



Engineering 'Lunch & Learn' Series

Installation of Floating Facilities and Mooring Legs – Project Examples

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Submarine Pipelines Consulting Engineers*





Agenda:

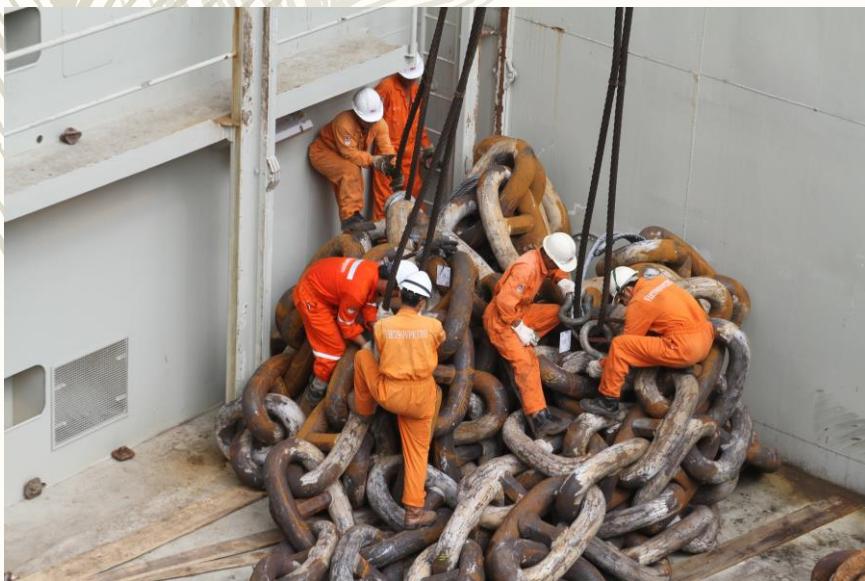
Project examples for:

1. Mooring chain off-loading from transportation vessel
2. Mooring chain loading to MSV for chain installation
3. Pile preparation and load-out
4. Typical suction pile installation
5. Example of FPSO installation encompassing
 - ✓ Anchor piles
 - ✓ Mooring chains
 - ✓ Mid-water arch
 - ✓ Flexible riser

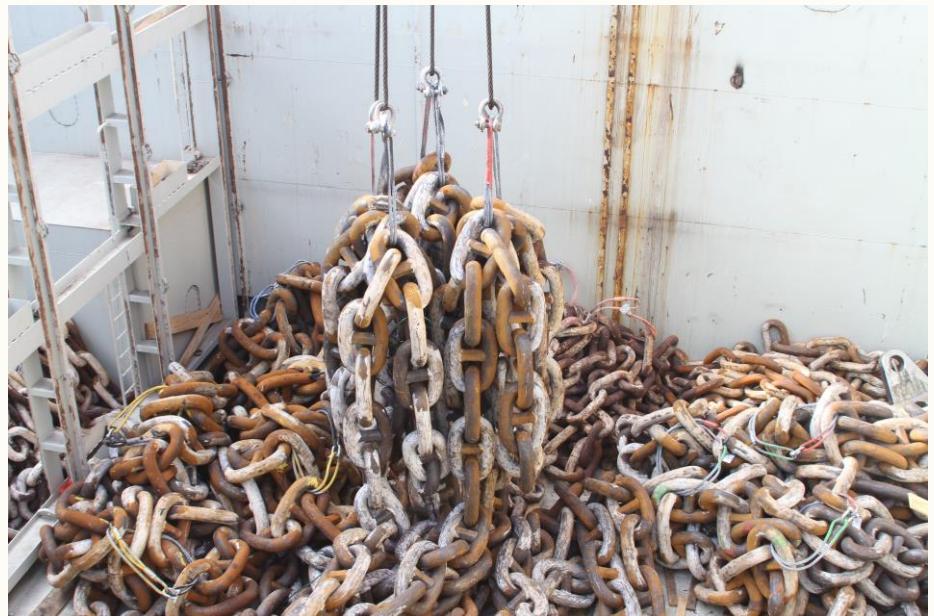


*Typical Off-loading of Mooring Chains
from Transportation Vessel*

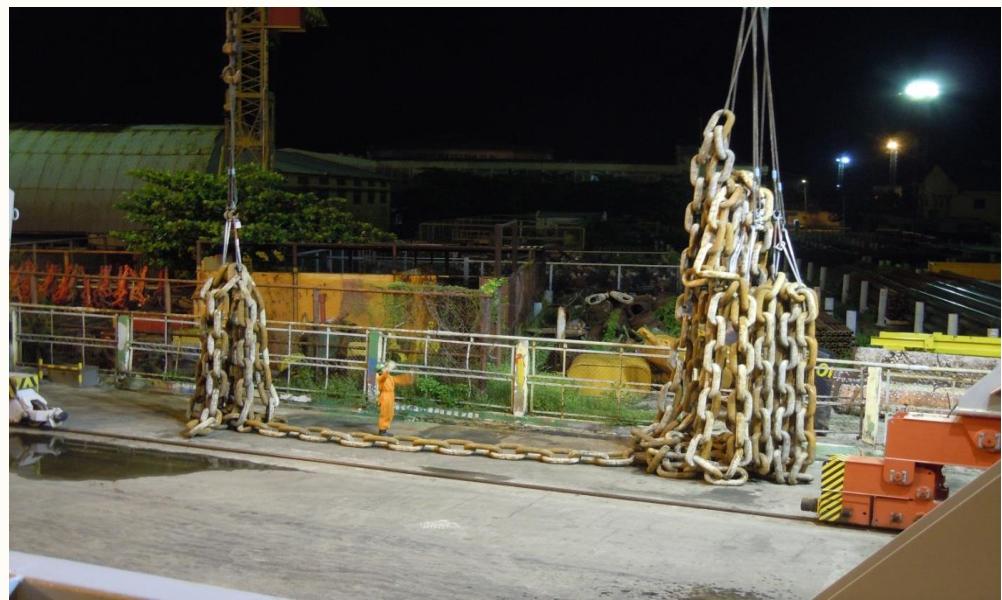
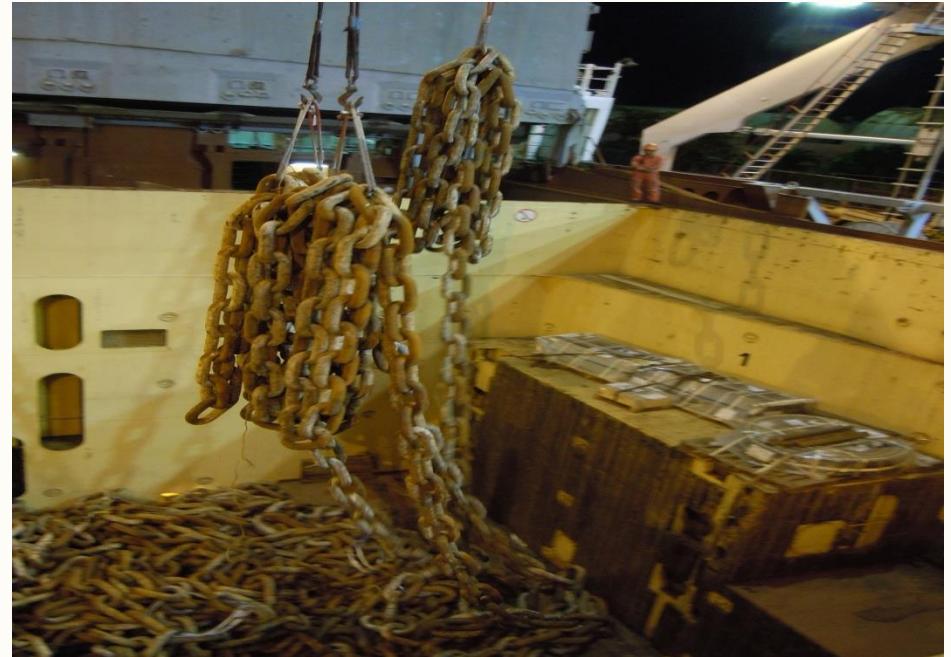
Typical chain transportation vessel – top cover closed during transit



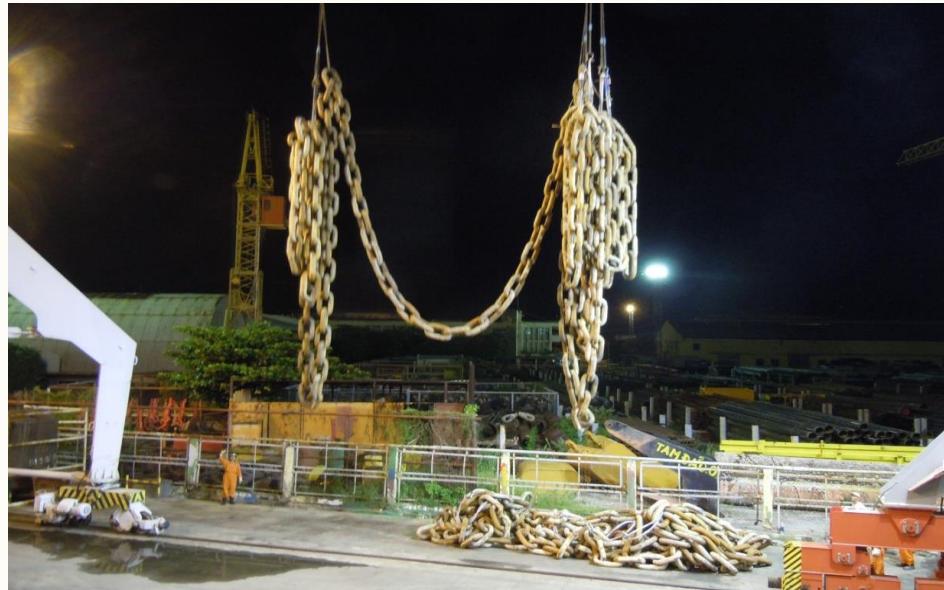
Rigging chains for off-loading



Off-loading of chain at wharf using wharf cranes



Chains are first off-loaded onto quayside, then transferred by trailers to storage yard



Transferring of off-loaded chains at quayside to storage yard



Off-loading of 2nd shipment of chains using crane barge



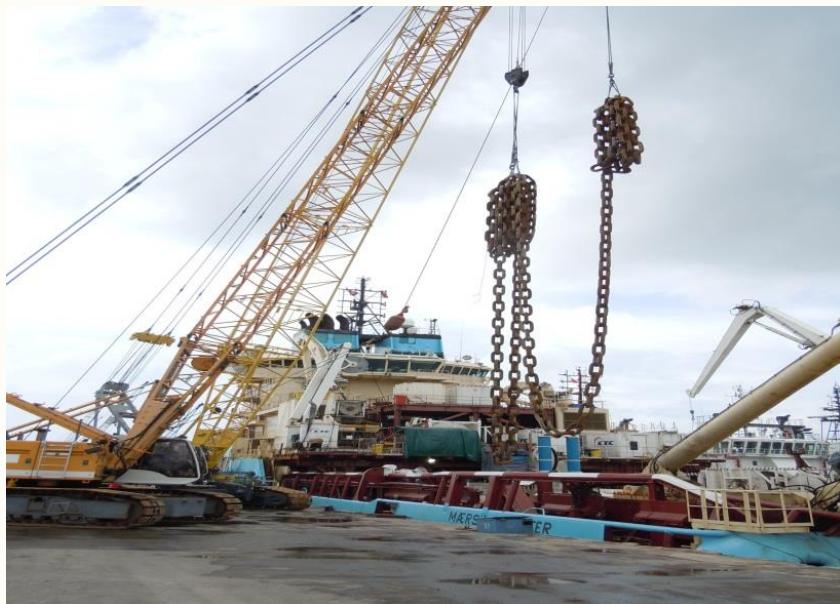


Loading of mooring chains onto MSV and chain-locker

Loading of chains from storage yard onto trailer to transport to installation vessel



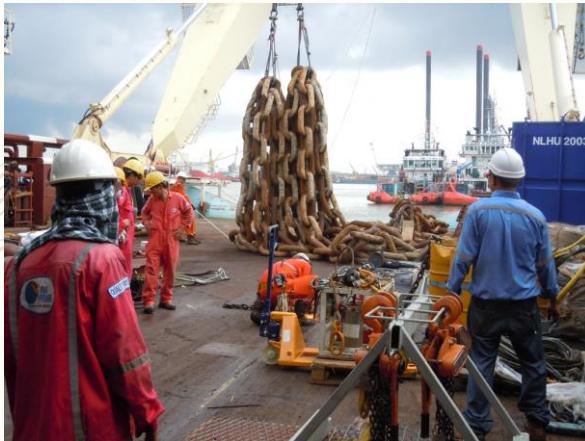
Loading chains directly from quayside to installation vessel



