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Introduction to Submarine Pipeline Installation: Conventional and Non-Conventional Methods

17 May 2013

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Presentation Contents

- Types and Functions of Submarine Pipelines
- Various Types of Pipeline Installation Methods
- Typical Pipelay Vessels
- Conventional pipeline installation – typical method
- Unconventional pipeline installation – typical methods
- Davit lift for ‘stalk on’ of riser, PLEM, etc.
- Surface tie-in of 2 pipeline segments
- Subsea Piling of PLEM
- Subsea Intervention – Typical Methods
- Pre-commissioning (outline)
- Rock armour production and rock dumping
- Examples of Pipeline Installation Engineering

What is a Submarine Pipeline?

- A pipeline is a tube or conduit, usually metal, that carries liquids (such as water and gasoline) or gas (such as natural gas) from one place to another
- A submarine pipeline refers to a pipeline that is installed under water, resting on the seabed of the waterway, frequently used for petroleum or natural gas transportation across sea, river, lake, or bay.

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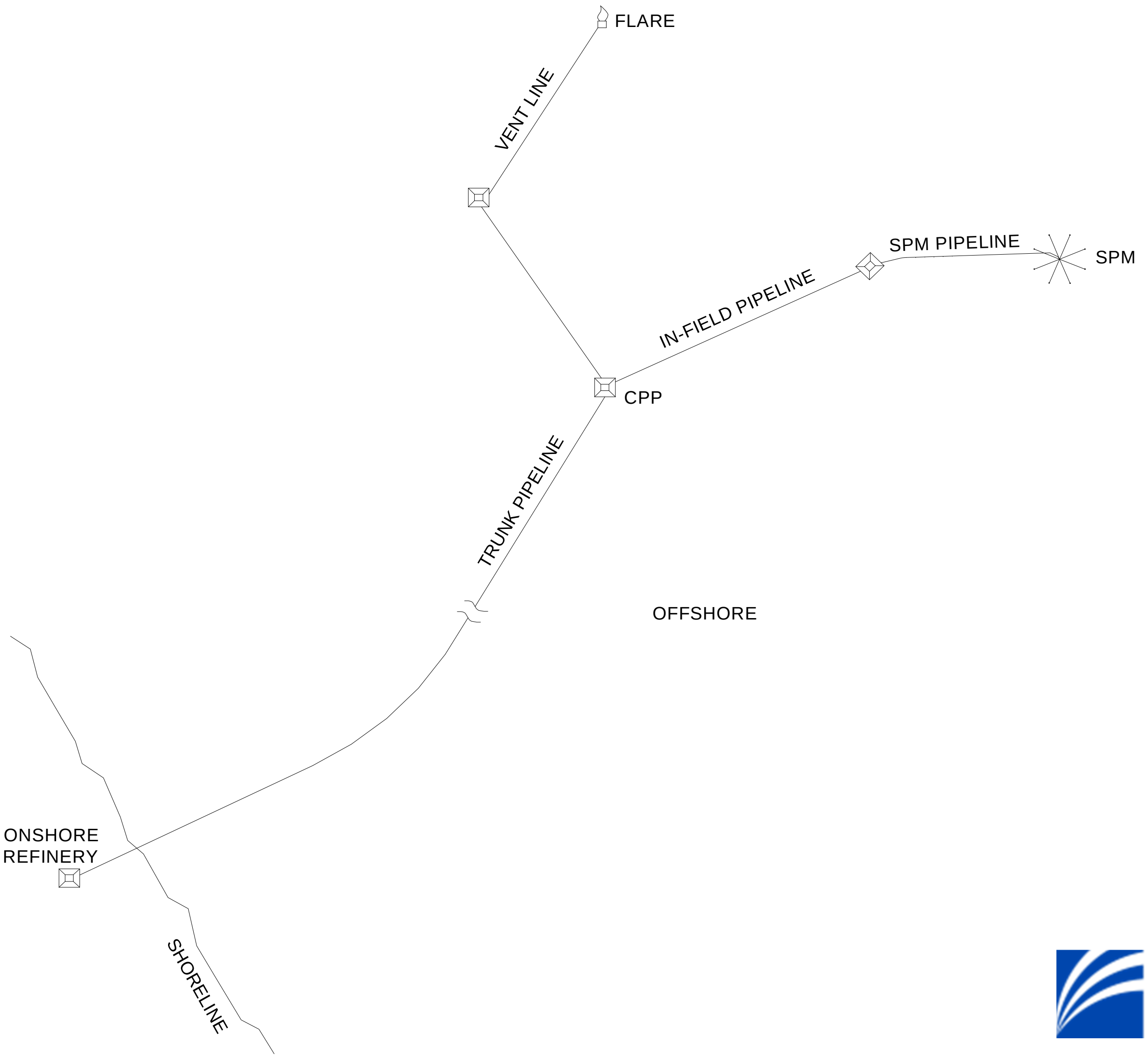
Schematic Showing Hypothetical Oil Field with Various Types of Pipelines



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Conventional Pipelaying Techniques

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Typical Pipelay Vessels:

- Conventional laybarges
- Semi-submersible laybarges
- DP laybarges
- J-lay laybarges
- Reel Lay laybarges

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Schematic Showing Pipelaying By Conventional Lay Barge (S-Lay)

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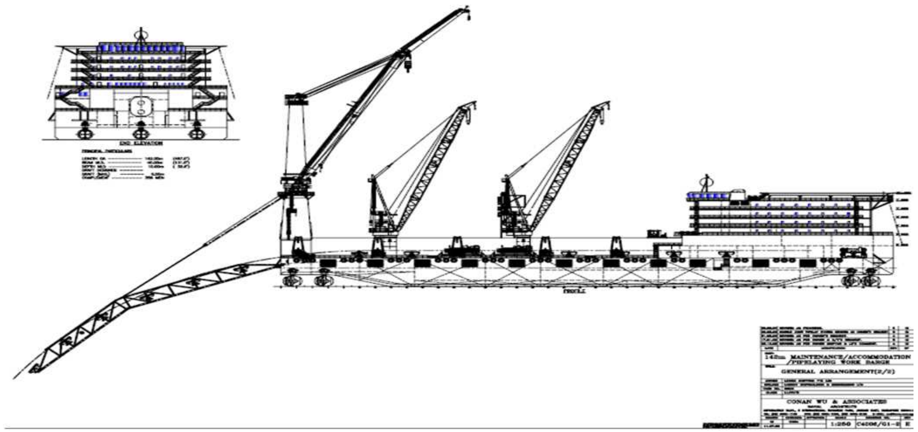
Lewek Champion

HEAVYLIFT & PIPELAY VESSEL

Shallow to Medium depths pipelaying



DP2 Heavylift & Pipelay

EMAS's deepwater DP pipelay vessel, Lewek Centurion (a.k.a. Caesar)

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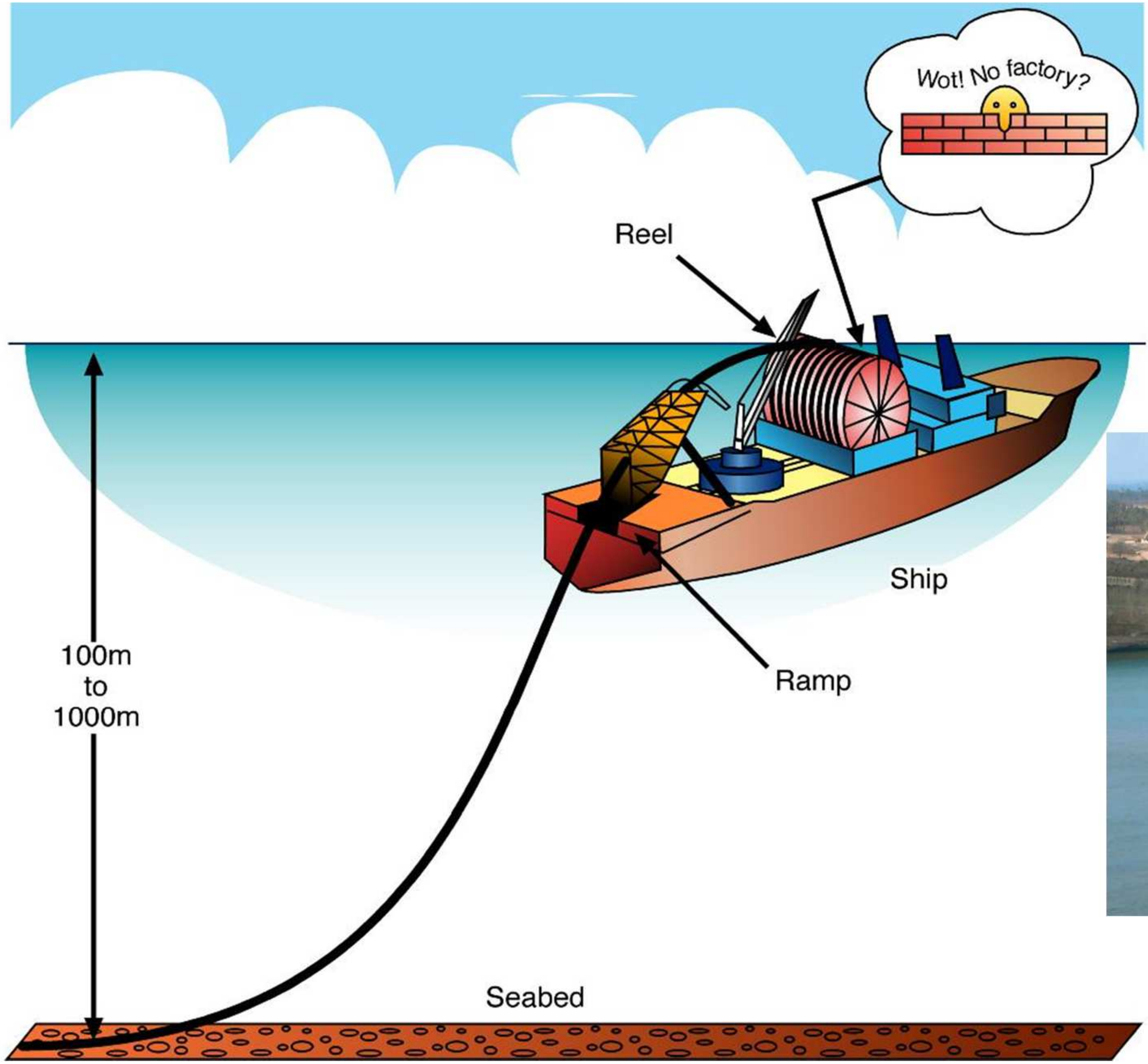
Semi-Submersible Laybarges: Examples

Name: Derrick Barge 101
Owner: J Ray McDermott

Name: Castoro 7
Owner: Saipem

Schematic Showing Pipelaying
By Conventional Lay Barge (J-Lay)

REEL-LAY: Typical concept



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EMAS Reel-lay vessel "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. The vessel is capable of reaching 600 foot depths, and a 150 metric ton deepwater crane capable of reaching

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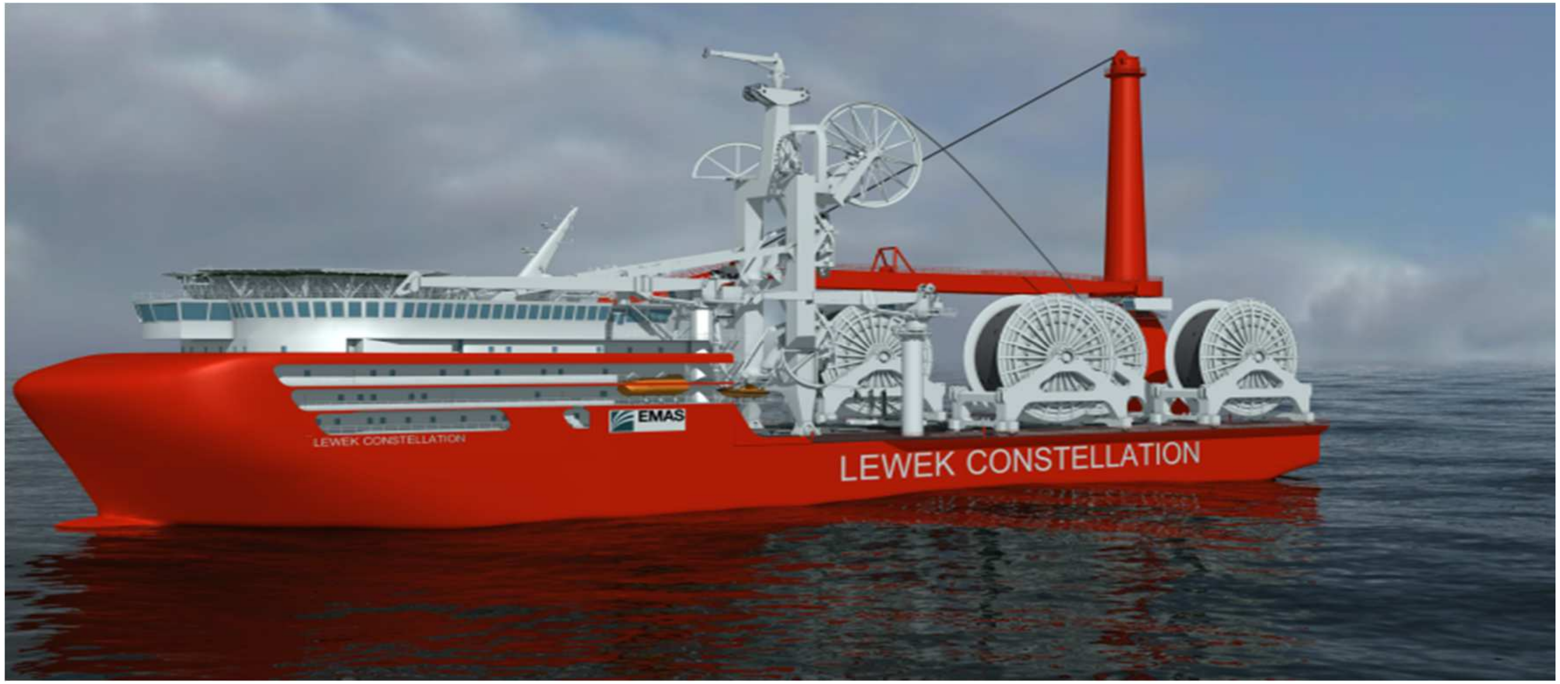
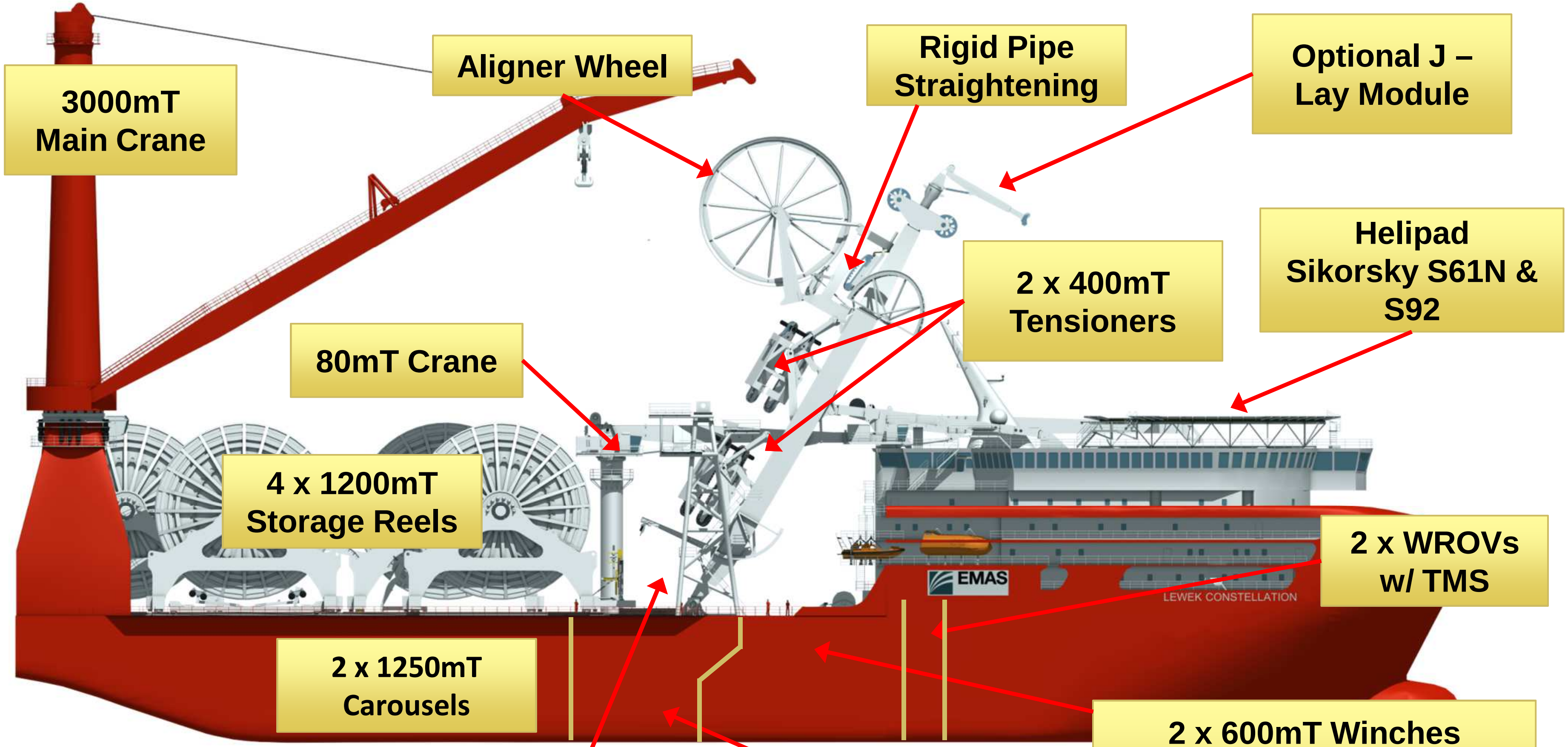
EMAS's State-of-art Multi-lay Vessel



- Rigid pipelines and SCR's up to 16" (by reel lay)
- Umbilicals and flexibles
- Flexible and Rigid Jumpers
- Heavy Lift / Subsea Construction
- Topsides, Manifolds, Piles

Modern Reel Lay Vessel: EMAS's Multi-lay Vessel "Constellation" (Operating 2014)



Length: 178m
Beam: 46m
Max Draft 10.5m
POB: 239
Speed: 12.5kts

Non-Conventional Pipelaying Techniques

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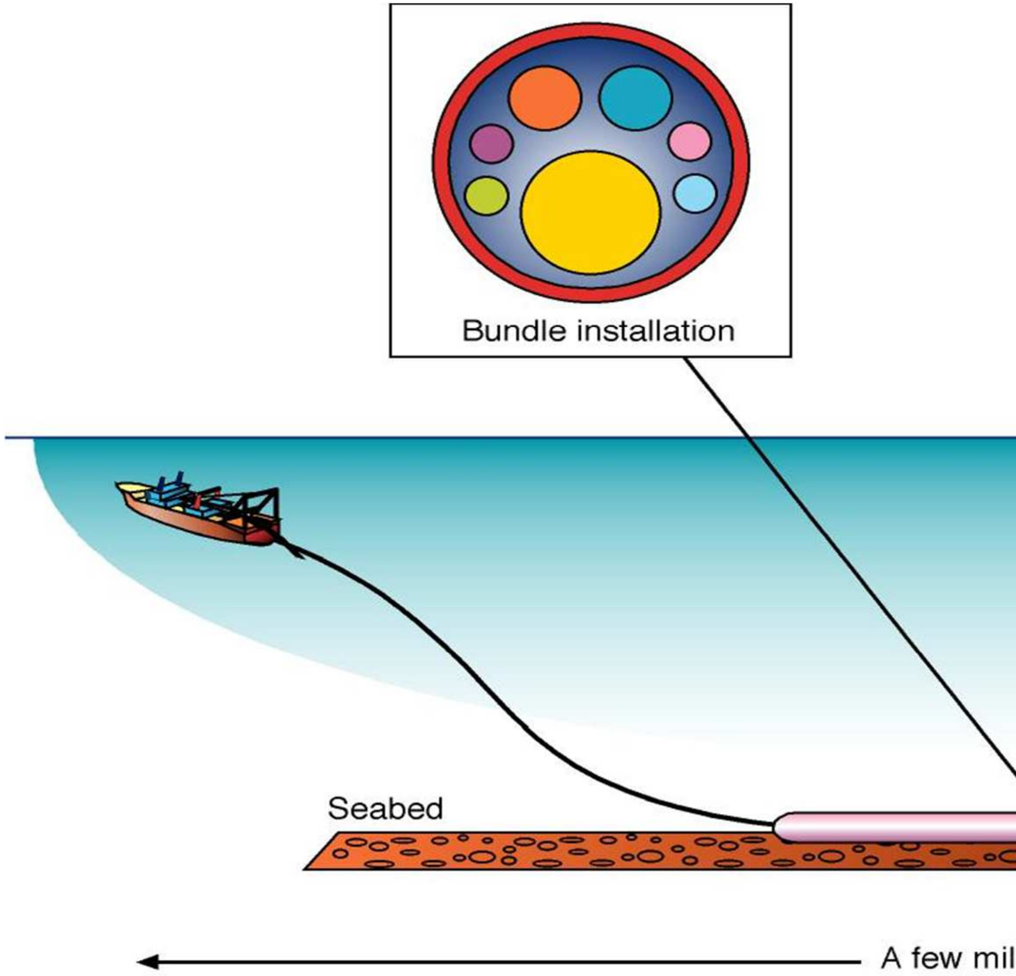
Bottom Tow Method



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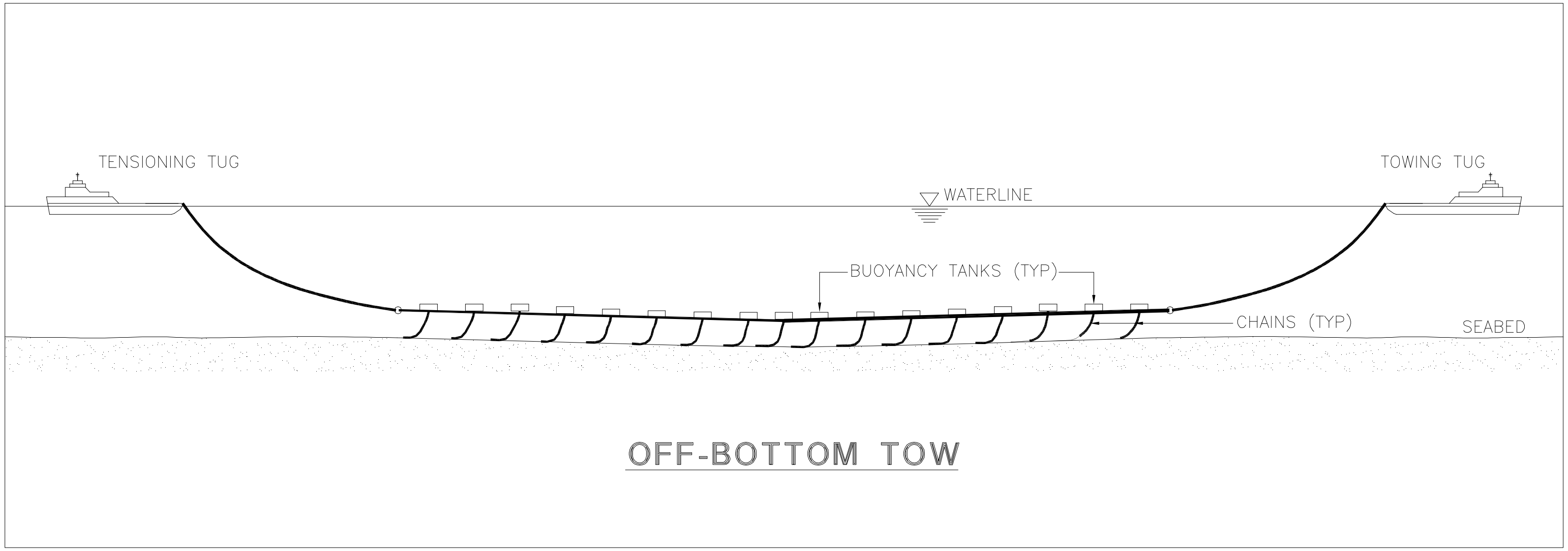
Off-bottom tow concept



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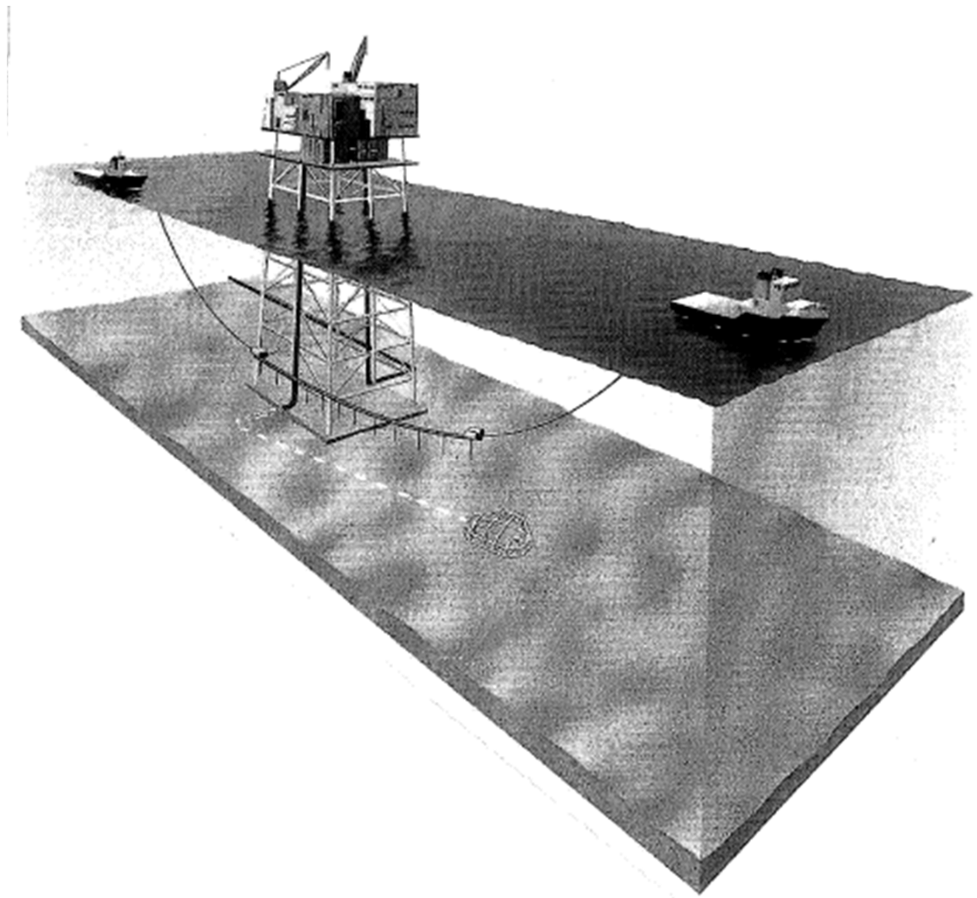
Controlled Depth Tow Method Concept



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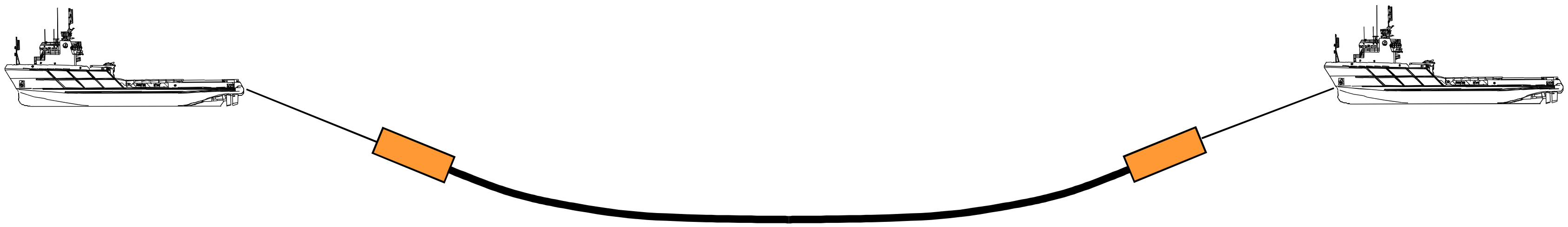
Control Depth Tow Method



‘Push-Pull’ Method of Pipeline Installation at Shore Approach (by Geocean)

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Horizontal Directional Drilling by Forward Thrusting

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Conventional Laybarges
&
Typical Operation

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Conventional Laybarge Enterprise 3

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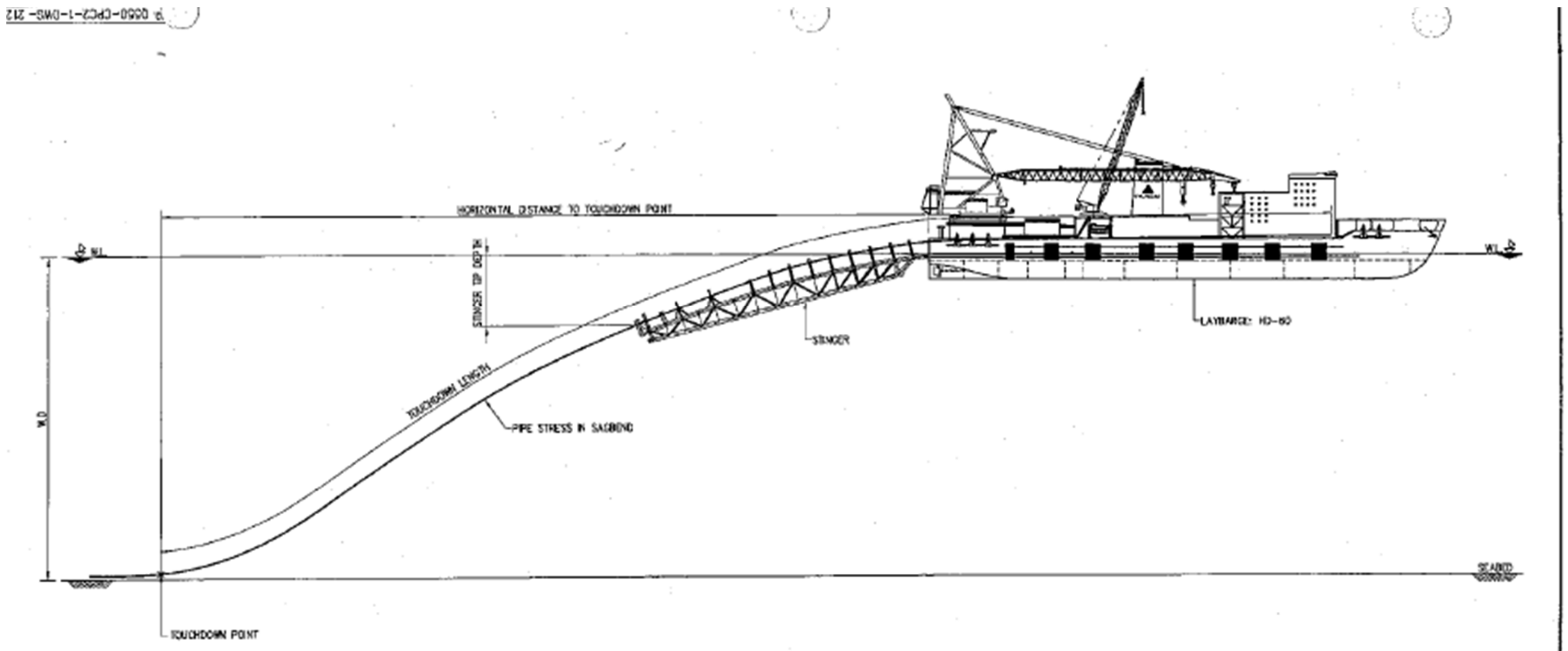
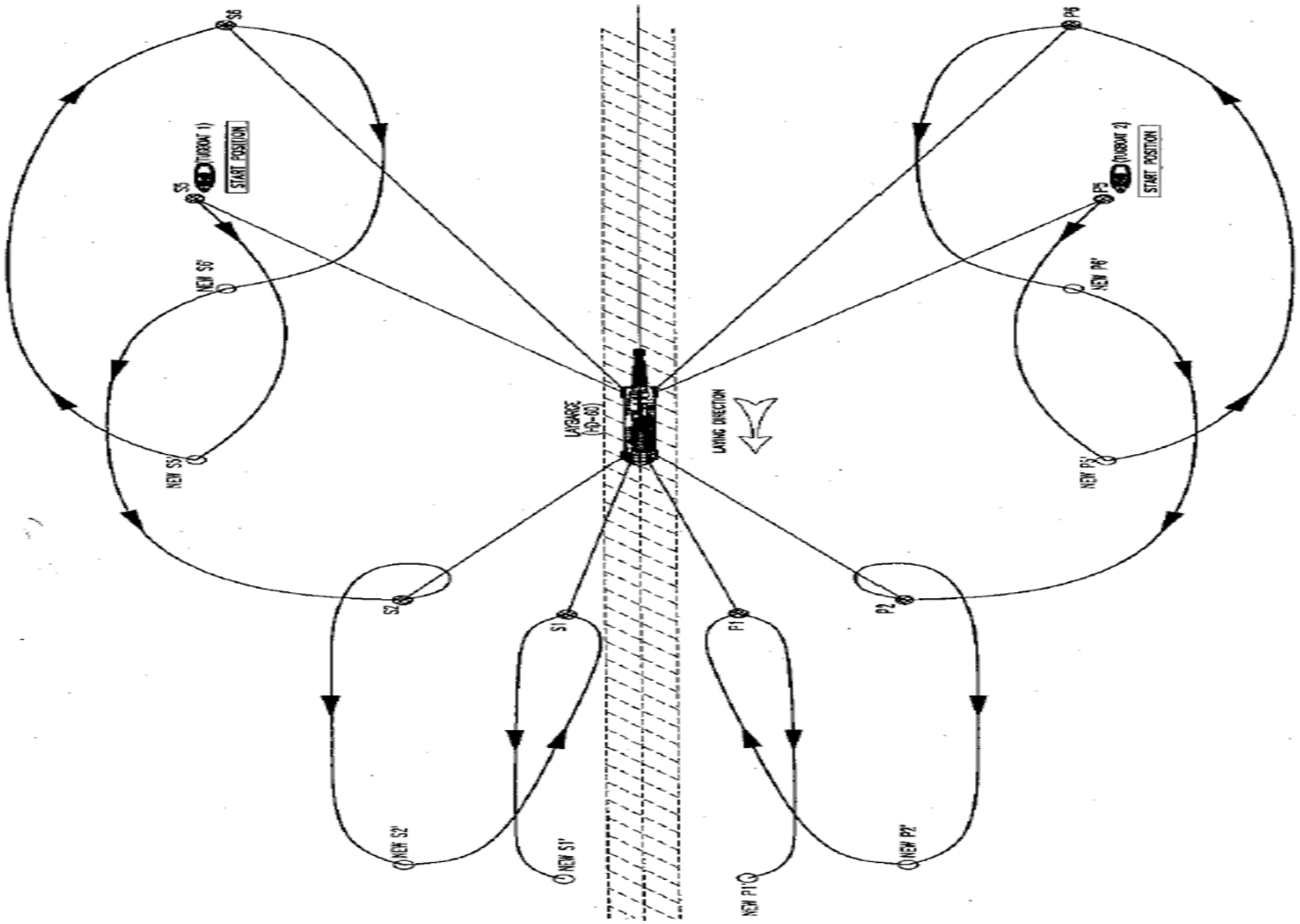
Convention Pipeline Installation : Laybarge



NORMAL LAYING SUMMARY TABLE

PIPELINE	K.P POINT	PIPE O.D. (INCH)	WALL THK. (MM)	CONCRETE COATING THK. (MM)	WATER DEPTH (M)	STINGER TIP DEPTH (M)	TENSION (KN)	MAX. PIPE STRESS (%SMYS)		HORIZONTAL DISTANCE TO TOUCHDOWN (M)	TOUCHDOWN LENGTH (M)	REMARKS
								OVERBEND	SAGBEND			
TUNGHSIAO – TATAN	1.8 ~ 84.0	36	15.9	85	85	11.9	2000	83	38	377	535	–
TAICHUNG – TUNGHSIAO	1.8 ~ 38.6	36	14.3	85	55	11.9	650	71	55	259	413	–

Typical Mooring Pattern and Anchor Handling Procedure



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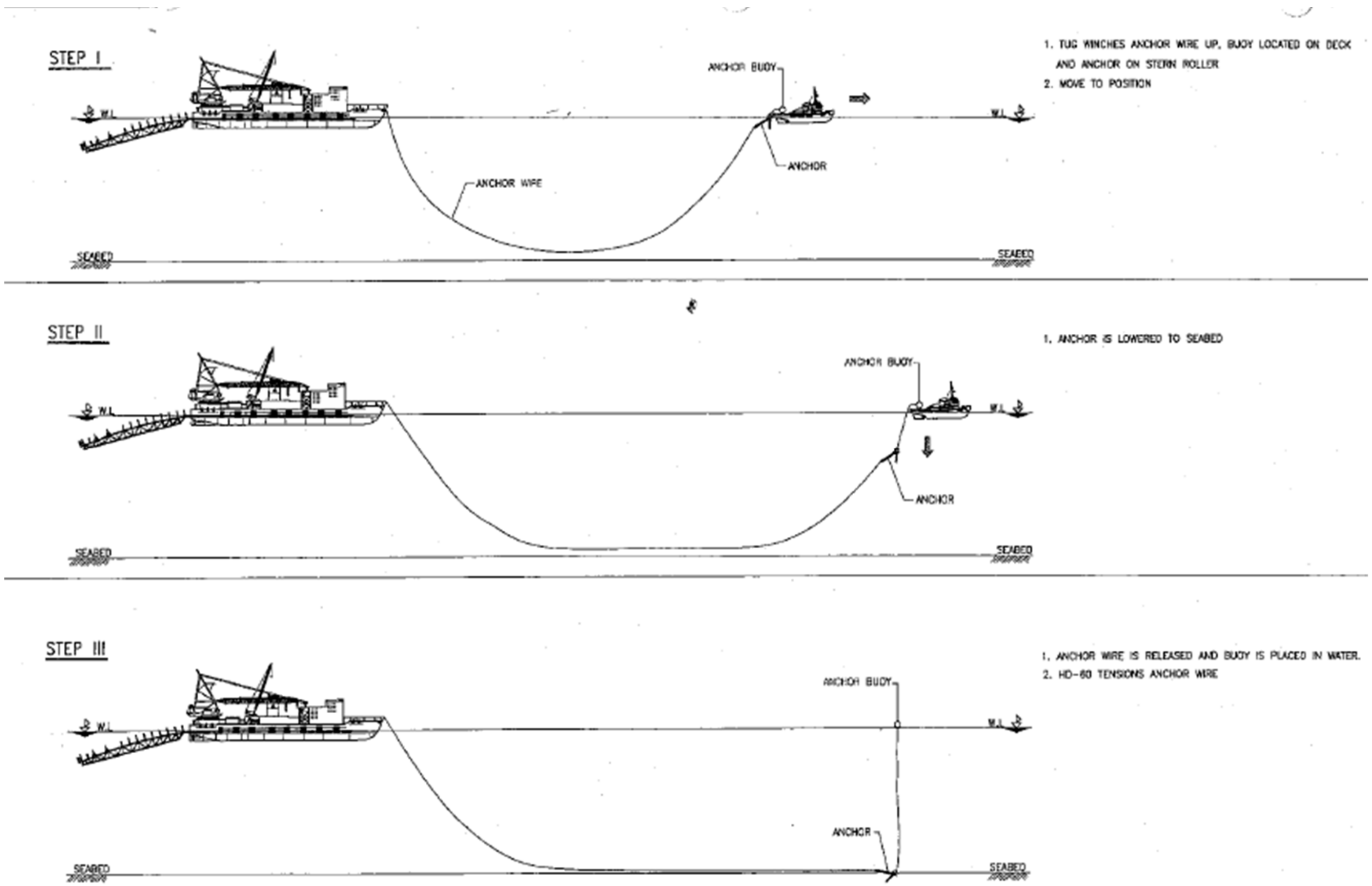
Running of Anchors by Anchor Handling Tug



