vessels Required to Recover Pipelines to Surface
- Remote Operations Essential to Success of Deepwater Pipeline Intervention
History of Deepwater Pipeline Repair

- 1973 Exxon JIP – 16 Participants
- Repair 36” Concrete Coated Pipe in 3,000 Feet Sea Water
- Based on Large ROVs that were Non-Existent at the Time
- Ended 1977 with Report Only
History of Deepwater Pipeline Repair

1974 – Shell JIP – 6 Participants

- Repair of 36” Concrete Coated Pipe to 3,000 Feet Sea Water
- Proposed Subsea Catamaran Vessel
- Ended 1977 with Report Only
1977 - Statoil
- Repair of 36” Concrete Coated Pipe in 1,500 Feet Sea Water
- Based on HydroTech Manipulating Frame to Install Connectors
- Operated by Oceaneering WASP
- Ended Same Year with Report Only
History of Deepwater Pipeline Repair

1981 – Gulf Oil JIP – 4 Participants
- Repairs to 8,000 Feet Sea Water
- System Based on Large (Non-Existent) ROVs and Existing Equipment
- Ended 1983 with Preliminary Design Only
Deepwater Pipeline Repair Options

- Re-Lay Pipeline Or Portion of Pipeline
Deepwater Pipeline Repair Options

Pipeline Repair Clamp
Deepwater Pipeline Repair Options

Surface-Lift-Layover
The Reality of Deepwater Pipeline Repair

- A Comprehensive Pipeline Repair System Must Exist to Minimize Loss of Production
- More Complete Systems Have Been Available in Europe over the Last Decade than in the Gulf of Mexico
- Estimated Worst Case Repair Scenario for Gulf of Mexico would take 8 months
Pipeline Repair Philosophies

- European Shallow Water Tie-in and Repair Philosophy
  - On-Bottom Hyperbaric Welding
    - Competitive in European Markets
    - All Welded System
    - High Strength / High Reliability
    - Limited by Water Depth
Pipeline Repair Philosophies

- European Deepwater Pipeline Repair Philosophy
  - On-Bottom Repair As Strong As Pipeline
  - Automated Hyperbaric/Other Welding (Development)
  - Horizontal Mechanical Connections
  - Slip-On/Forged Mechanical Connectors
  - Remote On-bottom Flange Tie-Ins
Pipeline Repair Philosophies

- Gulf of Mexico Shallow Water Tie-In and Repair Philosophy
  - Surface Welding
  - Break-Over Tie-Ins
  - Flanges
Pipeline Repair Philosophies

- Gulf of Mexico Deepwater Pipeline Repair Philosophy
  - Surface Welding of Mechanical Connectors
  - Vertical Connectors / U/M-Shaped Jumpers
  - Slip-on Mechanical Connectors (Remote Installation Under Development)
The Major Deepwater Pipeline Repair Systems of the World

Where Have We Been?
Where Are We Now?
Where Are We Going?
The Major Deepwater Pipeline Repair Systems of the World

- Statoil Pipeline Repair System
- Snam/Sonsub Pipeline Repair System
- Stolt MATIS Pipeline Repair System
- Shell Deepwater Pipeline Repair System
- Oceaneering Pipeline Repair System
Statoil Pipeline Repair System

- Origins in 1987
- Covered 1000 km of Pipelines
  - Statoil’s Statpipe System
  - Norske Hydro’s Oseburg Transportation System
- First System Based on Hyperbaric Welding
- Water depth limitation to 1,200 Feet
  Sea Water
Statoil Pipeline Repair System

- 1993 Began Development of Deepwater Pipeline Repair System
- Design Criteria
  - Remote Diverless On-Bottom Repair
  - Morgrip Mechanical Connector
  - Strong As Original Pipeline
  - Design Life of 50 Years
  - 20” Pipelines or Less
Statoil Pipeline Repair System