Landing chain on the deck of installation vessel



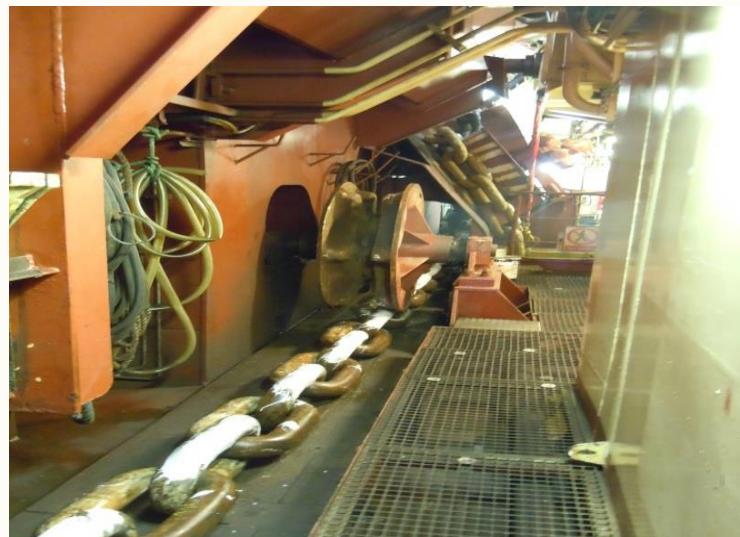
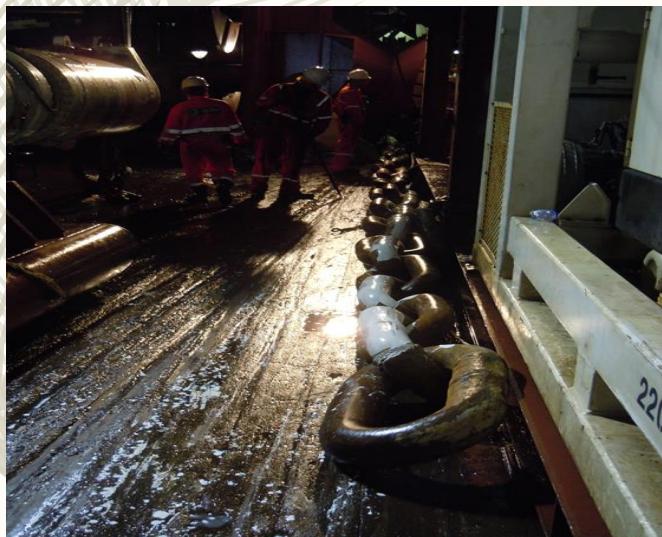
Sorting out chain on the deck prior to loading into chain locker



Unwinding chain & loading into the chain locker



Unwinding & marking chain & loading into the chain locker



Chains being loaded into chain locker in reverse order of lay

Note: Chains are marked to provide visual that chain is straight after installation





Piles preparation & loading

Trial fitting of mooring shackles & dimensional checks prior to load-out

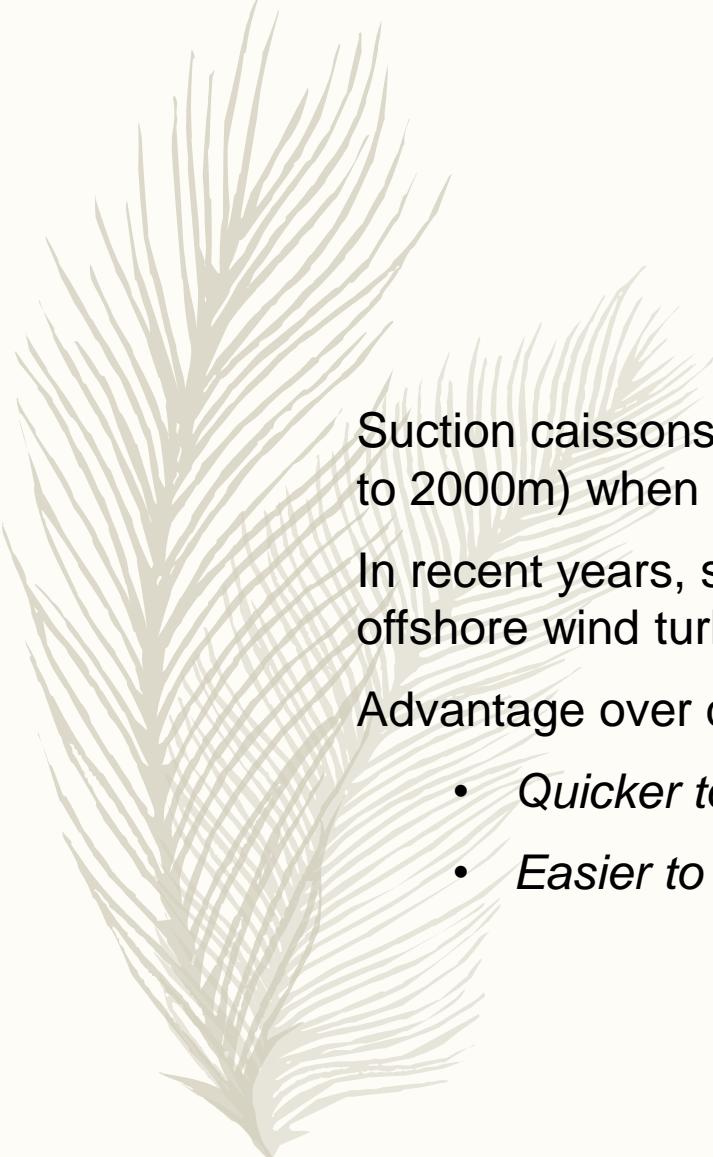


Loading out of piles on material barge



Typical pile guide frame (PGF) used for subsea piling





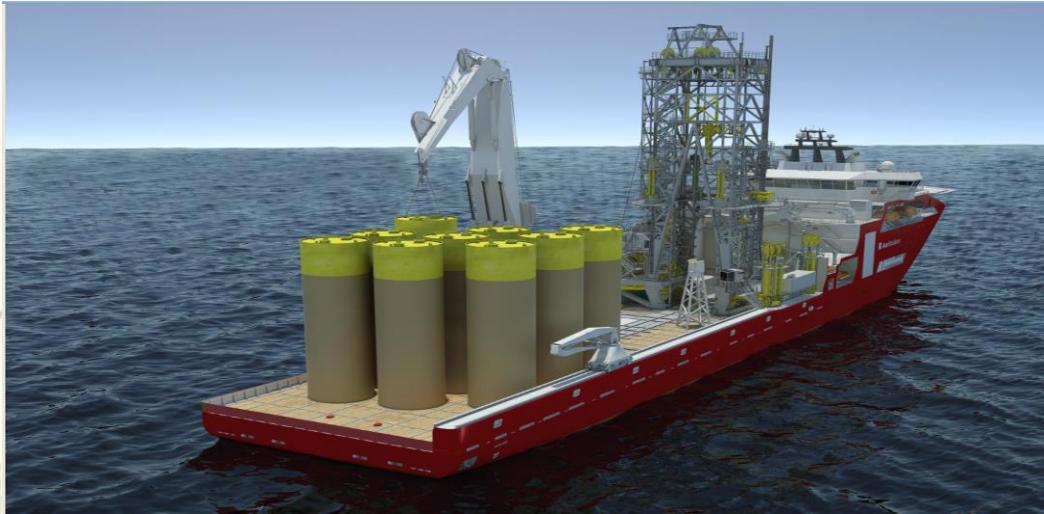
Suction Piles

Suction caissons are used often in deep water applications (up to 2000m) when conventional driven piling is difficult.

In recent years, suction caissons have also seen usage for offshore wind turbines in shallower waters.

Advantage over driven piles:

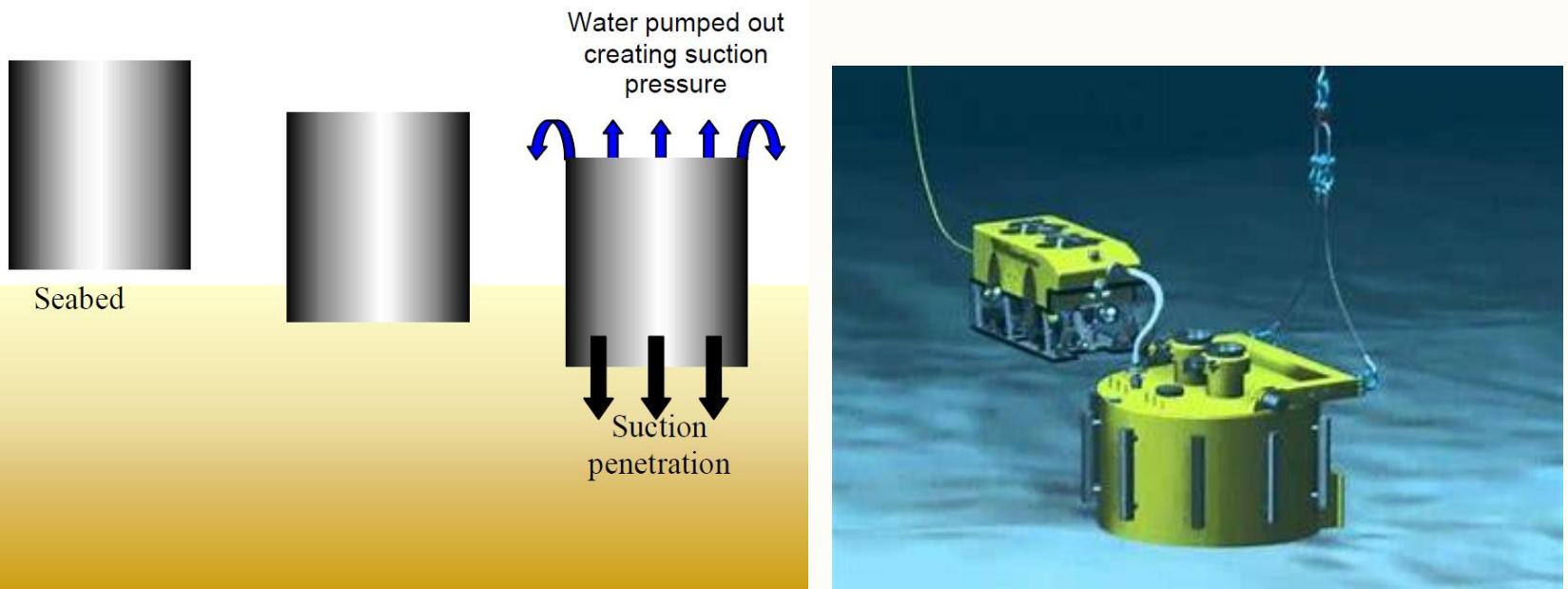
- *Quicker to install*
- *Easier to remove during decommissioning*



Suction pile is effectively a caisson embedded in the marine sediment. This embedment is typically achieved through creating a negative pressure inside the caisson. The foundation can also be rapidly removed by reversing the installation process, applying an over air pressure inside the caisson skirt. The suction caisson technology functions very well in a seabed with soft clays or other low strength sediments. The suction caissons are in many cases easier to install than piles, which must be driven (hammered) into the ground with a pile driver.

Suction piles become better alternative to driven piles in deepwater because of technical challenges and cost associated with deep water applications. In addition, such caissons provide a greater resistance to lateral loads than driven piles because of the large diameter typically used.

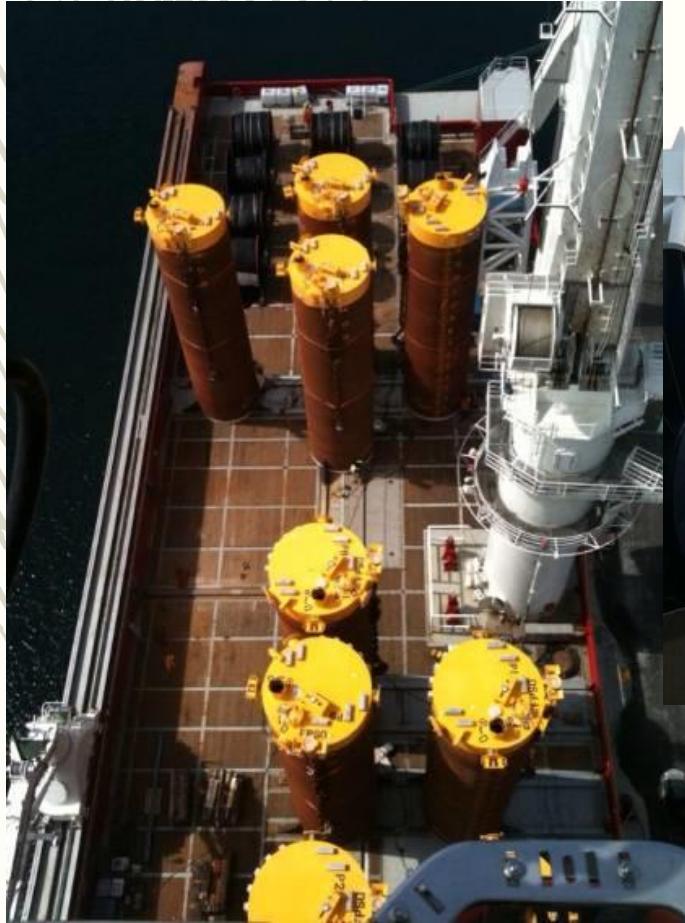
Installation sequence of suction caissons (a) Touchdown phase (b) Penetration due to self weight/ballast (c) Water pumped out to create suction penetration



Some contractors regard suction caissons as better alternative to driven piles for deep water because of technical challenges and costs associated with installation of driven piles:

- Heavy lift vessels can be avoided, simplifying and shortening the installation procedure.
- Another advantage is that there is more control over the installation process.
- Suction caissons also provide greater resistance than vertical driven piles and drag anchors because of the larger diameters typically used (Colliat et al., 1995).