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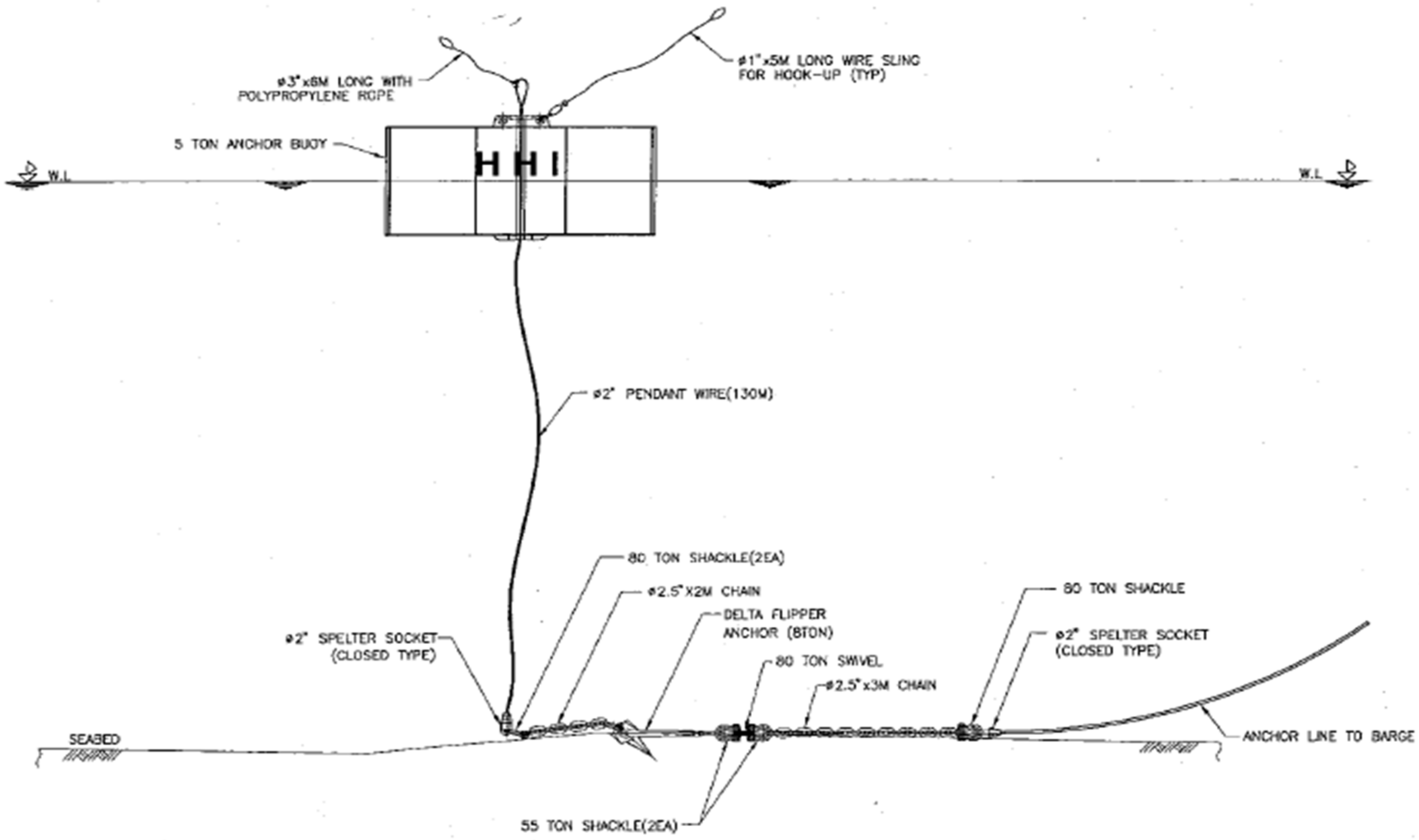
Marker Buoy with Pendant Wire for Anchor Recovery



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Control Tower where mooring lines are monitored and barge movement is co-ordinated during pipelaying

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Surveyor on Barge plotting As-laid Pipeline Profile, and helping to guide barge positioning

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Material Barge with Pipe Moored to Laybarge

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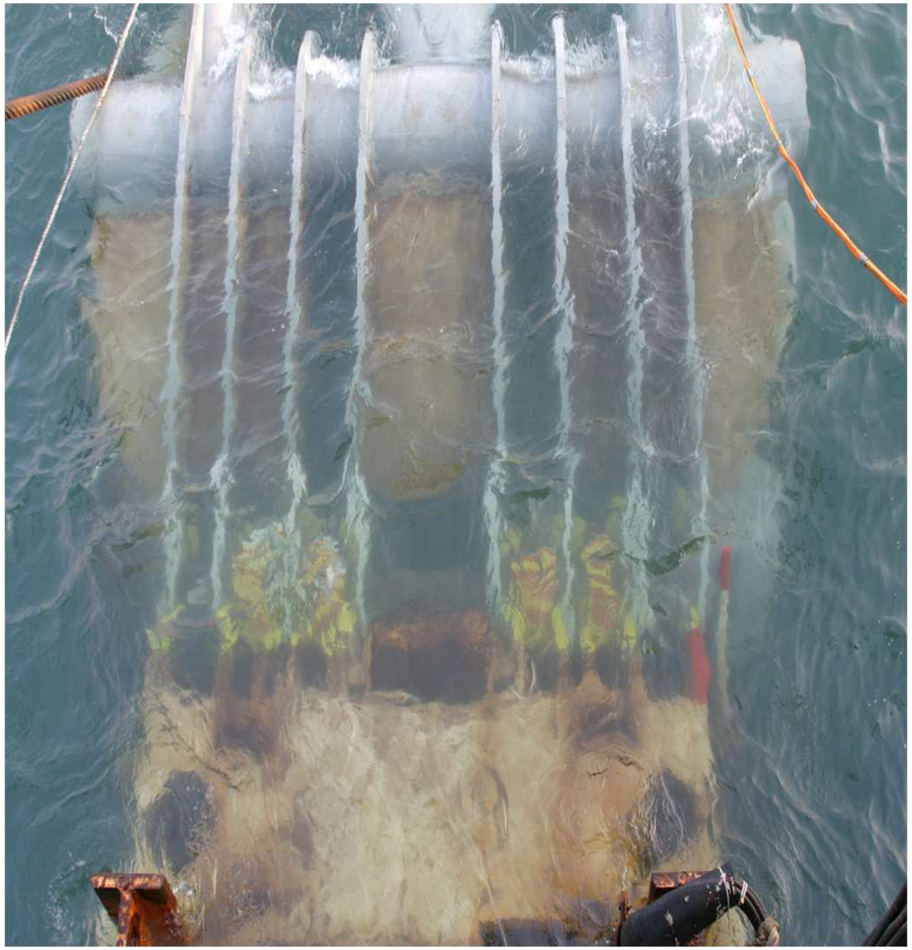
Typical Truss Stinger & Stinger hitched to the 'hitch point' at stern of barge immediately after last barge roller



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Recovery of Pipeline to Laybarge

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Recovering Pipeline from Seabed for Pipelay

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Barge moves backwards as Pulling Head is pulled in over the barge rollers

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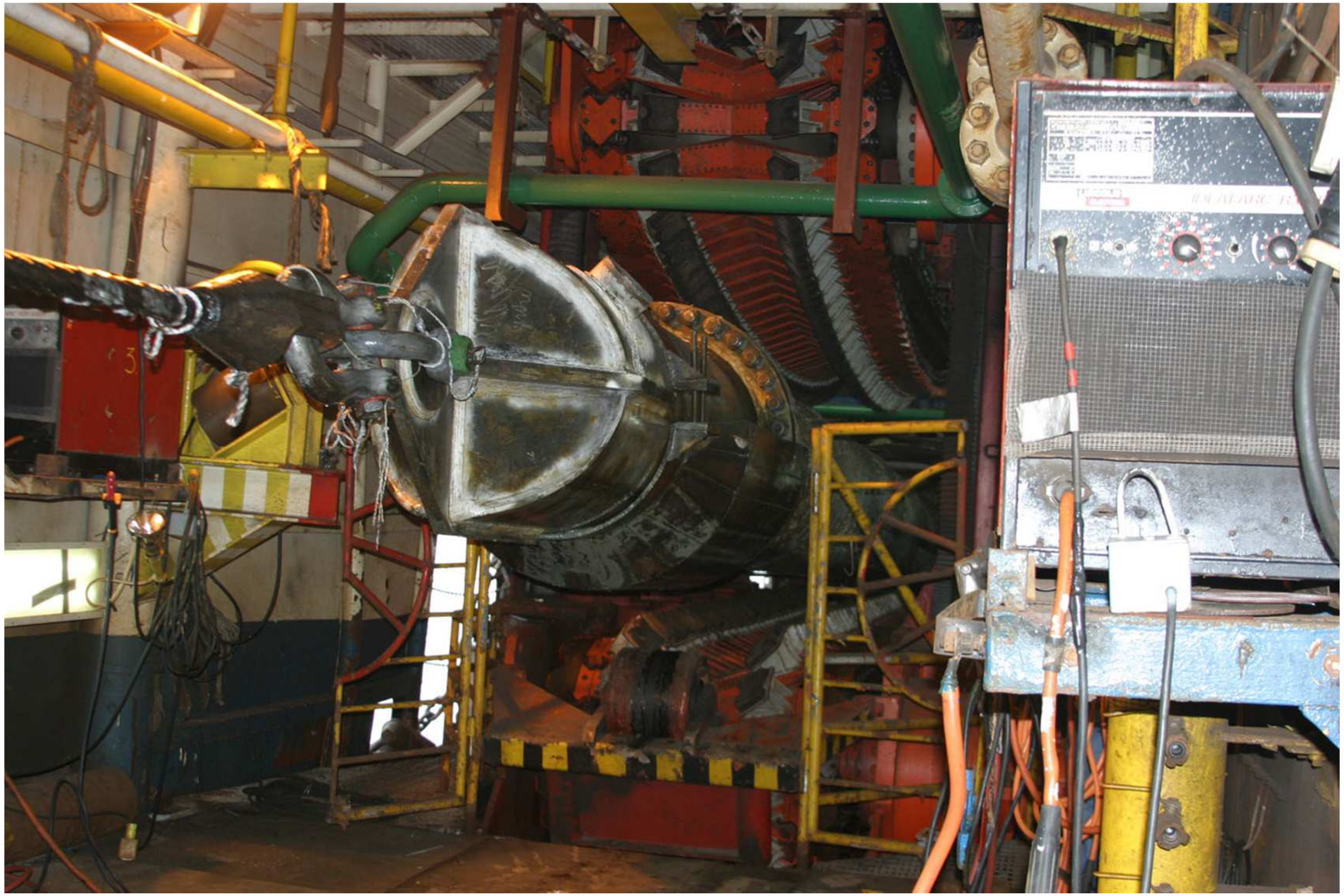
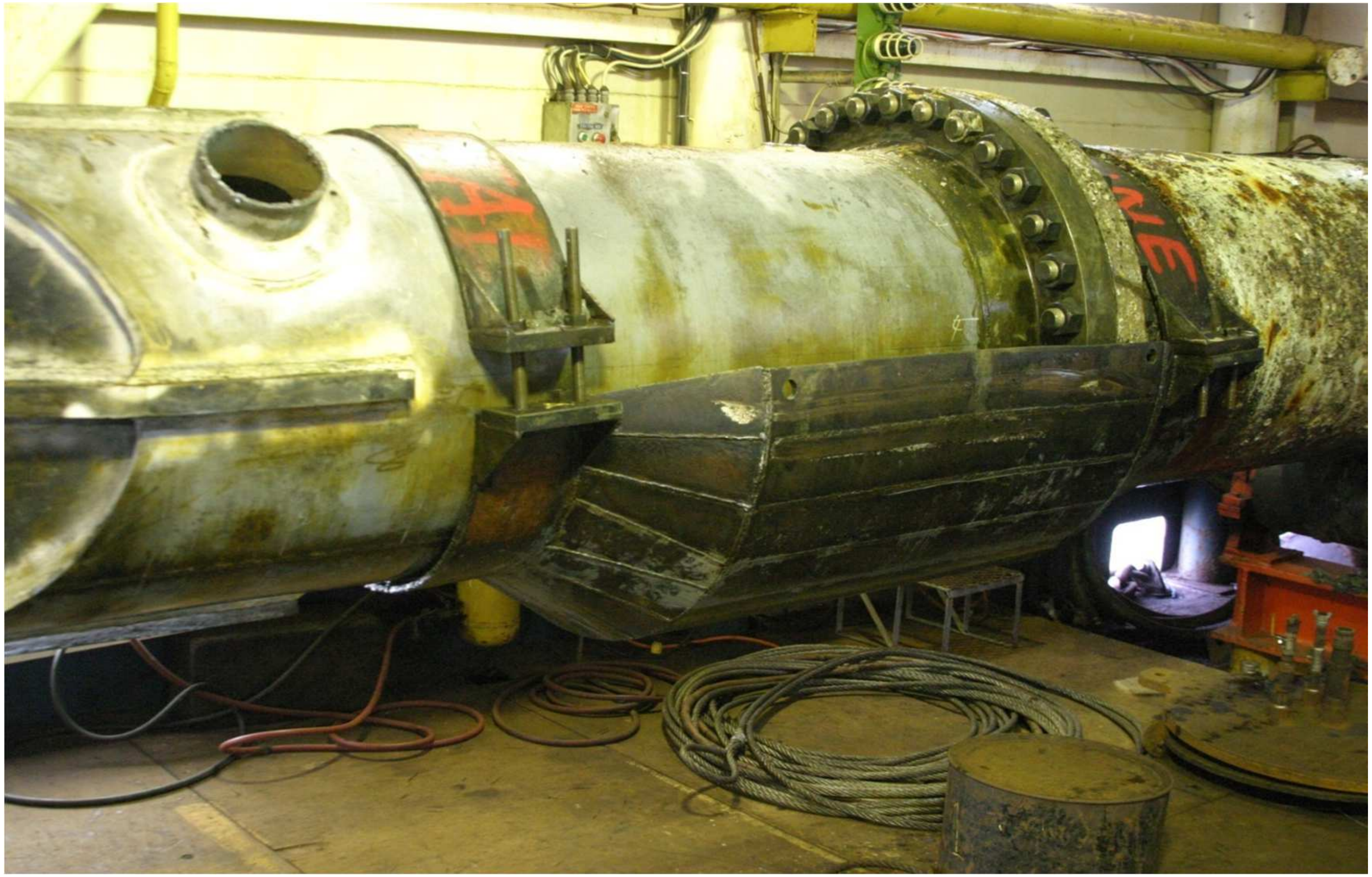
Pulling head is pulled past the tensioner



Flange Protection – to protect flame during Abandonment or Recovery



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Ends line pipe are grinded and cleaned prior to welding

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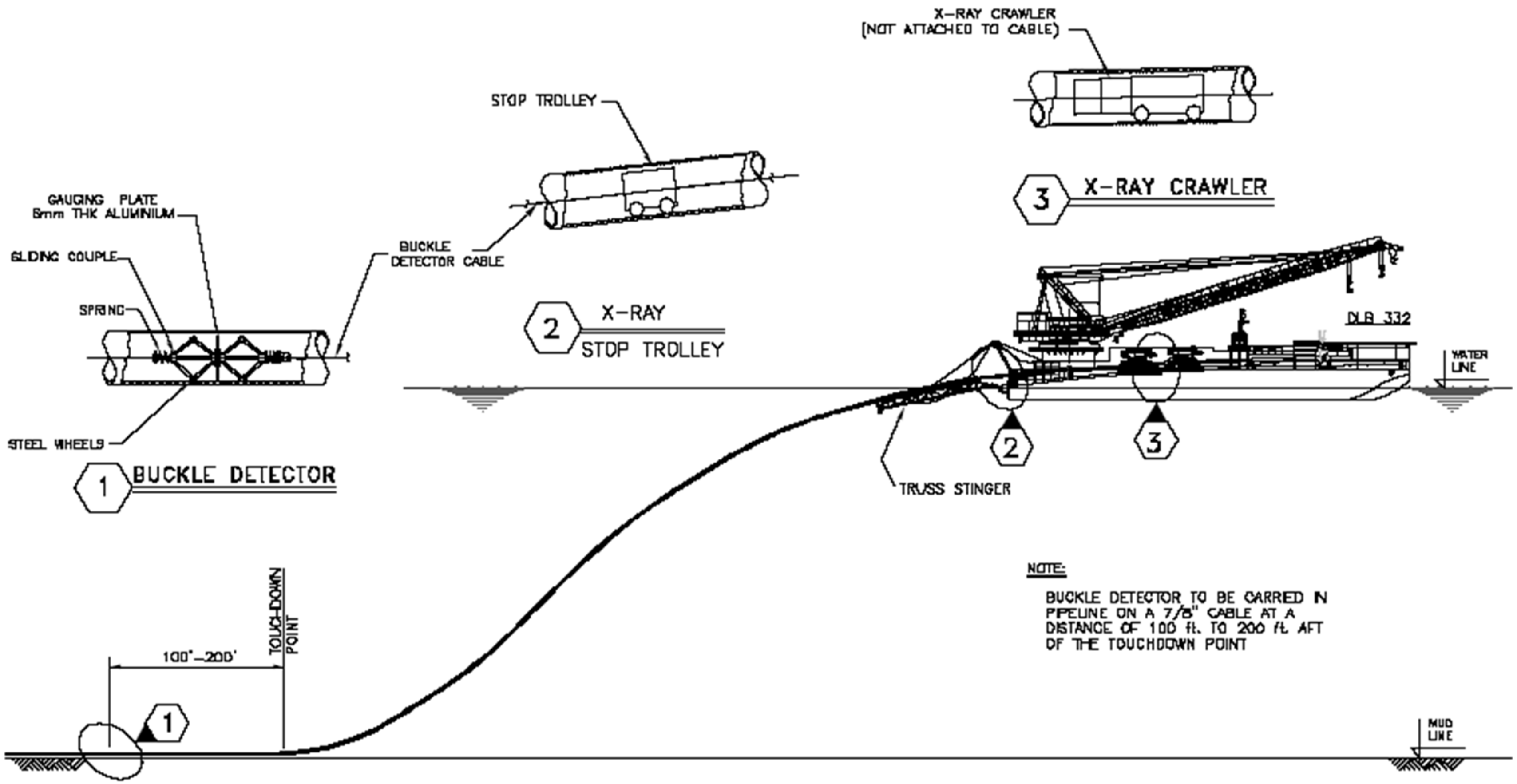
Location of Buckle Detector & Stop Trolley in the Pipeline



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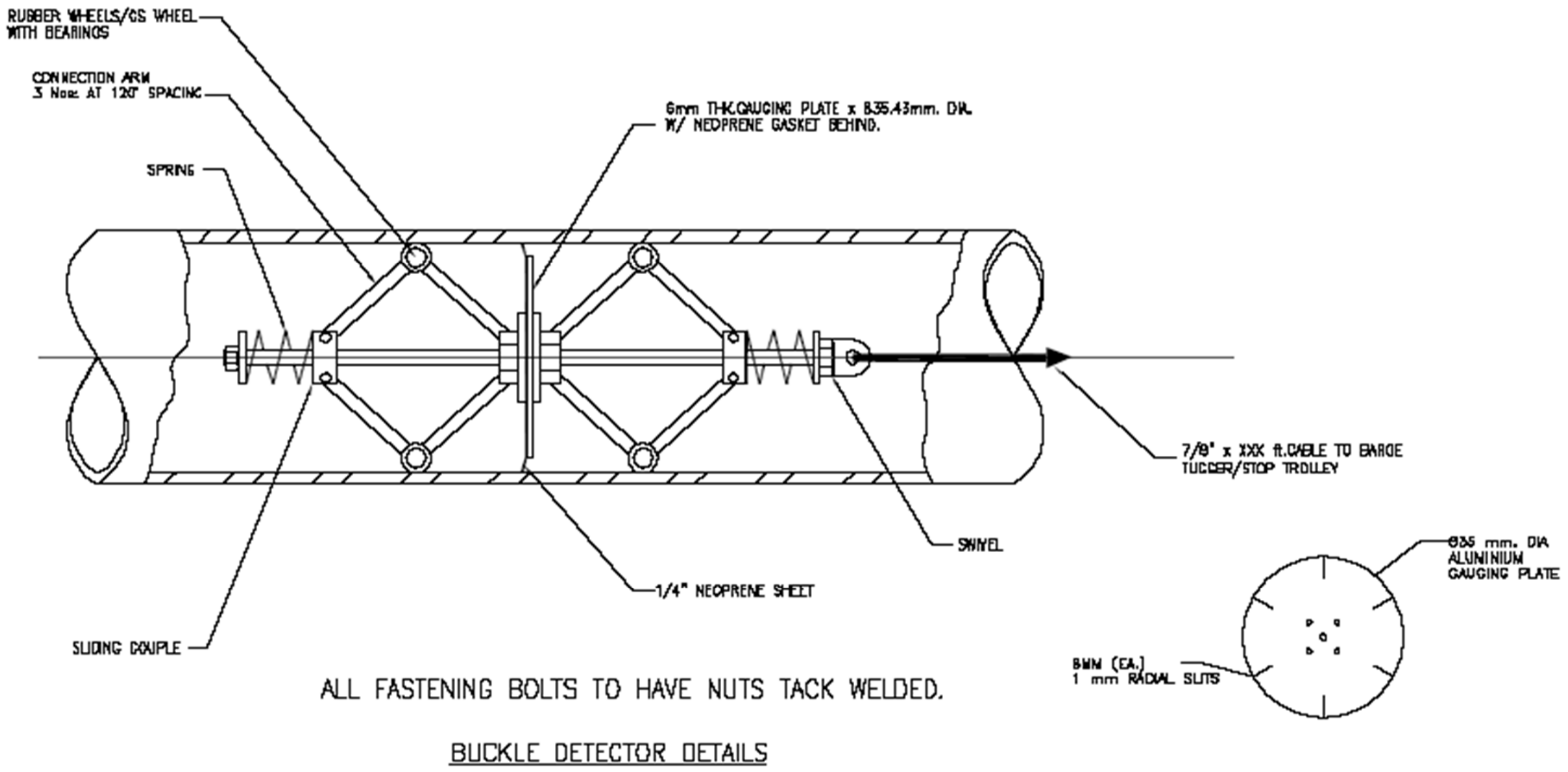
Buckle Detector Details



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Buckle Detector is place inside pipe, flange closed and B.D. 'blown down' to sagbend

Line is connected to the internal line-up clamp to pull it to alignment station

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Getting Internal line-up clamp to position

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R04

Aligning 2 joints of pipe at alignment station

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Joints are aligned properly and welding may begin

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Commencement of welding

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Manual Welding of Line Pipe

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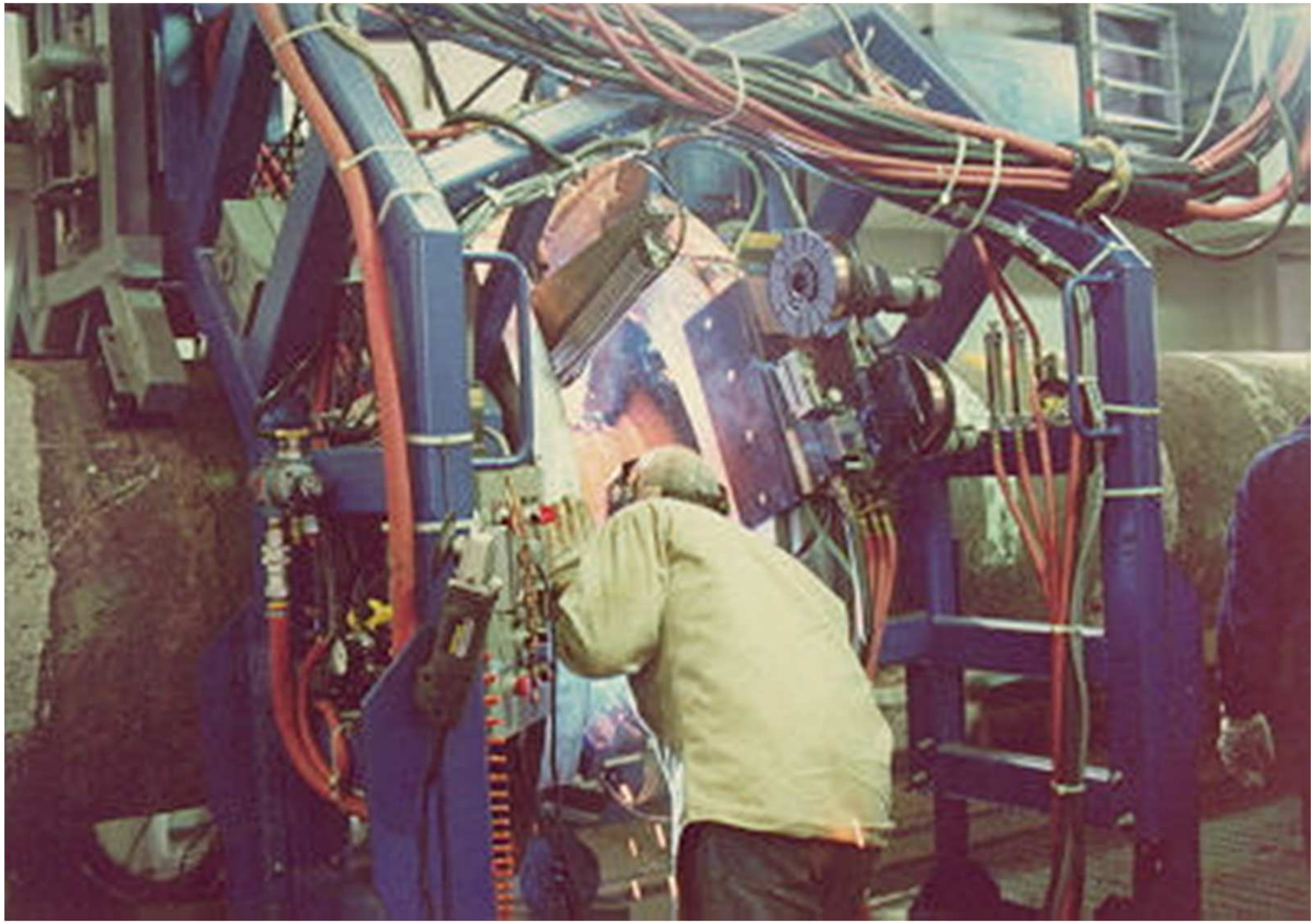
Tension Machine Applies Tension on Pipeline to Control Sagbend Stress

Semi-automatic Welding on Laybarge



Application of Corrosion Tape Wrap Foam Filling

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Pre-heating of pipe before wrap is applied

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Applying ‘cigarette wrap’ corrosion coat

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Final touches to the field wrap – ensuring a 'tight' fit

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Holiday Detector to Check for Integrity of Field Corrosion Wrap

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Container with Part A and Part B chemical, which when mixed will form the Polyurethane Foam

Pump for Injecting 2-part Foam System

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Wrapping plastic sheet, which acts as mould for foam injection

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Injection Foam Chemicals

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Removing Excess Foam

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What field joint looks like before it goes into the sea

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Installing Metal Sheeting for Mastic Pour (old days – extremely rare nowadays due to health hazards)

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Pouring Mastic into Field Joint Annulus

Cooling of Mastic before Field Joint enters Sea

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X-ray Film for wrapping around field weld

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Wrapping X-ray film around weld and locating X-ray machine to that location

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Trying to get the internal X-ray machine to the X-ray station

Primitive Lead Shield for use during X-ray

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X-ray Machine inside Pipe

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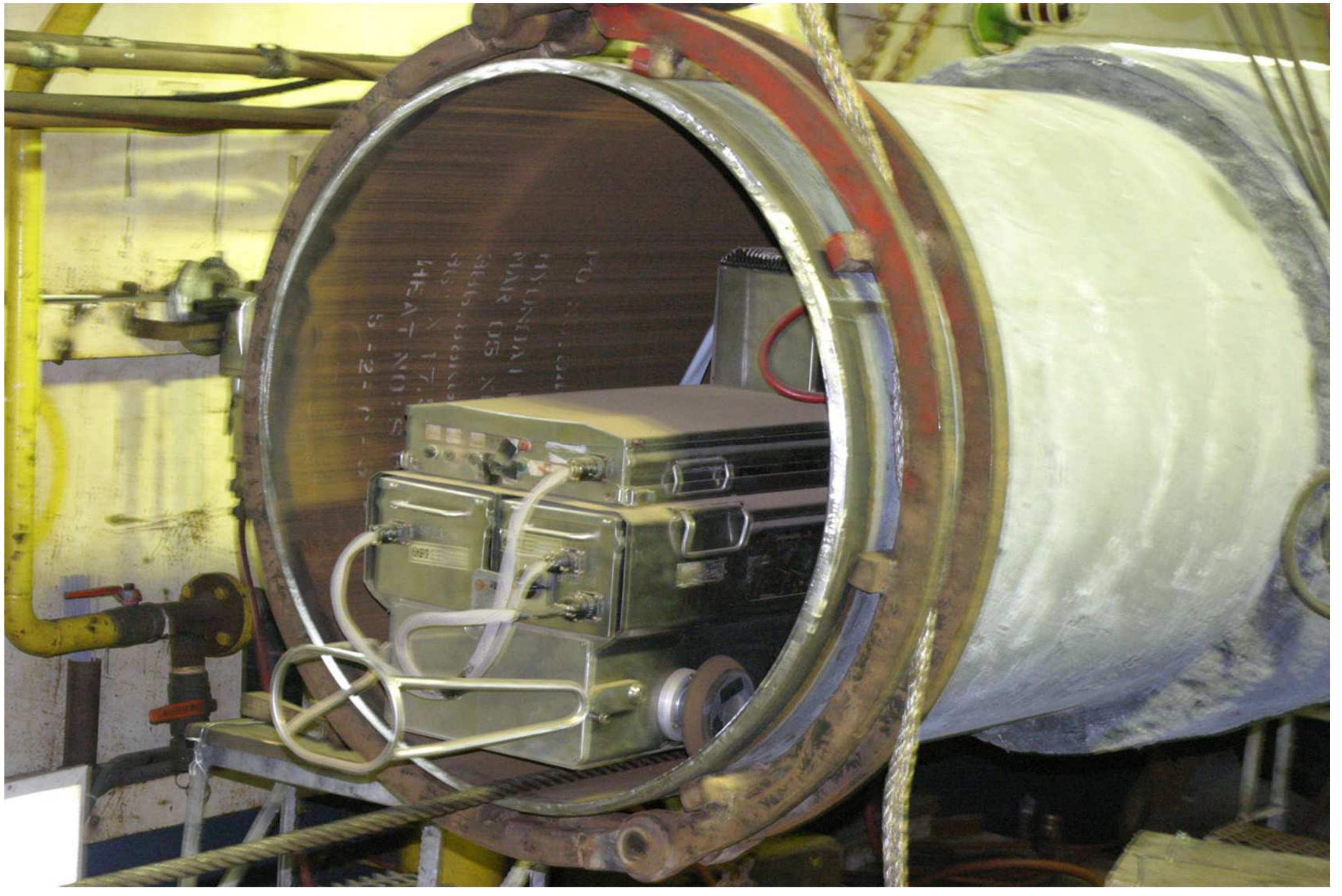

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Removing X-ray Machine

Removing ‘stop trolley’

Removing Buckle Detector

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DIKAWA

An undamaged Gauging Plate on the Buckle Detector Confirms that Pipeline has not been damaged during Pipelaying

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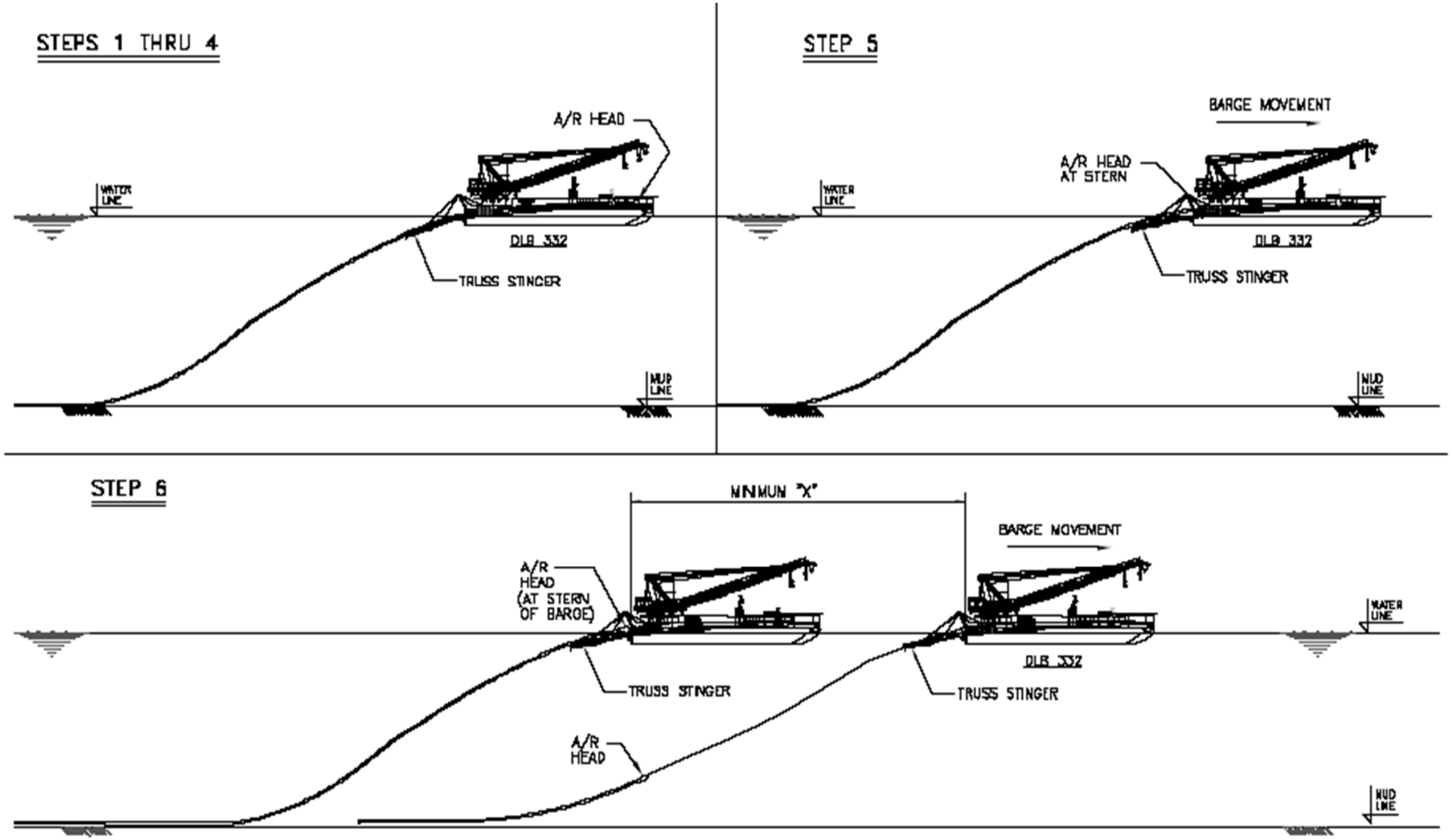
Abandonment Procedure



Aligning Pulling Head to End of Pipeline for Welding

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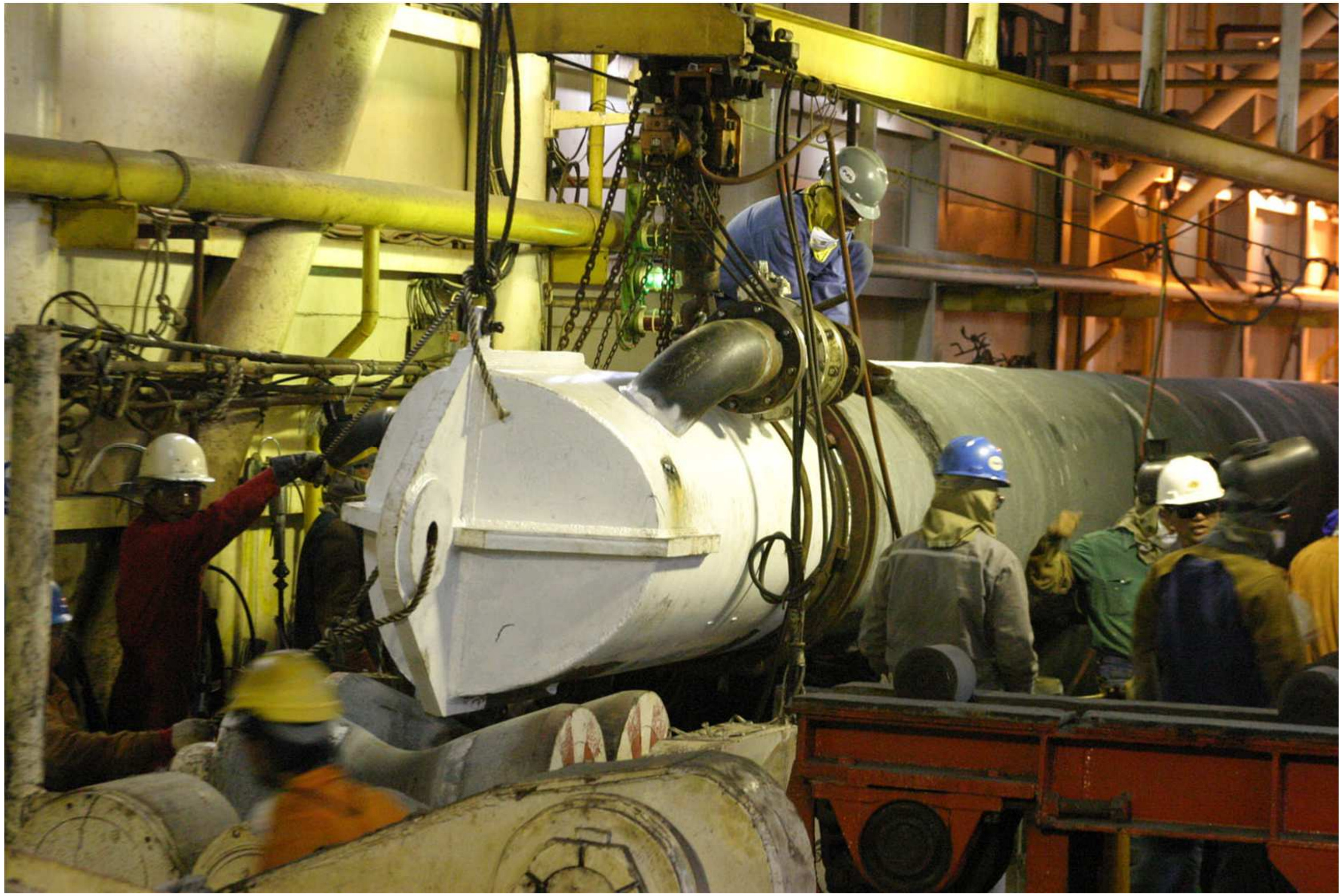
Welding of Pulling Head