Morgrip Mechanical Connector
Statoil Pipeline Repair System

- 1996 Haltenpipe Mid-Line Tie-In During Pipeline Construction Using Statoil PRS
- First Remote On-Bottom Tie-In Performed Using Mechanical Connectors
- 16” Pipeline in 460 Feet Sea Water
Statoil Pipeline Repair System
Statoil Pipeline Repair System

- Current Participants Include Statoil, Norske Hydro, and Phillips Petroleum Co.
- Total of 7000 km of pipeline covered
- 42" Diverless Repair System Under Development
Statoil Pipeline Repair System

Current Pipeline Systems Covered by PRS
MMS

Statoil Pipeline Repair System

42” Morgrip Connector
Statoil Pipeline Repair System

- Current PRS Components
  - 2 Hyperbaric Welding Habitats
  - 6 Pairs of H-Frames
  - 2 Morgrip Installation Modules
  - One High Pressure Abrasive water jet system used for pipe cutting, concrete removal, and corrosion coating removal
Statoil Pipeline Repair System

Limitations for Gulf of Mexico Applications

- Large and Heavy System Requires Large Heavy Lift Vessel to Deploy
- All equipment is located in the North Sea Area
Statoil Pipeline Repair System

Large 70 Ton H-Frame Can Handle Up to 48” Concrete Coated Pipe
**Snam/ Sonsub Deepwater Pipeline Repair System**

- Origins in late 1970’s by Sonsub
- Snam Trans-Mediterranean Pipelines
- 2000 Feet Sea Water Max. Depth
- Pre-Dated “Work Class” ROVs
- Used 14 Autonomous Modules
- Diameter Specific to the 20” Pipelines
Snam/ Sonsub Deepwater Pipeline Repair System

- 1993–Sonsub AROWS
- Revolutionary Repair Philosophy
- 20” and 26” Trans-Med Pipelines
- Based on Work Class ROVs
- Simpler ROV Operated Tools
- System Designed around the X-Loc Connector
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Snam/ Sonsub Deepwater Pipeline Repair System

X-Loc Telescoping Spool Piece
MMS
Snam/ Sonsub Deepwater Pipeline Repair System

1995 Sonsub Diverless Sealine Repair System (D.S.R.S.)
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Snam/ Sonsub Deepwater Pipeline Repair System

Pipeline Handling H-Frame
Snam/ Sonsub Deepwater Pipeline Repair System

- Combined New Snam Cold Forging / Collet Connection System with Sonsub D.S.R.S.
- The Latest Stand-By System for the 20”/26” Trans-Mediterranean Pipelines
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Snam/ Sonsub Deepwater Pipeline Repair System

Telescoping Spool Piece with Snam Connection System
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Snam/ Sonsub Deepwater Pipeline Repair System

- 1997-BP Foinaven Project-North Atlantic (West of Shetlands)
- Diverless Flange Tie-In System
- 8” and 10” Pipelines
- 1,500 Feet Sea Water
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Snam/ Sonsub Deepwater Pipeline Repair System

BRUTUS
MMS

Snam/ Sonsub Deepwater Pipeline Repair System

BRUTUS – Axial Force Tool
Snam/ Sonsub Deepwater Pipeline Repair System

BRUTUS – Reaction Tool
MMS Snam/ Sonsub Deepwater Pipeline Repair System

BRUTUS – Bolt Insertion and Tensioning Tool and Nut Magazine

[Images of BRUTUS tool]
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Snam/ Sonsub Deepwater Pipeline Repair System

BRUTUS Completed Flange Connection
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Snam/ Sonsub Deepwater Pipeline Repair System

◆ BRUTUS – First Project
- June 2000 – North Sea
- Construction Subsea Tie-In
- Statoil Norne/Heidrun Pipeline
- 16” ANSI 1500 Taper-Lok Flange
- 1000’ Sea Water
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Snam/ Sonssub Deepwater Pipeline Repair System