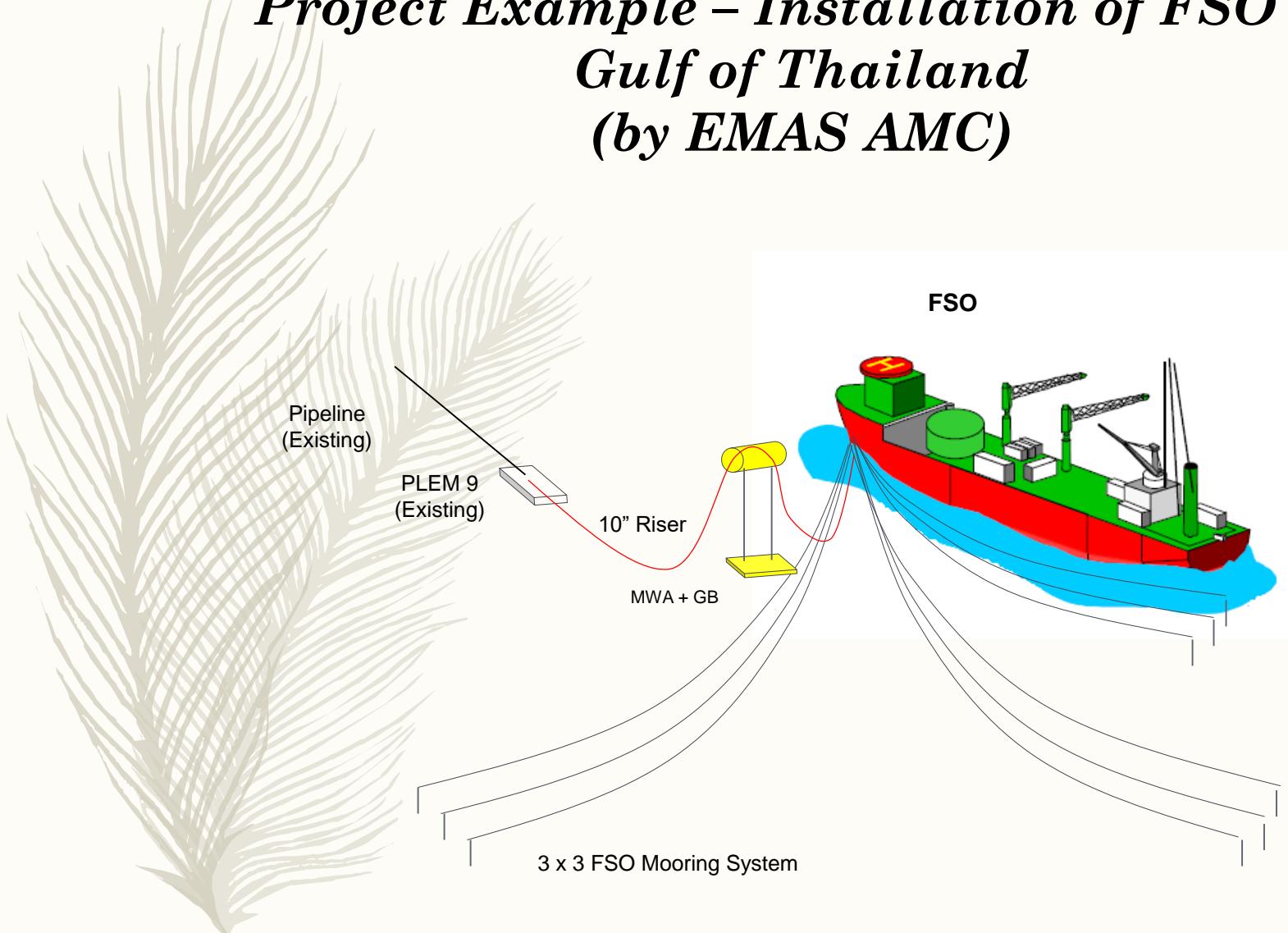
Suction piles are typically transported vertically on the installation vessel to facilitate installation (vertical lift and deployment)



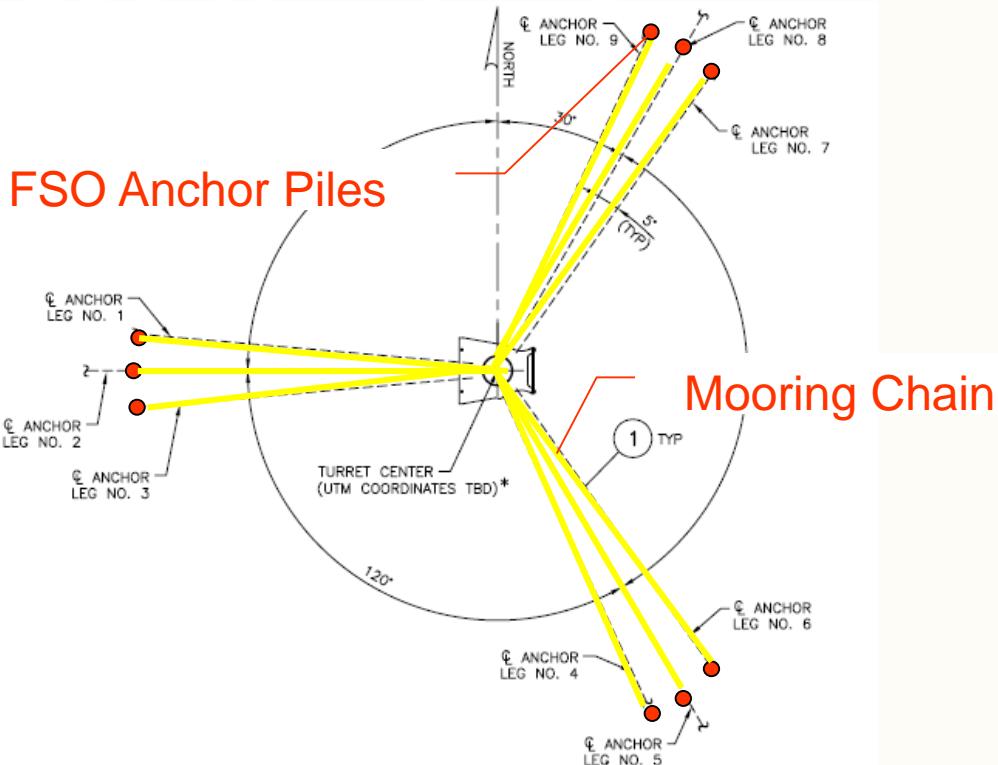
If suction piles are transported offshore via a separate transportation barge, the piles could be arranged horizontally, in which case, they will be lifted up horizontally and up-righted in the water or after it is placed on seabed



Project Example – Installation of FSO in Gulf of Thailand (by EMAS AMC)

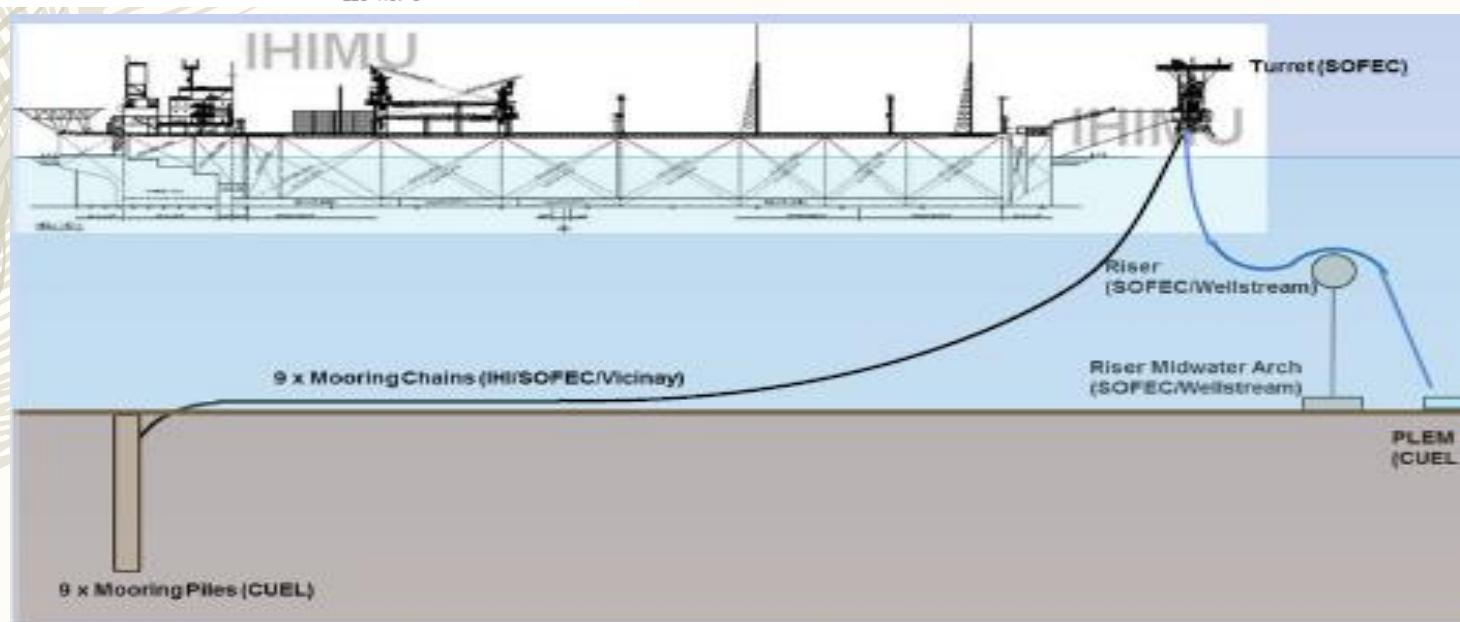


FSO Anchor Piles



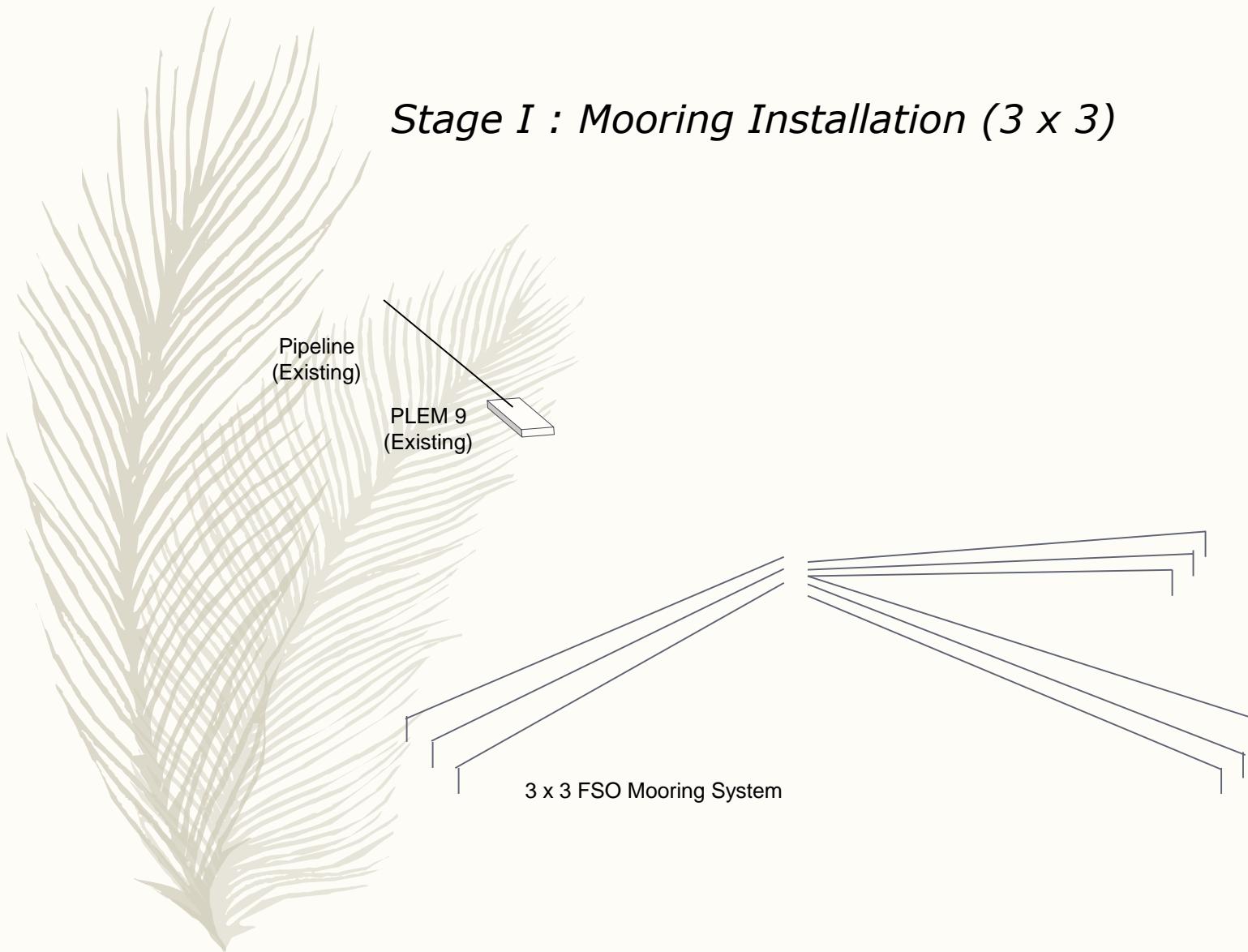
Installation sequence

- *Install Mooring Legs*
- *Install MWA w/ Gravity Base*
- *Hook up Mooring Legs to FSO*
- *Install Flexible Riser*