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A&R Wire Attached to Pulling Head and Pipeline is Ready for Abandonment

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Strapping of Davit Lift Attachment Point to facilitate subsequent Davit Lifting Operation

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Tension is Transferred from Tensioner to A&R Winch, and Tensioner is Opened Up

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Pulling Head goes down last barge roller and onto Stinger

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After pulling head leaves the stinger, the barge moves forward on its anchors and pay out A&R wire

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Snapshots from EMAS AMC's operation in Thailand

(on Laybare 'Lewek Champion')

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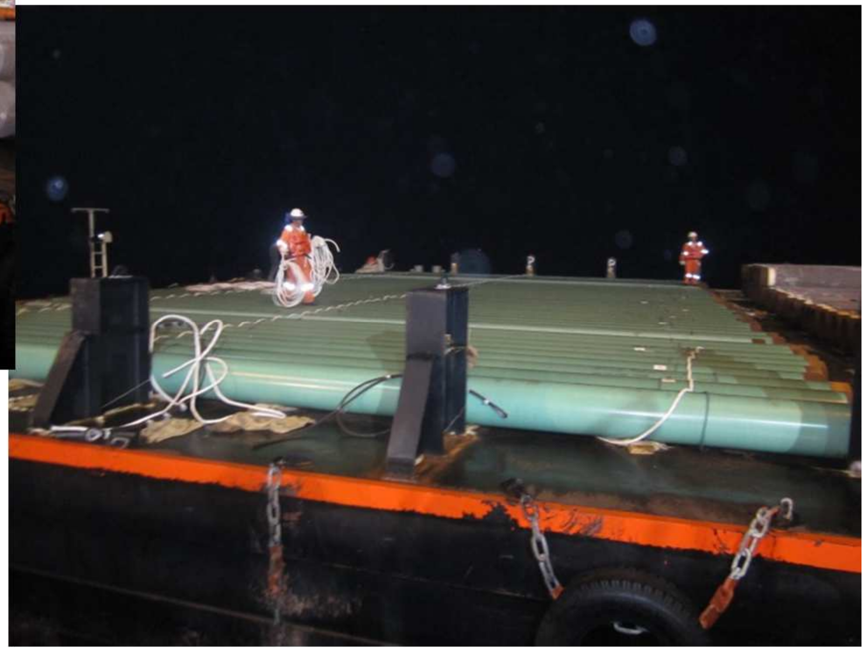
Line pipe arriving at site and being loaded onto laybarge (Champion)



Grit blasting of field joint on Lewek Champion in preparation for application of corrosion coating

Grit blasting, pre-heating, application of HBE (high build epoxy) coating and holiday detection of field joint coating

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Application of heat shrink sleeve on Lewek Champion

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Completing field joint coating

Installing sheet metal on field joint before injecting foam

High density foam is creating through injection of a 2-part chemical

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Connecting the laydown head (launcher/receiver) to end of pipeline via flange connection

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Tightening bolts using hydraulic tensioner

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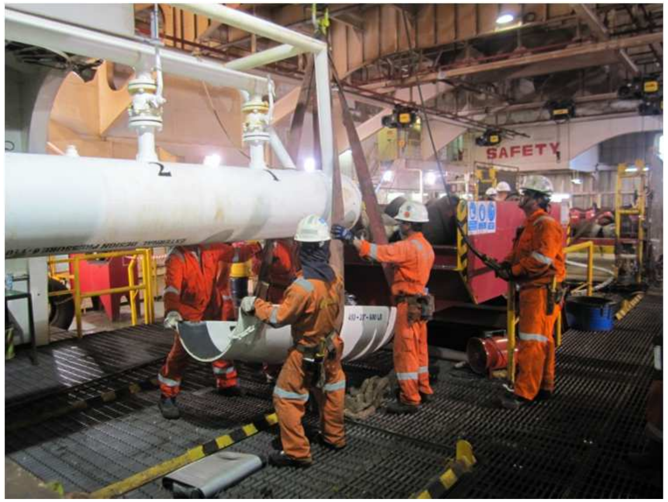
Installation of flange shroud to facilitate movement of flange along the rollers and down the stinger



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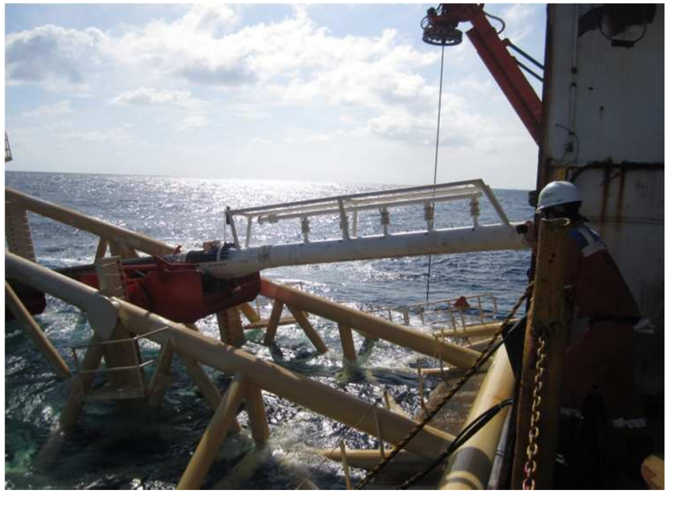
Laying down pipeline at end of pipelaying (a.k.a. pipe abandonment)



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Davit Lifting of Pipeline for ‘Stalking on’ of PLEM/Riser

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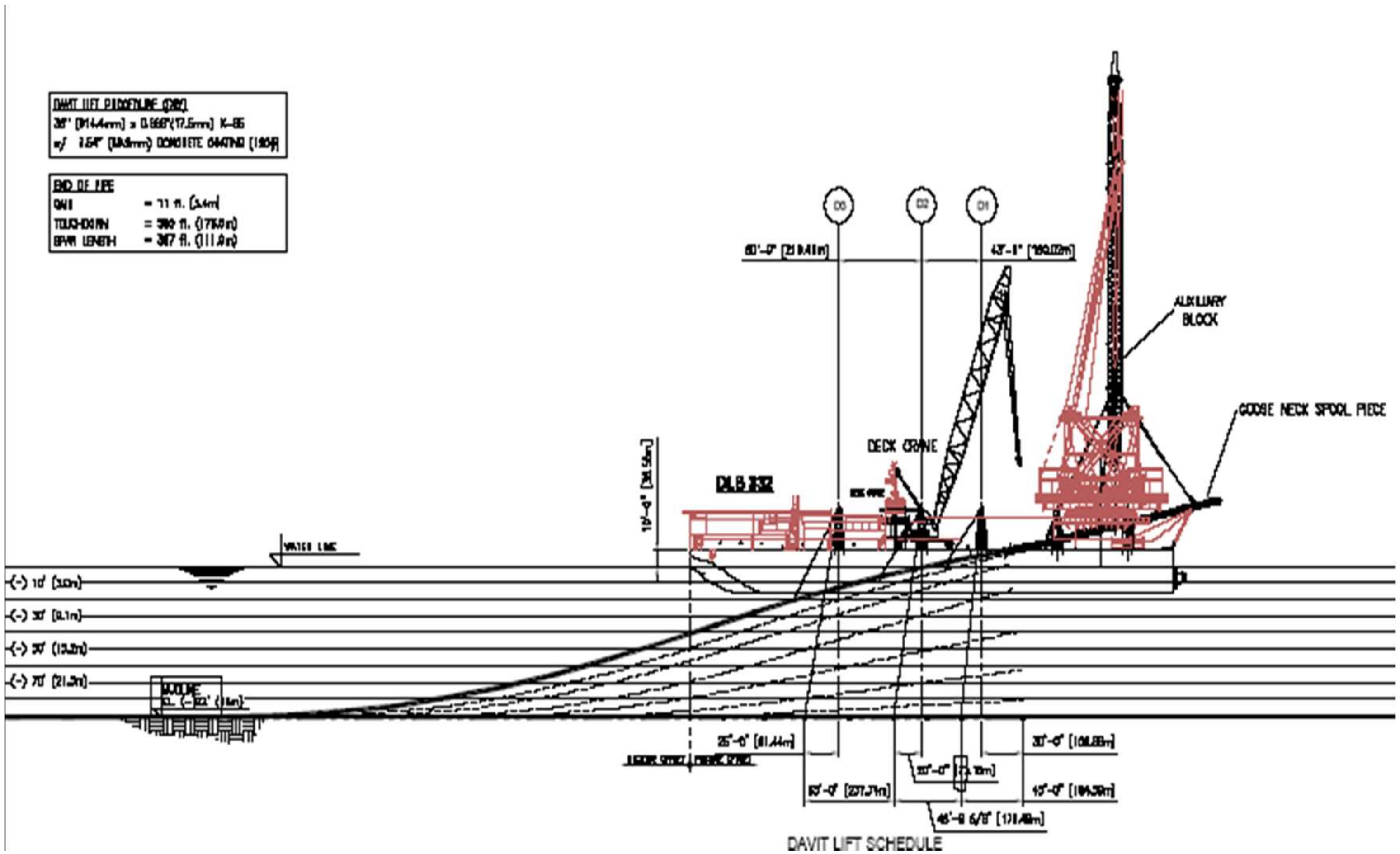
Davit Lift Sequence – Lowering is Reverse



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Pipe is picked up by Davits in Controlled Manner till Pulling Head is ‘sufficiently’ above waterline

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Pulling head is Cut and Removed

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Field cut is grinded and bevelled for welding to another section

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Stabbing Guide is attached to pipe end to facilitate Stalk-on operation

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Rigging up PLEM for Lifting

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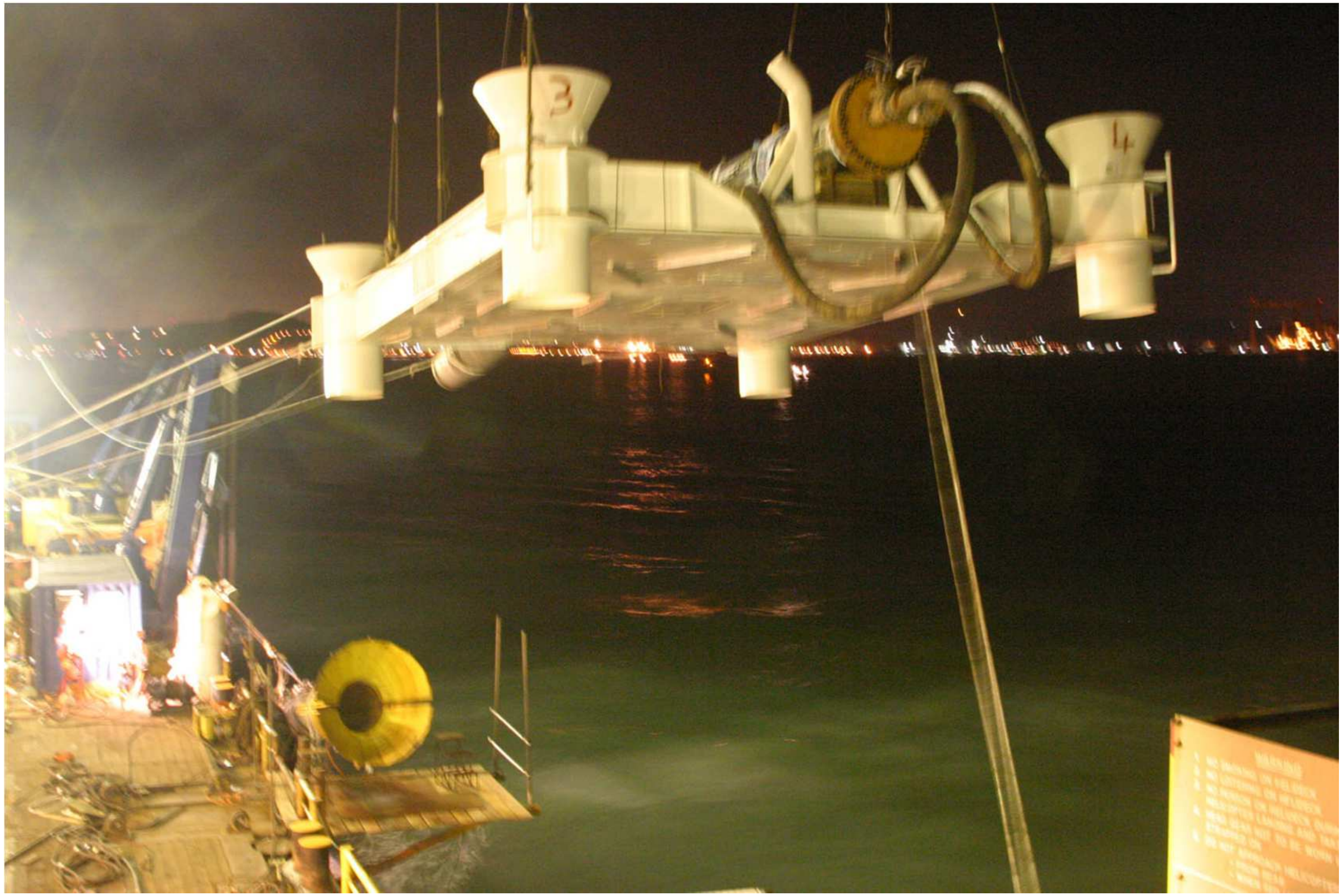
Lifting PLEM for Stalk-on to lifted pipeline



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Aligning PLEM pipe to lifted pipeline for welding

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Field Welding carried out in open sea – Canvass cover used to block the wind

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Installing 'Rockguard' wrap instead of Foam at Field Joint

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Final touches before PLEM is lowered

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Commencement of PLEM lowering

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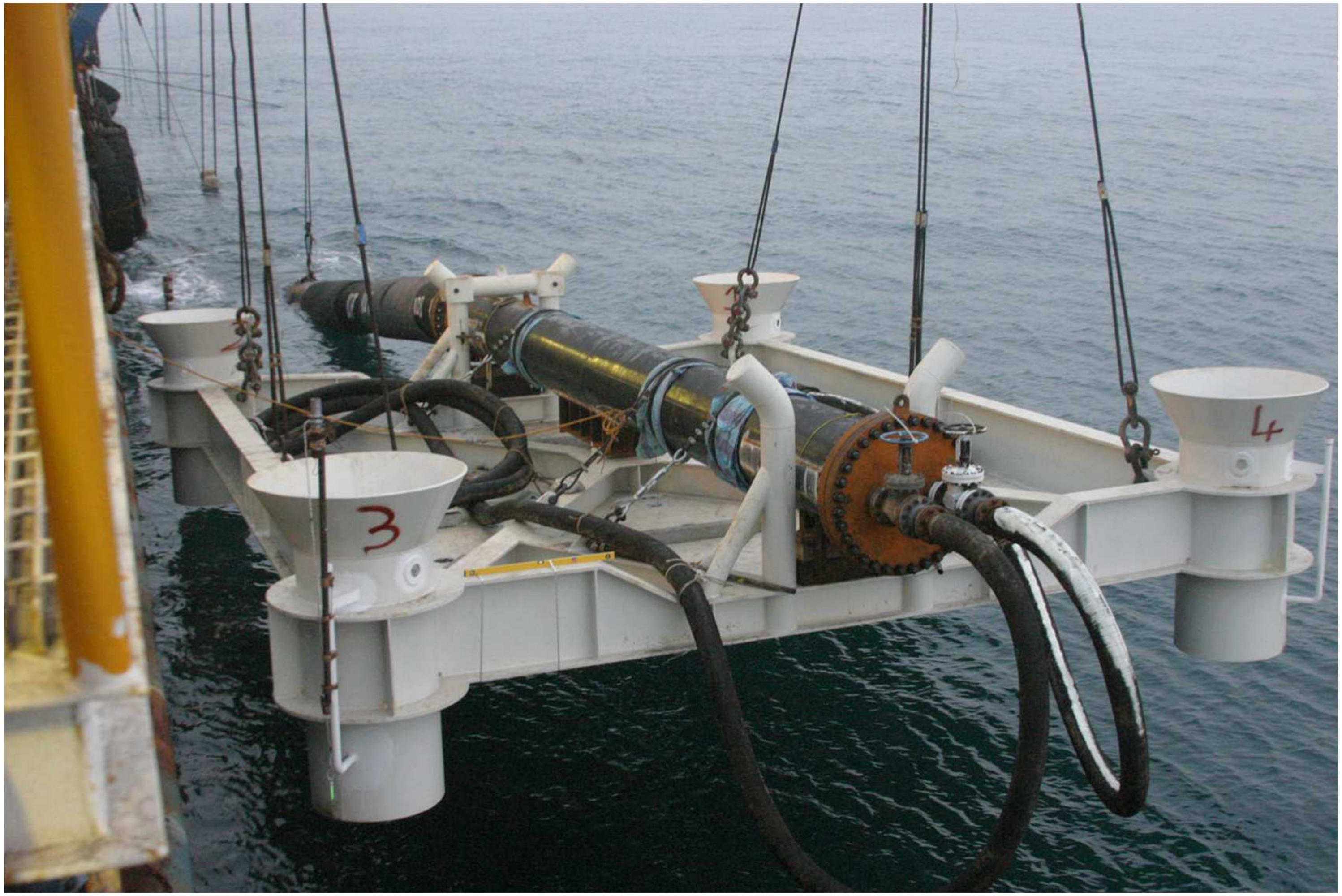
107
108
109

PLEM being slowly lowered into water by carefully executed davit lowering procedure



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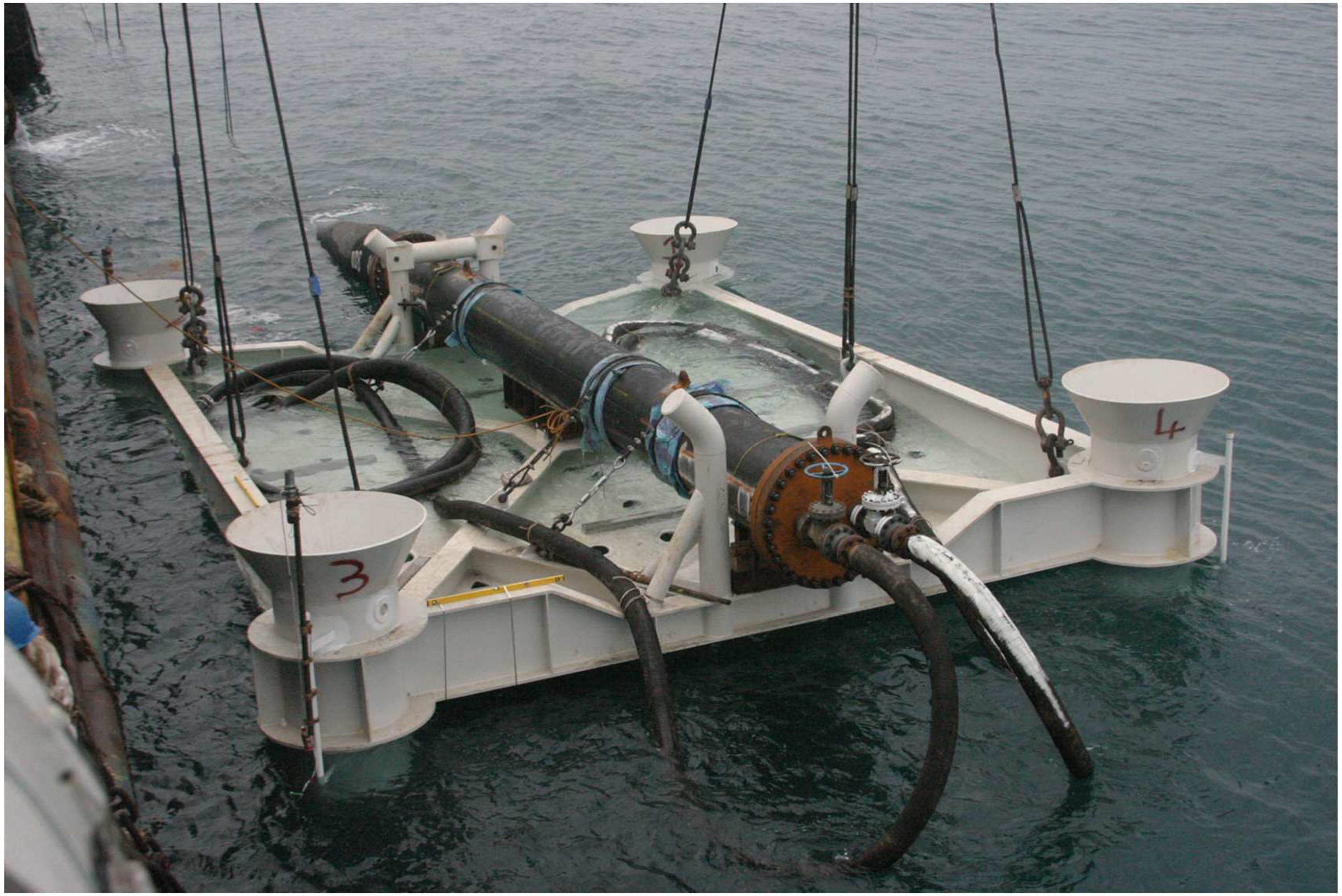
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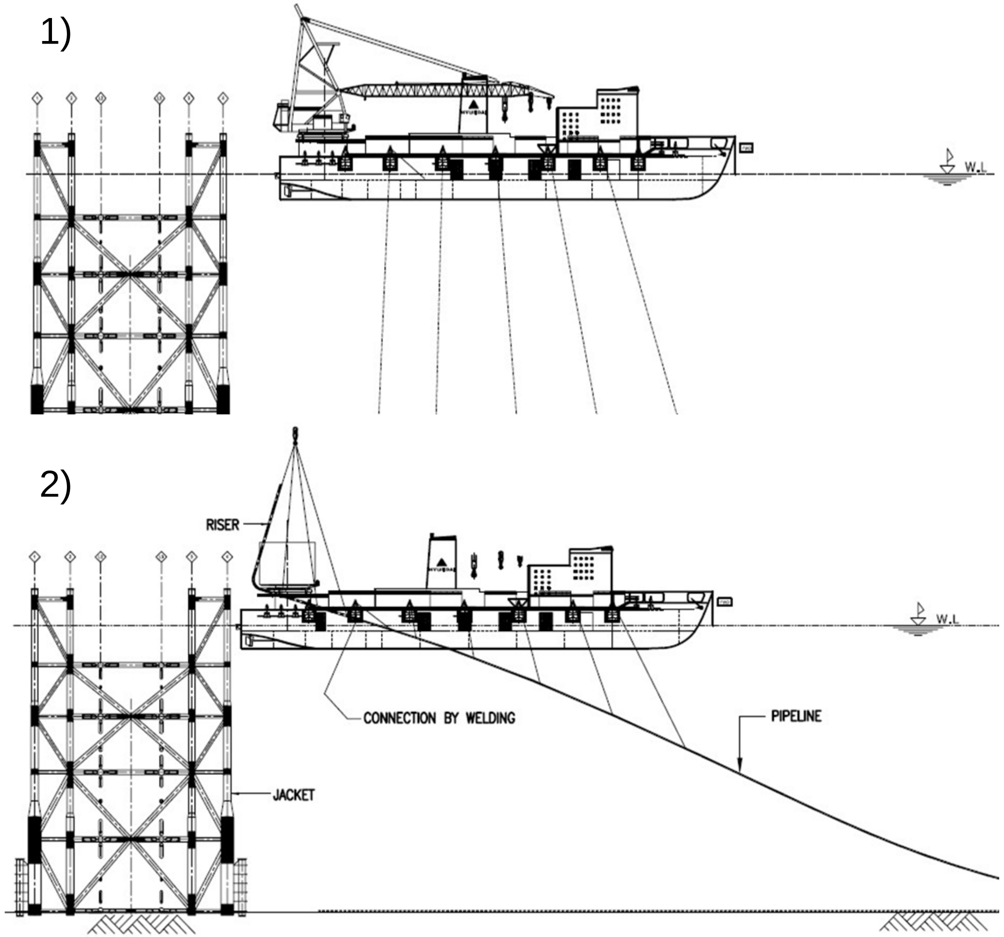
RISER INSTALLATION BY STALK-ON METHOD

1)

2)



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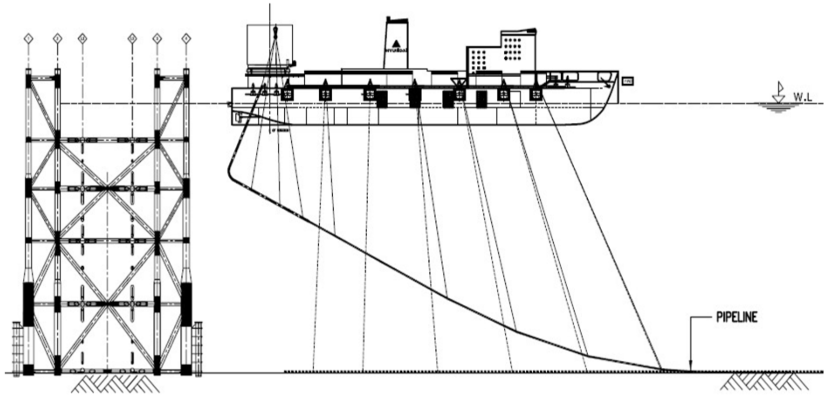
RISER INSTALLATION BY STALK-ON METHOD (CONT'D)



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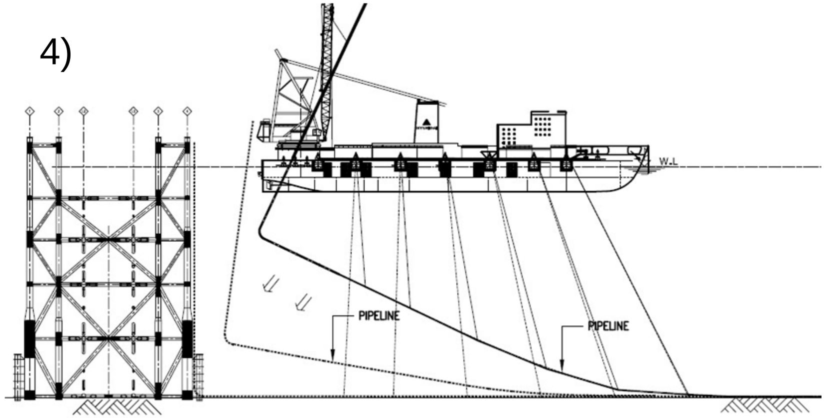

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Piling of PLEM

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Installing Pile Guide Frame on side of Barge

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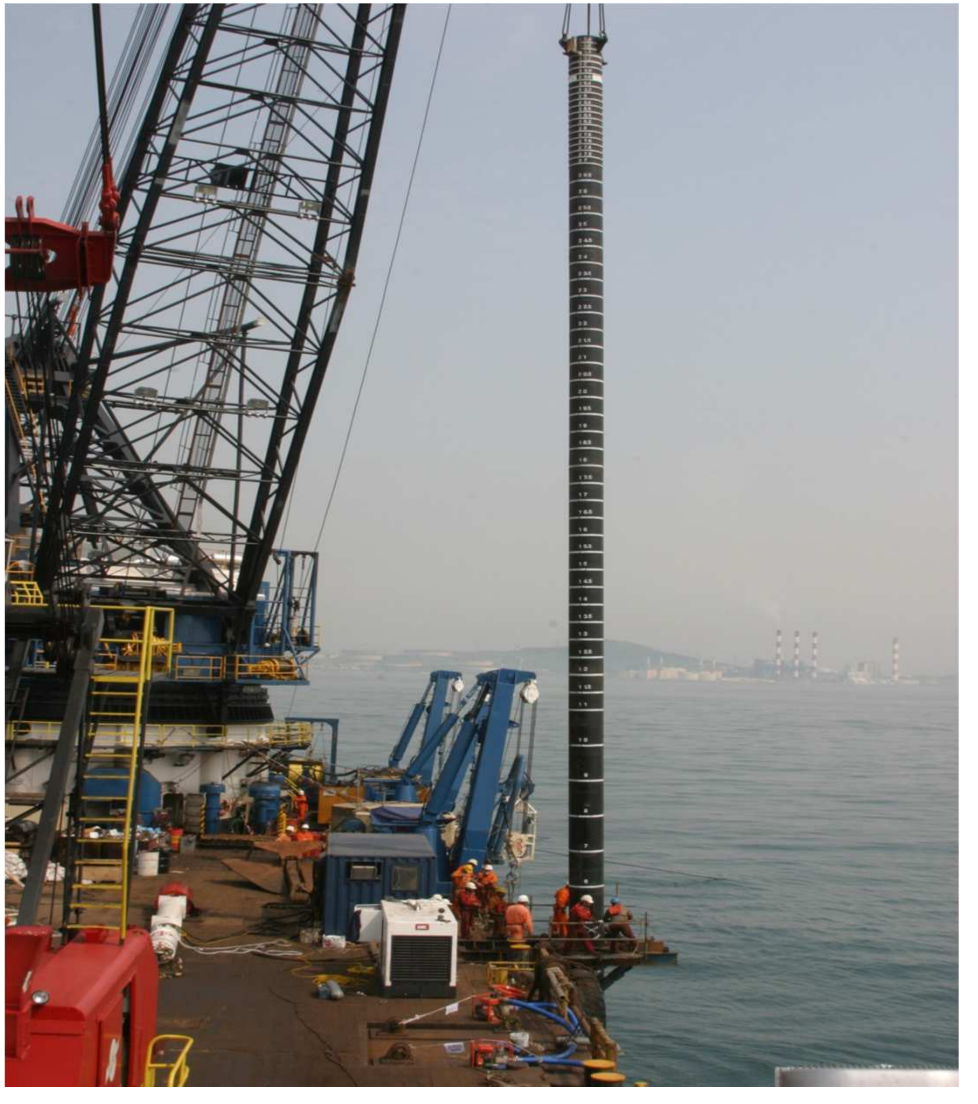
Stabbing Pile over Guide Frame



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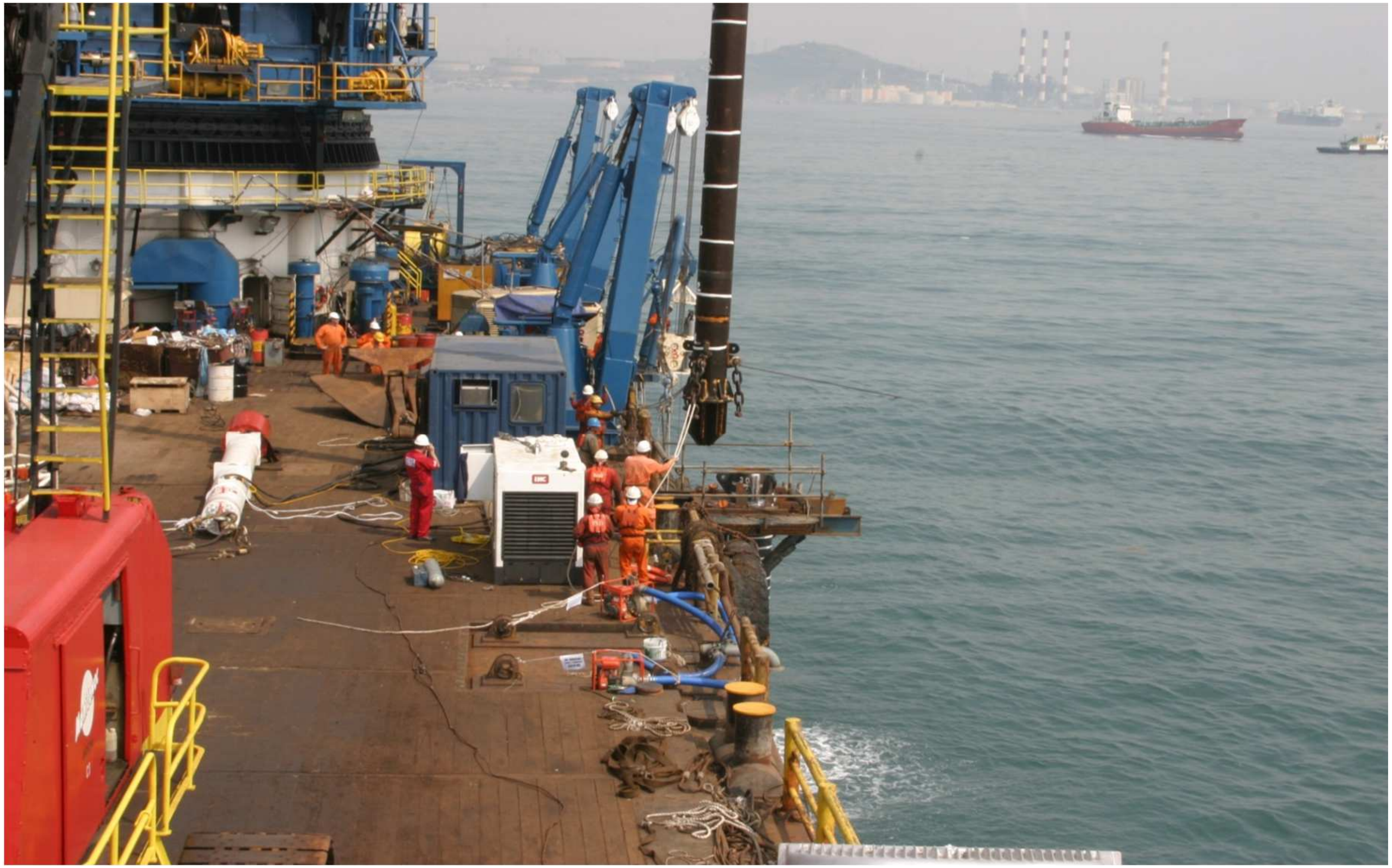
Placing Stabbing Guide over Pile



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Lifting Hydraulic Hammer for Placing over Pile

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Driving Pile with Hydraulic Hammer

End of Piling – Pile has reached Desire Penetration

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“Unconventional Pipeline Installation by Bottom Pull Method – Project Example (Landfall to landfall)

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Shell Singapore :
Bundle of 8 pipelines and 2 Fiber optic Cables

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Stringing of Line Pipe to form Pipe Strings

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Completed Pipe Strings Ready for Bundling prior to Bottom Pull

View of Stringing Yard, Showing Bundle Pull in Progress

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Pipe Bundle on Lauchway complete with buoyancy drums ready for Pull

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Attachment of Buoyancy Tanks on Pipeline Bundle

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Pipeline Bundle Installation by Bottom Pull

Pulling Winch in Operation at the Pulling Site

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Pulling Winch at the Pulling Site

Singapore PUB: Twin Water Pipelines

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CNOOC : Weizhou Pipeline Project

W Natuna Pipeline Tuas Crossing : Bundle of 3 Pipelines

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"Unconventional Pipeline Installation by Bottom Pull Method – Project Example (Landfall to Offshorel)

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Linear Winch on the Pull Barge

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Excavating Soil on Both Sides of Pipeline During Low Tide

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Removing Buring Pull Wire from Soil During Low Tide

Oil Drums Strapped to Pull Wire to Prevent Cable Sinkage Due to Soil Liquefaction

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“Unconventional Pipeline Installation by Surface Tow (Rentis) Method –

Project Example

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Surface Tow Method – Pulling Pipe Bundle to Beach

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Launching of Pipeline Bundle

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Putting 'Jumped' Trolley Back on Track

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Launching of Pipeline Bundle

Trailing End of Pipeline Bundle Entering Sea

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Towing of Pipeline Bundle to Site

Connecting Pulling Head to Pre-installed Wire at Platform Leg

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Retrieval of Stripping Wire

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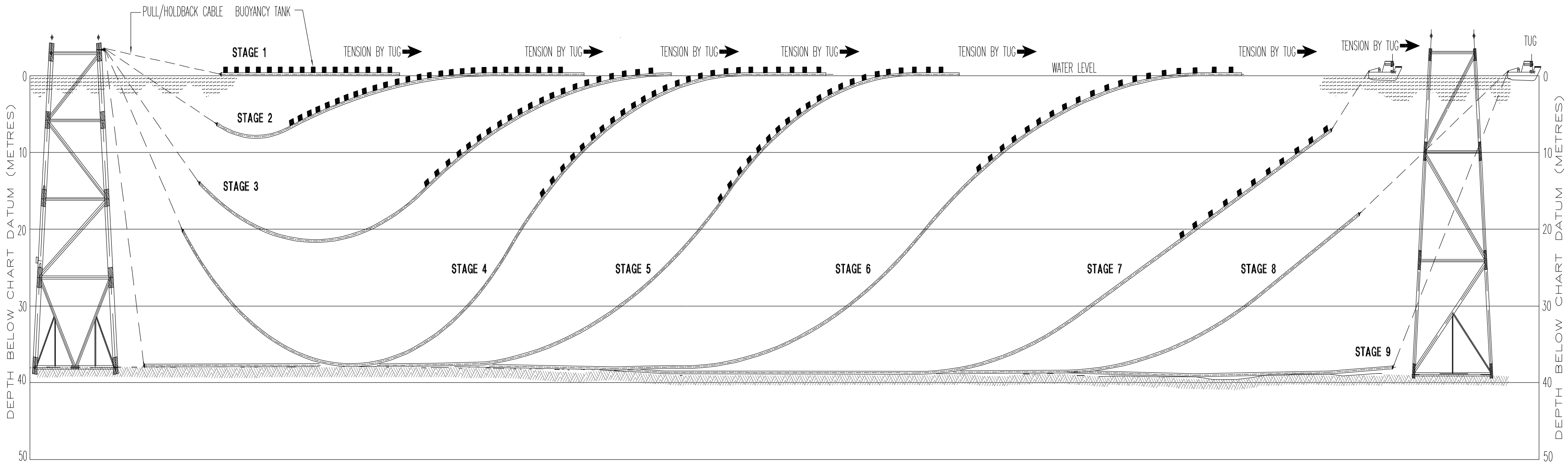
Schematic Showing Stripping of Buoyancy Drums and Laying of Pipeline