D.S.R.S. / BRUTUS Integrated System
Snam/ Sonssub Deepwater Pipeline Repair System

Gulf of Mexico Applications

- D.S.R.S. - Large and Heavy System Requires Large Heavy Lift Vessel to Deploy
- BRUTUS – More Portable But Requires D.S.R.S. Type Support
- BRUTUS and D.S.R.S. Equipment Are Located In Europe
June 1999 – Diverless Flange Connection
Statoil Loke Project North Sea
Construction Tie-In of 8” ANSI 1500 Taper-Lok Flange
260’ Sea Water
Stolt MATIS

Components and Procedures
- Flange Alignment Frame
Stolt MATIS

Components and Procedures
- Flange Alignment Tool
Stolt MATIS

- Deep MATIS System is Currently Under Development
- Elf Angola Girassol Project
  - June 2000 Sea Trials in North Sea
  - November 2000 Girassol Construction
  - 82 Diverless Flange Connections
  - 4,600’ Sea Water
Stolt MATIS

Components and Procedures
- Deep MATIS Module Under Construction
Stolt MATIS

MATIS Support Tools Under Development
- H-Frames
- Leak Detection
- Mechanical Pipe Cutter
- Concrete Removal
- FBE Removal
- Metrology
- Hydrate Plug Detector
- Pipe Deburial
- Pollution Containment
Stolt MATIS

- MATIS as Repair System
- Easily Adaptable for Existing Diameters
- Deployable from DSV
- Requires Surface Lift of Pipeline Ends
- Multiple MATIS Modules Required for Large Diameter Ranges
Stolt Future Development Goals

- Remote On-Bottom Diverless Repair with Jumper / Mechanical Connectors

BIMS Remote Articulated Connector
Stolt Future Development Goals

- Wet Friction Welding
  - Better weld metal characteristics than arc welding
  - Not dependent on water depth
  - Automated (diverless) process
  - Not expected to be perfected for several years
Stolt Future Development Goals

Friction Stitch Welding Process
Stolt Future Development Goals

Friction Stitch Welding Process
Shell Deepwater Pipeline Repair System

The First Comprehensive Pipeline Repair System in the Gulf of Mexico
Shell Deepwater Pipeline Repair System

Shell Stake in Deepwater

Deepwater Pipeline Operation in Gulf of Mexico Based on Mileage

- Shell: 60%
- ExxonMobil: 20%
- Other: 20%
Shell Deepwater Pipeline Repair System

- **Shell, Equilon, and Coral Gas (Tejas)**
  Developing Repair System

- **Goal is to Minimize Down Time to 1 Month**

- **Includes**
  - Surface Lift OR On-Bottom Repair
  - Commissioning
  - Uninhibited Flow at Start-Up
Shell Deepwater Pipeline Repair System

Surface Lift Repair Procedure
Shell Deepwater Pipeline Repair System

Advantages to Surface Lift Repair Procedure

- Allows Welded Male Hubs
- Allows Accessibility to Pipe Bore for Hydrate Plug Remediation
- Proven Procedure
Shell Deepwater Pipeline Repair System

Disadvantages to Surface Lift Repair Procedure
- Requires Heavy Lift Vessel
- Not Applicable in All Damage Scenarios
Shell Deepwater Pipeline Repair System

On-Bottom Repair
- Eliminates Surface Lift
- Based on grip and seal connectors
Advantages of On-Bottom Repair
- Heavy Lift Vessel Not Required
- Serves as contingency if Surface Lift is Not Possible
Disadvantages of On-Bottom Repair
- Procedure Not Proven
- No Accessibility to the Pipe Bore
- Mechanical Seal Reliability
Shell Deepwater Pipeline Repair System

Philosophy:
- System Based on Proven Technology
- All Components Adapted from Existing Products and Equipment
- Covers Sizes: 12”, 14”, 16”, 18”, 20”
Shell Deepwater Pipeline Repair System