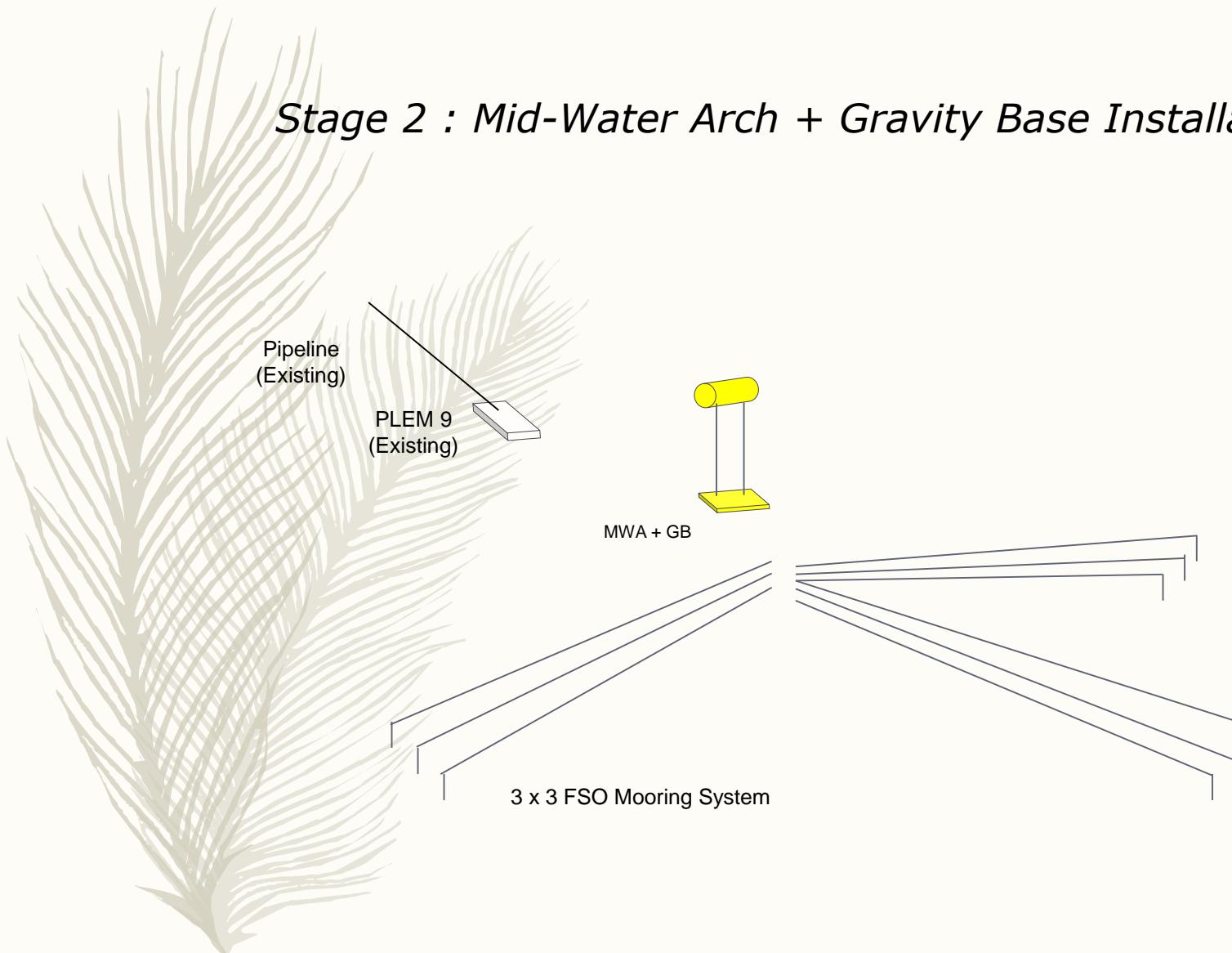
Installation Sequence

Stage I : Mooring Installation (3 x 3)