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Commencement of Buoyancy Drums' Removal

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Stripping of Buoyancy Drums in Progress

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Final Stage of Buoyancy Removal – Note that Pipeline has Partially Settled to Seabed

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Collection of Buoyancy Drums after Pipeline Installation

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“Conventional Pipeline Installation – Initiation Types

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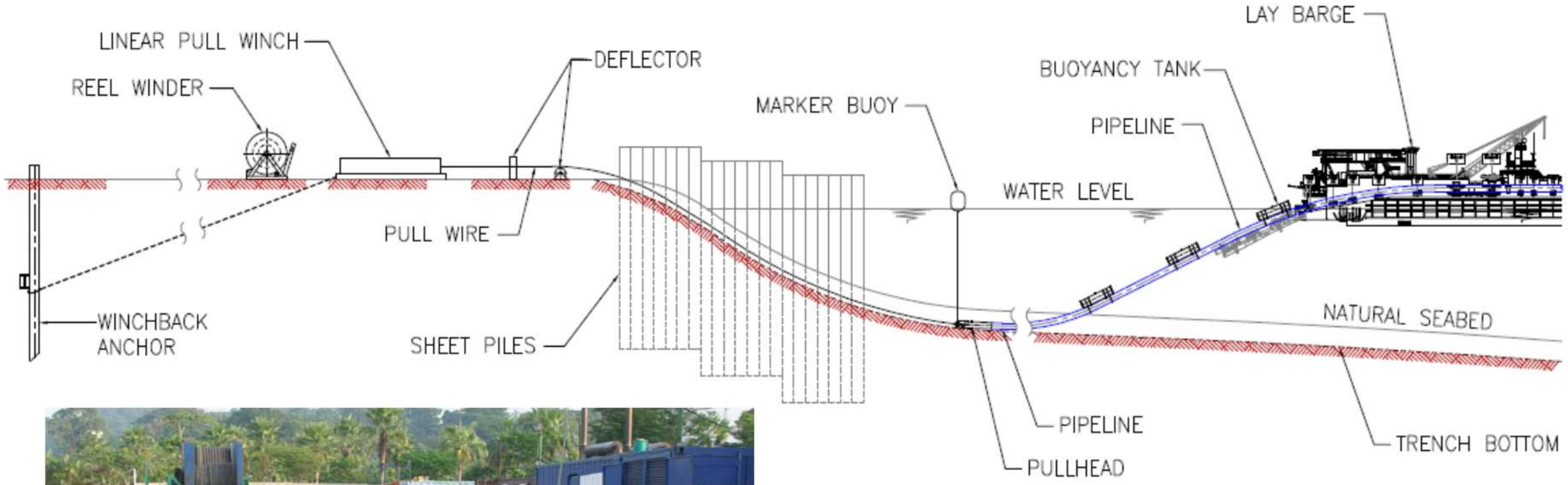
Concept for the Pipelay Initiation at Shore Approach using Linear Pull Winch



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Typically Beach Pull Operation for Pipelay Initiation

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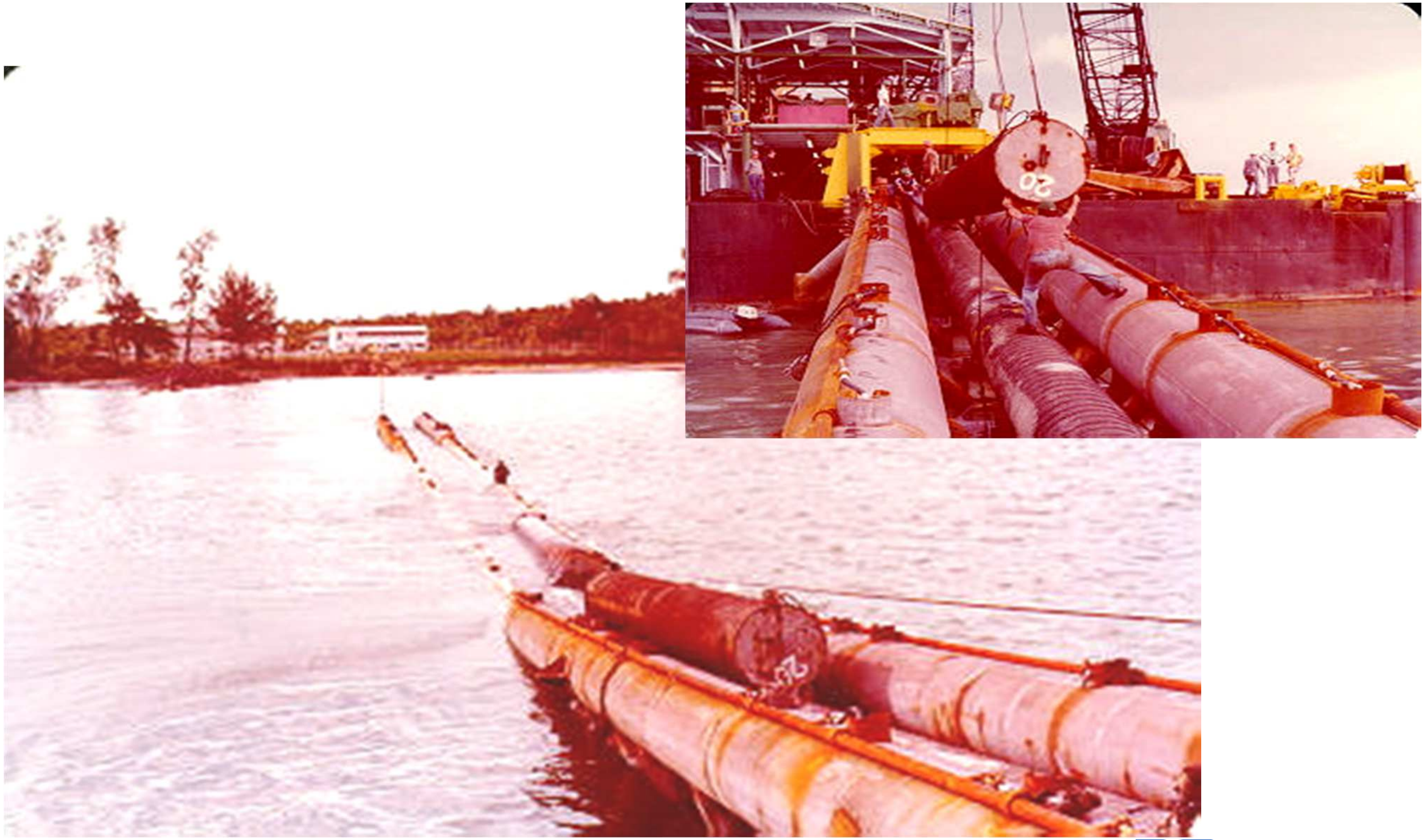
Pipelay Initiation – Pullhead being Pulled to Beach



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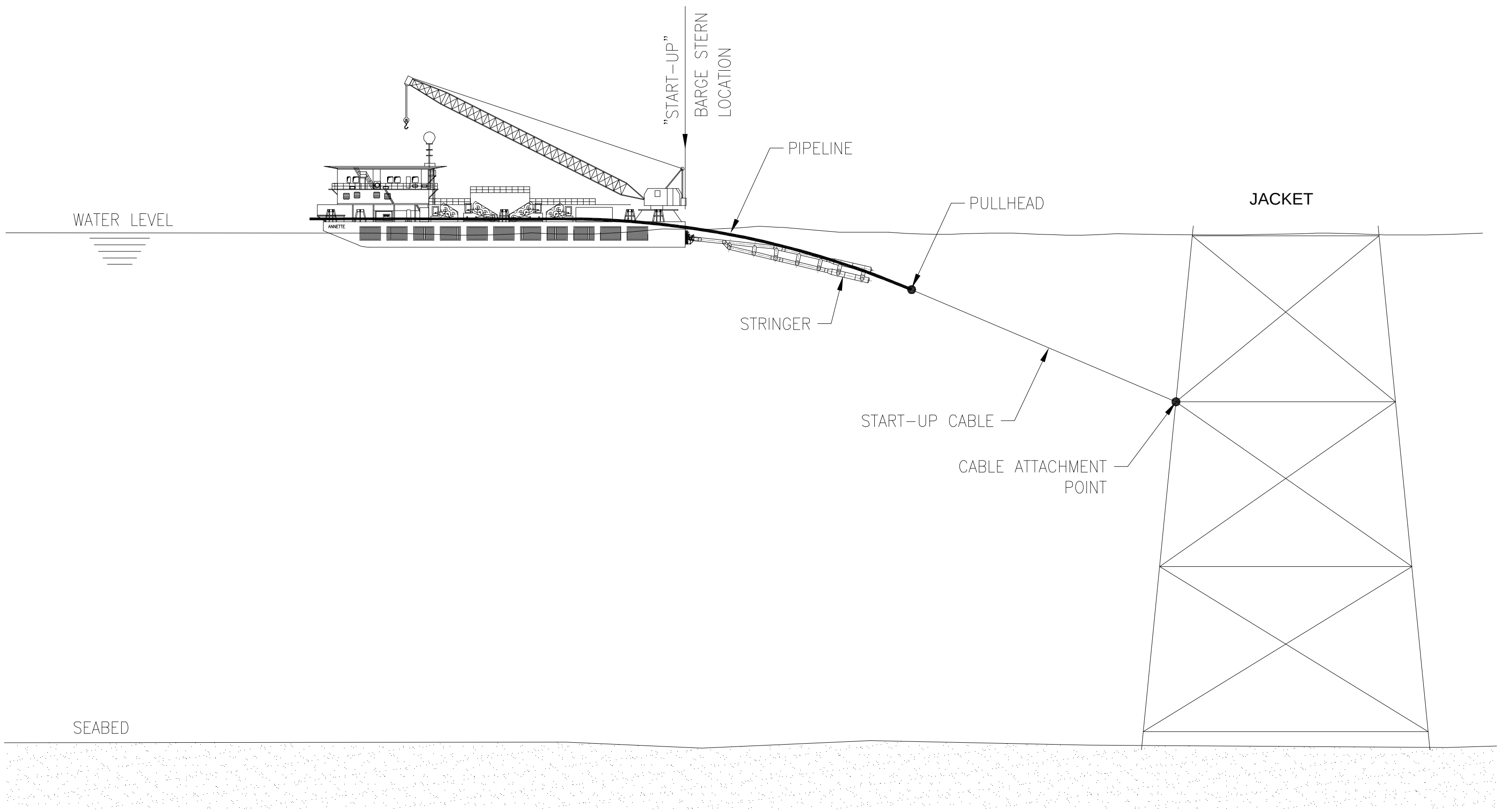
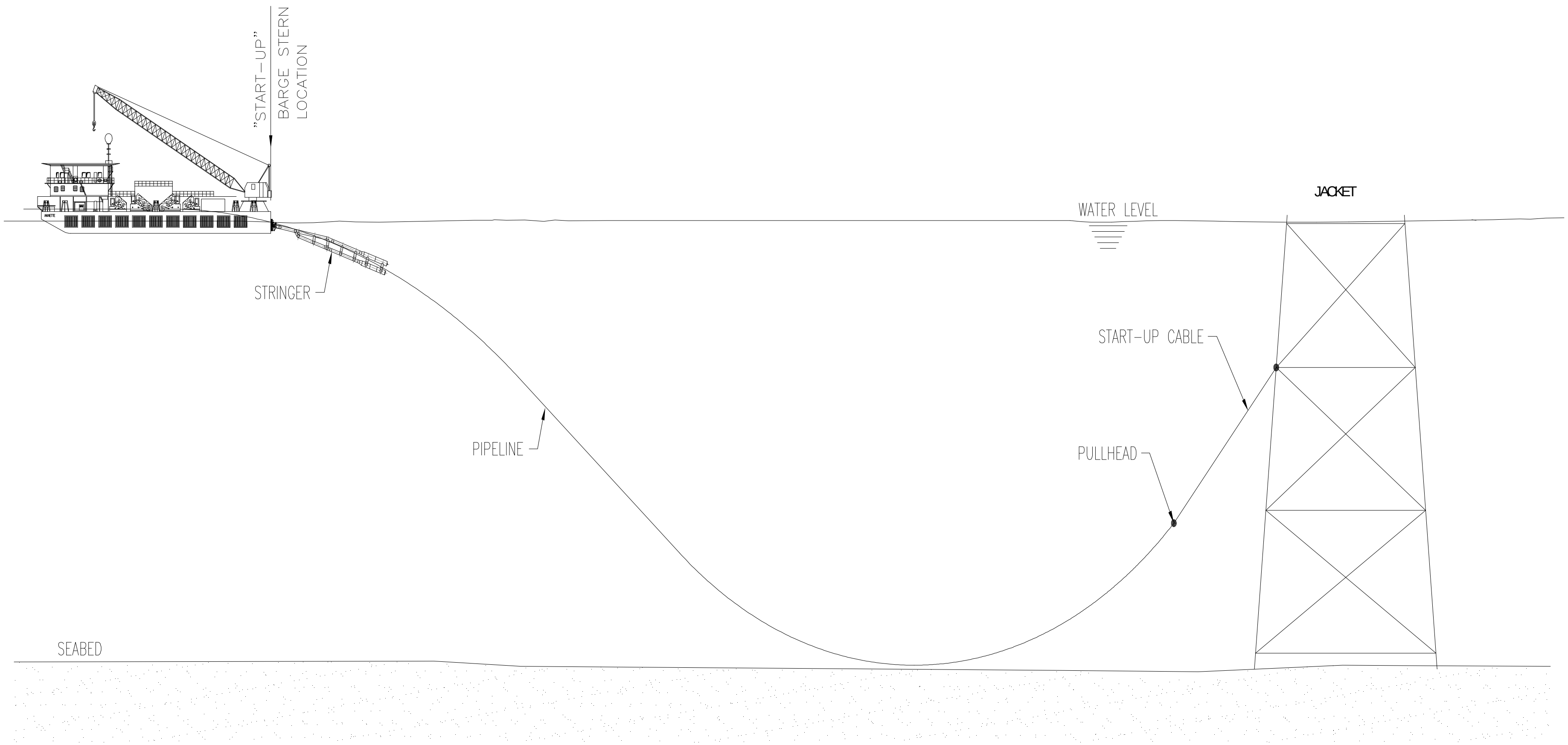


JACKET START-UP (INITIAL)



JACKET START-UP (FINAL STAGE)

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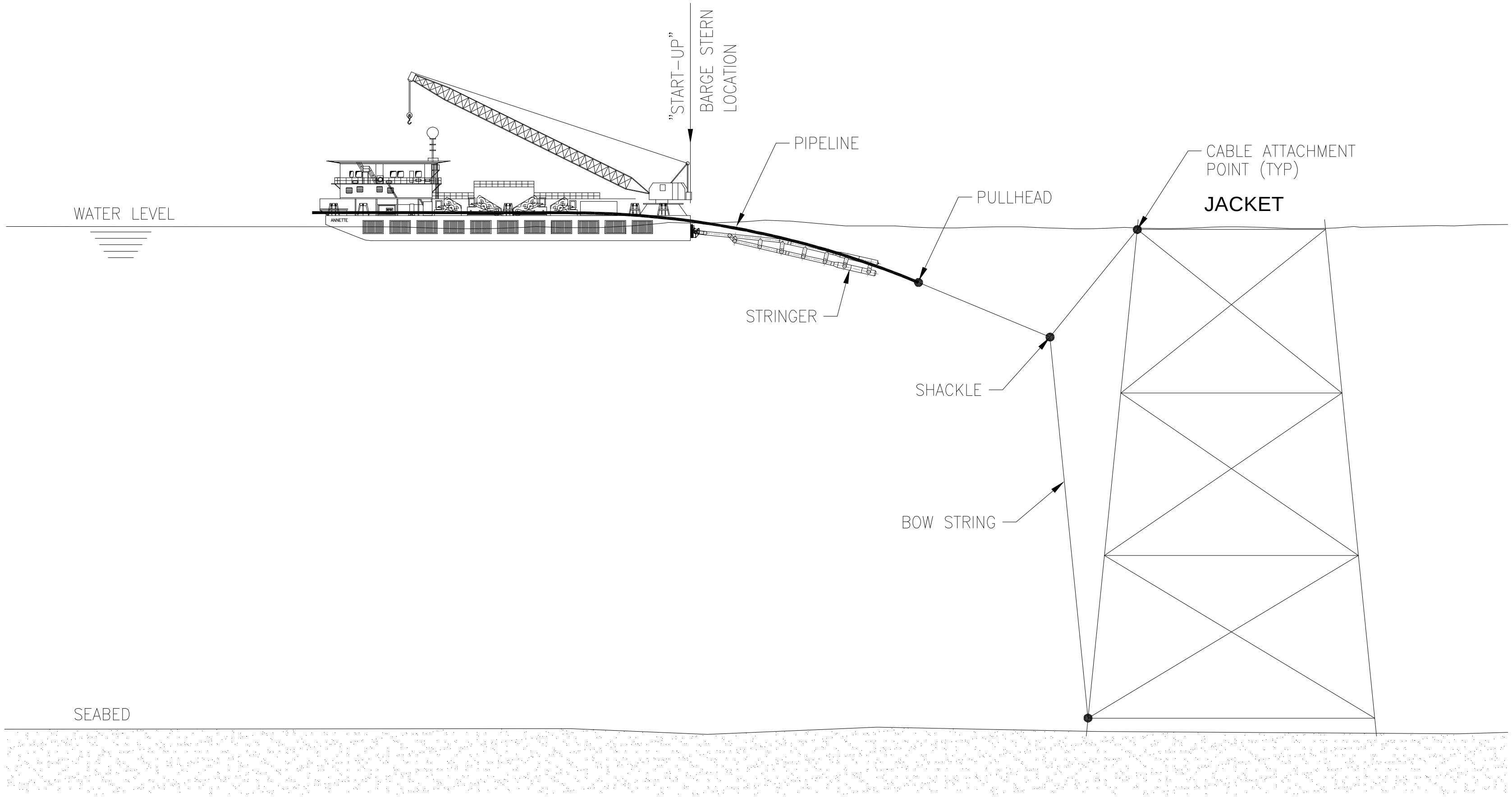

BOW STRING START-UP (INITIAL)

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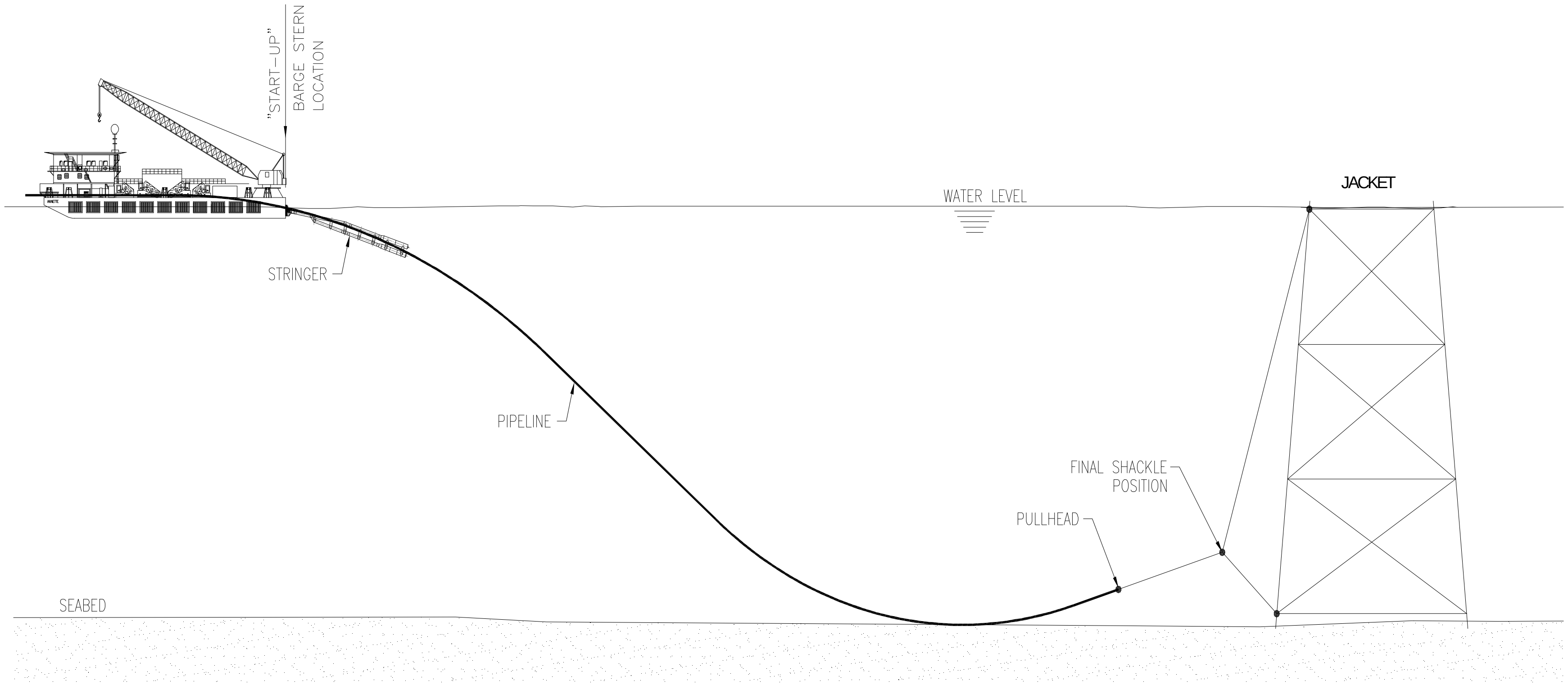
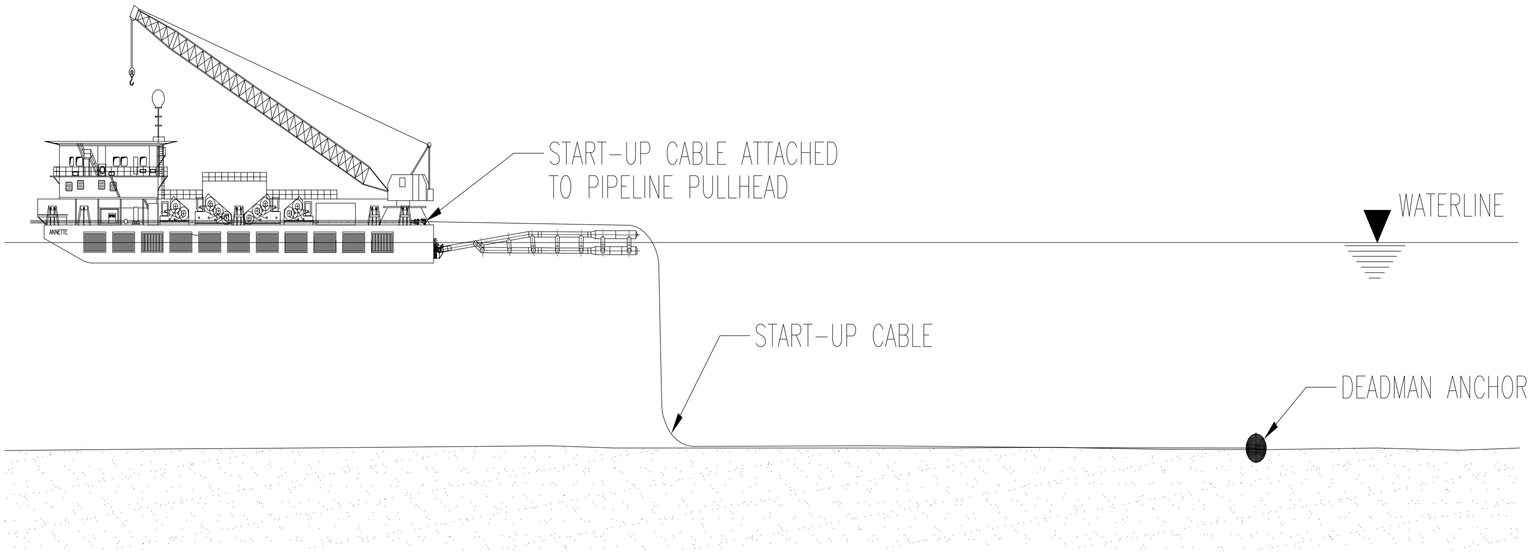


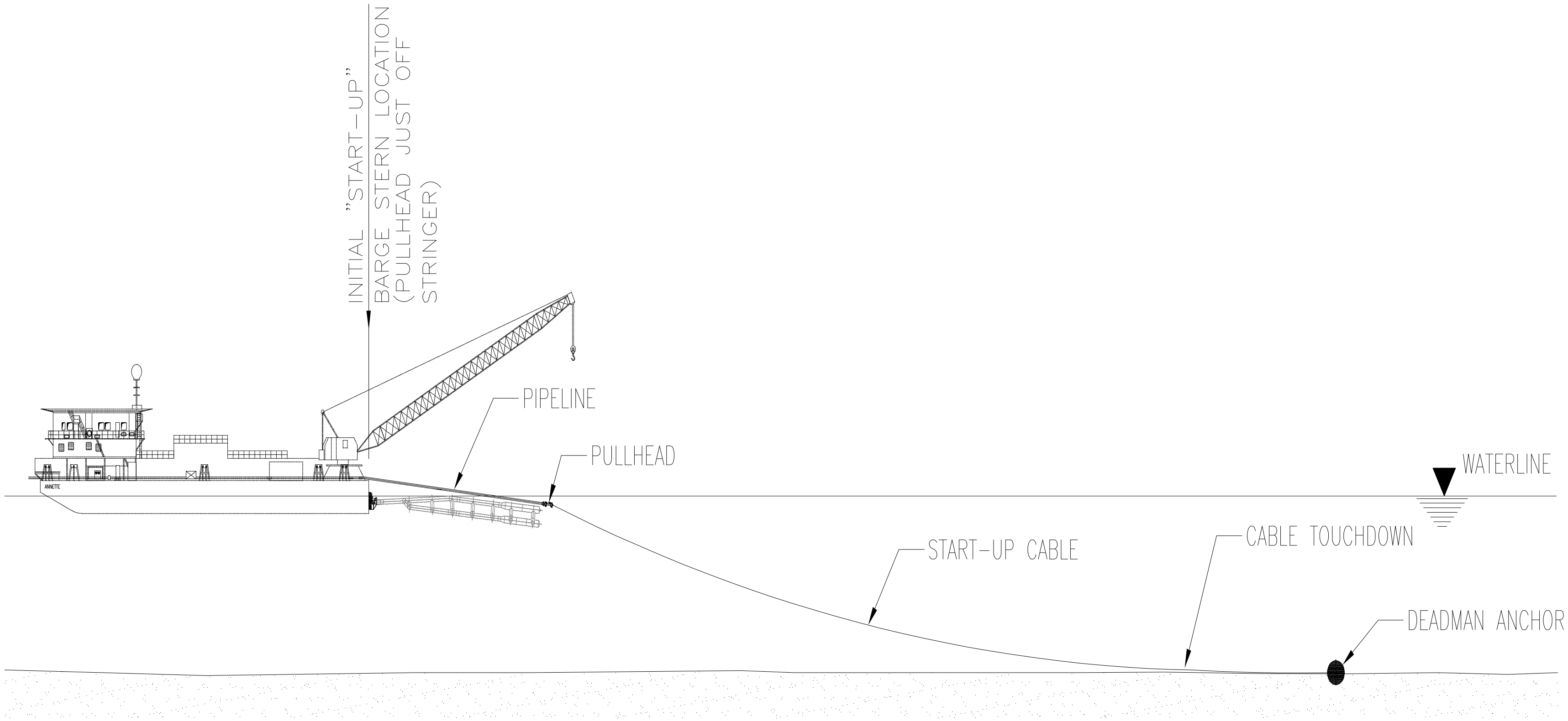
BOW STRING START-UP (FINAL STAGE)

Anchor Start-up Procedure #1



STAGE 1:
ATTACHMENT OF START–UP CABLE TO PULLHEAD

Anchor Start-up Procedure #2



STAGE 2:
PROPER POSITIONING OF BARGE, PIPELINE, STINGER & COMMENCEMENT OF PIPELAY INITIATION

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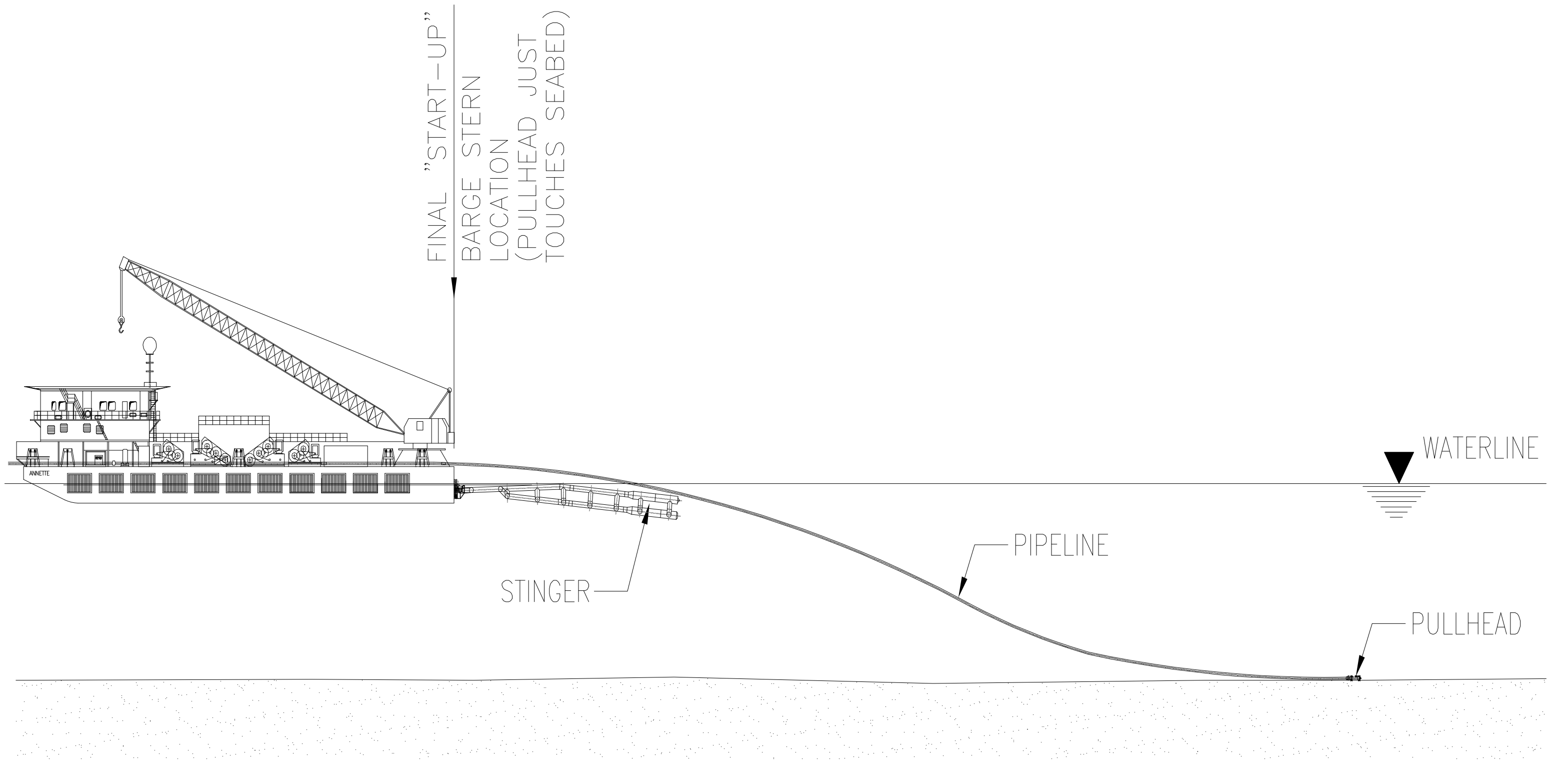
Anchor Start-up Procedure #3



STAGE 3:
END OF PIPELAY INITIATION & COMMENCEMENT OF NORMAL PIPELAY

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"Unconventional Pipeline Installation – Initiation & lay away by Push-pull Method (Geocean)

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Dredging (Pre-trenching) for Pipeline Installation at Shore Approach to Landfall

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View from Laybarge Showing Shore Pull

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Shallow Draft Layvessel used for Installing Pipeline at Shore Approach (Shallow Water)

Basic Tensioner for Shallow Water Pipelaying – In this case, it is used for 'Pushing' the pipe

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Buoyancy Drums Used to Provide Positive Buoyancy

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Pipeline Floating towards Landfall Point

Note the Marsh Buggy Dragging the Pull Wire Towards Landfall

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Pulling of Pipeline towards Landfall by Backfoe

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Completion of Push-pull Operation

Removal (& Collection) of Buoyancy Drums to Settle Pipeline onto Seabed

Backfilling after Pipeline has been Installed

Re-instatement of Site at End of Project (Including Planting of Tree Seedlings)

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Horizontal Directional Drilling

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HDD by Forward Thrusting

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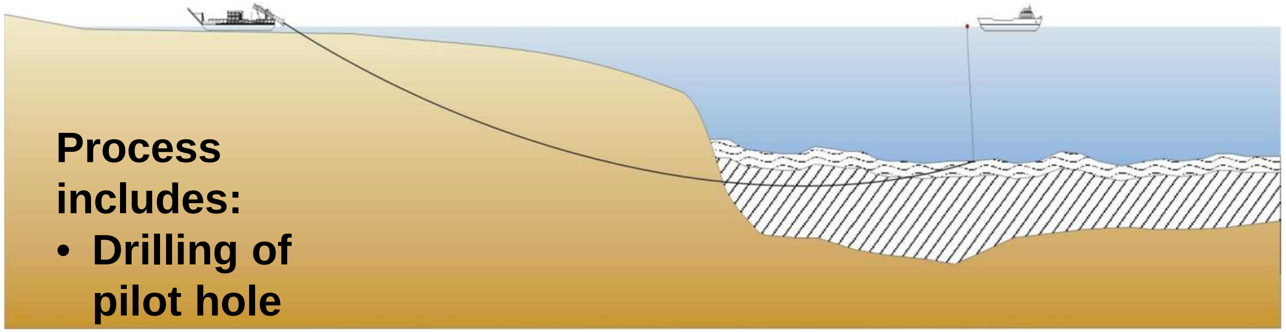
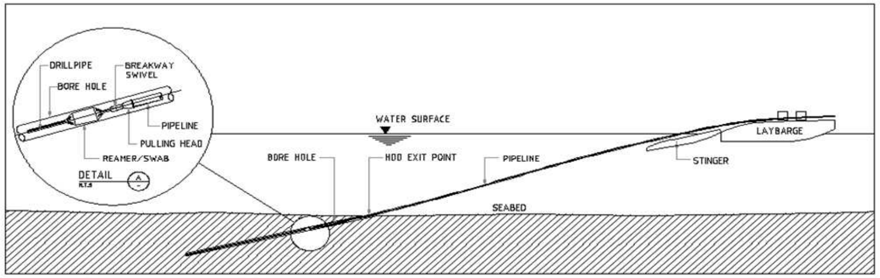
HDD from landfall to offshore location



Process includes:
- **Drilling of pilot hole**
- **Reaming of bore hole**
- **Swabbing**
- **Pulling in of product line**



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Drilling of Pilot Hole in Conventional HDD Operation

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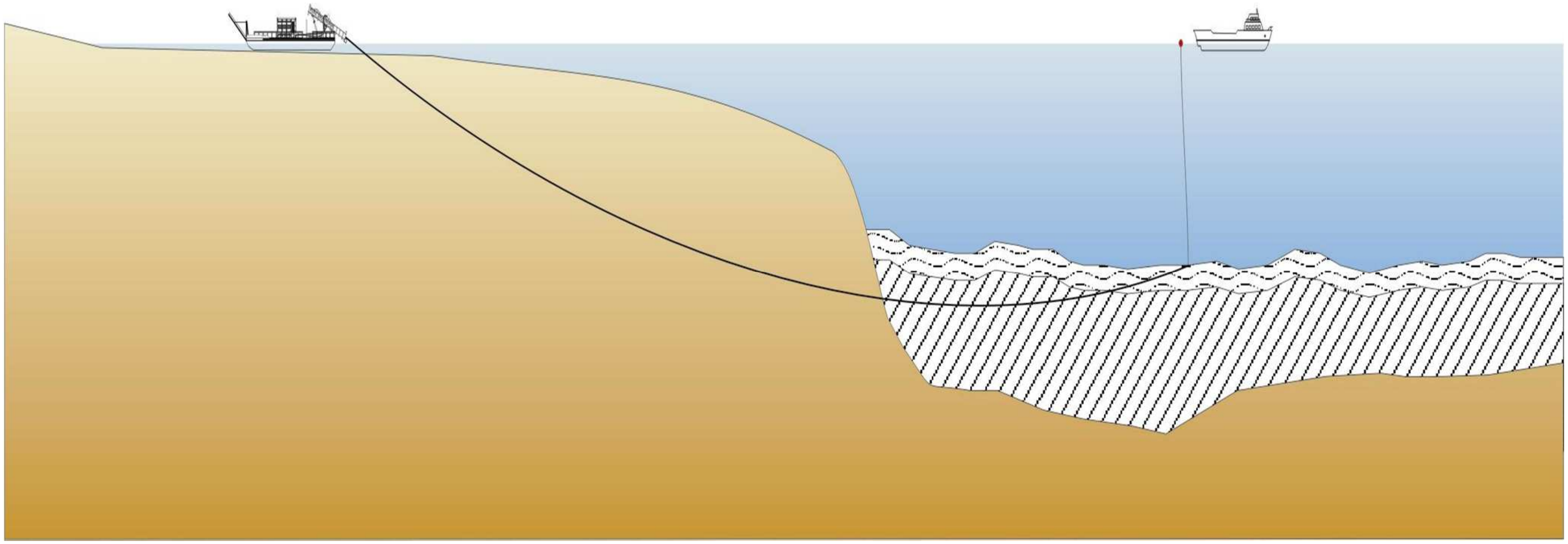
Drilling of Pilot Hole

- Pilot hole is drilled from shore based HDD equipment to a designated “exit” point offshore
- A jet-head assembly is used at the “front” of the drill pipe
- On exiting the seafloor, compressed air is blown through the drill bit to aid location of exit point