**Summary of Major Components:**
- Mechanical Connectors (Collet, Grip & Seal) - HydroTech
- H-Frames - HydroTech
- Diamond Wire Pipe Cutter - Sonsub
- Concrete and FBE Removal Tool - Sonsub
- Hydrate Detection Tool - Oceaneering
- Discharge Containment Tent - Oceaneering
- Taut Wire Metrology - Oceaneering
- Acoustic Metrology - Leased from Fugro/Chance
Additional Requirements

- Agreements with Contractors and Service Companies for Repair Emergencies
- Repair Manual
Shell Deepwater Pipeline Repair System

- System Limitations
  - Steel Catenary Risers
  - Pipe-In-Pipe Systems
  - MAOP > 6,000 PSIG
Shell Deepwater Pipeline Repair System

**Status:**

- System Ready by August 2000
- Soliciting Participation from Other Deepwater Operators
- Draft Participation Agreement Prepared in a DeepStar Committee Base on R.U.P.E. Model
Oceaneering Deepwater Pipeline Repair System

- Based on WASP Atmospheric Diving System
- On-Bottom Repair Capabilities to 2,300’ Sea Water
- Up to 14” Pipelines
Oceaneering Deepwater Pipeline Repair System

- Oceaneering Pipeline Repair Tools
  - WASP ADS – Rated to 2,300’ Sea Water
  - ROVs
  - Smart Flange Plus Connector
  - Hydraulic Smart Connector
  - WACHS Guillotine Saw
  - PMT – Taut Wire Metrology
MMS

Oceaneering Deepwater Pipeline Repair System

◊ WASP Atmospheric Diving System
Oceaneering Deepwater Pipeline Repair System

Smart Flange Plus Connector

- The Ring Type Joint is standard. (Ring Joint seal is provided)
- The design of the Smart Flange compensates for certain errors in measurements.
- Smart Flange is set when flanges mate.
- Torque on the upper nuts automatically sets Smart Flange. (Studs and nuts are provided with Smart Flange)
- Lower nuts are trapped by the flange housing.
- Standard ANSI weldneck flange is provided as part of the assembly.
- Flange may be swiveled for easy alignment.
- Screw-on cap allows 100% testing before delivery.
- Seamless forged flange housing (SA-165 standard, SA-350 - LF - 1, and others available).

Load from tension in the pipe is transferred through the slip and Load Limiting Device to the forged housing.

Buna "N" elastomer seal is standard. Viton™ elastomer seal optional. Others available on request.
Oceaneering Deepwater Pipeline Repair System

Hydraulic Smart Connector
Oceaneering Deepwater Pipeline Repair System

WACHS Guillotine Saw
Oceaneering Deepwater Pipeline Repair System

- First Deepwater On-Bottom Pipeline Repair in Gulf of Mexico
  - Mariner 4” Dulcimer Flowline Repair
Mariner 4” Dulcimer Flowline Repair
- Summer 1999
- 1,100 Feet Sea Water
- WASP Installed Smart Flanges
- Performed off of 243’ MSV
MMS

Oceaneering Deepwater Pipeline Repair System

- Mariner 8” Pluto Repair
  - October 1999
  - Leaking Weld Found During Hydrotest
  - Surface Lift by the Pipeline Lay Vessel
  - 2,150 Feet Sea Water
  - ANSI Flange Make Up On-Bottom Using WASP
Oceaneering Deepwater Pipeline Repair System

Reflange A-Con Variable Alignment Connector
Oceaneering Deepwater Pipeline Repair System

- Diverless Hot Tap
  - Williams Field Services JIP
  - Oceaneering, HydroTech, T.D. Williamson
Conclusions

- Deepwater Pipeline Repair Systems Are Available to the Gulf of Mexico
- The First Comprehensive System Will Be Available to the GOM by August 2000
- Pipeline Repair Scenarios have been Reduced from 8 months to 1 month