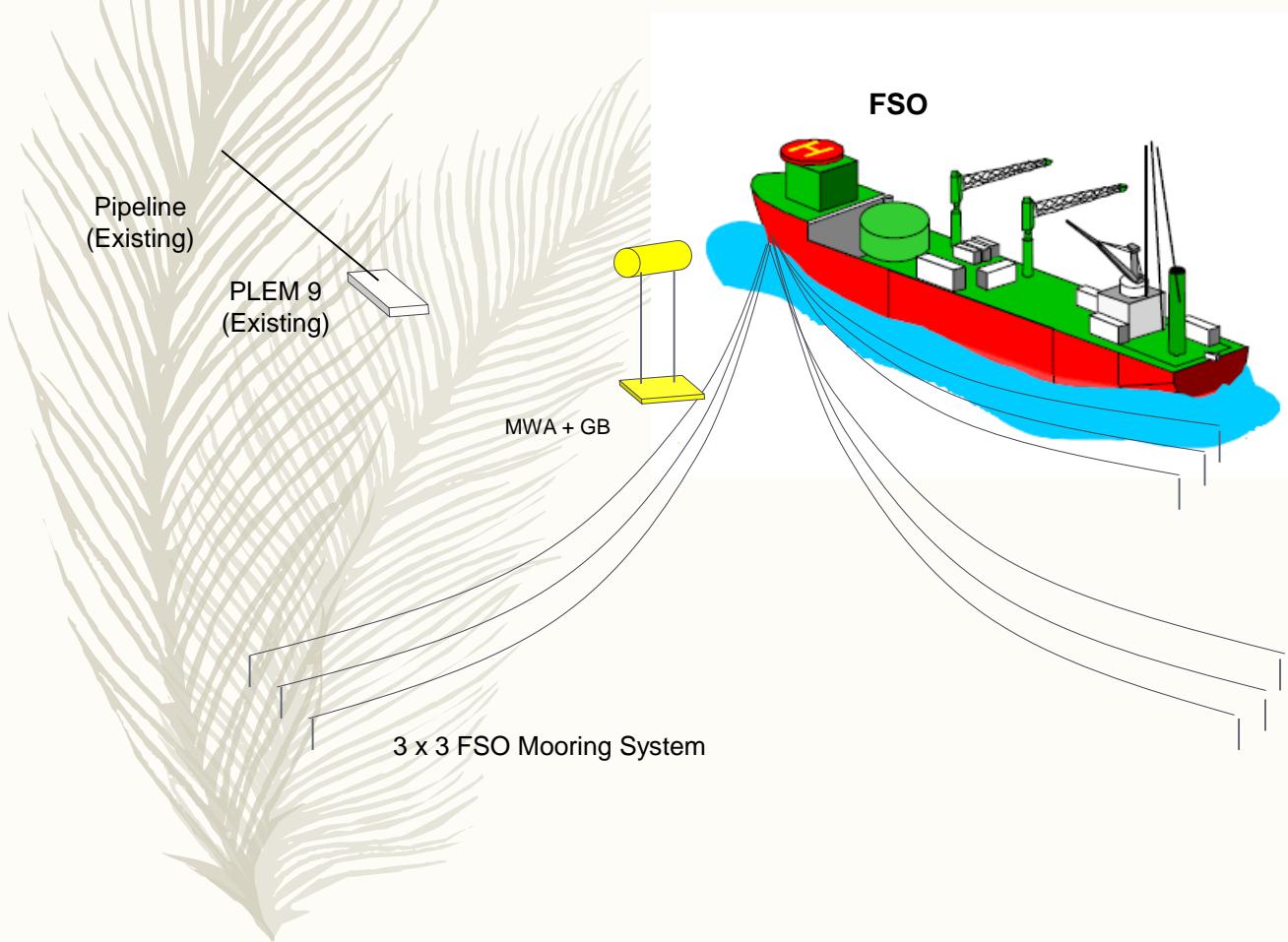
Installation Sequence

Stage 2 : Mid-Water Arch + Gravity Base Installation



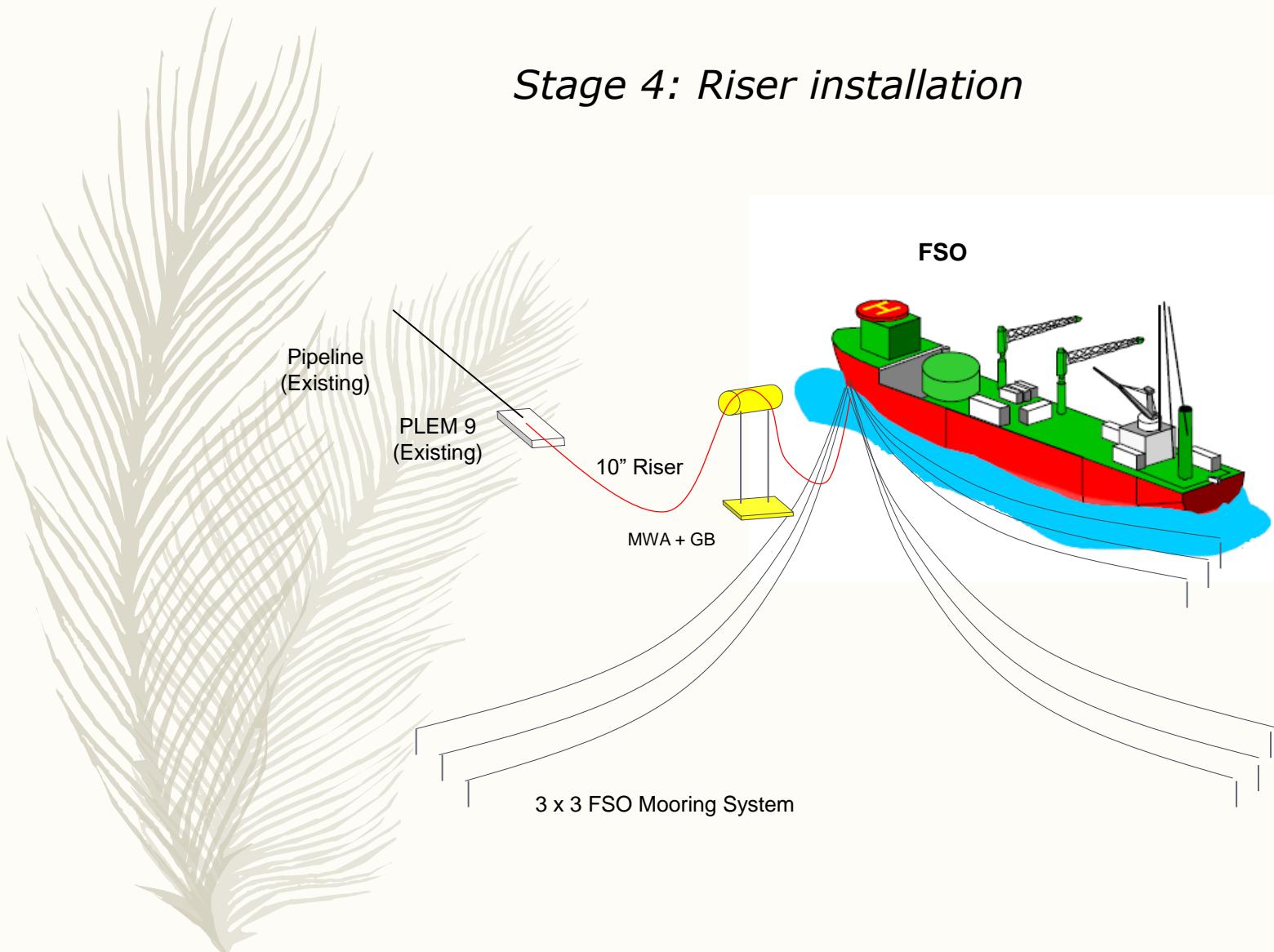
Installation Sequence

Stage 3: Hook-up of mooring chains to FSO & chain tensioning



Installation Sequence

Stage 4: Riser installation



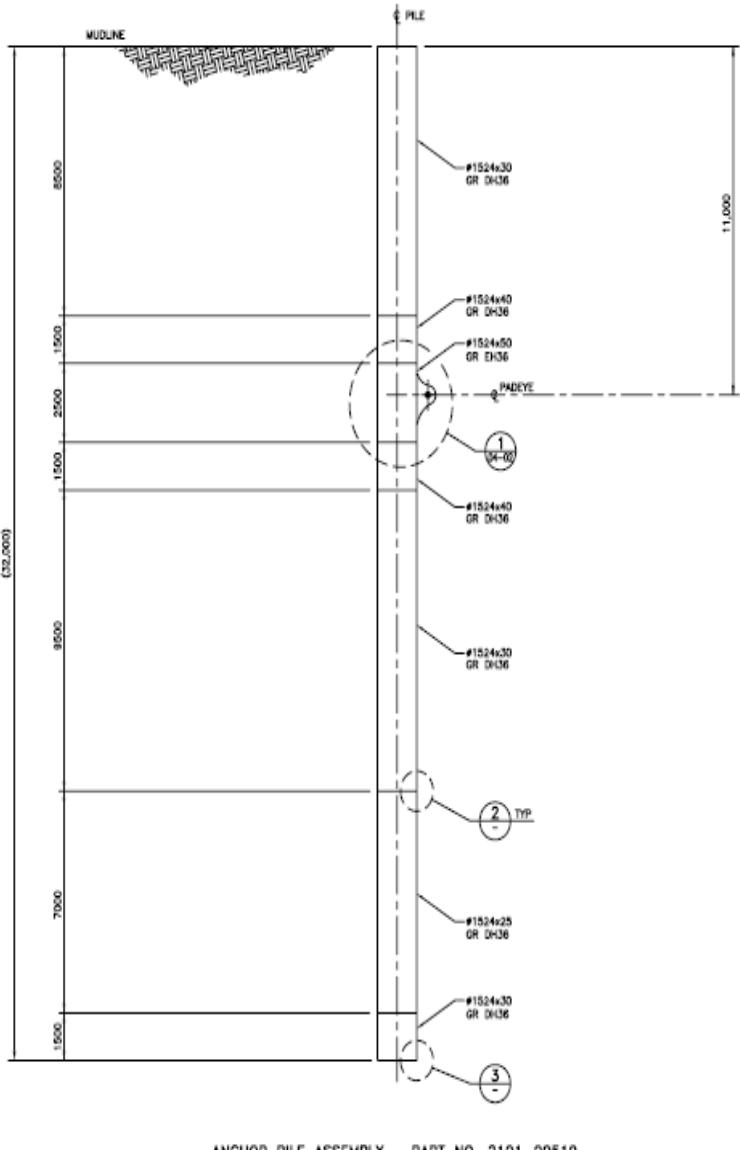


Mooring anchor pile installation

Pile & chain installation sequence

- Overboard and position pile guide frame (PGF)
- Overboard the anchor pile w/ chain connected and stab into the PGF
- Upend and stack the Pile Hammer onto the Pile Follower.
- Lift the Pile Hammer & Follower and stack onto the Anchor Pile
- Drive pile to target depth.
- Recover the Piling Hammer and Pile Follower to deck
- Lay chain
- Pre-tension chains
- Lay down the Chain c/w Subsea Buoys.
- Relocate piling template to next location.
- Repeat the steps above for the remaining FSO anchor piles and mooring chains.

FSO Mooring System



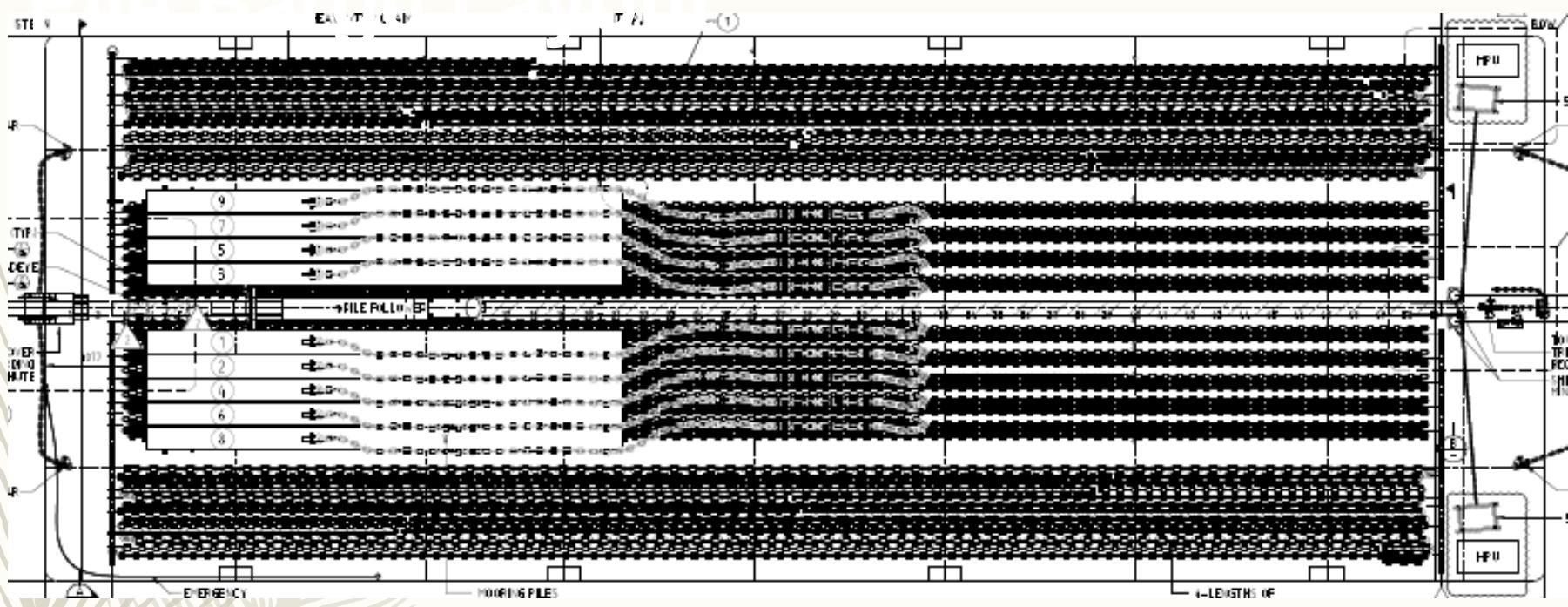
FSO Anchor Piles

Diameter	: 60" OD x 25/30/40/50mm WT
Length	: 32m
Weight in air	: ~ 39Te
Weight in seawater	: ~ 34Te
Chain attachment	: 11m from Pile Top
Driven depth	:Flushed with Seabed
Quantity	: 9

Pile Follower

Diameter	: 36/60" OD x 38/50mm WT
Length	: 22.5m
Weight in air	: ~ 34Te
Weight in seawater	: ~ 30Te
Quantity	: 1





Piling Template

PILING GUIDE FRAME

Footprint : 16.6 x 17.7m
Height : 12.3m
Weight in air : 43 Te
Weight in seawater : 38 Te

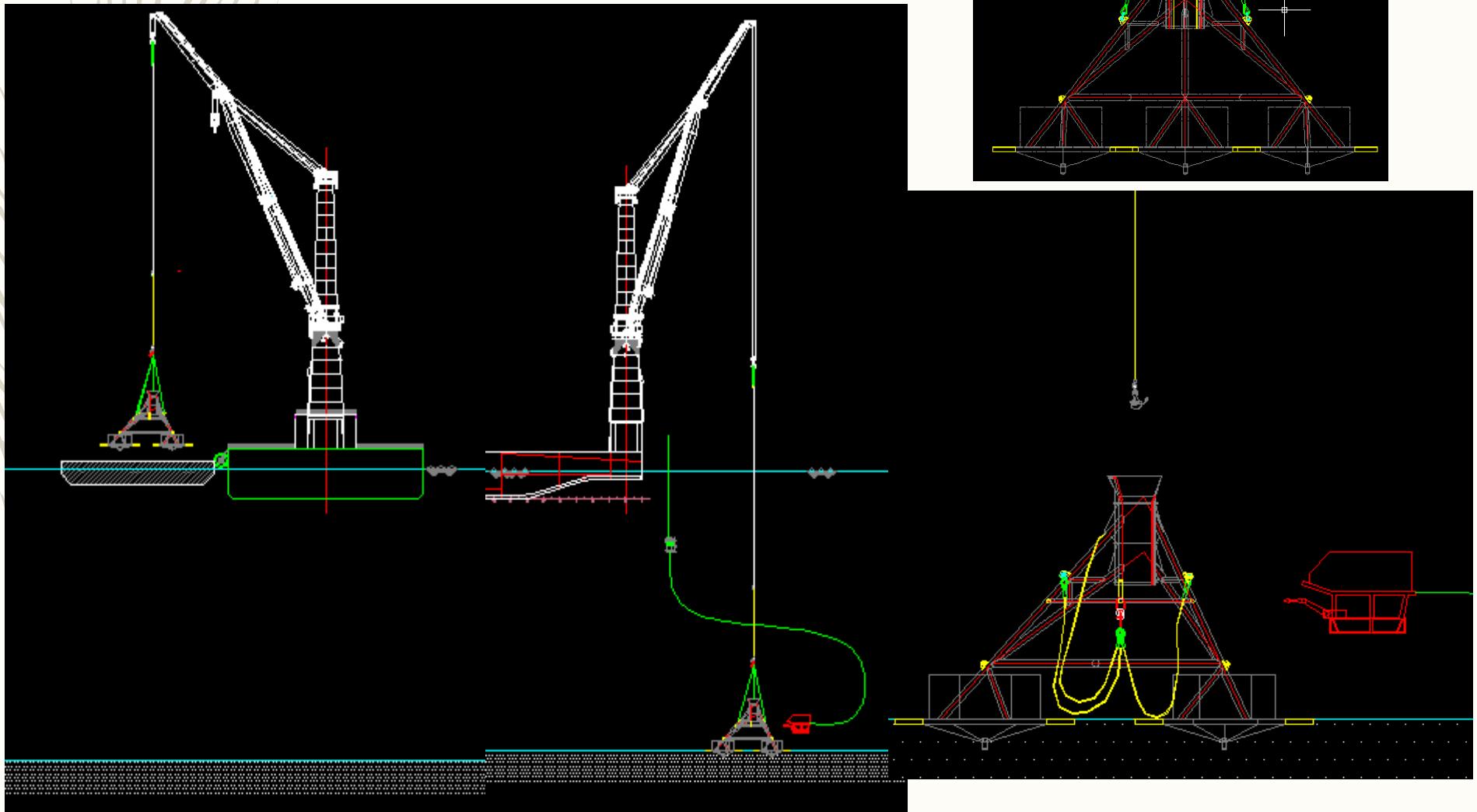
Piling guide frame installation:

- Install 2 or 3 survey beacons on the Piling Template transponder buckets
- Lift and overboard the Piling Template within target circle
- Use ROV to orientate the piling template or use orientation clump weight if the current is strong

USBL Transponder at (3 Locations)



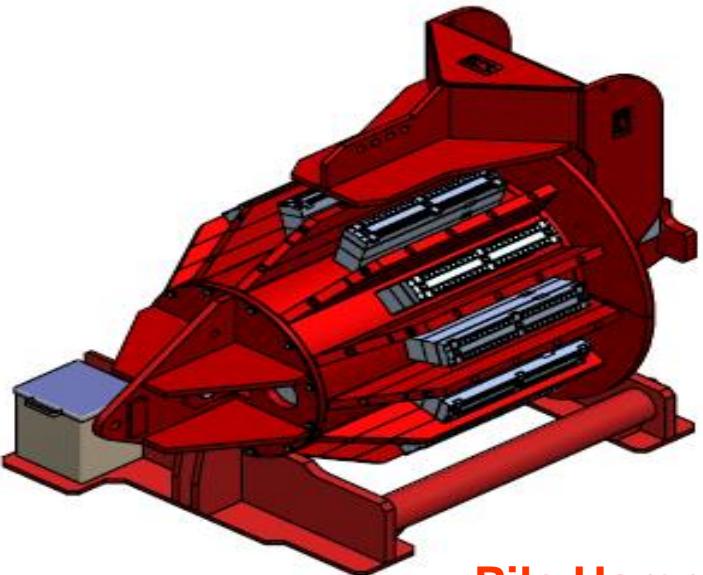
*Upending and off boarding the pile
guide frame, and manoeuvring it into
position*



Pile Off Boarding

Upending and off boarding the pile via pile lifting tool, and manoeuvring the pile to the Hang Off Frame





60" Internal Lifting Tool

Footprint : 2.3m x 3.3m

Height : 2.9m

Weight in air : 13Te

Weight in seawater : 12Te

Pile Hammer (S-280)