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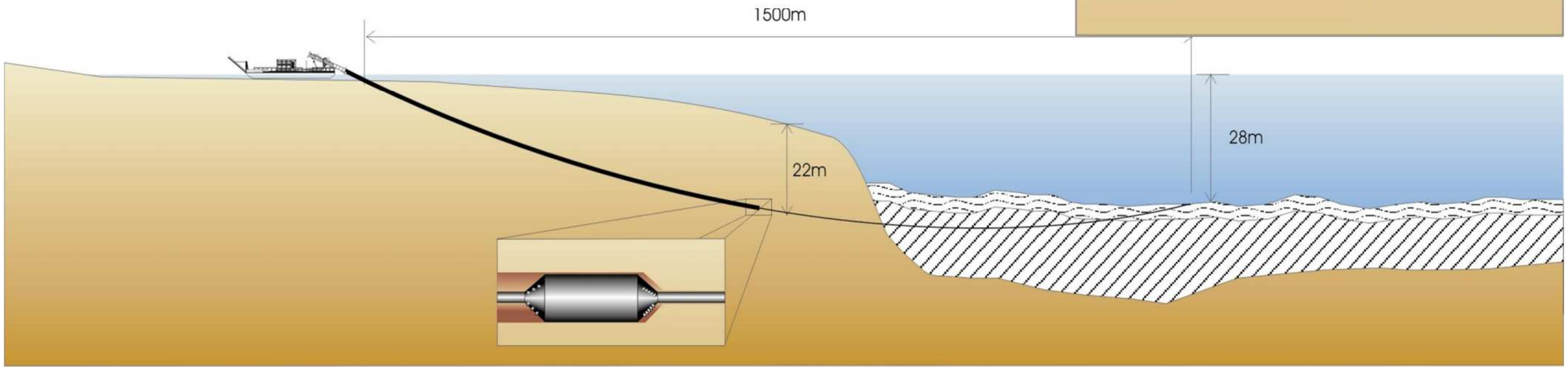
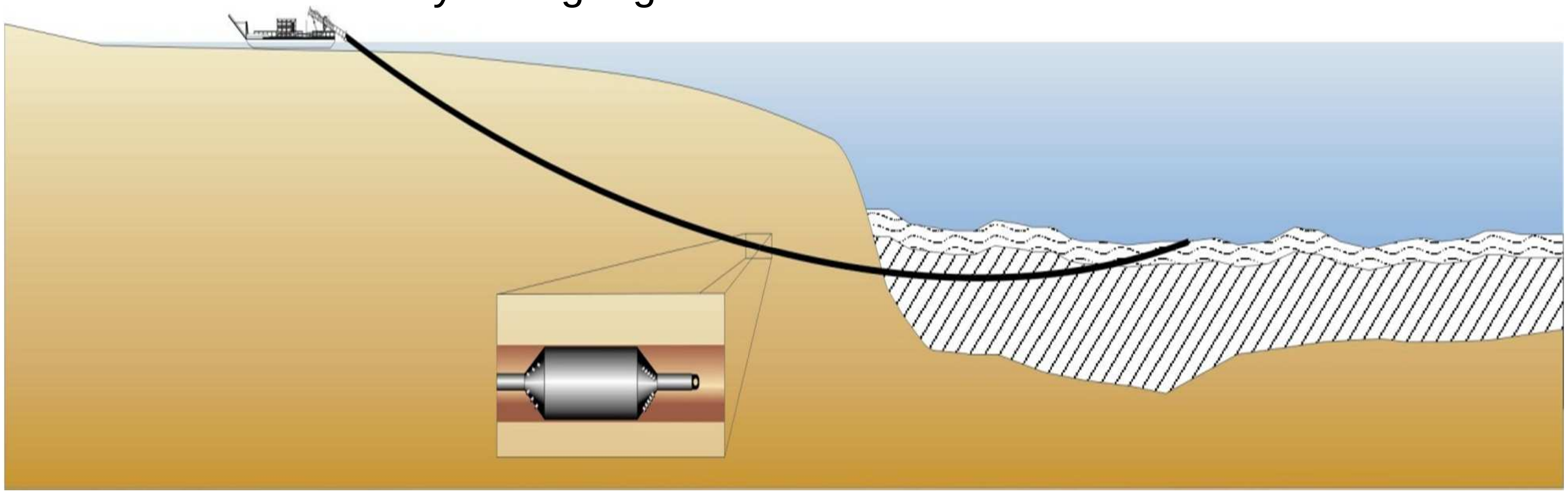
Reaming of bore hole

- Pilot hole is forward reamed using barrel reamers
- Hole diameter will be 50% larger than size of product pipe



Hole Swabbing/Cleaning

- On completion of the reaming the bore hole will be swabbed with a suitable size barrel swab
- The swab is advanced from the entry surface to the sub-sea exit location and then back to the entry surface location
- High pressure sea water is discharged at the leading end of the swab as it is advanced into the bore hole hydraulically clearing the bore hole of debris
- The swab will verify hole gauge to a suitable size



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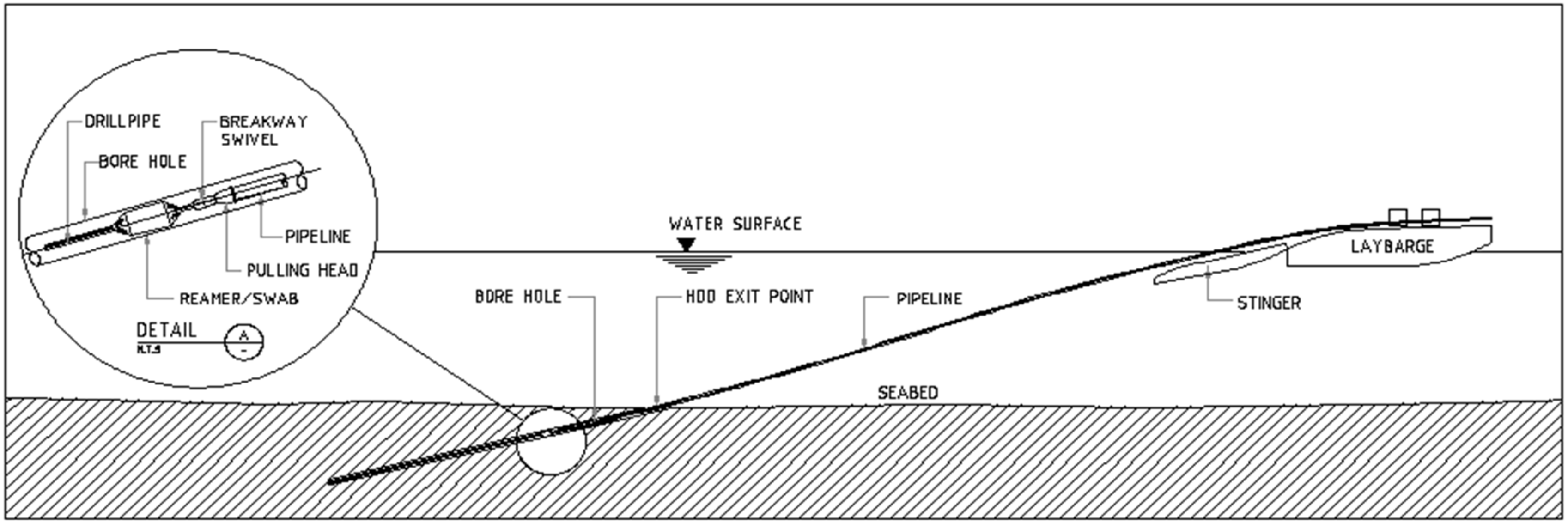
Pulling-in of Product Pipeline

- Reamer/swab is retrieved by laybarge and connected to pipeline pulling head
- As line pipe is welded on the laybarge, the pipeline is pulled into the HDD bore hole
- When the pipeline pulling head reaches the HDD entry point, pulling head is anchored
- Normal pipelaying follows



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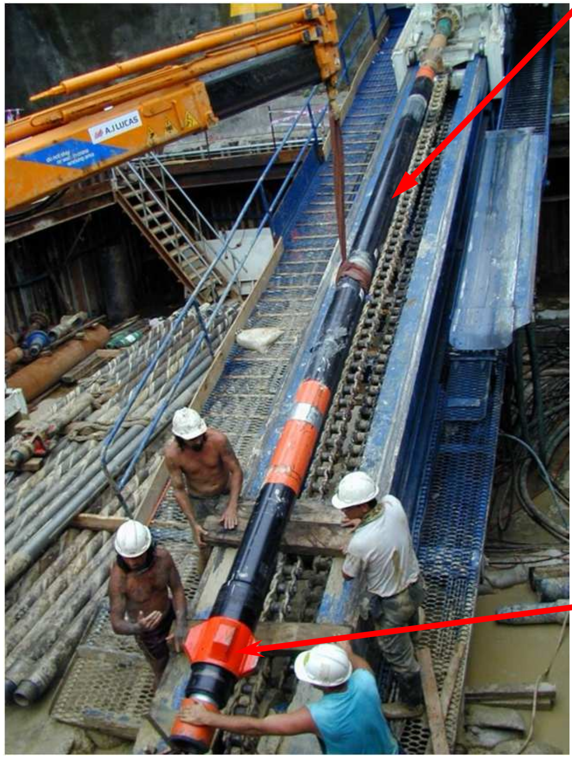
Pilot Hole Tooling

Power Unit (Rotor and Stator)

Transmission Unit

Bearing Section Assembly



Drill bit

Tubular housing & Stabilizer


72inch – 1828mm
Stepped Reamer

Surface Tie-in

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Lifting of 2 Pipeline Segment to Surface for Tie-in

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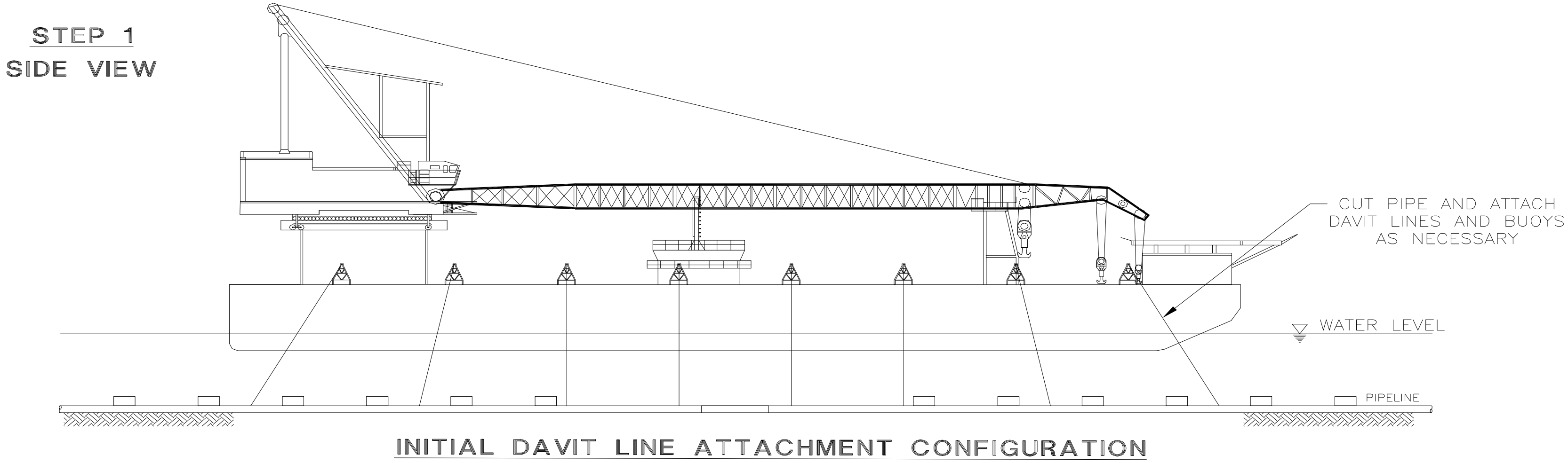
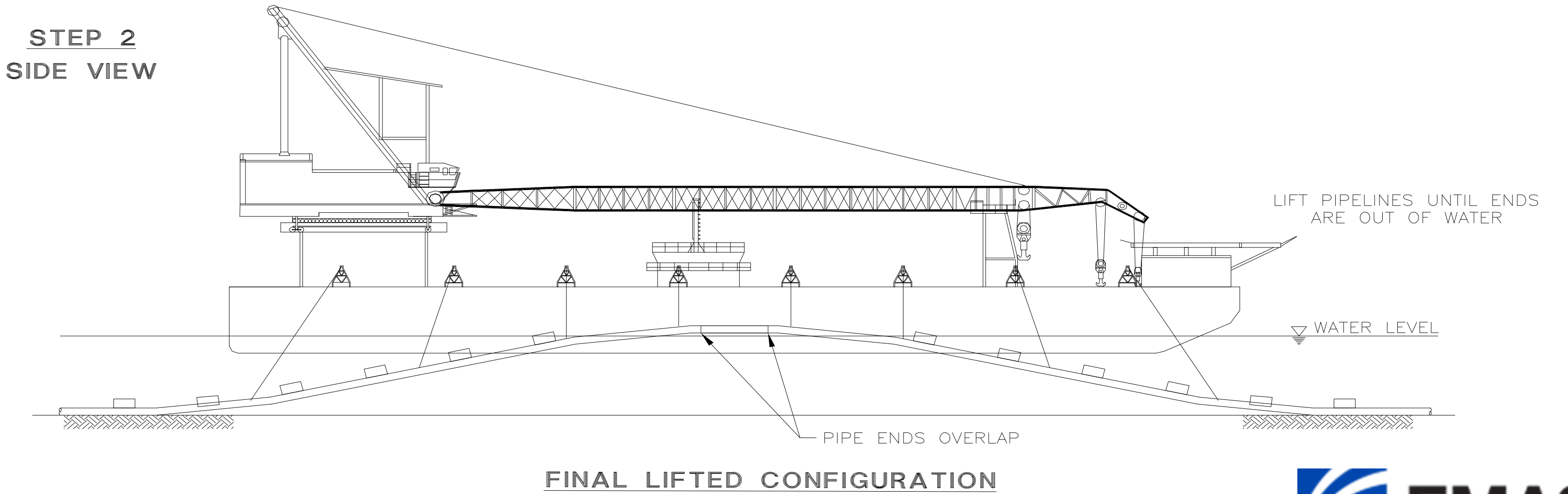
Davit Lift Sequence for Surface Tie-in





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Barge Davits and Buoyancy Tanks are Used for Pipe Support & Stress Control

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Surface Tie-in –
Note Ends of Both Pipe Segments Horizontal

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Lining up Both Ends for Marking and Cutting

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Preparing Pipe Ends for Welding

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Welding of Tie-in Joint

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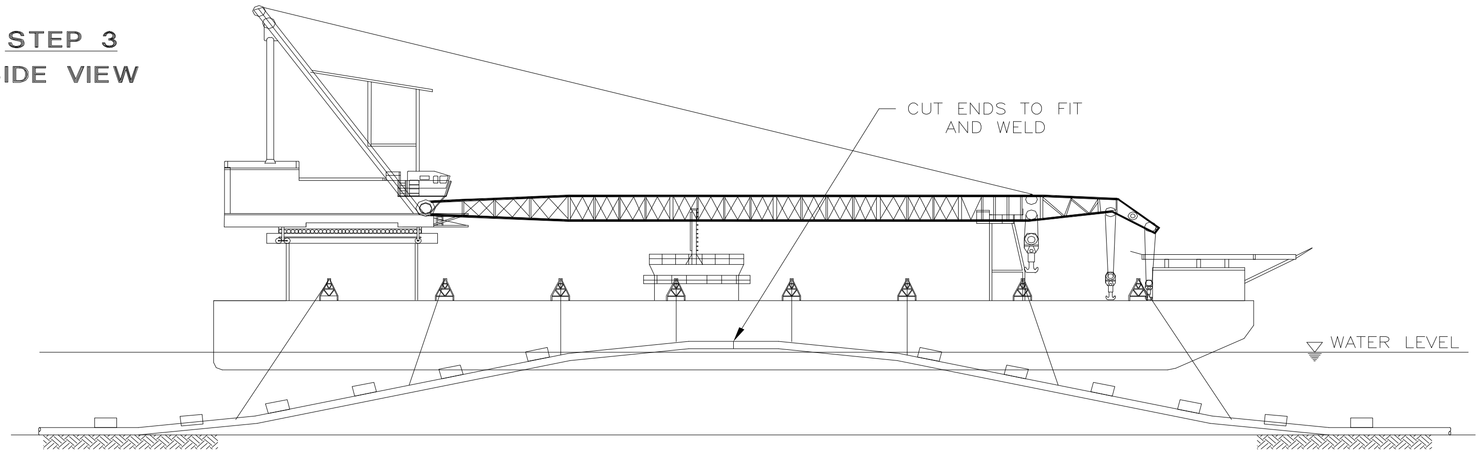
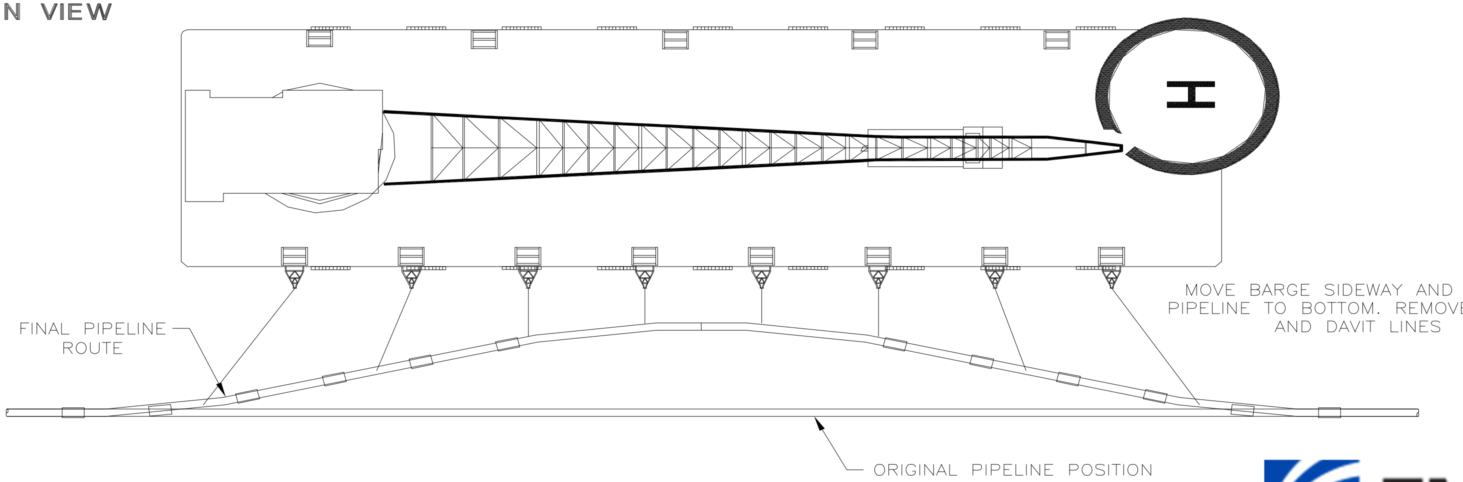
Lowering of Completed Tie-in with Lateral Movement

STEP 3
SIDE VIEW



FINAL LIFTED CONFIGURATION

STEP 4
PLAN VIEW



FINAL INSTALLED CONFIGURATION

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Various Trenching Methods used by Seabed Intervention as part of Pipeline Installation (for protection, span correction, etc)

Geocean's Marine Autonomous Excavator

Pre-trenching in Shallow Water using Cutter Suction Dredger

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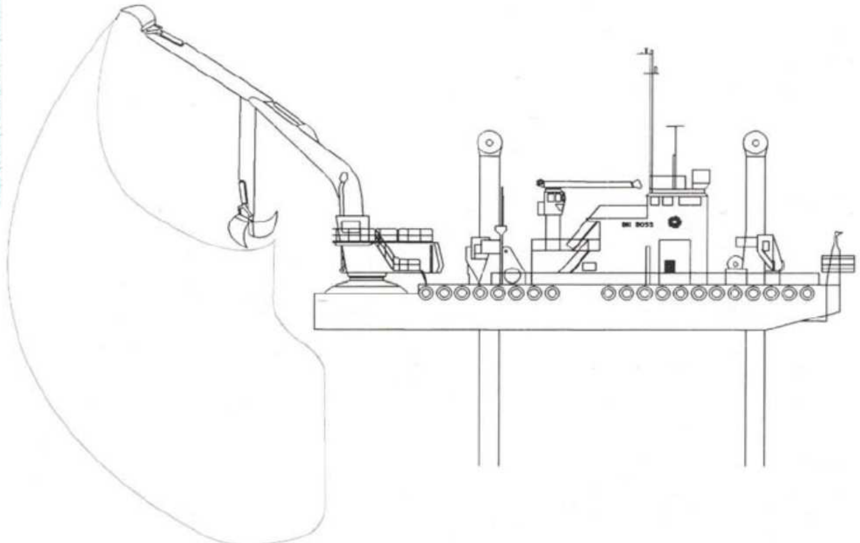
Dredging using Backhoe Dredger



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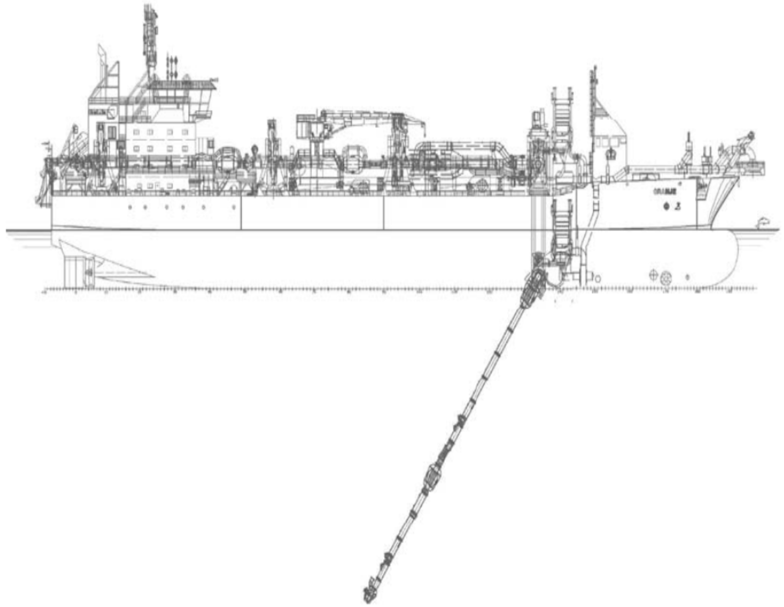
Cutter Suction Dredger

Tideway Cutter Suction Dredger “d’Artagnan”

Construction Methods
Pre-Pipelay Dredging: Trailer Suction Dredger



Boskalis' Trailer Suction Hopper Dredger Prins der Nederlanden

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Post Pipelay Jetting

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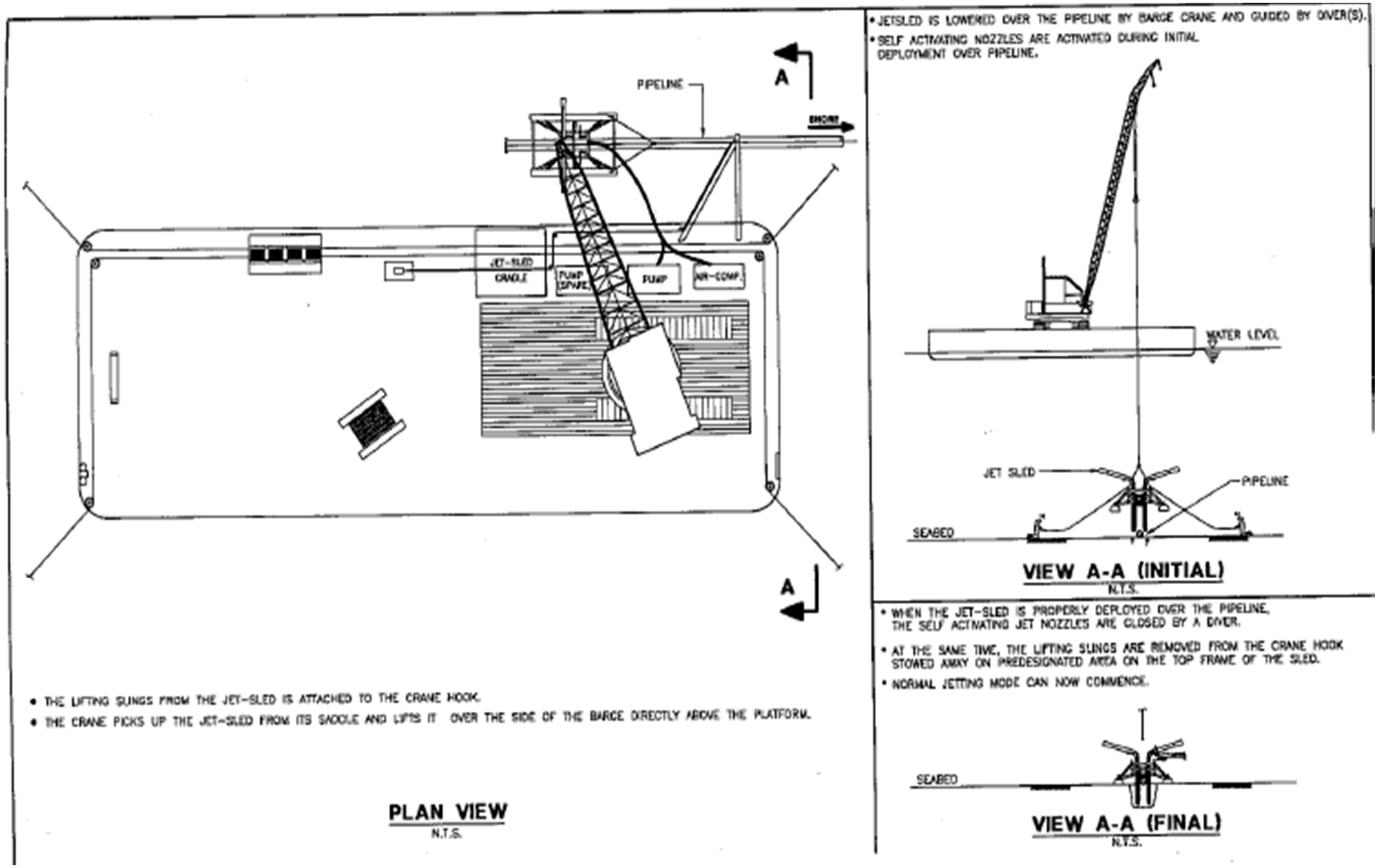
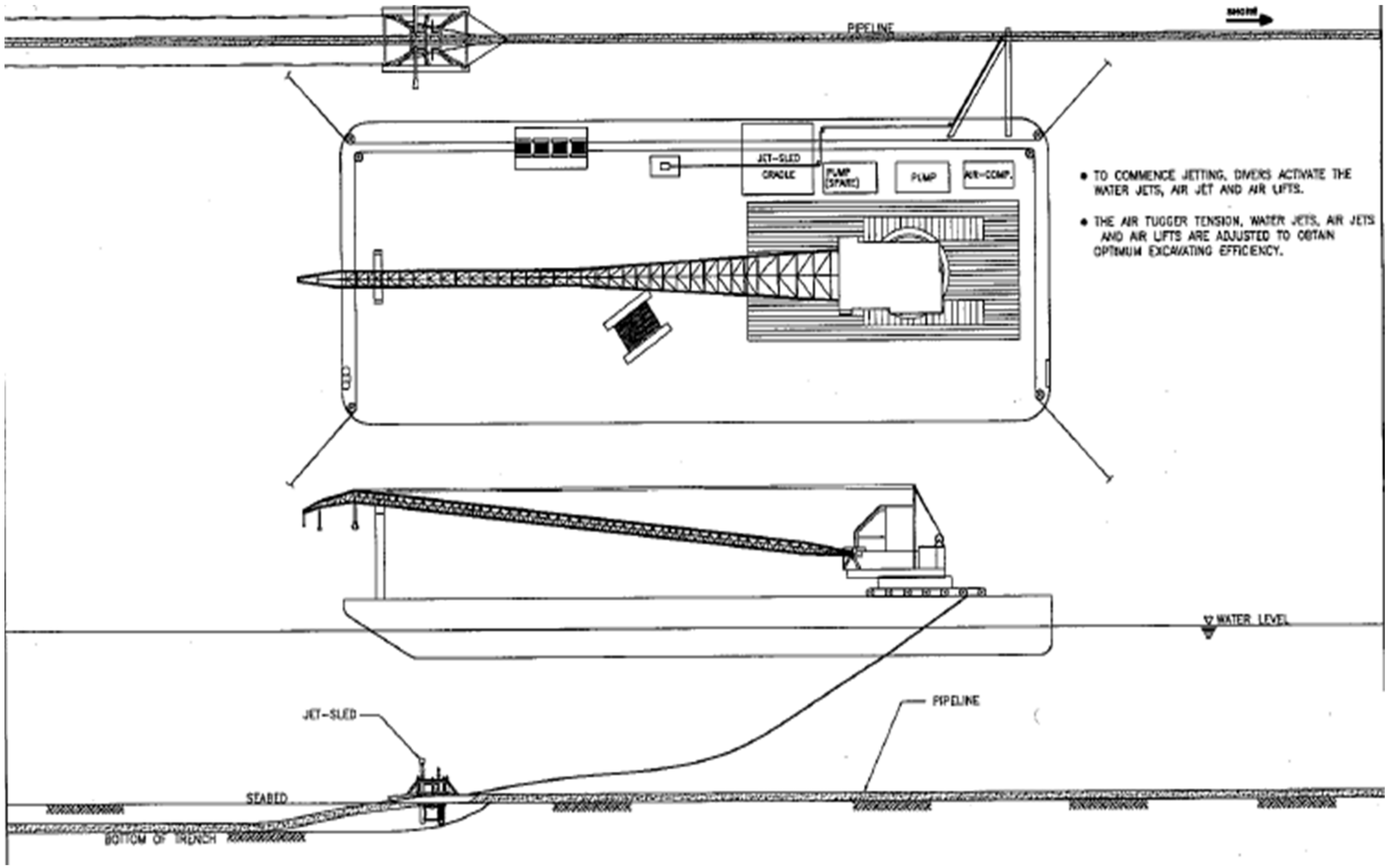
Schematic Showing Typical Deployment of Jet Sled



Schematic Showing Normal Jetting Made During Post-Trenching Operation



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Deployment of Jet-Sled

Deployment of Jet-Sled

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Jetting in Progress

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Closer View of Jetting Claw, Showing Nozzles and Eductors

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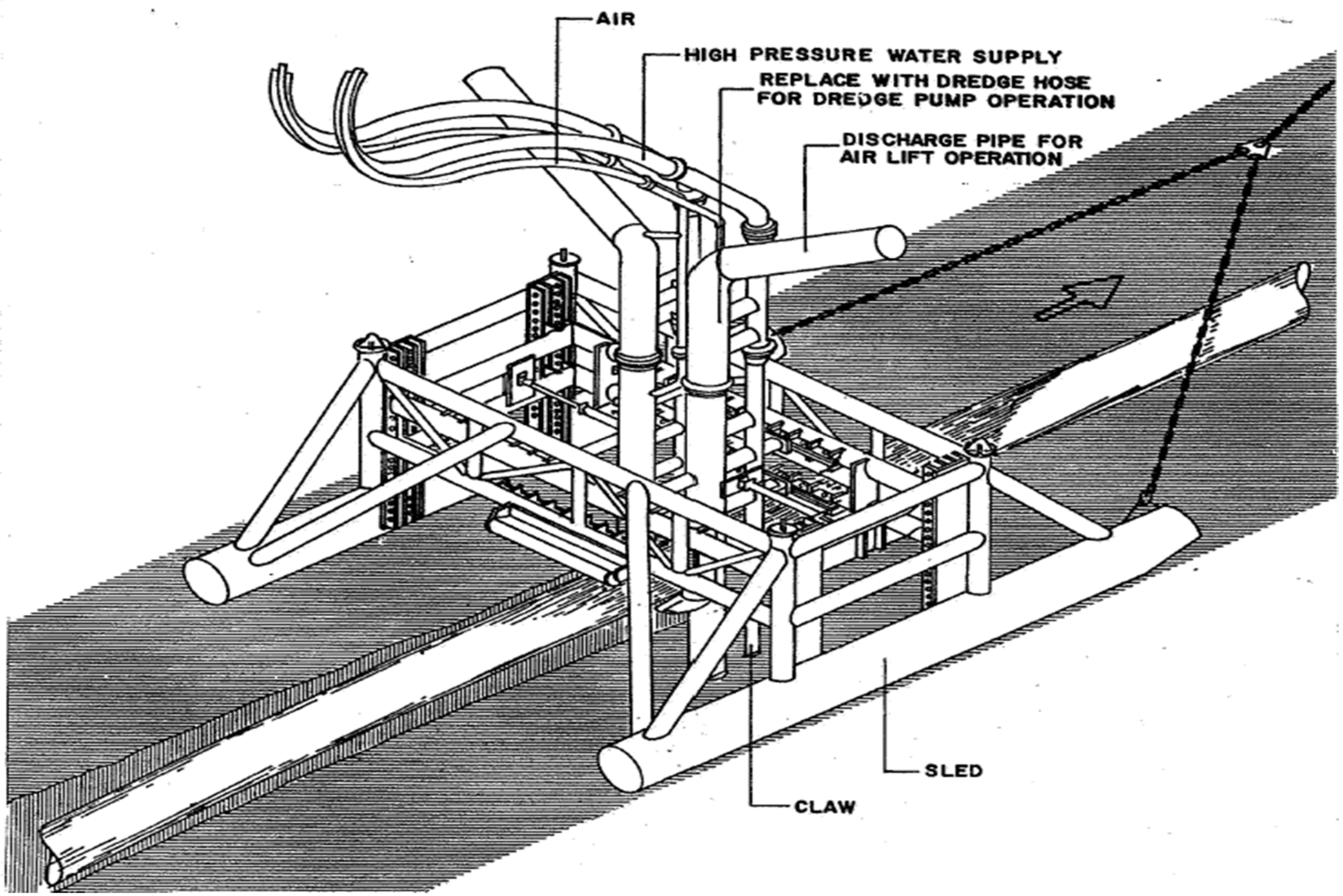
Typical Jetsled Deployed on Pipeline



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Another Type of Jetting Machine (without airlift)

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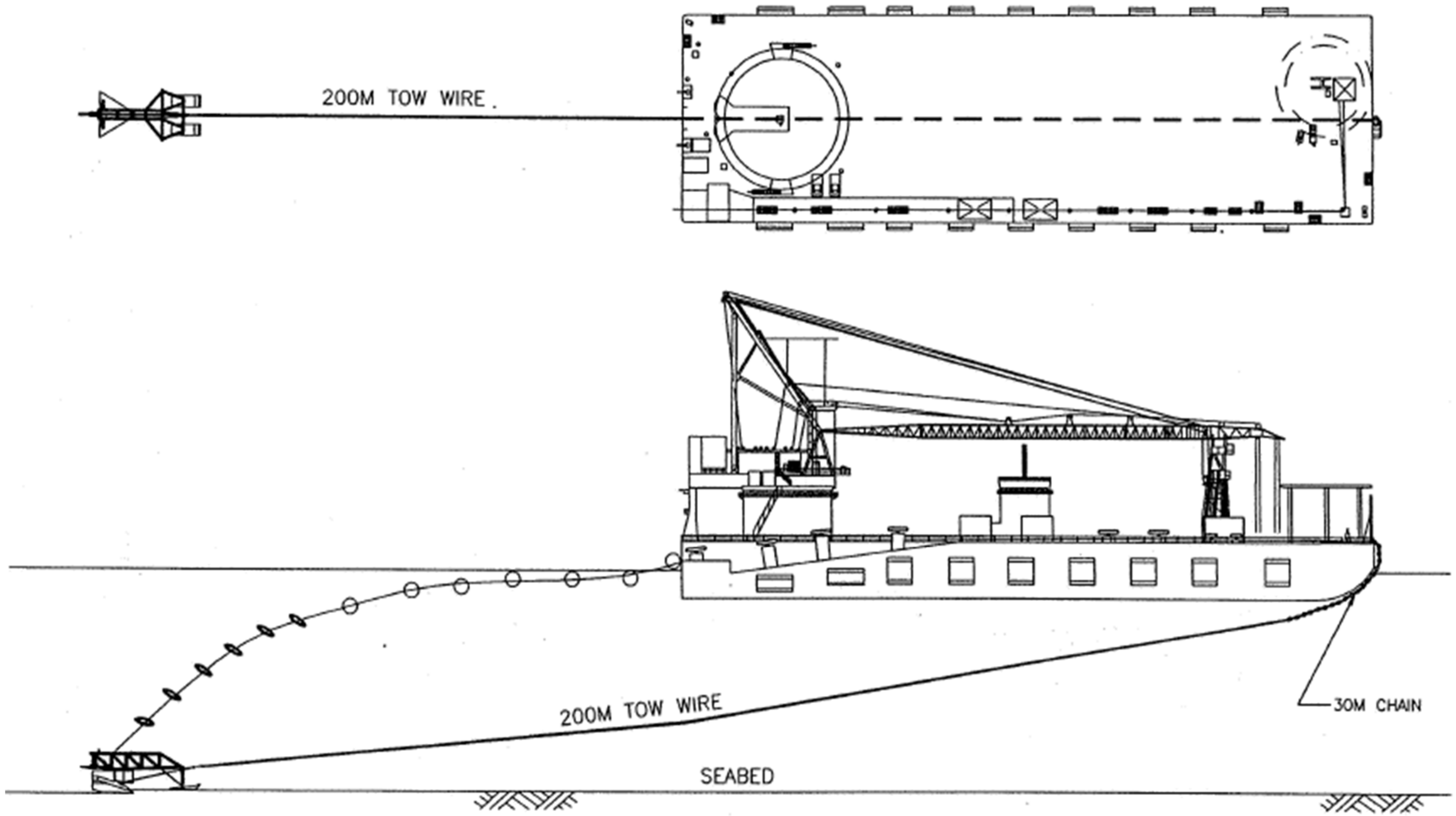
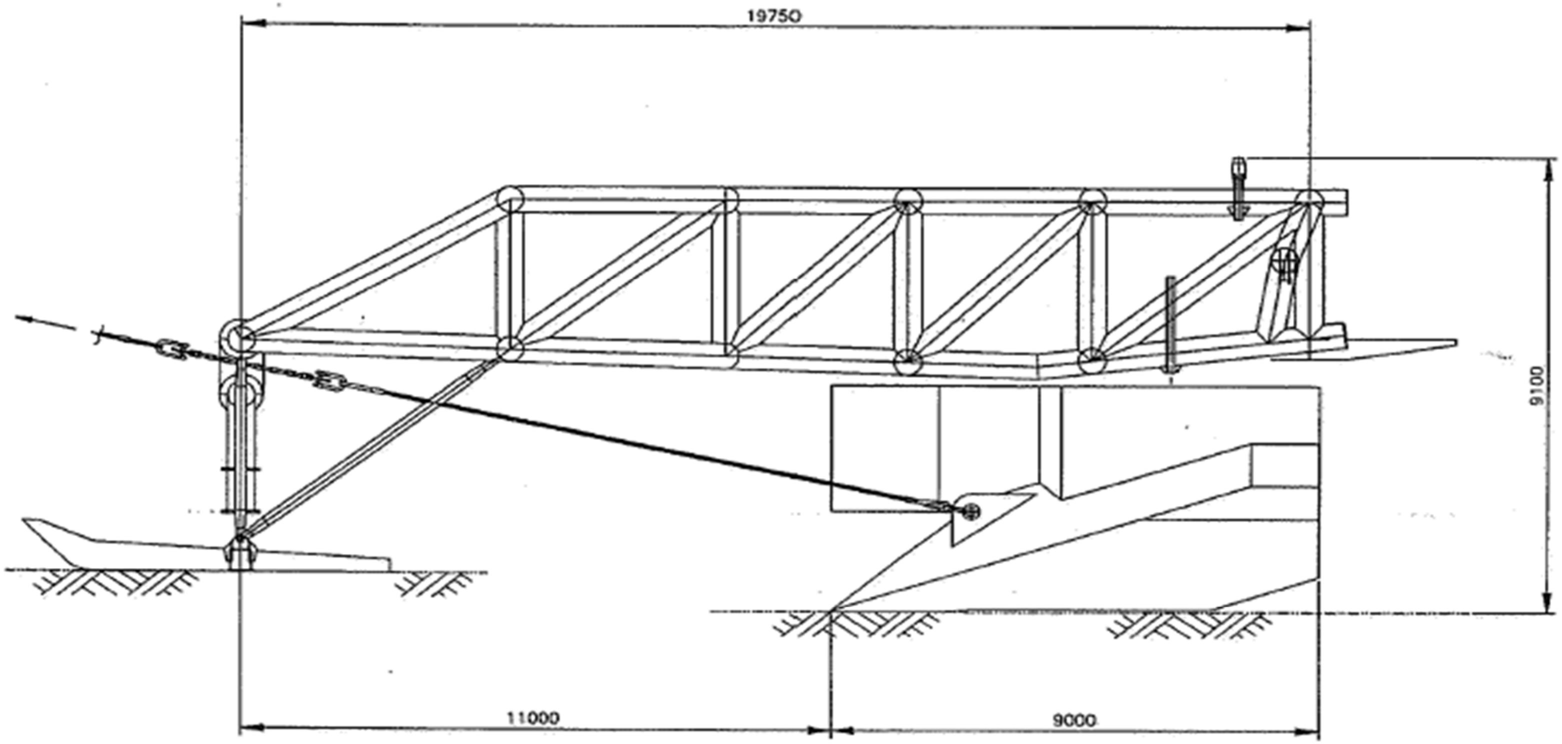
Typical Arrangement for Post-trenching using Plough