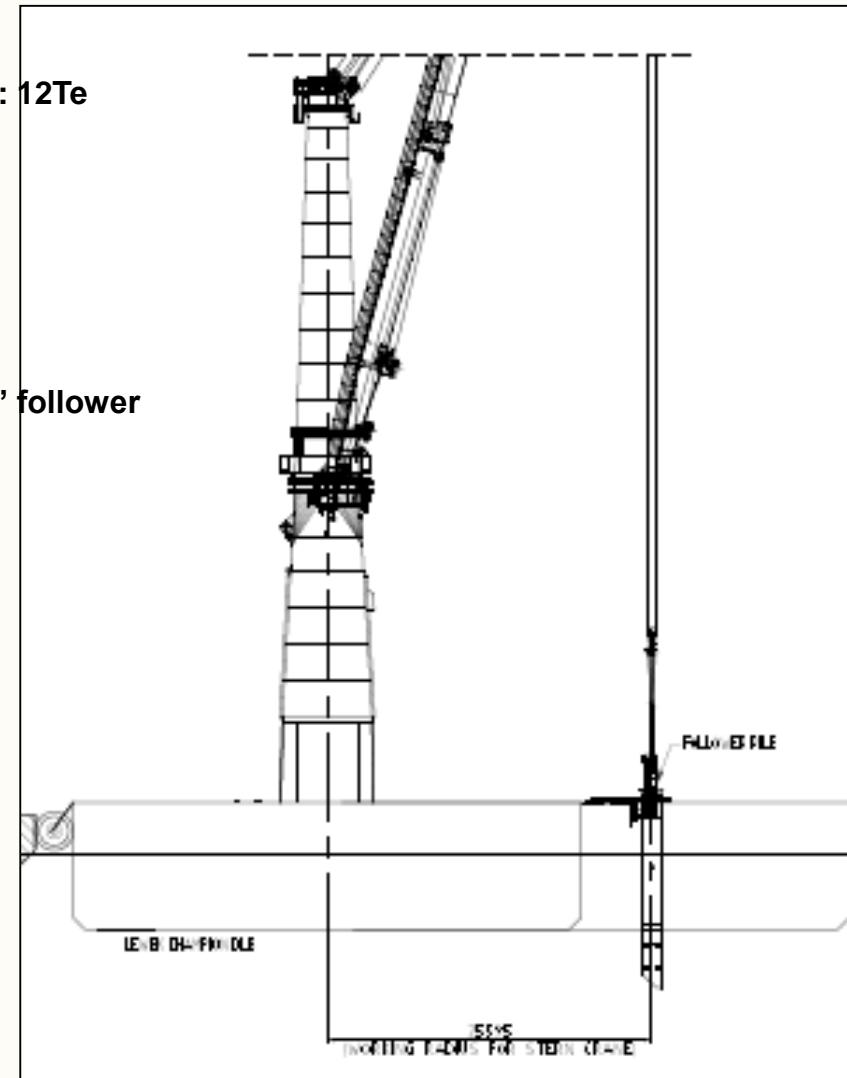
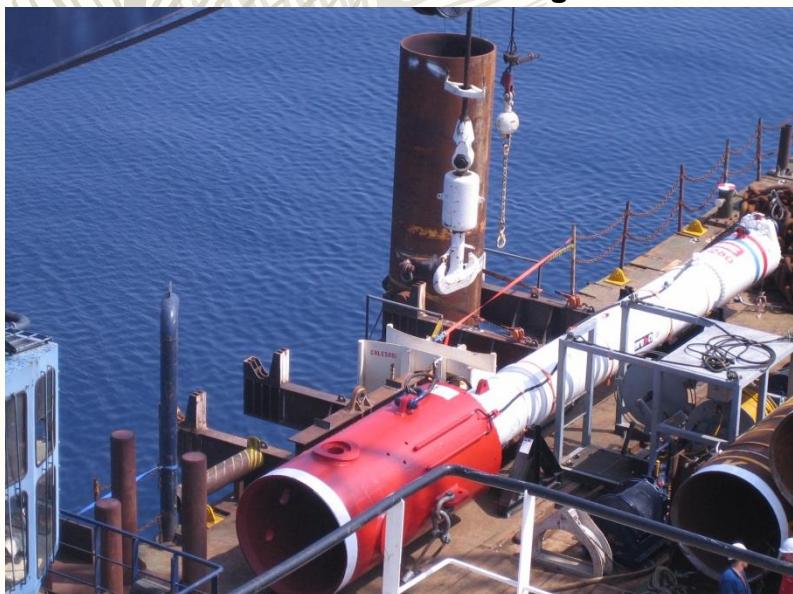
Sleeve : 56" with insert plate for 36" follower

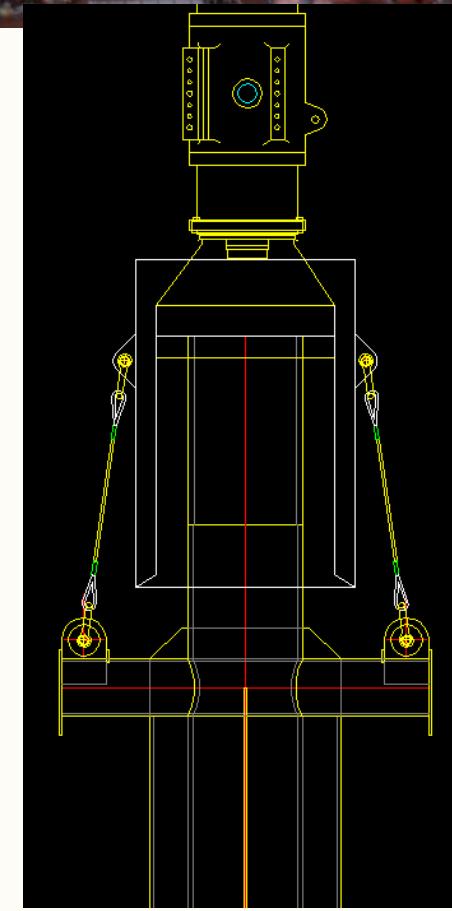
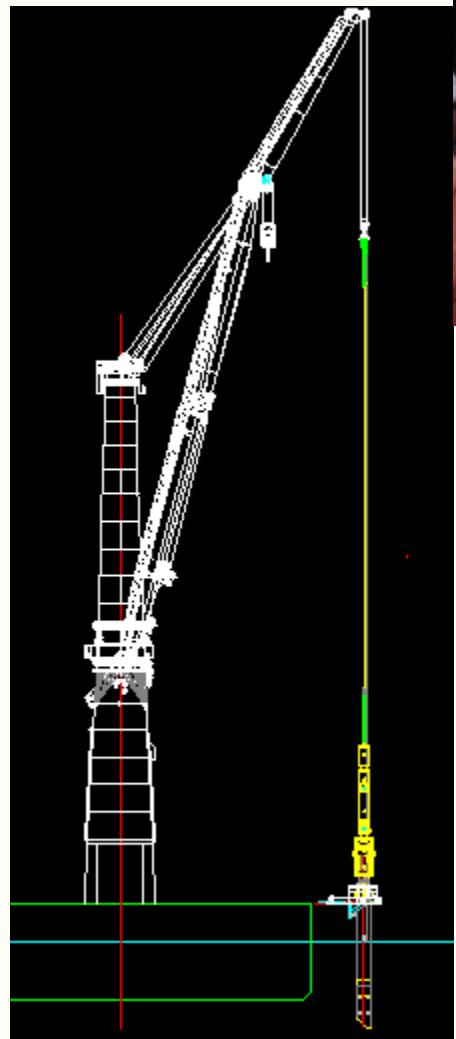
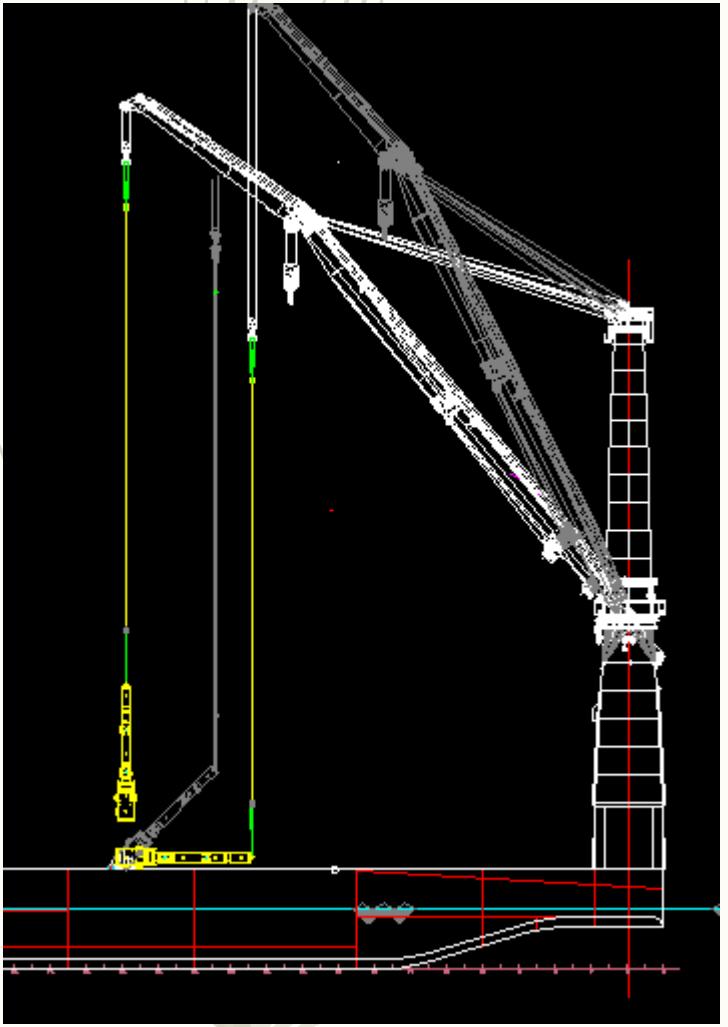
Footprint : 12.6m x 3.2m