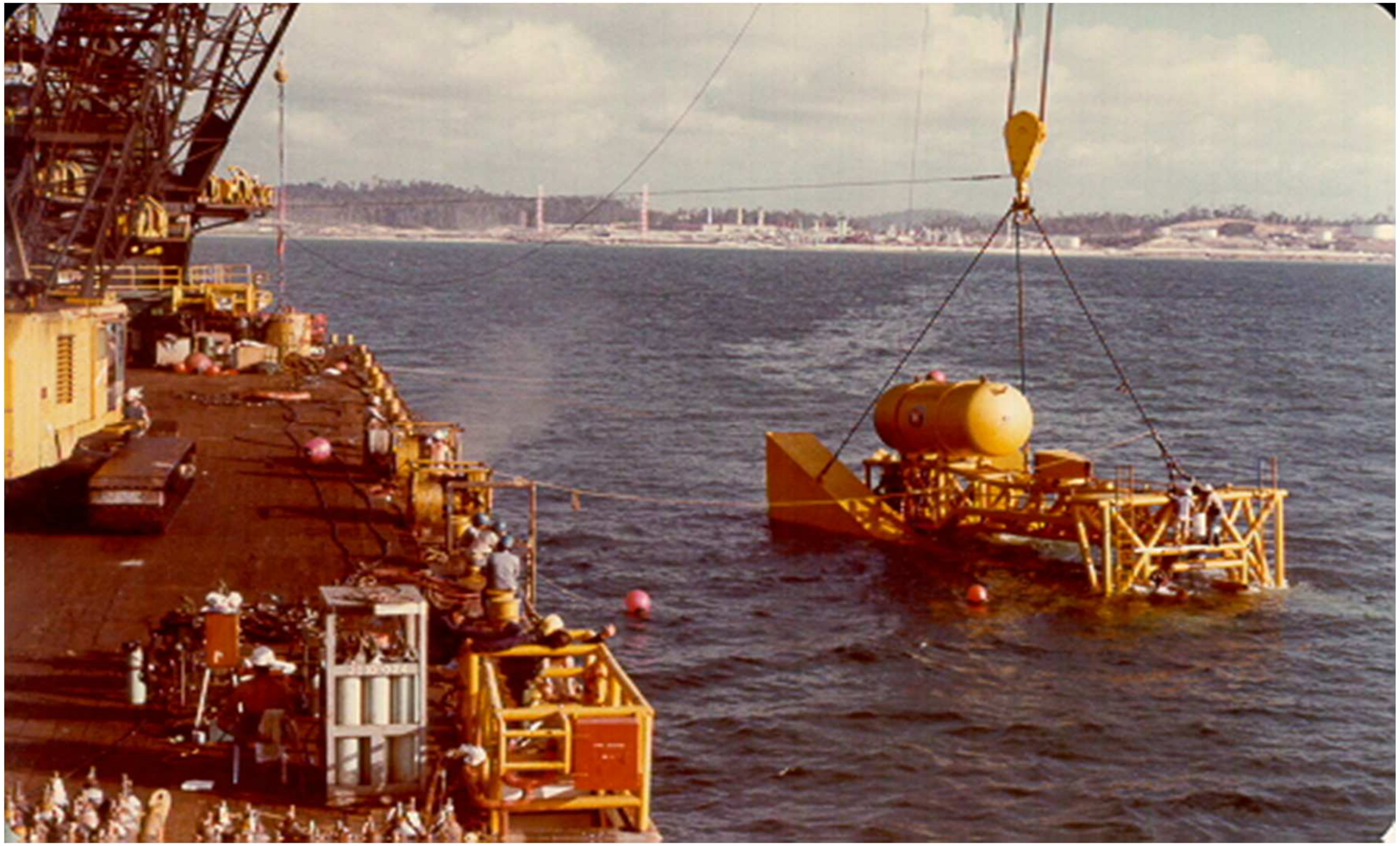


Typical Post-trenching Plough



ROCKWATER F.A.S.T. PLOUGH
ELEVATION

Deployment of Plough from laybarge



View of Plough in Action during Dry Run

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View of Trench made by Plough

Post-trenching Plough on Barge after Operation

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Mattresses Transport to Site on Material Barge

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Picking up of Mattress with Special Frame

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Lowering Mattress over Exposed Pipeline

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Drilling and Blasting Operation

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Drilling Rig in Operation

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Tool Pushers Drilling Holes on the Hard Seafloor

Specialist Holding Explosives which are Ready for Use

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Tool Pusher Lowering Explosives Into Pre-drilled Holes

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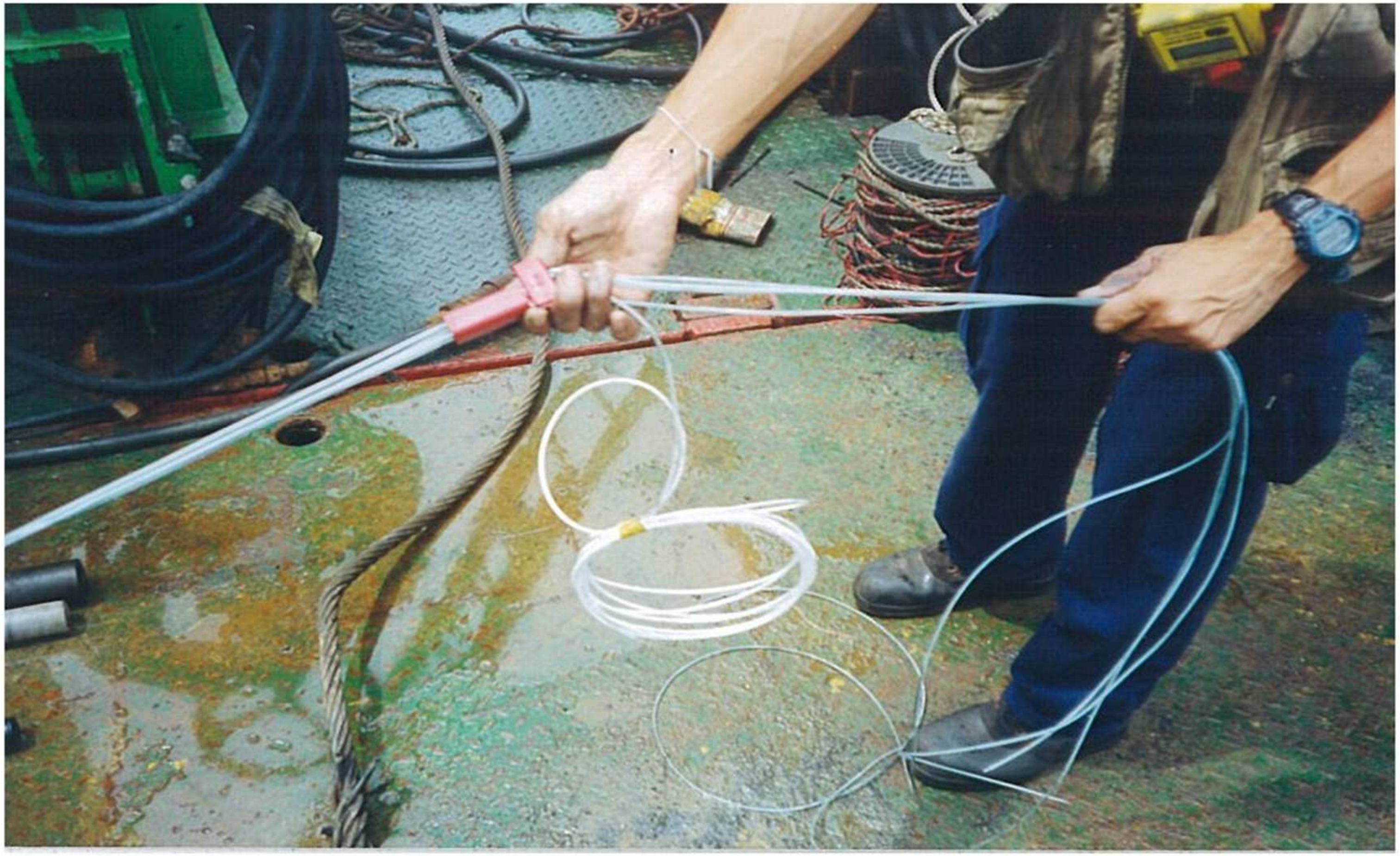
Bundling and Paying Out of Explosives' Detonation Wire



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Underwater Explosion Causes Ripples on the Water Surface above the Drilled Holes

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Removal of Blasted Rocks by Backhoe Dredger

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Depositing Dredged Materials on Hopper Barge

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Pre-commissioning

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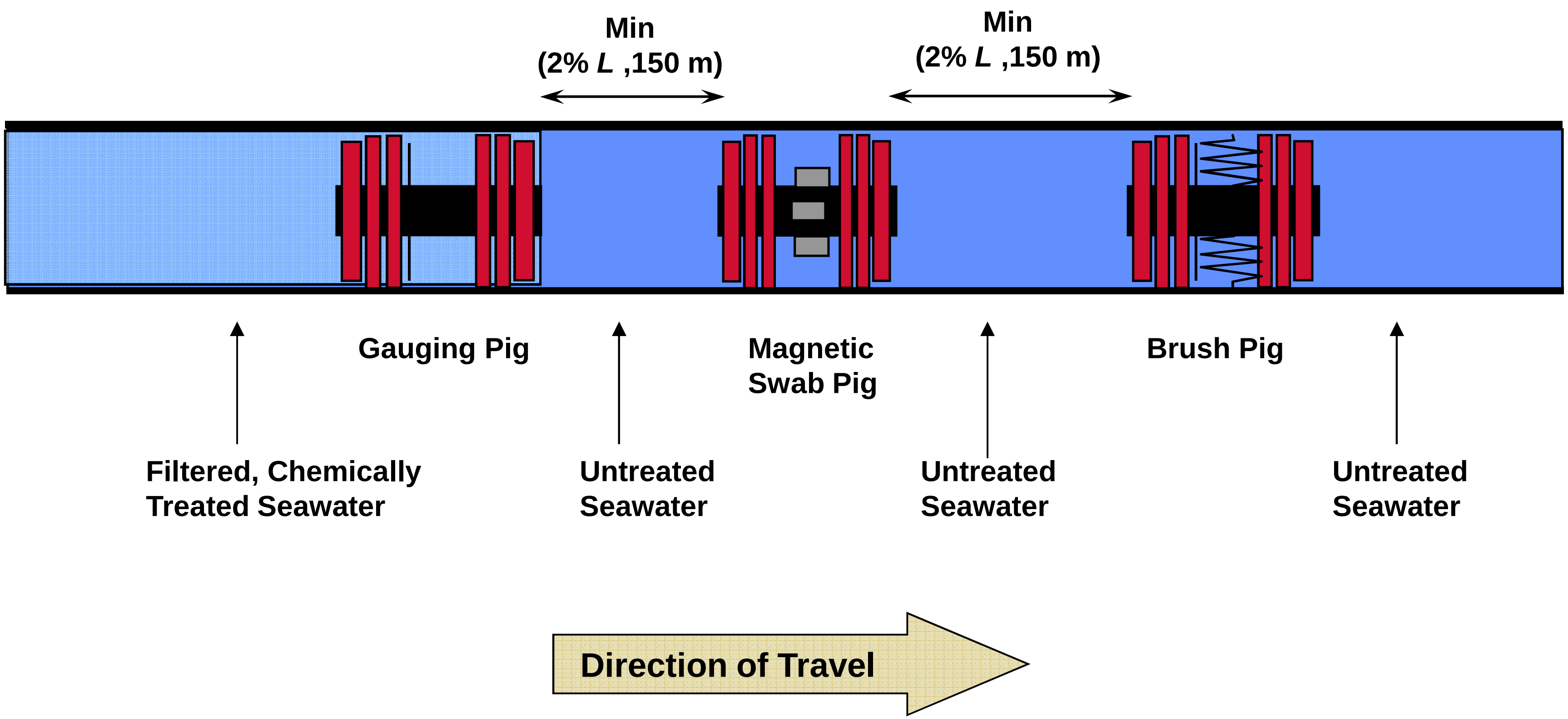
What is pre-commissioning?

- Undertaken after completion of construction
- Purpose is to prepare pipeline system for commissioning
- Main activities:
  - Pigging
    - **Cleaning**: remove construction debris
    - **Gauging**: check pipeline bore for ovality and indication of major blockage (i.e. dry buckle)
    - **Flooding**: fill pipeline with water to enable hydro test
    - **OOS (Out of Straightness) survey**
  - Hydro test/ Strength test
  - Dewatering, drying
  - Preservation: Nitrogen packing

Pigging

Typical pre-commissioning Flooding, cleaning & gauging pig-train



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Cleaning & Gauging

Cleaning or swabbing

Performed using a scrapper or magnetic swab to remove construction debris or foreign matter in the line.

Gauging

Performed using a gauging pig equipped with aluminium disk slightly smaller diameter than pipeline bore: DNV O97%.

To determine that there is no protruding inside the pipeline which might to cause an obstruction.

To ensure that the ovality of the pipeline is within accepted tolerances.

Electronic Gauging

As the alternatives of aluminium gauging plate, one may use flexible slotted polyurethane.

Each segment of this flexible plate carries on-board sensors, which in turn direct signals to mating sensors housed within an electronics vessels.

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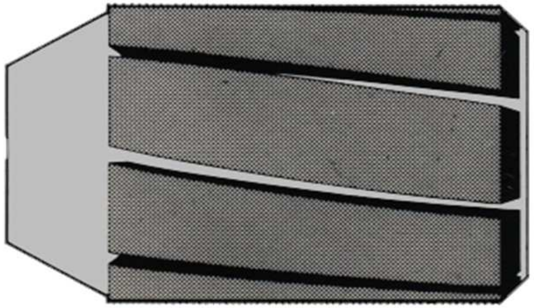
Type of Pig

Foam Pig

Constructed from polymer foam
(i.e.: polyurethane).

Suited to pipelines with very tight radius and where a significant variation in the pipe ID exist

Depend on their type, these pigs are widely used for cleaning, liquid removal, swabbing, drying, and product separation.



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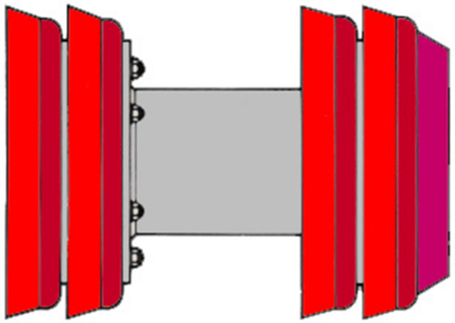
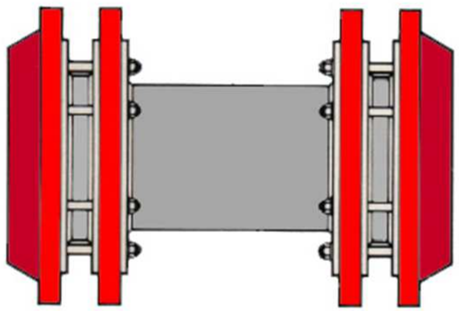
Mandrel pig

Mandrel pigs are constructed out of a number of parts that are mounted on a central tube.
This allows for a great deal of flexibility in the configuration of discs or for the replacement or refurbishment of the pig. Widely used in cleaning or gauging activities (+ gauging plate)



One directional

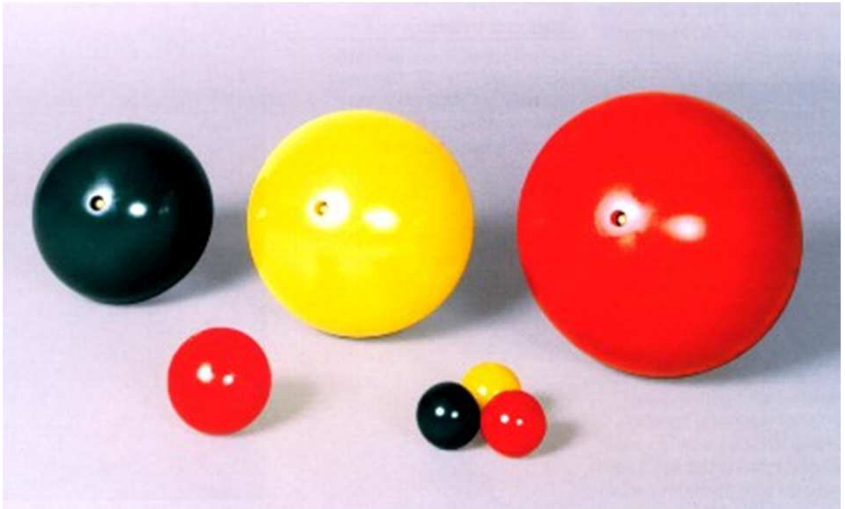


Bi-directional

Spherical pig

The main uses of sphere pigs are:

- Minimize product contamination when used to separate fluids being transported through a pipeline.
- Purge air and dewater during hydro testing.
- Confirm accuracy of flow meters.
- Pass through out-of-round pipe.
- Navigate through tees, ells, and full port valves.
- Are suitable for automatic launching.
- Remove condensate and paraffin build-up.



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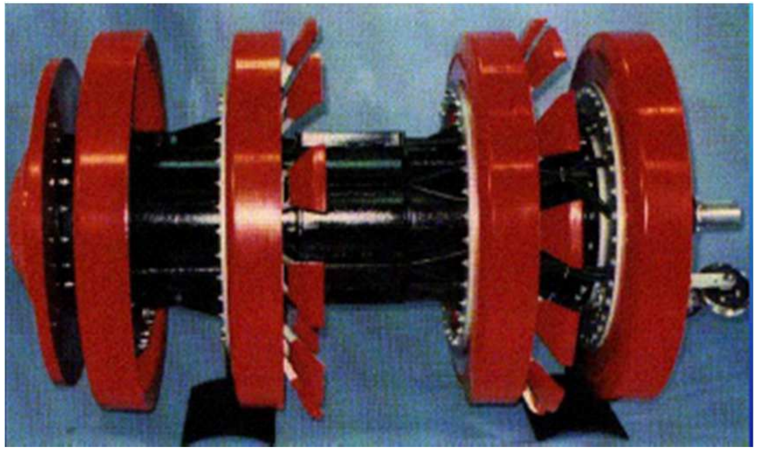
Specialty pig

Calliper pig

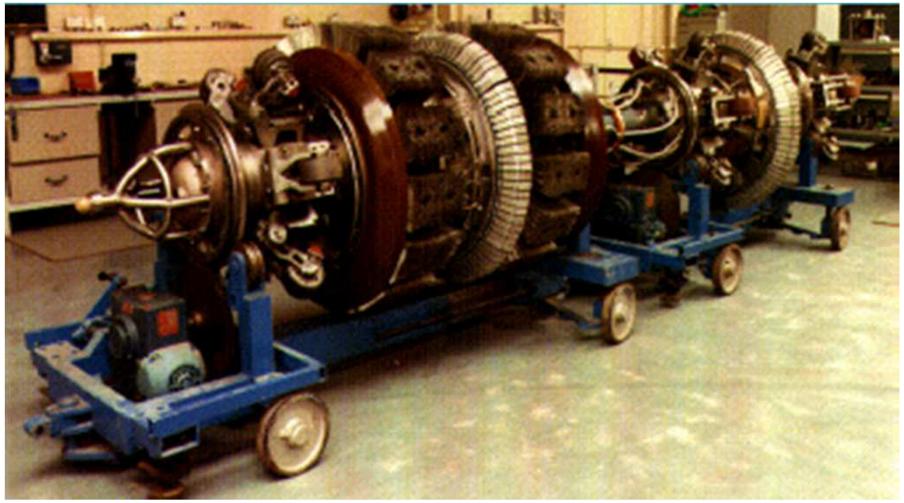
As the caliper pig travels through the pipeline it can show, girth weld penetration, pipe ovality and dents.The pig can pass dents up to about 15% of pipe diameter, so it can be used to gauge the line with minimal risk of jamming.

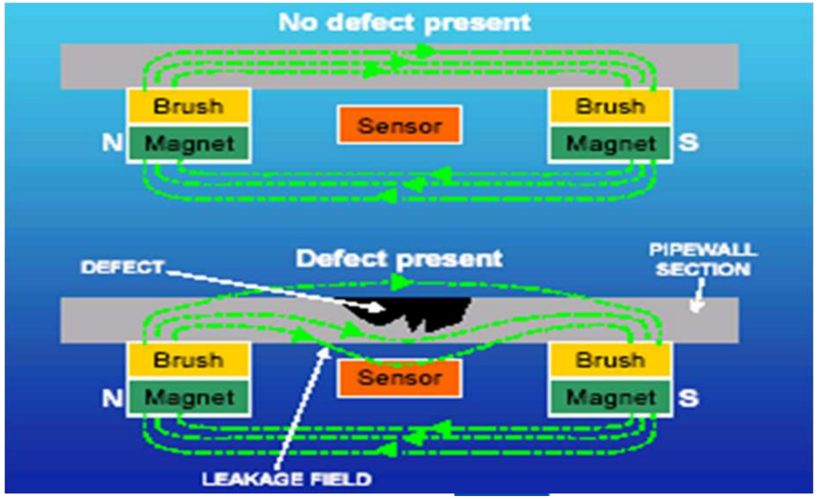
A caliper pig gives more information on the nature of any problems than a gauge pig, such as: dents, wrinkles, ovality, bend radius and angles, and occasionally indications of significant internal corrosions.



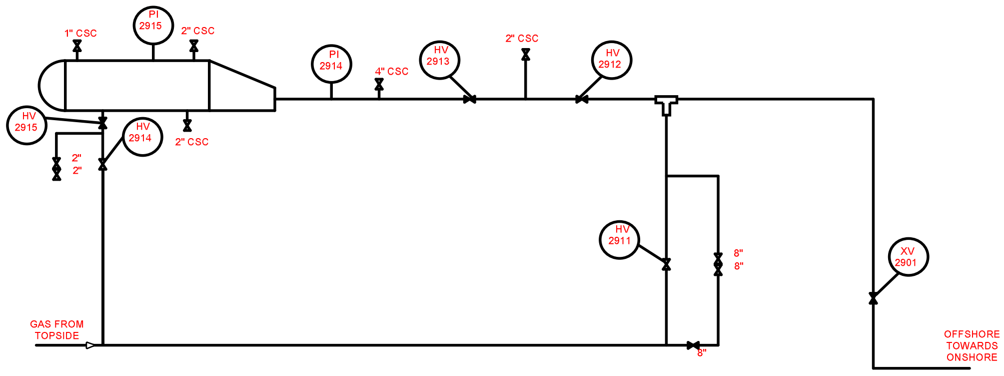
Magnetic Flux Pig

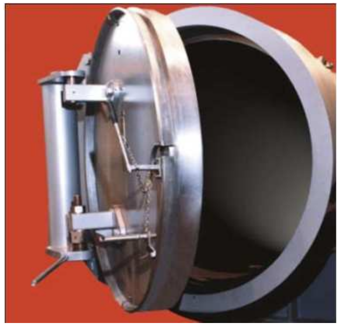
Use magnetic flux to detect defects along the pipeline



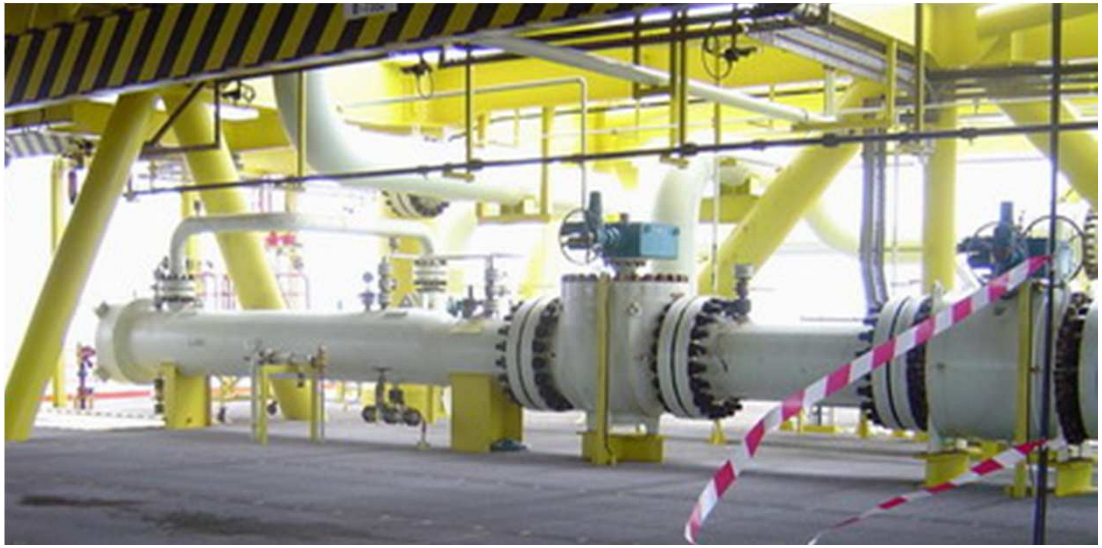


Pig Launcher/Receiver





Closure door



Pig with Gauging Plate pre-signed by Client

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Pumping Water from Sea for Pipe Flooding and Pigging

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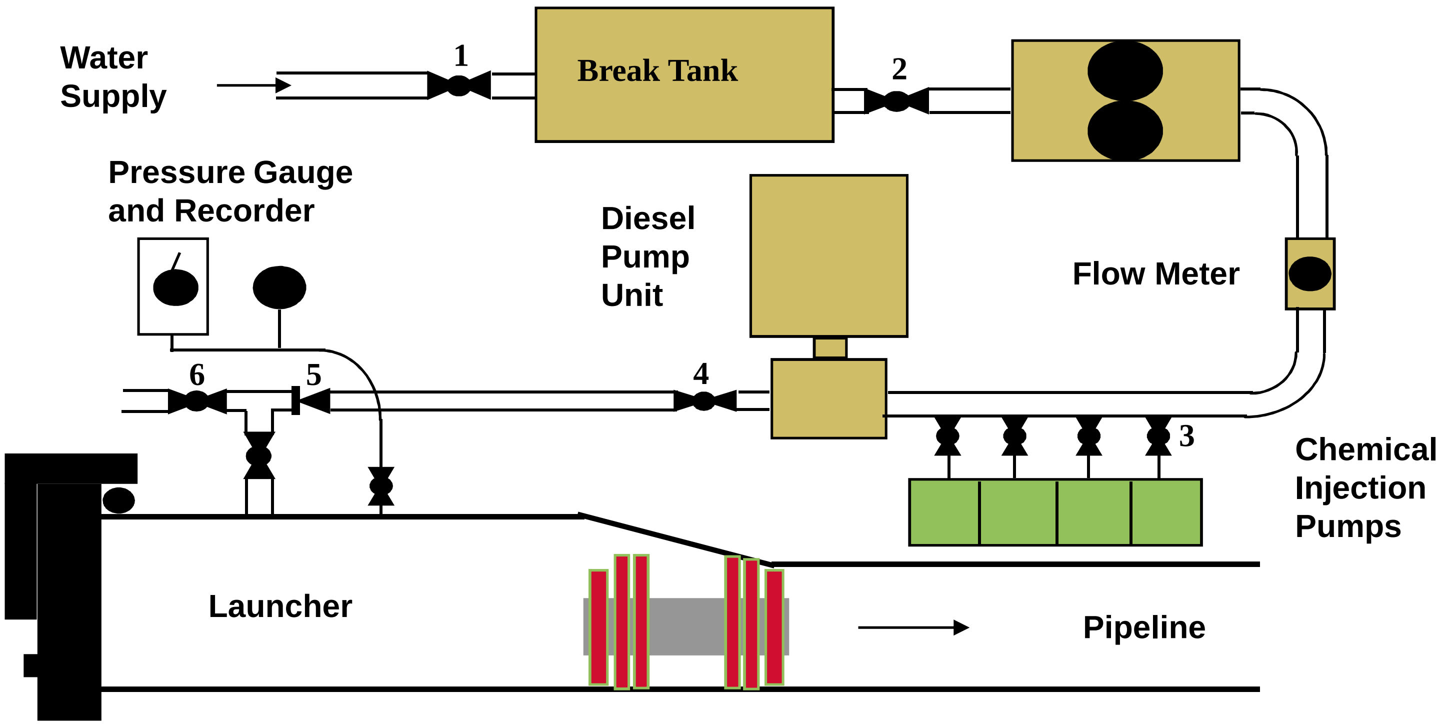
Flooding

Purpose: To fill pipeline with water to enable hydro test



Helping to Locate Pig inside Launcher

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Closing Flange and Commencing Flooding

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Pigging of Pipeline (Old Fashion Way)

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Completion of Pigging

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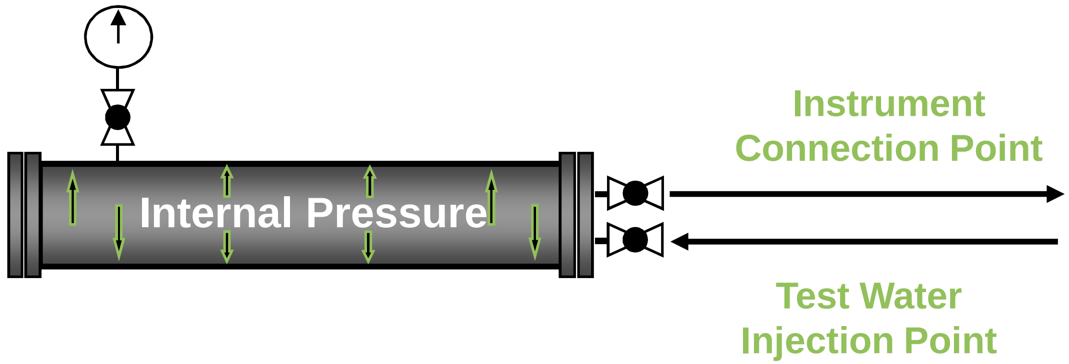
Hydro Test

- Injecting fluid (usually water + dye) to pressurize the pipe and first check for leakage
- To prove the strength of the pipe

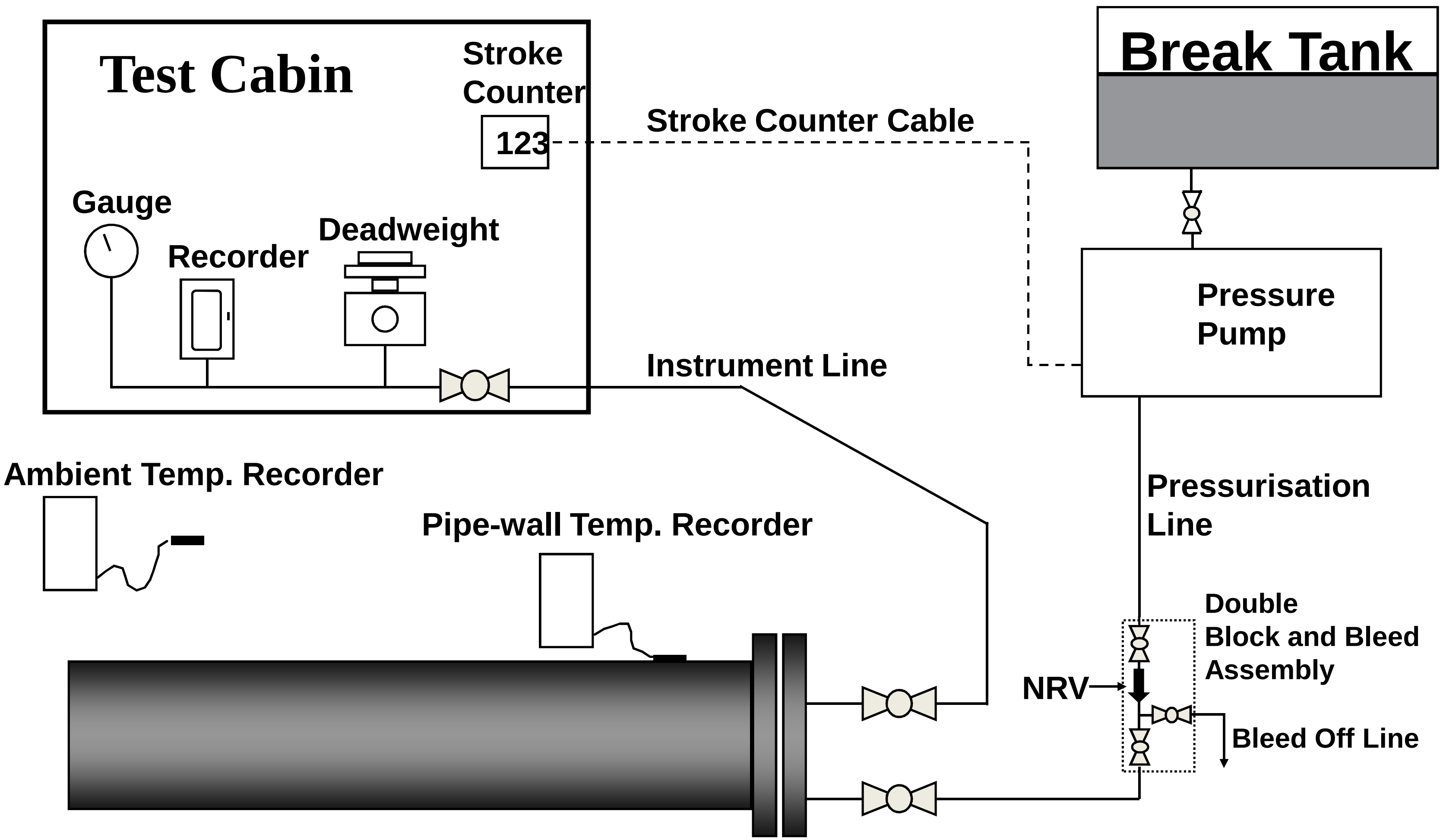


Pressure unit:
1 bar
= 1 kg/cm^2
= 14.504 psi

Hydro test pressure:

- Joints may be leak tested at 1.1 times design pressure for 3 to 6 hours
- Then all parts of system are strength tested at a pressure not less than 1.25 * design pressure or 90% hoop stress whichever is less.
  - Holding period = 24 hours

Hydro Test Layout



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Pressuring Pipe and Trying to Remove Air Pockets from Pipeline

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Pressuring Pipeline

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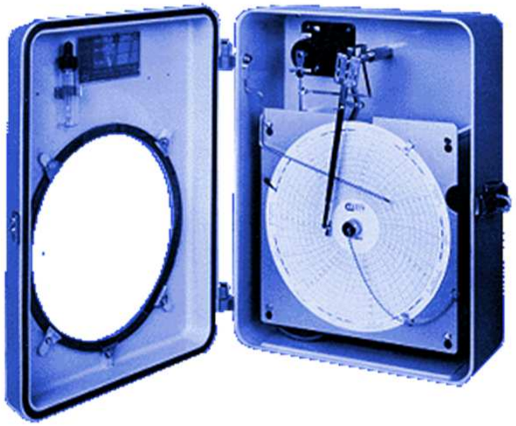
Shack where Pressure Profile is Recorded

Measurement Devices

Pressure gauge

Pressure/temperature recorder



Dead weight tester

Flow meter

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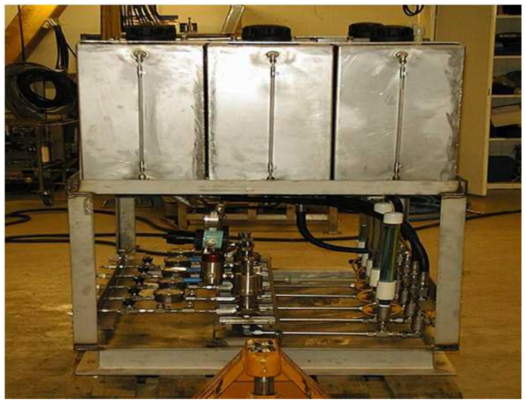
Break tank

Filter unit

Flooding/filling pump

Chemical injection skid



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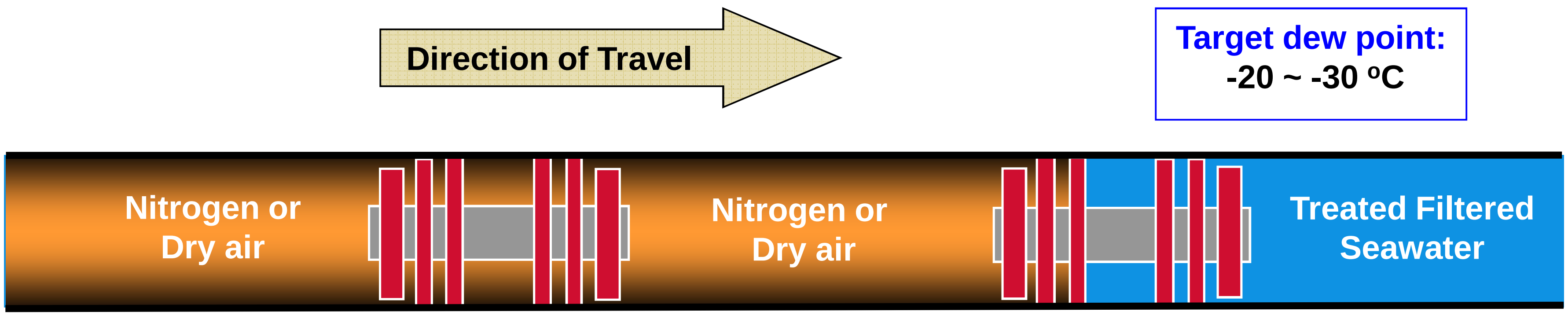
Dewatering

- Removing the water from the pipeline.
- Performed after hydro-testing.
- Nitrogen or dry compressed air is introduced and then the system is pressurised.
- Drains and flanges should be open sequentially until all the water is removed.
- The more water that can be removed, the more effective the vacuum drying will be.
- Monitoring:
  - Dew point (if measured flow show > 5 m/s)
  - Pressure (then can be converted to dew point using table or correlation formula)



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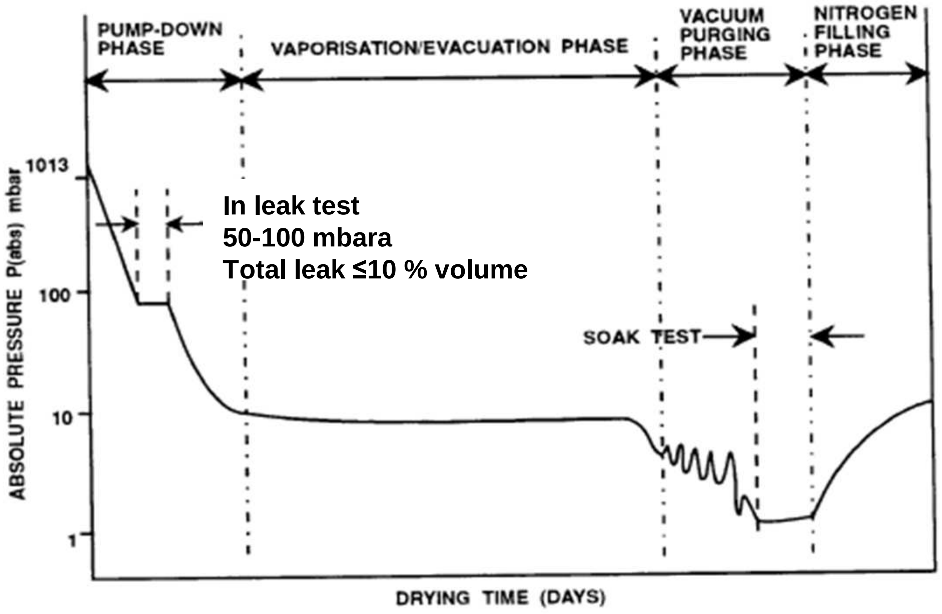
Drying

- Drying the pipelines is usually done for: dry gas, crude containing a high level of H_2S and CO_2, fuel lines
- The purpose is to vaporize the remaining water film in the pipeline and evacuate the water vapor afterwards.
- The vaporization can be performed by: passing the pipeline with dry air (-40 ^oC dew point), nitrogen (-60 ^oC), or by vacuum drying

- **Vacuum drying**: the vaporization is performed by lowering the pressure in the pipeline at which the water will **"boil"** at a temperature slightly lower than the surrounding.
- The process can last for 4-12 weeks, depending on the pipeline water content



At 1.013 bara water will boil at 100^{o}c

At 6.108 mbara water will boil at 0^{o}c.