Height : 2.9m

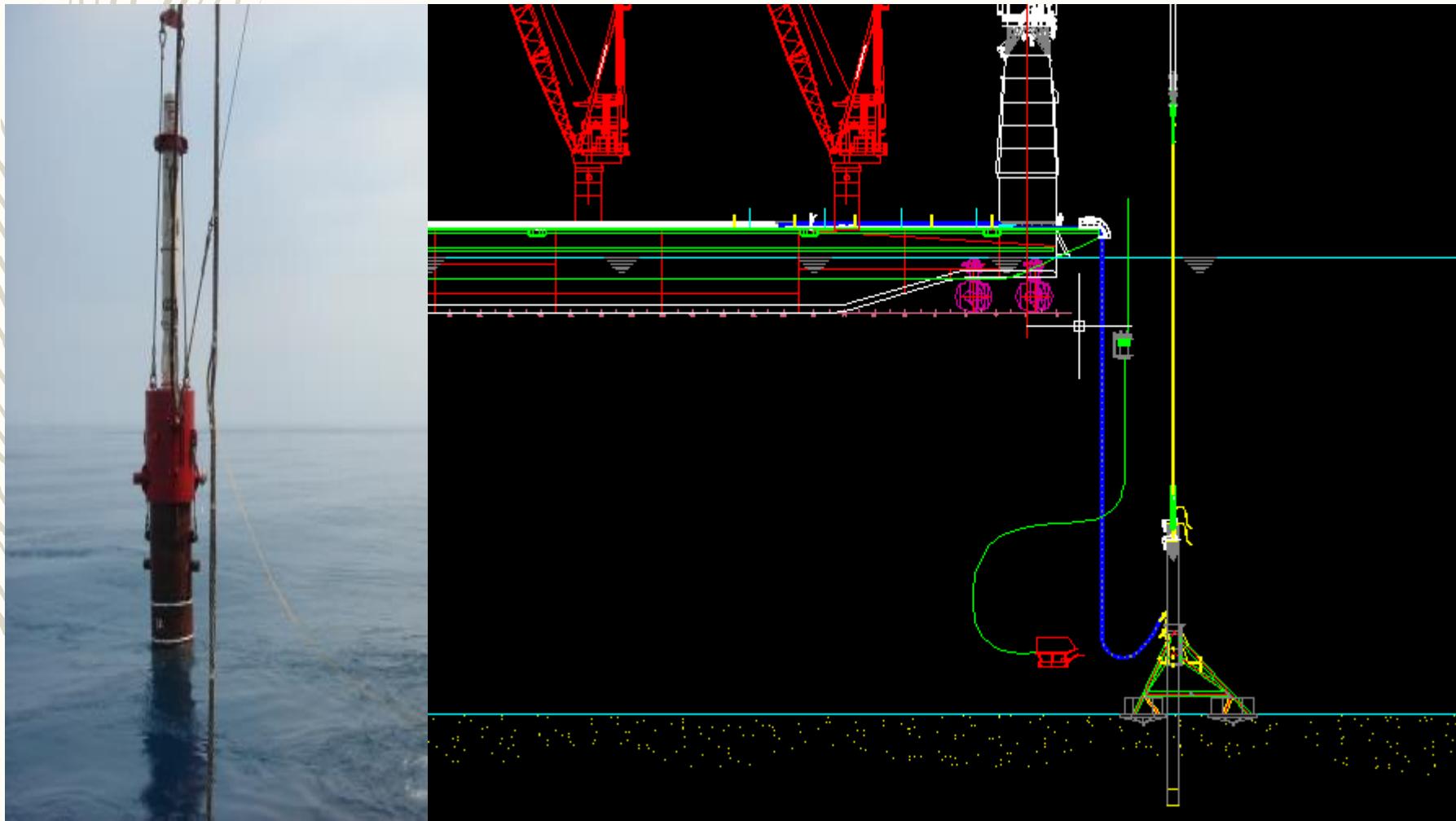
Weight in air : 55Te

Weight in seawater : 48Te

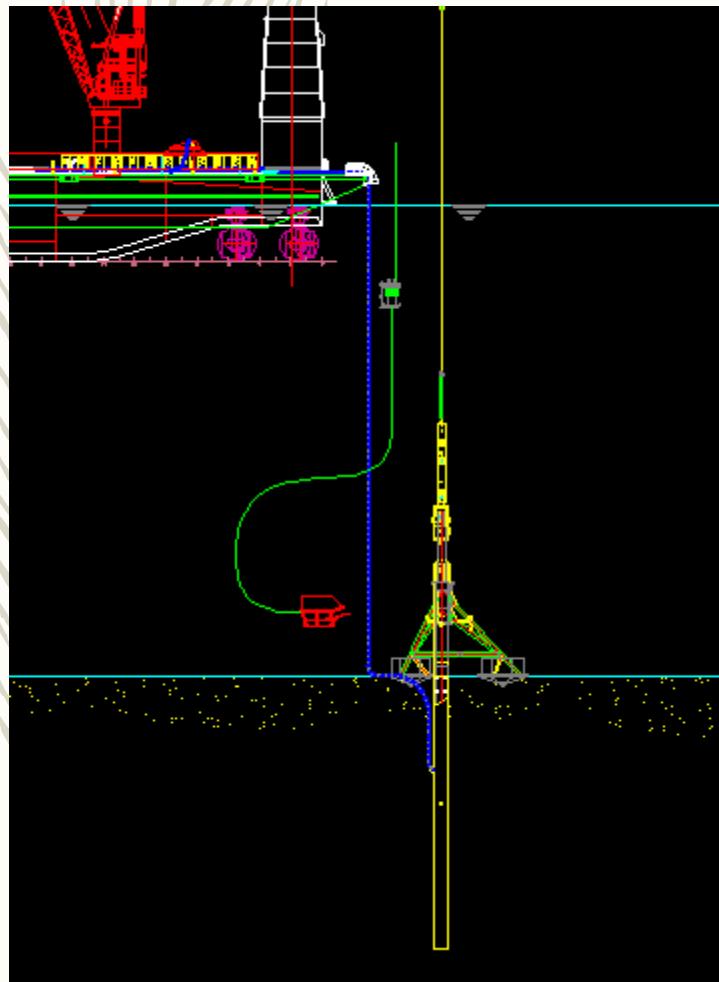




Off boarding the pile hammer cum pile assembly and stabbing it into the pile guide frame in preparation for pile driving



Underwater piling with underwater hammer





*Piled guide base and mid-water arch
installation*



Installation Sequence:

- *MWA Lifting, Lowering*
- *Pile Installation*
- *Pile-Pin Installation*

Mid Water Arch System



Mid Water Arch:

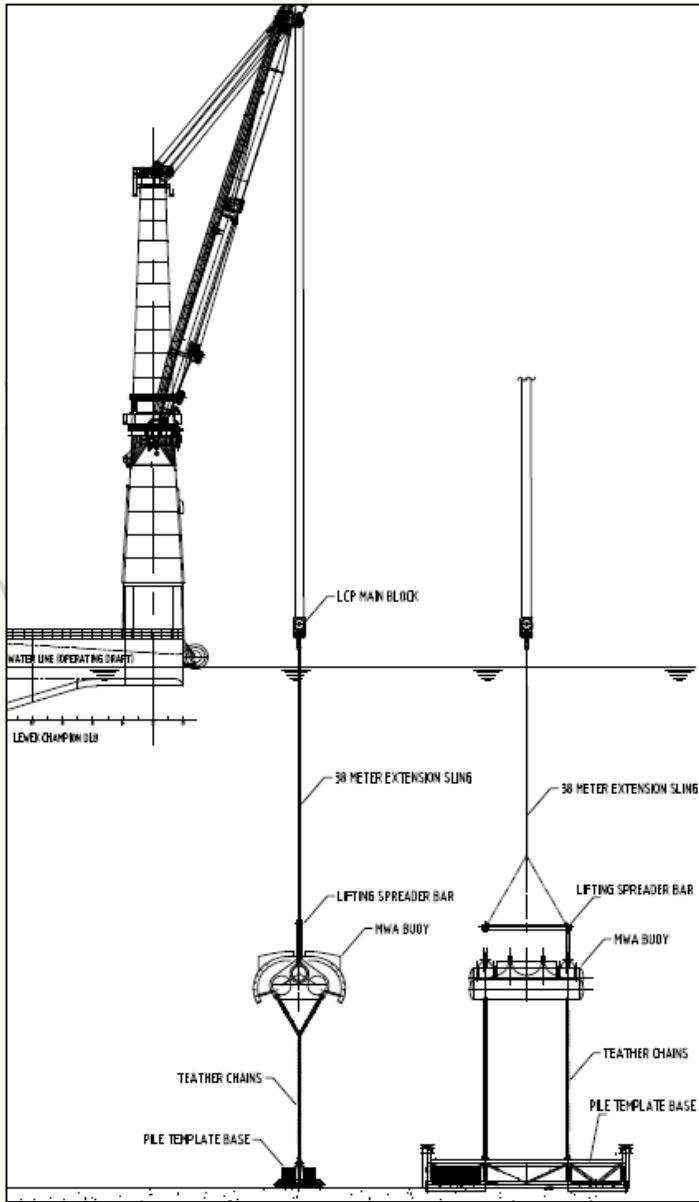
Dimension : 13m x 10.8m x 5.5m
Weight in Air : 98te (include Tether)
Buoyancy : 126te



Piled Gravity Base:

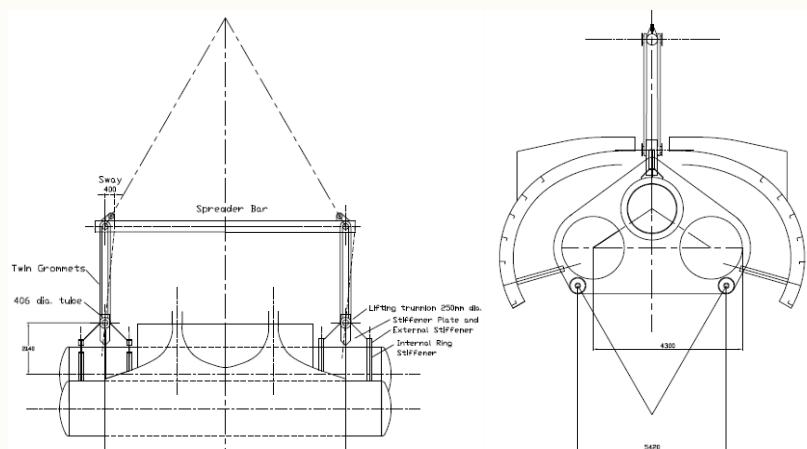
Dimension : 25m x 5m x 2.6m
Weight in Air : 186te (include Tether)
Weight in Seawater : 123te

PGB + MWA Installation



The PGB + MWA Installation is typically carried out in the following sequence:

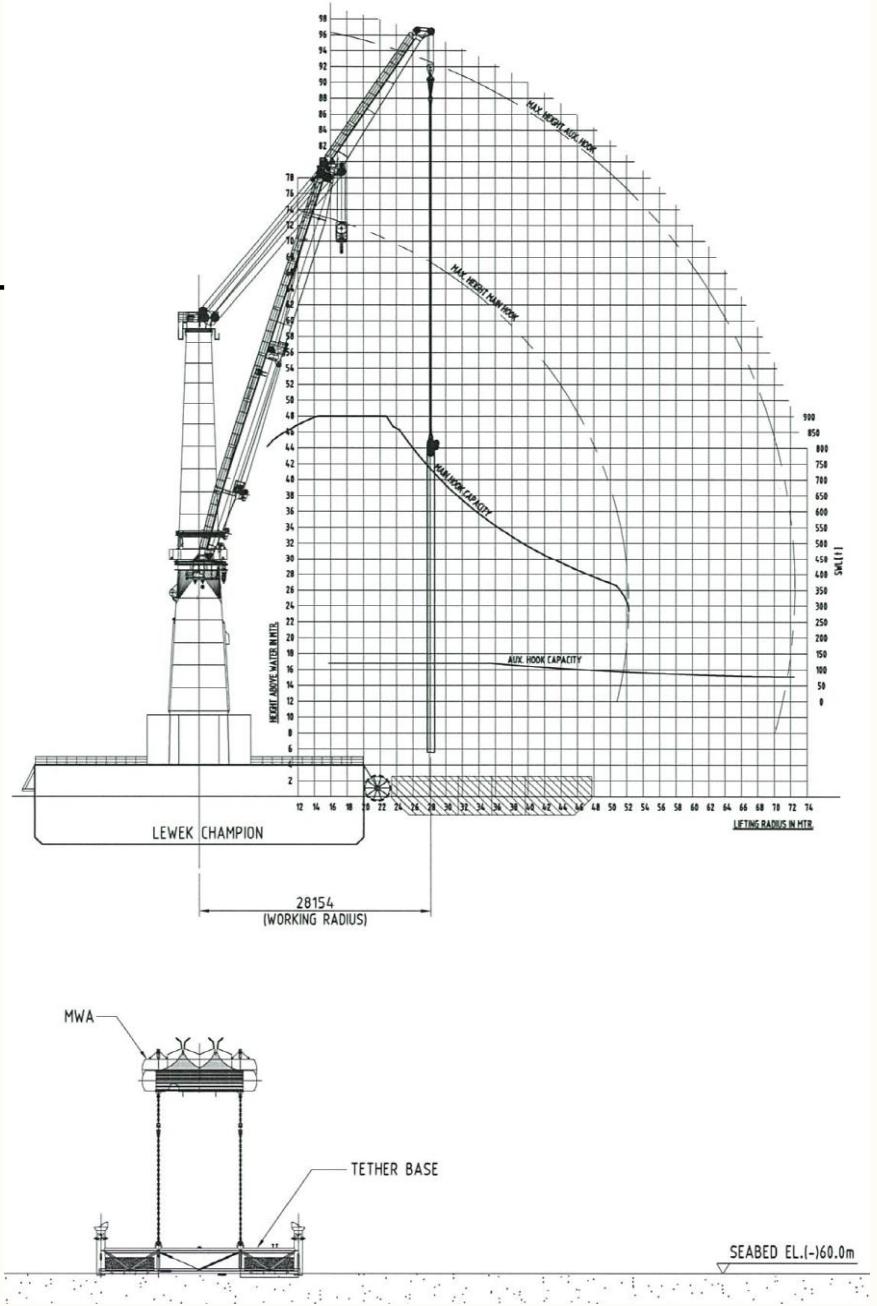
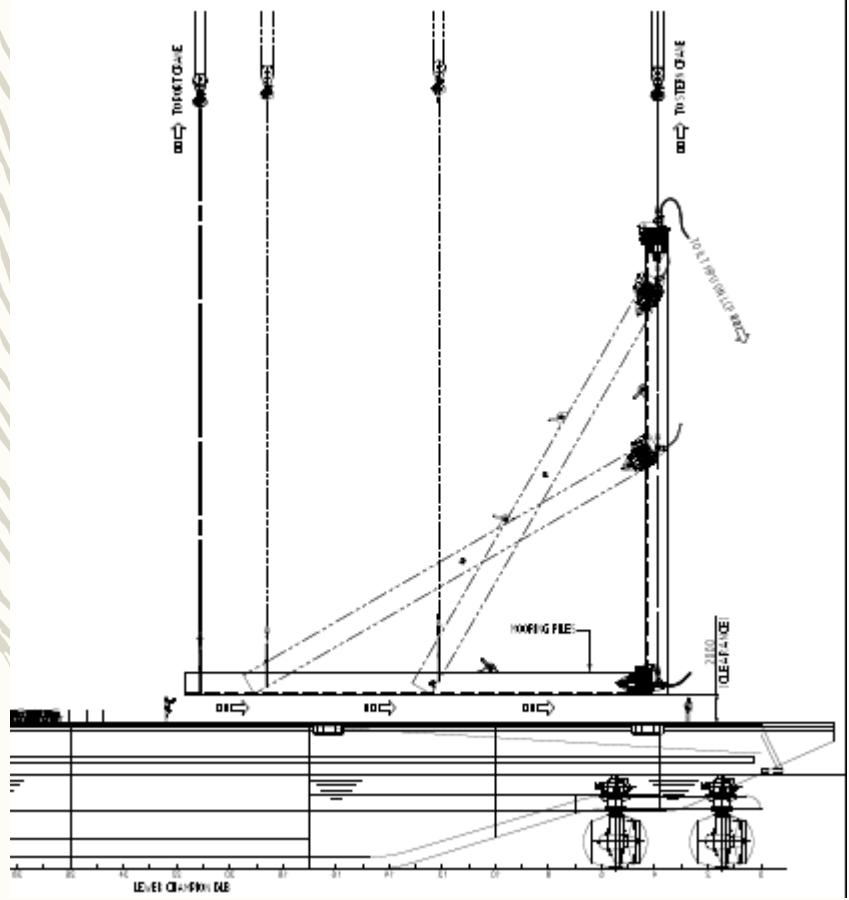
- Setup vessel at the PGB Location
- Assemble PGB and MWA
- Connect MWA lifting spreader beam to crane wire
- Lift and overboard the PGB + MWA
- Orientate the PGB + MWA to the correct heading using Orientation Clump Weight connected to the PGB
- Lower the assembly until PGB is resting on seabed
- ROV inspects penetration and inclination of the PGB
- ROV disconnects the Orientation Clump Weight & recover to surface
- ROV disconnects / cut the lift rigging underneath the Spreader Beam
- Recover the spreader beam to surface