Soak Test:
Isolating the pipeline with a specific low pressure (i.e 1-3 mbara) for certain hold period (i.e. 24 hours) to ensure the dryness of the pipelines.

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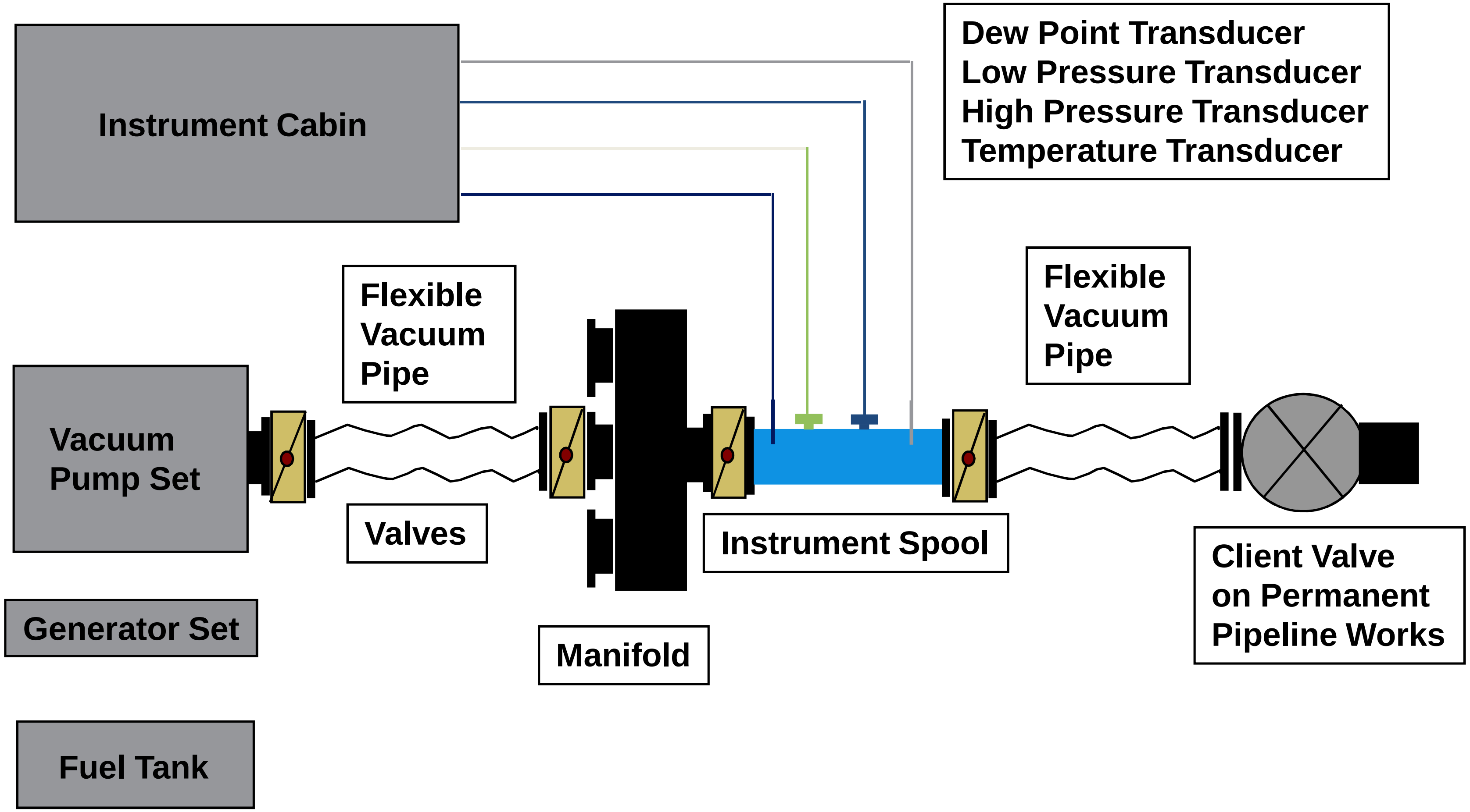
Vacuum Drying Spread



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Diesel Driven Vacuum Pumping Spread

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Preservation

- Following the acceptance of soak test result, the pipelines shall be preserved for future use.

- Performed by purging the pipelines with nitrogen and then “pack” it at a positive pressure of 0.5 -1.5 barg.

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Manufacture and Installation of Backfill Materials

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Granite Quarry –
Rock Extraction by Drilling & Blasting

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Rock blasting operation in Quarry

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Crushing of Granite at Quarry

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Grading of Armour Rocks

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Backfilling using Rock Dumping Vessel

Rock-dumping by Controlled Release of Backfill

Side Stone dumping - typical

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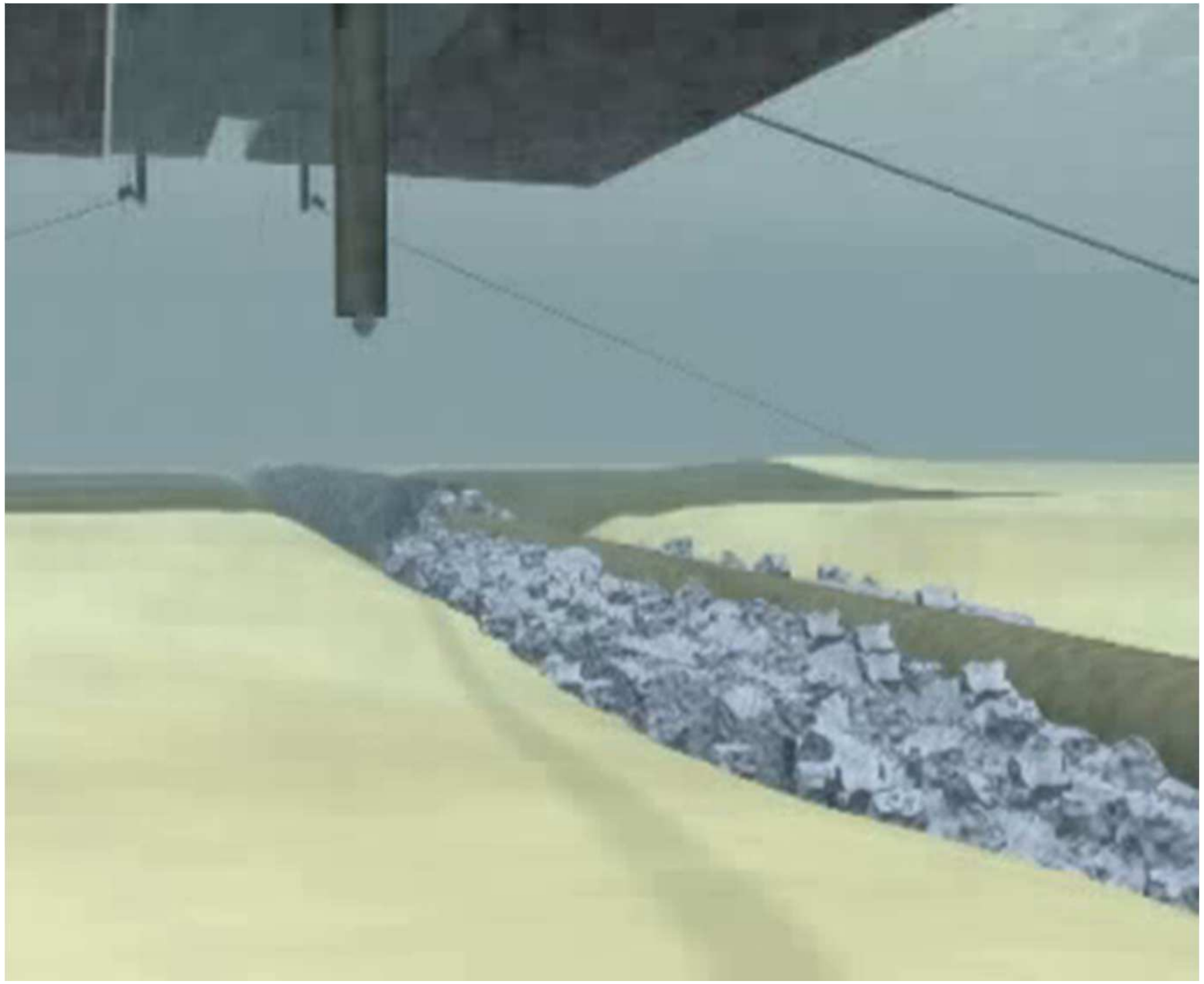
Backfilling using Tremie Pipe



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Backfilling with Gravel using Crane & Clamshell

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Marine Survey

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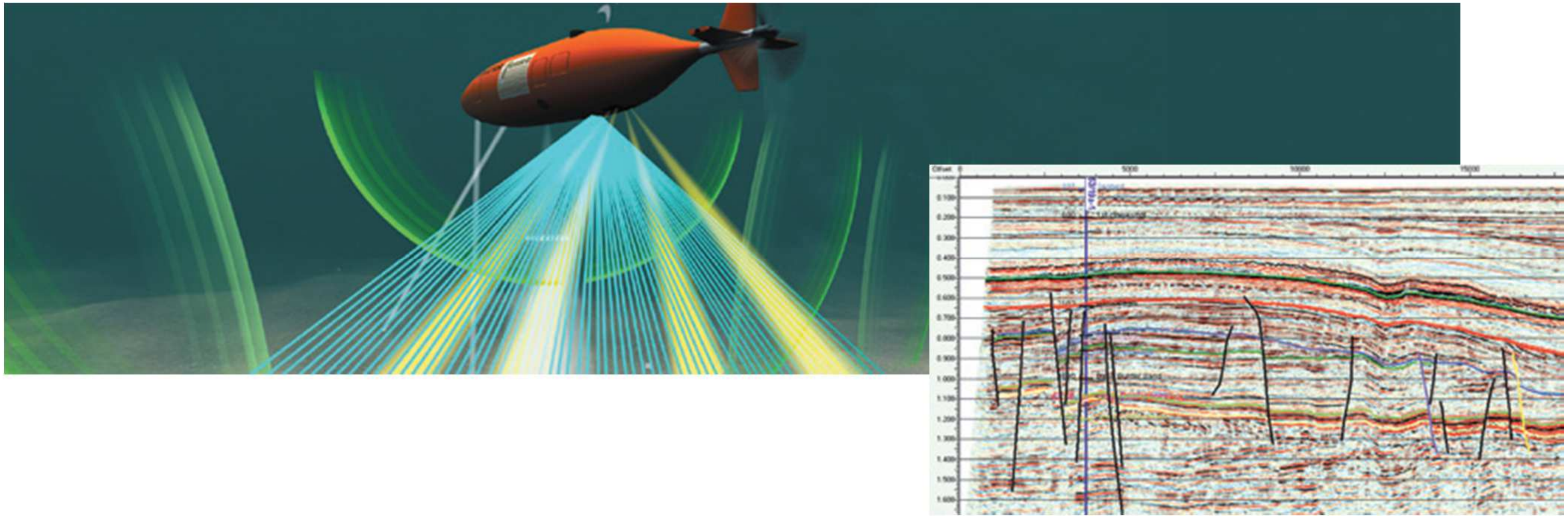
Hydrographic Survey of Seabed
(side scan sonar and echo sounder)



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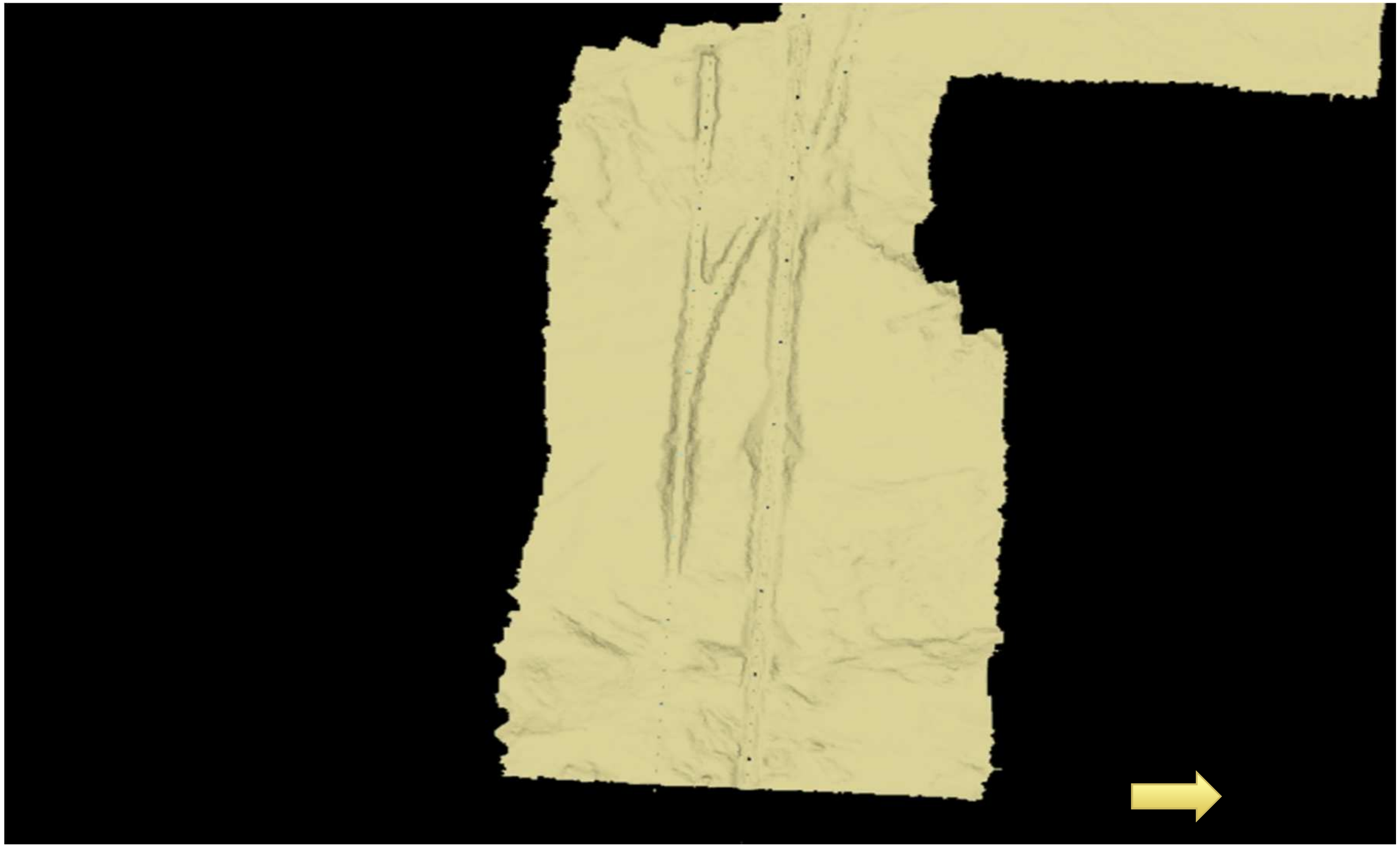
Views obtained from Multi-beam Survey



Examples of Installation Analyses Required Prior to Offshore Installation

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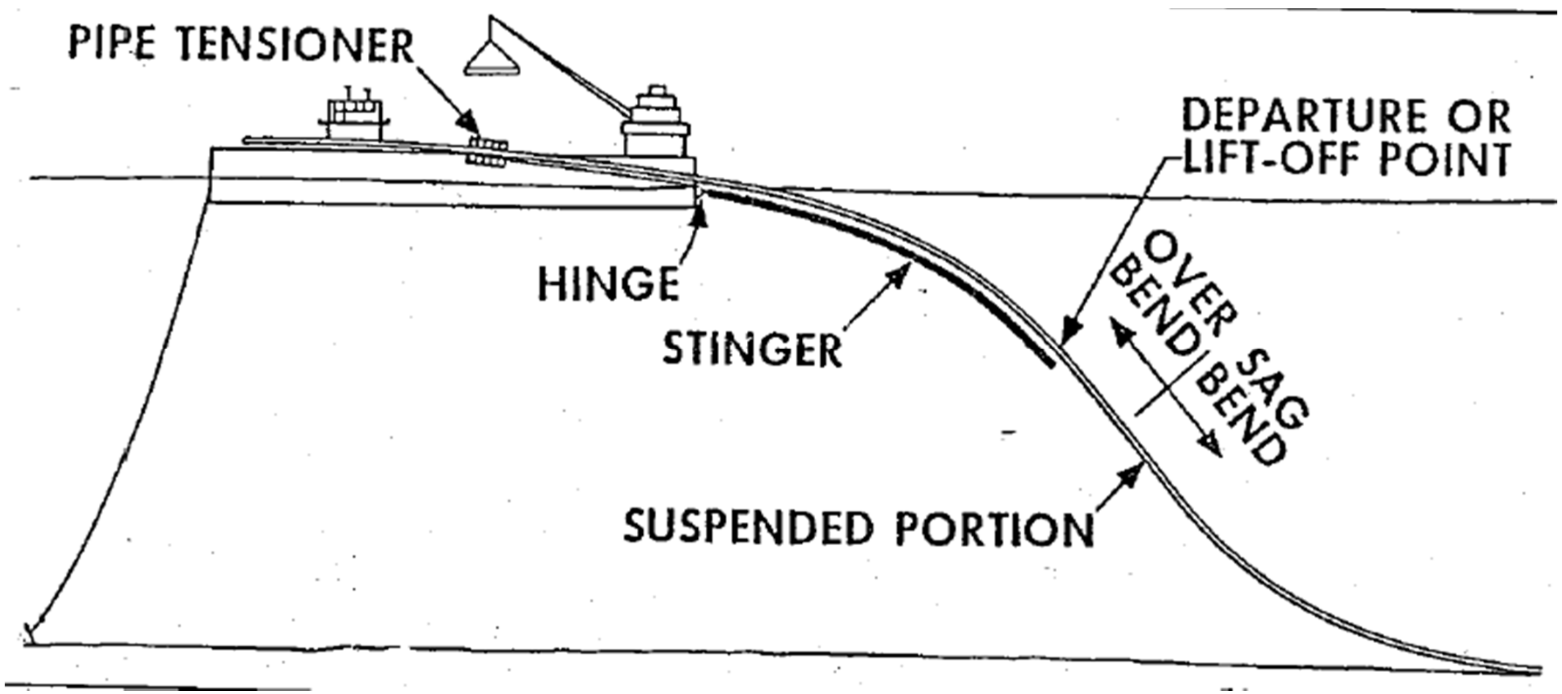
Terminology in Pipeline Engineering



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Example of Optimised Pipelay Analysis (barge with articulated stinger)

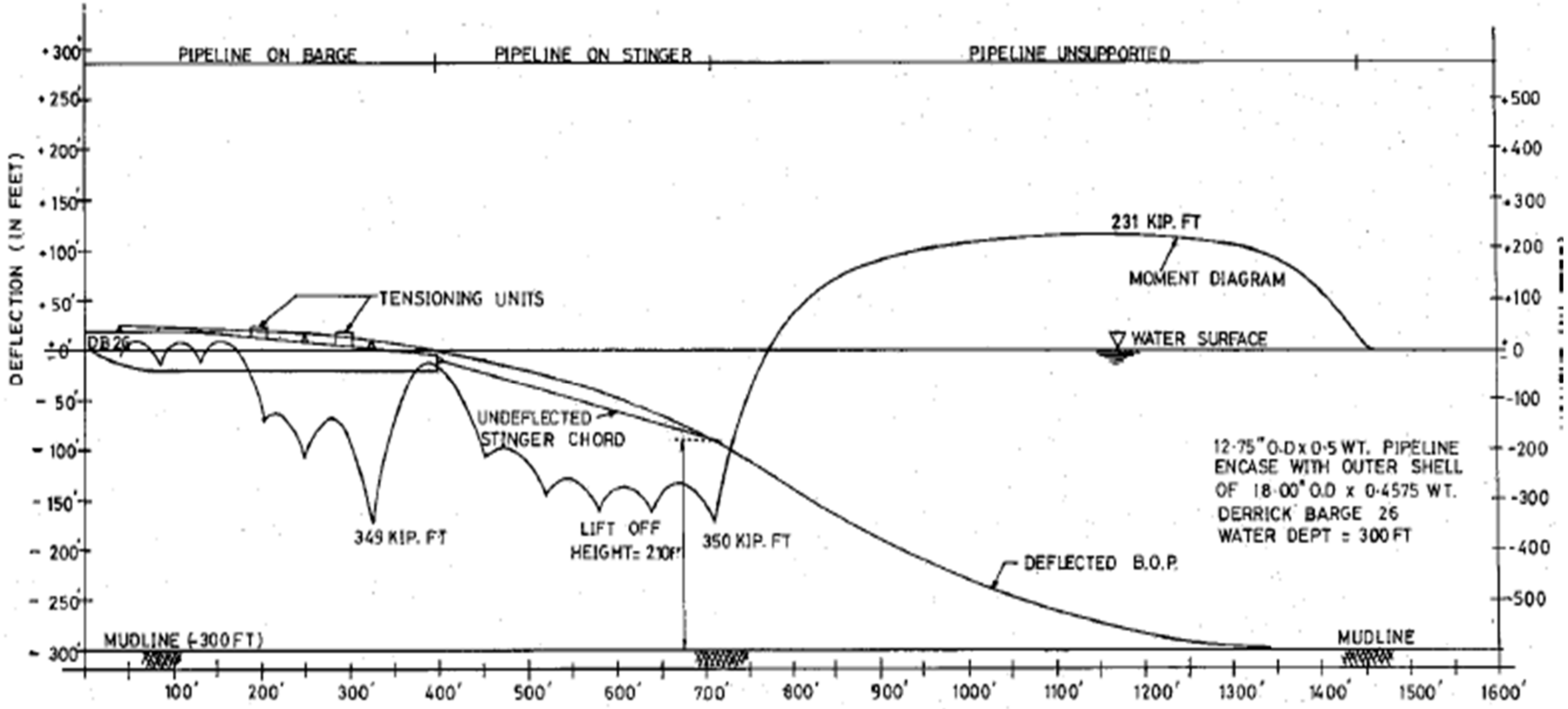
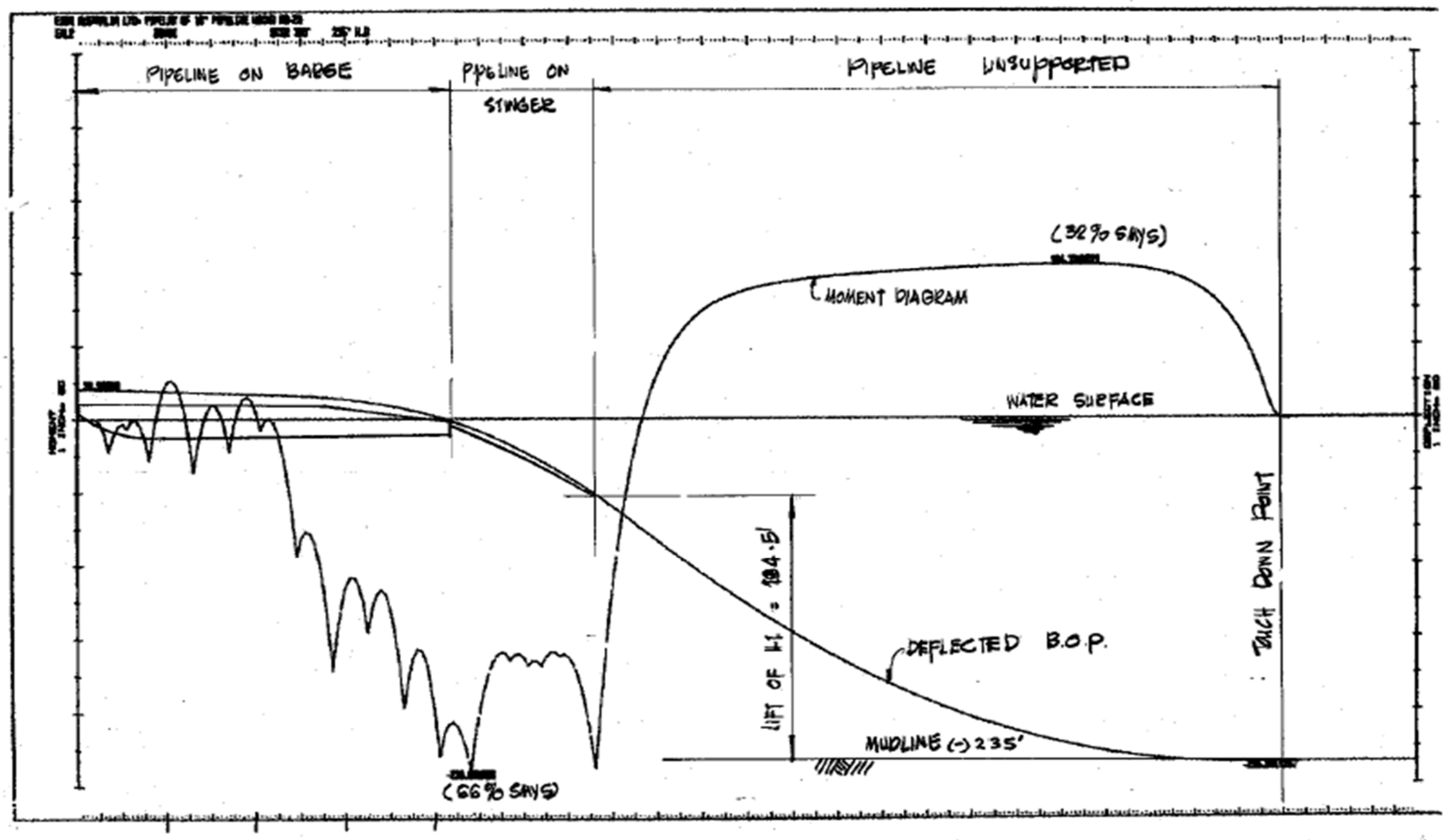
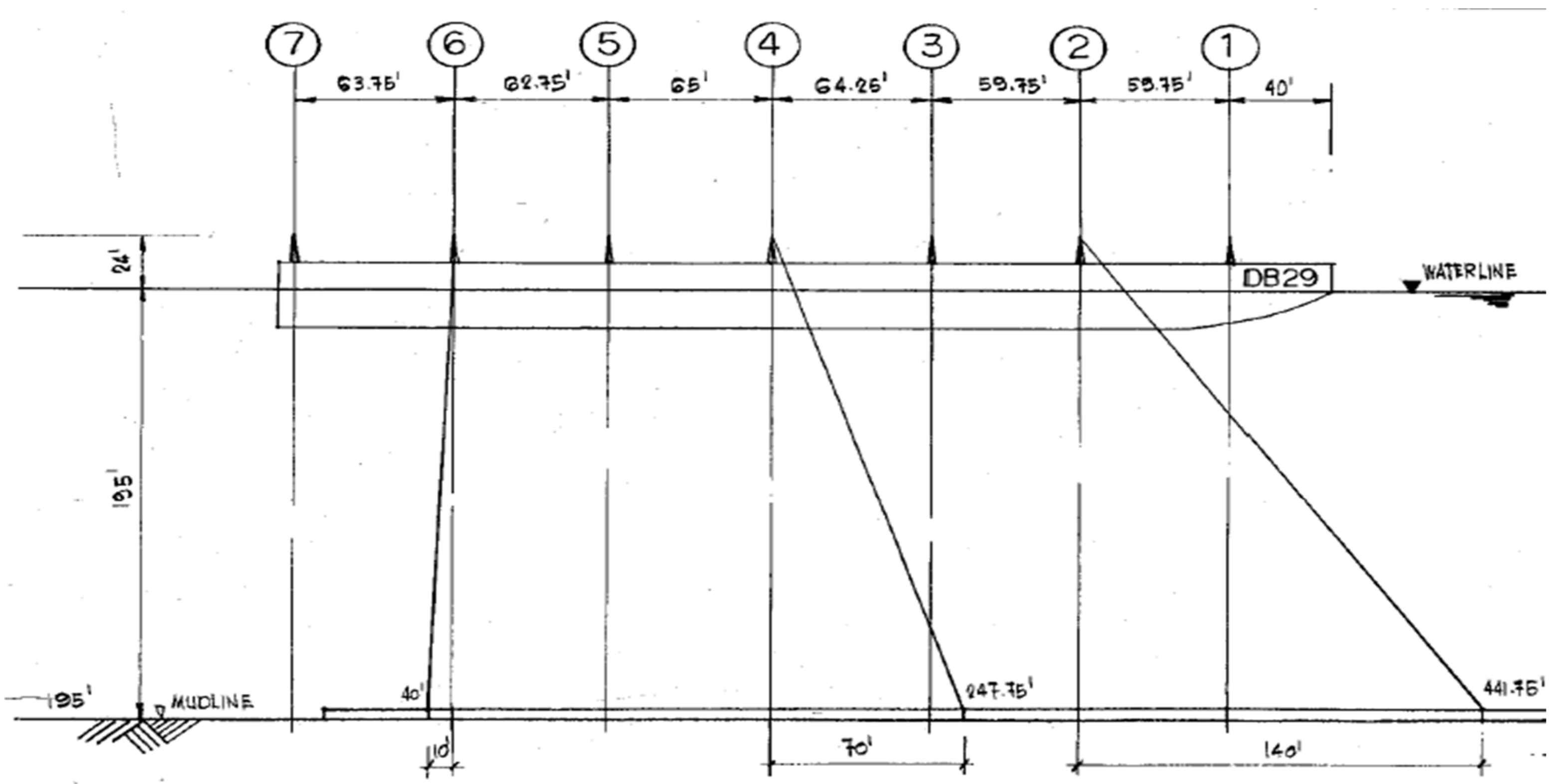


FIGURE 14. – TYPICAL LAYBARGE STRESS PLOT AND PIPE DEFLECTION CURVE.

Example of Optimised Pipelay Analysis (barge with truss stinger)



Example of Optimised Configuration for Davit Lift



INITIAL ATTACHMENT CONFIGURATION

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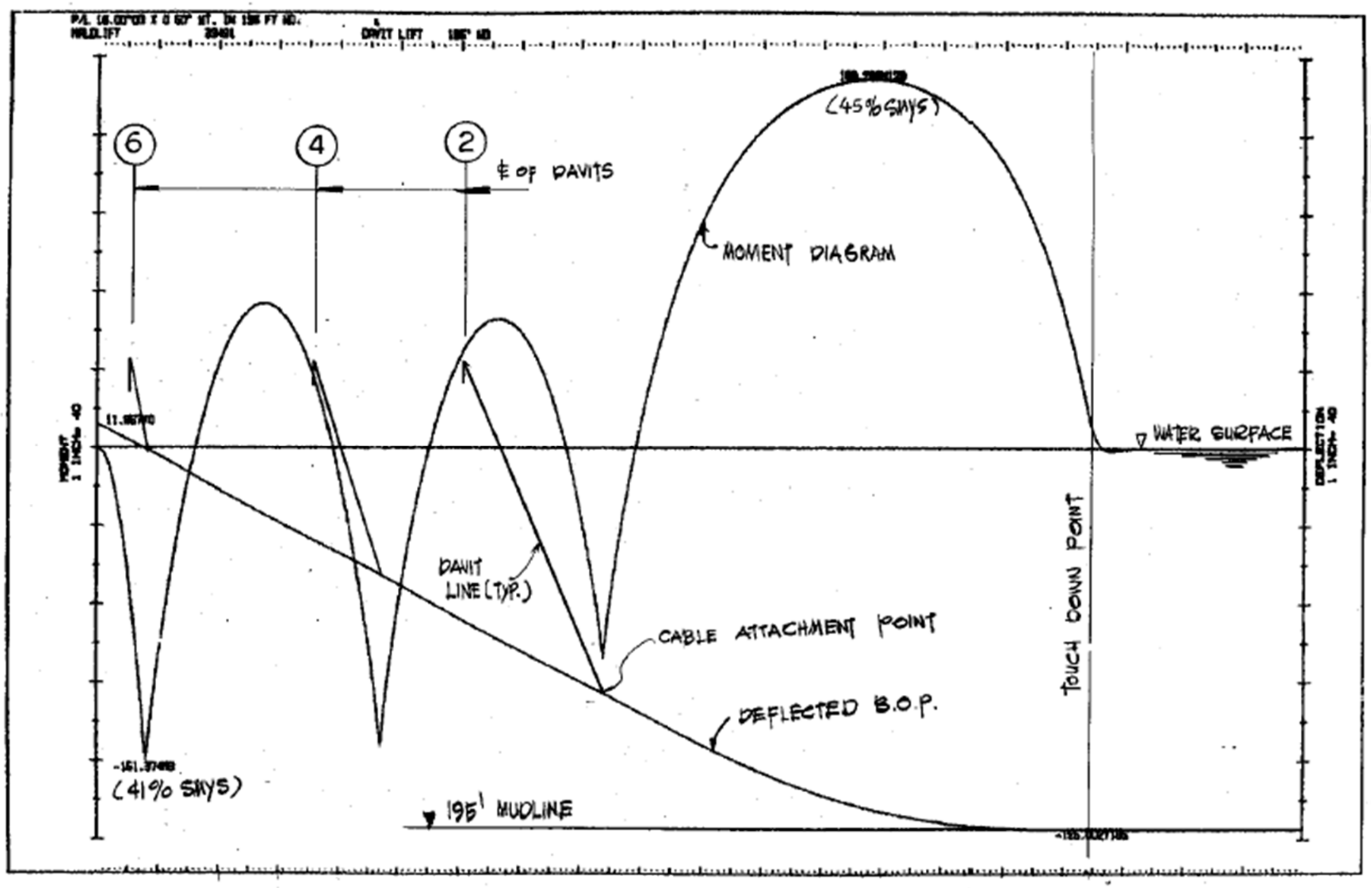
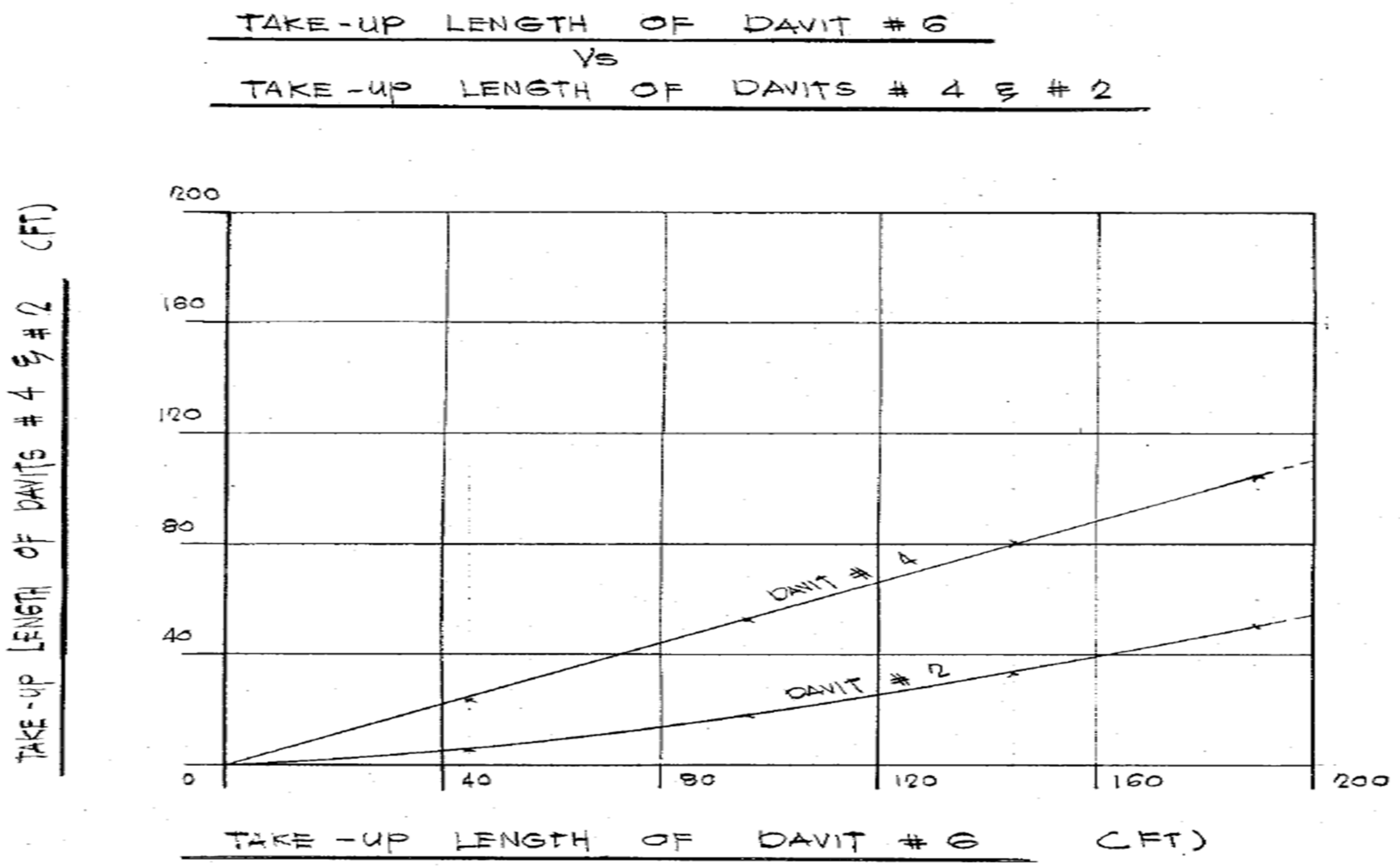
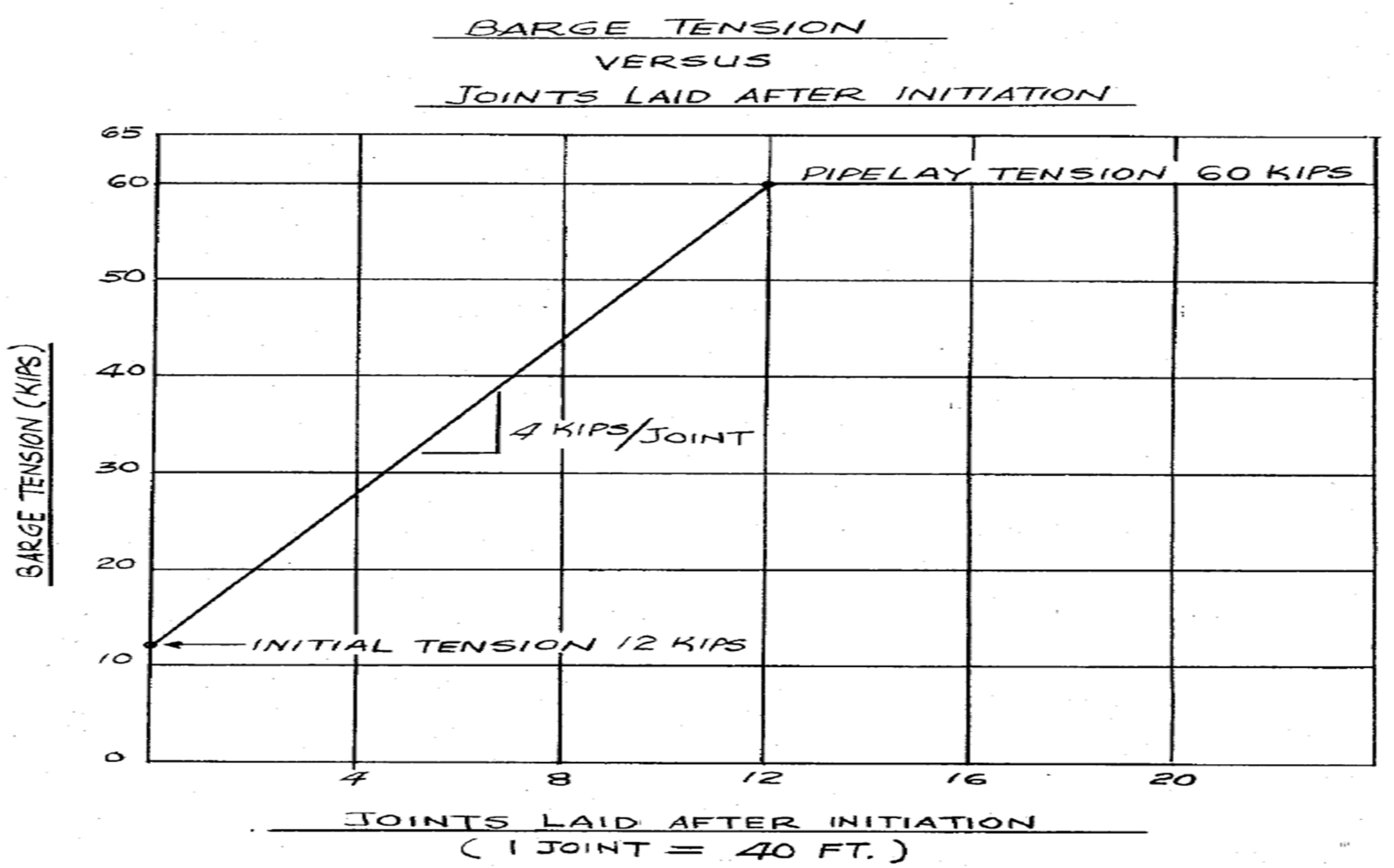
Typical Moment-Deflection Diagram of Pipeline in Final Lifted Configuration Using Davits



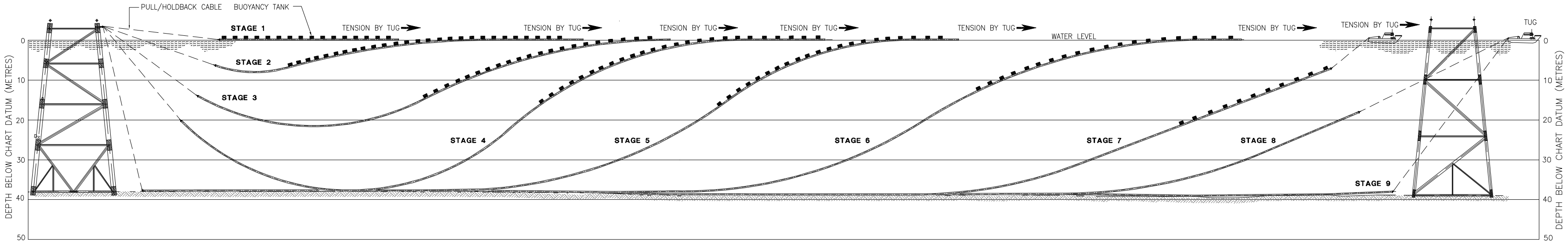
Typical Information to be Provided to Field Engineer for Actual Davit Lift Operation



Typical Information to be Provided to Field Engineer for Any Type of Pipelay Initiation



Sample Case: 12” Pipeline Installation by Rentis Method



No. of Drums Used	Stage	Tension Applied (tonnes)	Max. Depth of Drums[2] (m)	Max. Pipe Stress (%SMYS)
12 drums per pipe joint	1 (total of 50 m drums removed)	10 (98 kN)	-2.2	42
	2 (total of 100 m drums removed)	10 (98 kN)	-9.0	63
	3 (total of 200 m drums removed)	15 (147 kN)	-22.7	48
	4 (total of 500 m drums removed)	15 (147 kN)	-22.4	46
	5 (total of 900 m drums removed)	30 (294 kN)	-21.9	28
	6 (total of 1000 m drums removed)	30 (294 kN)	-	28
	7 (total of 1000 m drums removed + additional 150 ft cable released by tensioning tug)	10 (98 kN)	-	60

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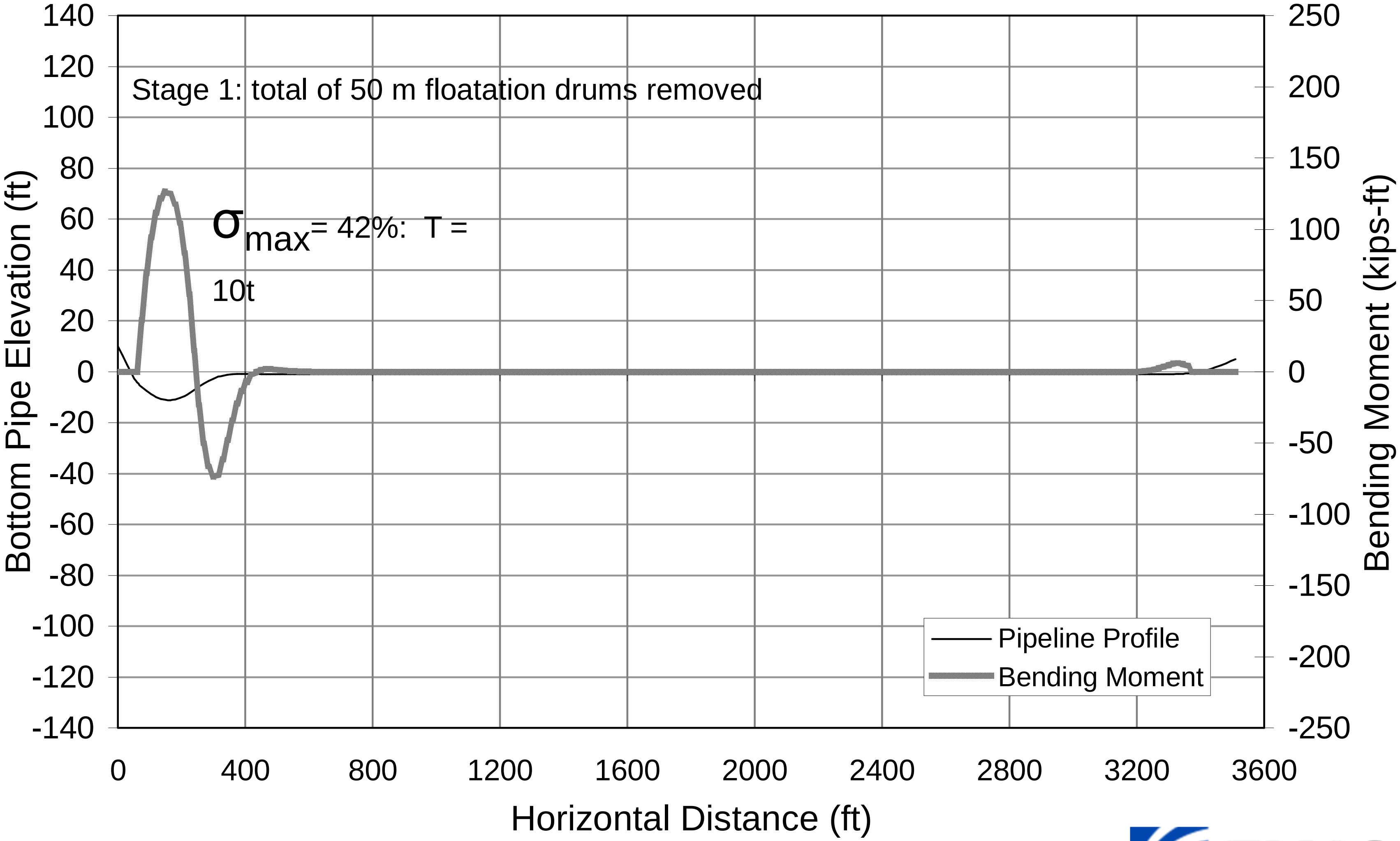
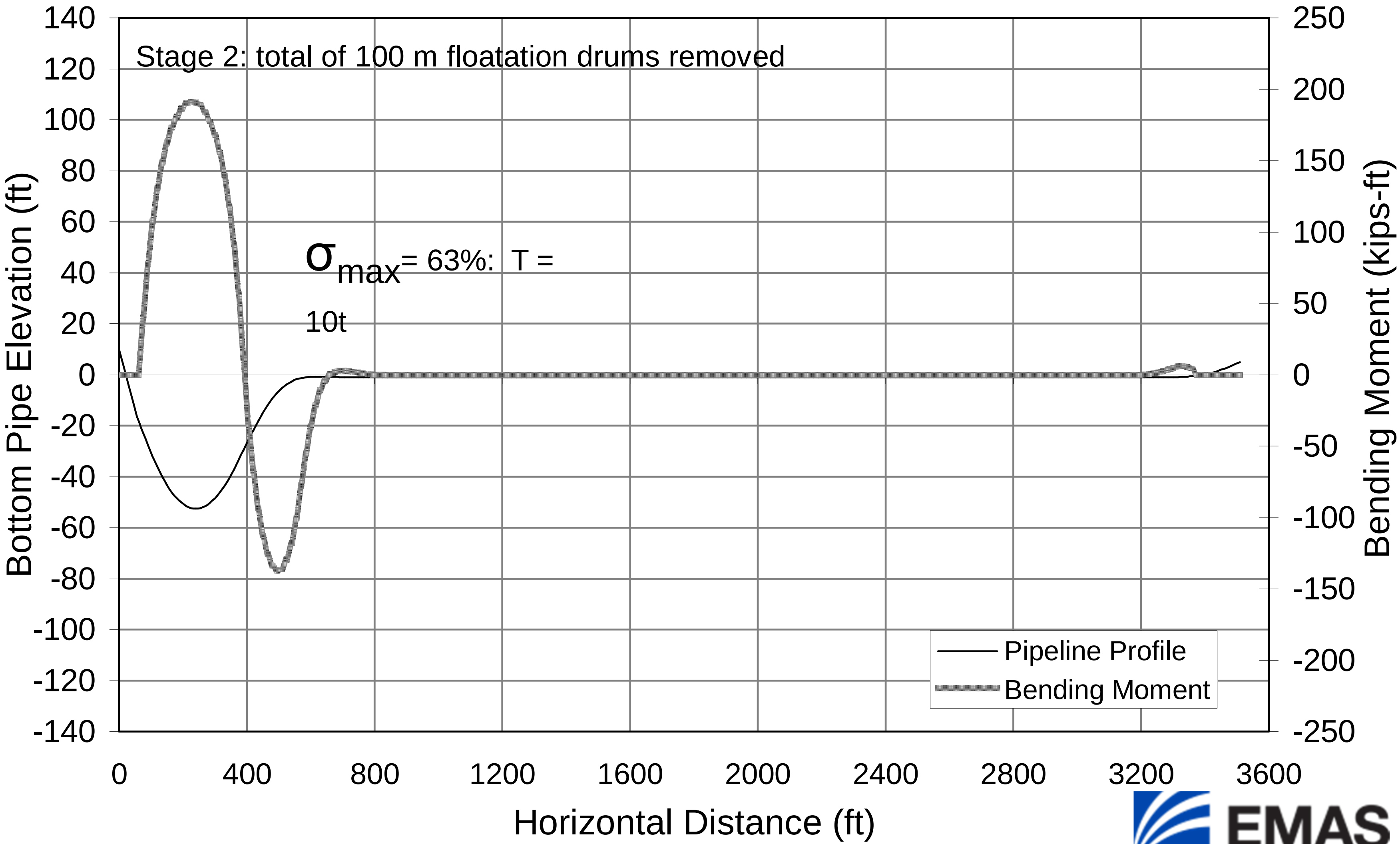


Stage 1: total of 50 m floatation drums removed
σmax= 42%: T =
10t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
Pipeline Profile
Bending Moment
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600

EMAS


Stage 2: total of 100 m floatation drums removed
σmax= 63%: T =
10t
Bottom Pipe Elevation (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
Bending Moment (kips-ft)
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600
Horizontal Distance (ft)
Pipeline Profile
Bending Moment

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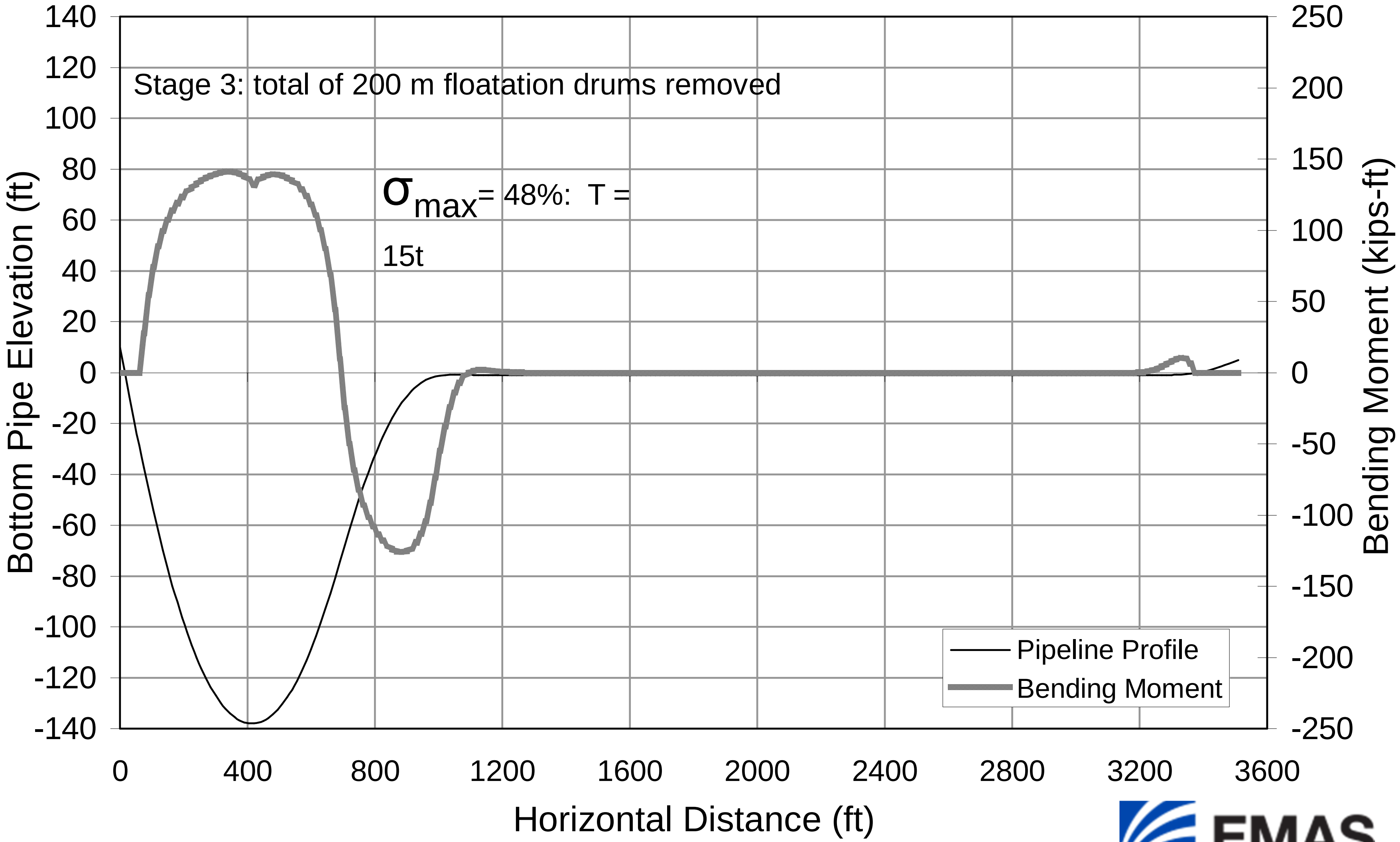
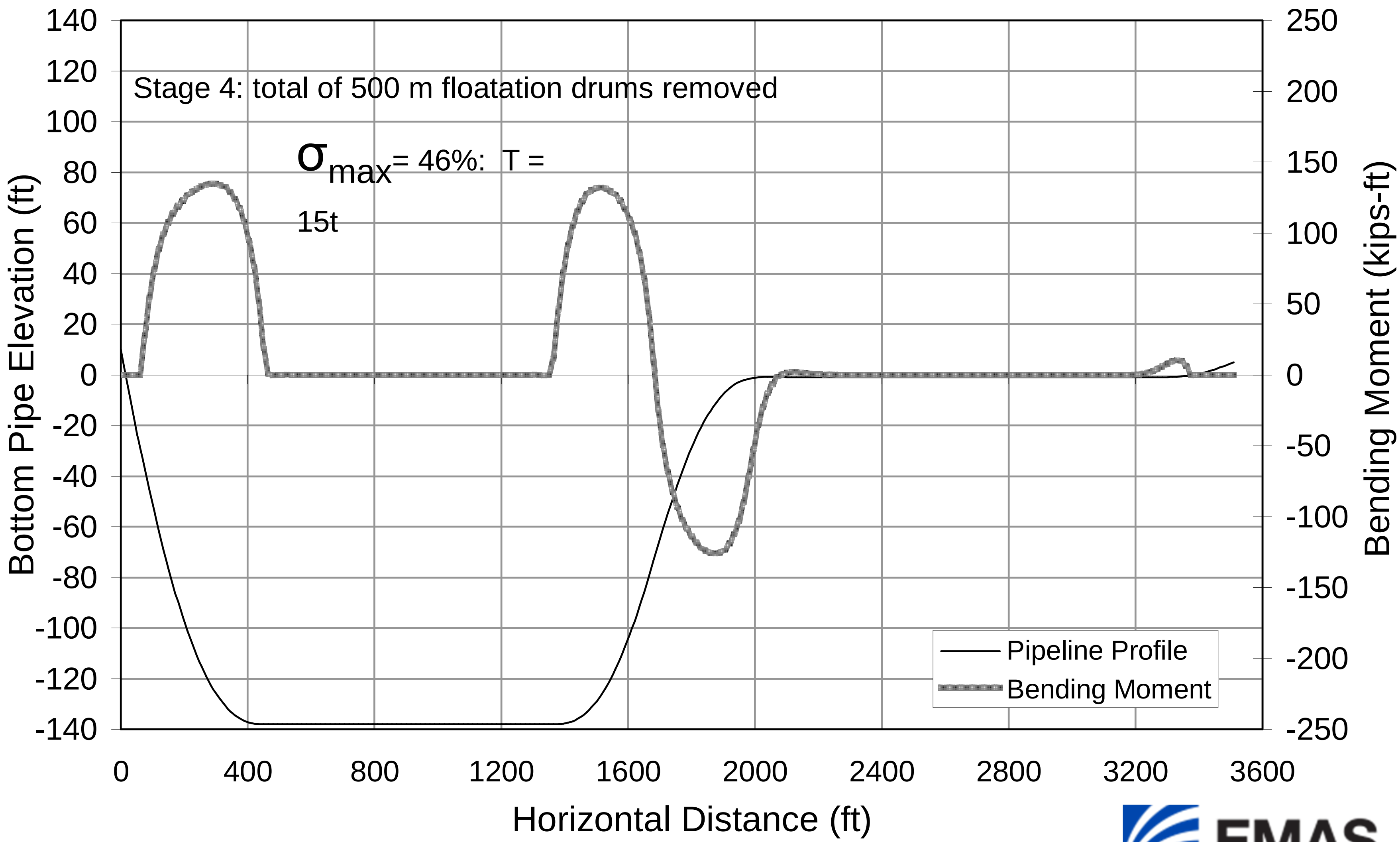
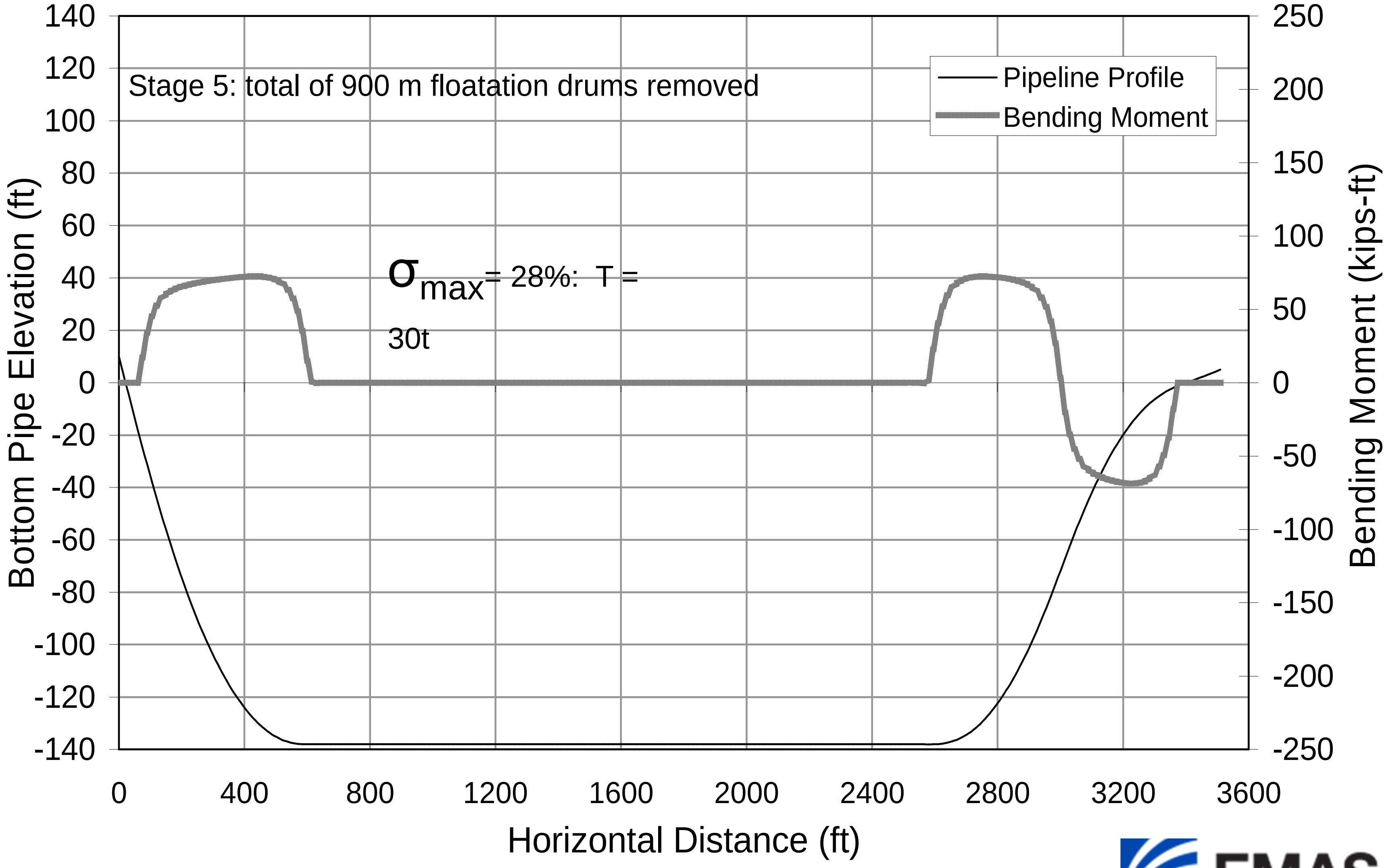


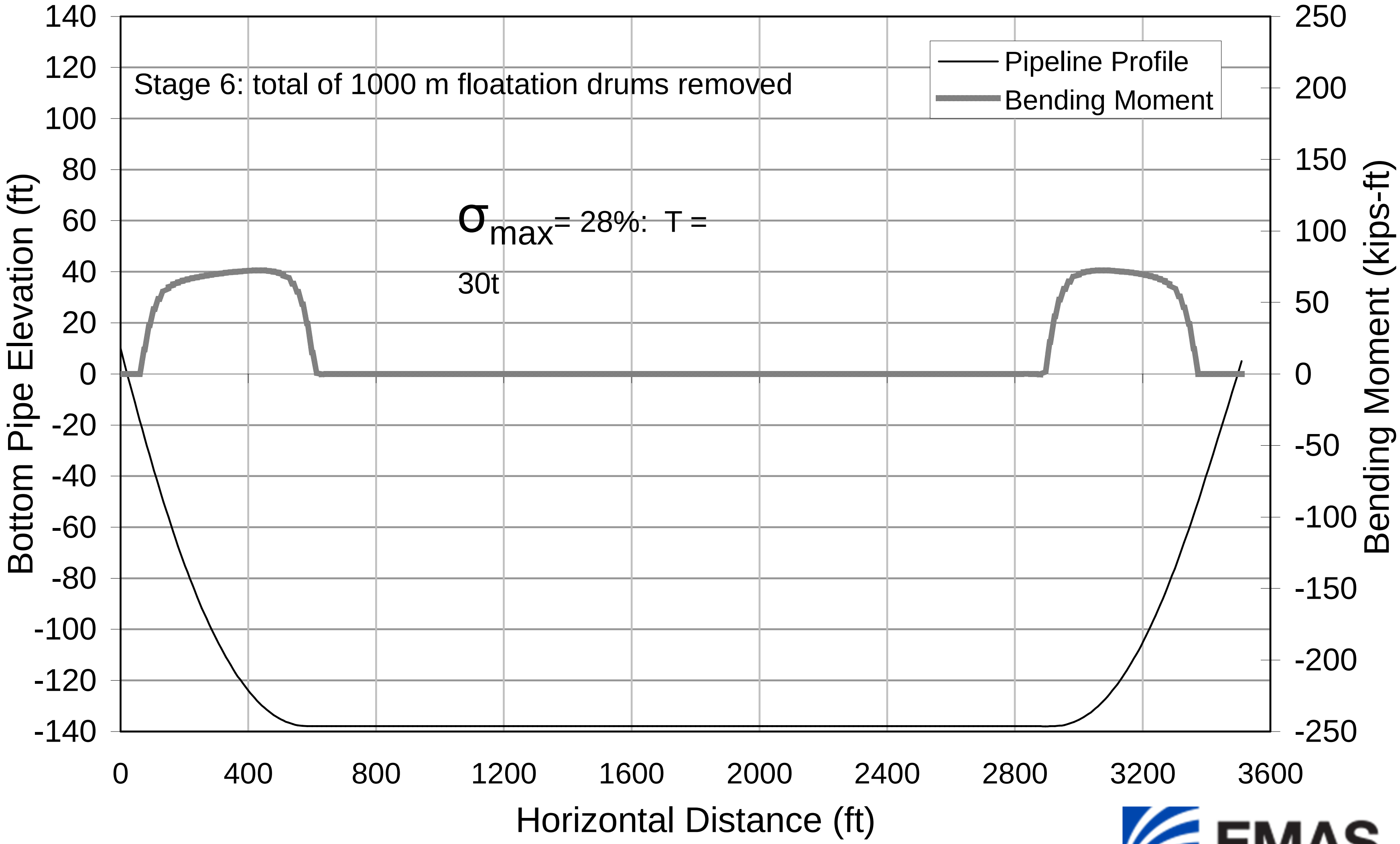
Stage 3: total of 200 m floatation drums removed
σ_{max}= 48%: T =
15t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
Pipeline Profile
Bending Moment
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600



Stage 4: total of 500 m floatation drums removed
σ_{max}= 46%: T =
15t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600
Pipeline Profile
Bending Moment

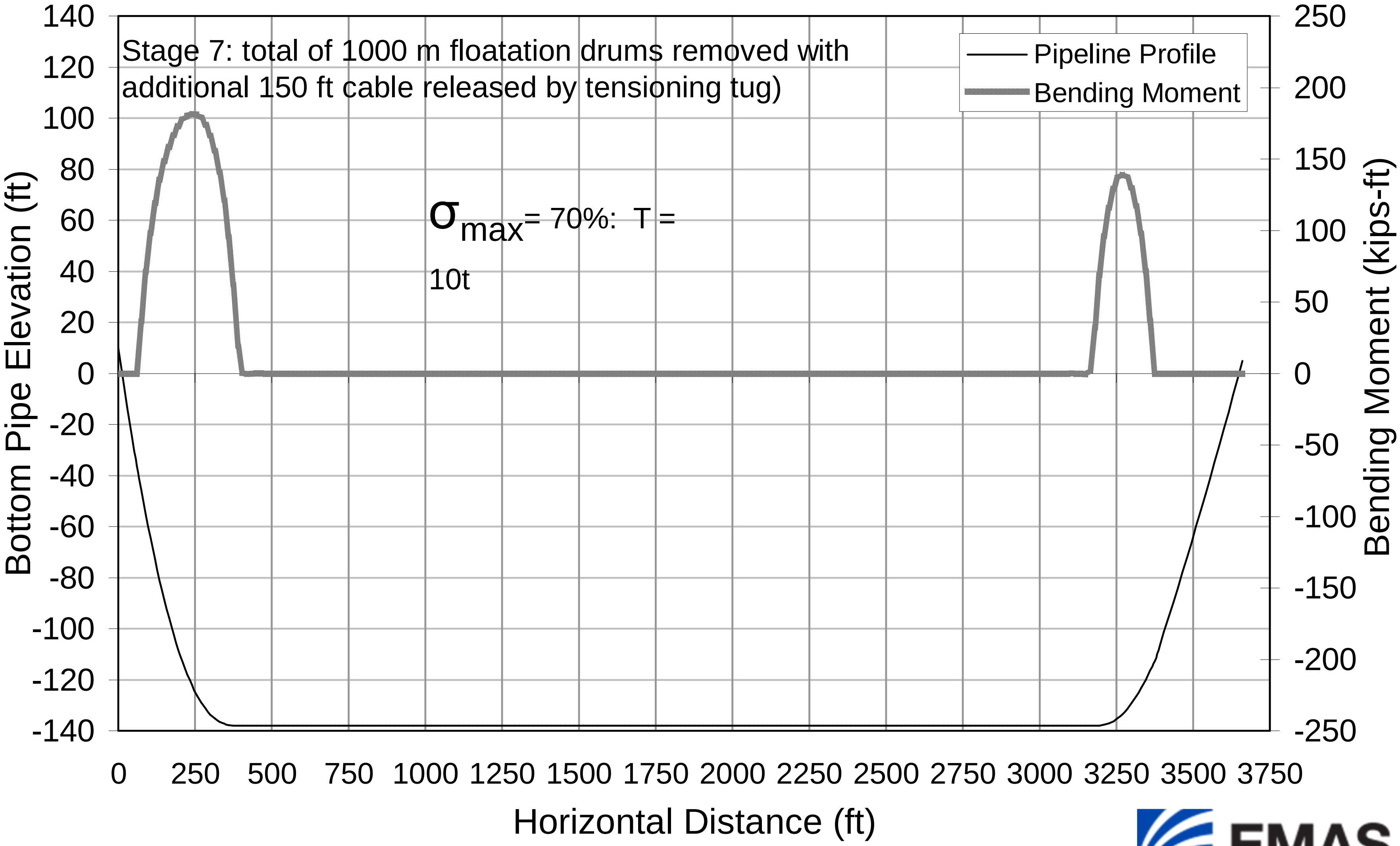
EMAS


Stage 5: total of 900 m floatation drums removed
Pipeline Profile
Bending Moment
σmax= 28%: T =
30t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600

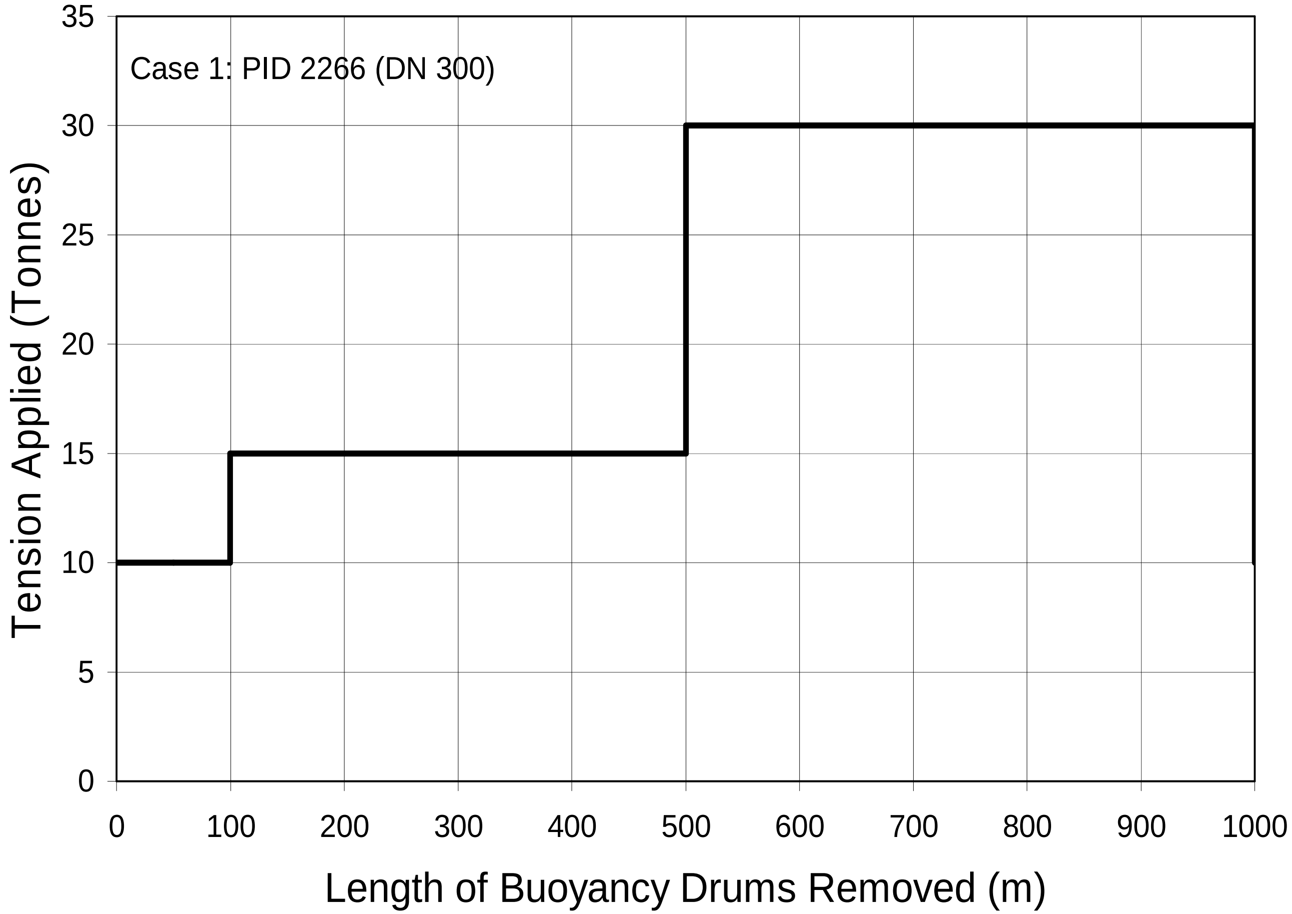


Stage 6: total of 1000 m floatation drums removed
Pipeline Profile
Bending Moment
σmax= 28%: T =
30t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600

EMAS


Stage 7: total of 1000 m floatation drums removed with additional 150 ft cable released by tensioning tug)
Pipeline Profile
Bending Moment
σmax= 70%: T = 10t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750

EMAS



Proposed Tension Requirement for Each Stage of Rentis Installation For Case 1: 12” (DN 300) Pipeline

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The End