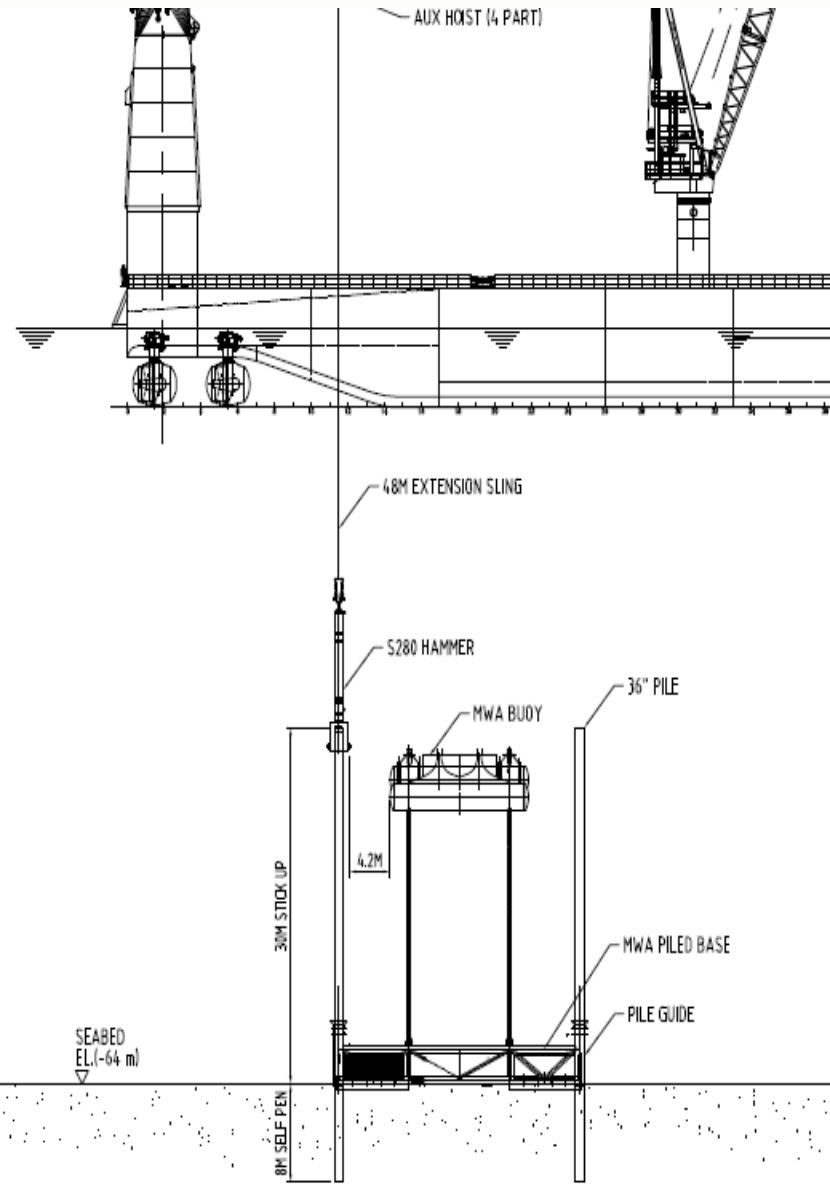
STEP: 4

Pile Splicing & Lifting

- 36" Dia x38.923m L
- Pile Wt =35MT

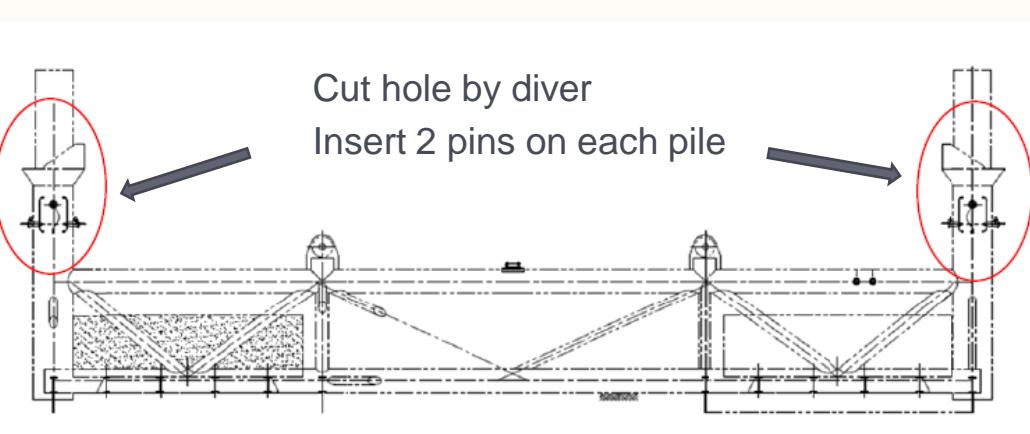


PGB + MWA Installation



Piling of the PGB is typically carried out as follow:

- Lift and upright the PGB pile.
- Stab the PGB pile to the Pile Sleeve on the PGB
- Repeat the same step for another PGB Pile
- Lift and upright the Piling Hammer
- Stab the Piling Hammer to the PGB Pile (no pile follower is needed)
- Complete Piling the PGB Pile
- Relocate the Piling Hammer to remaining PGB pile
- Complete Piling the PGB Pile
- Install the lock pins





FSO Hook-up



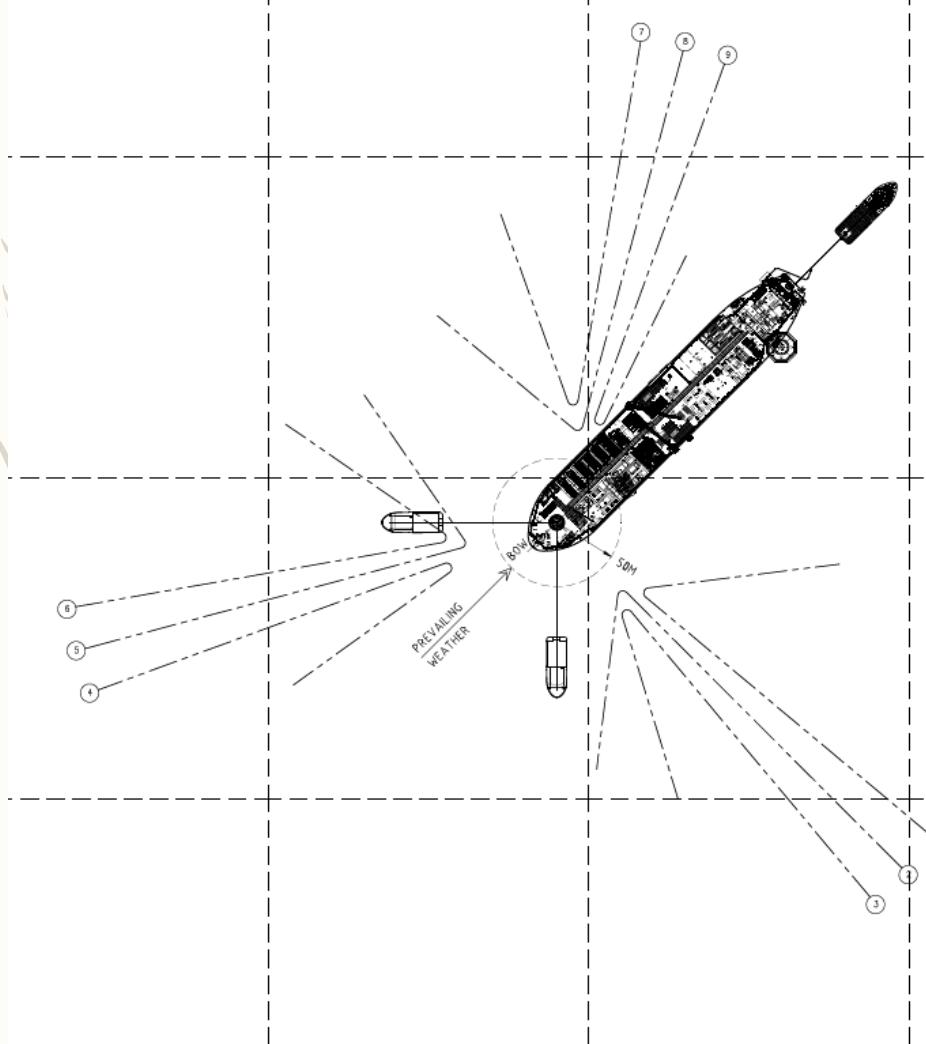
The FSO Hook Up is typically carried out in the following sequence:

- ROV carries out as-found survey of the chain (if required).
- Position the FSO in the correct heading and position using control heading tugs.
- Construction vessel (CV) deploys A&R Wire c/w ROV hook to the location of chain end.
- ROV connects ROV hook to recovery grommet on the chain
- CV recovers and secures the FSO mooring chain to deck.
- Paint the target chain link on the deck
- FSO lowers down the Pull-in messenger wire
- ROV connects A&R wire c/w ROV hook to the master link on the FSO messenger wire
- CV recovers FSO Pull-in wire and messenger wire to deck.

FSO Hook Up

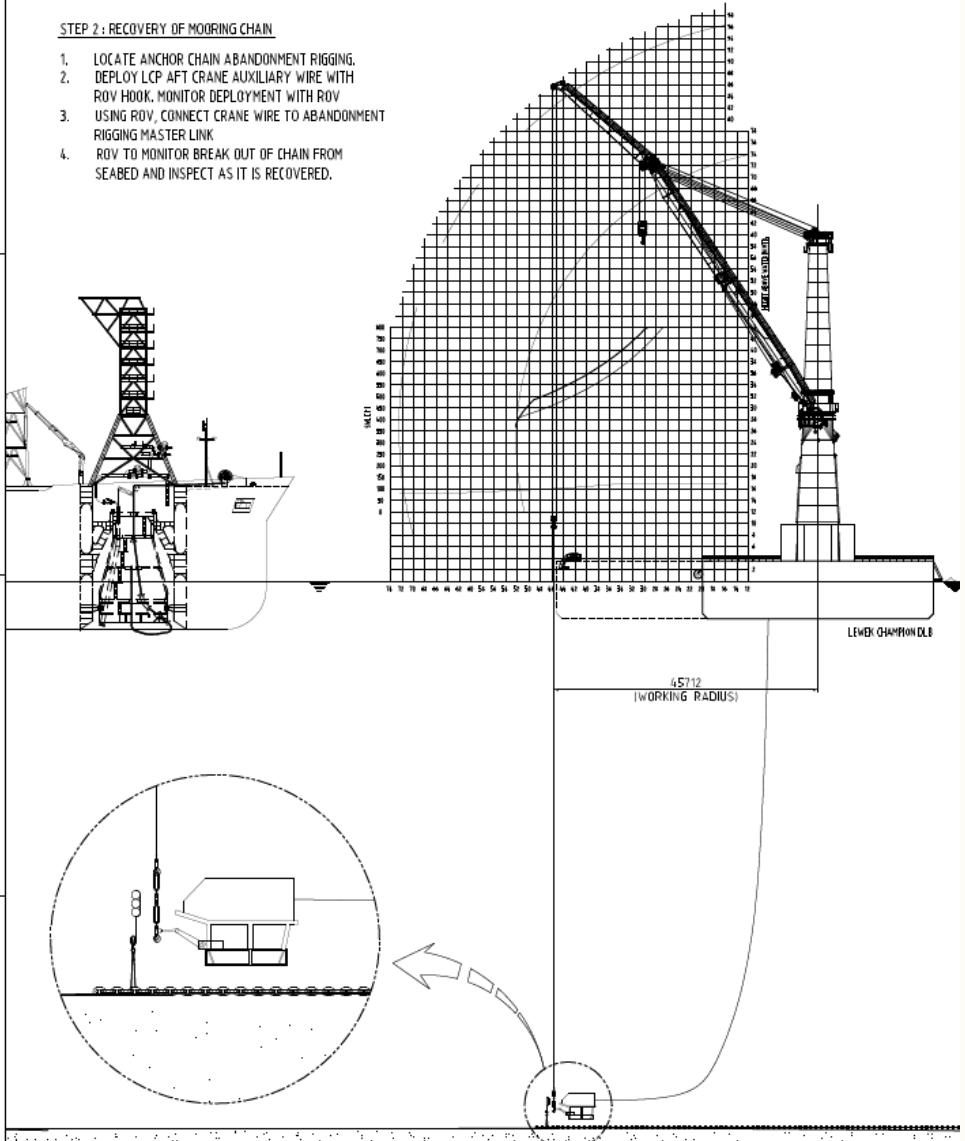
STEP 1: FSO ARRIVAL ON LOCATION

1. BRING FSO ONTO LOCATION WITH TUGS WHILE LEWEK CHAMPION ROV INSPECTS EACH CHAIN RECOVERY SLING ASSEMBLY.
2. AHT'S POSITION FSO IN A HEAD SEA ORIENTATION.



STEP 2: RECOVERY OF MOORING CHAIN

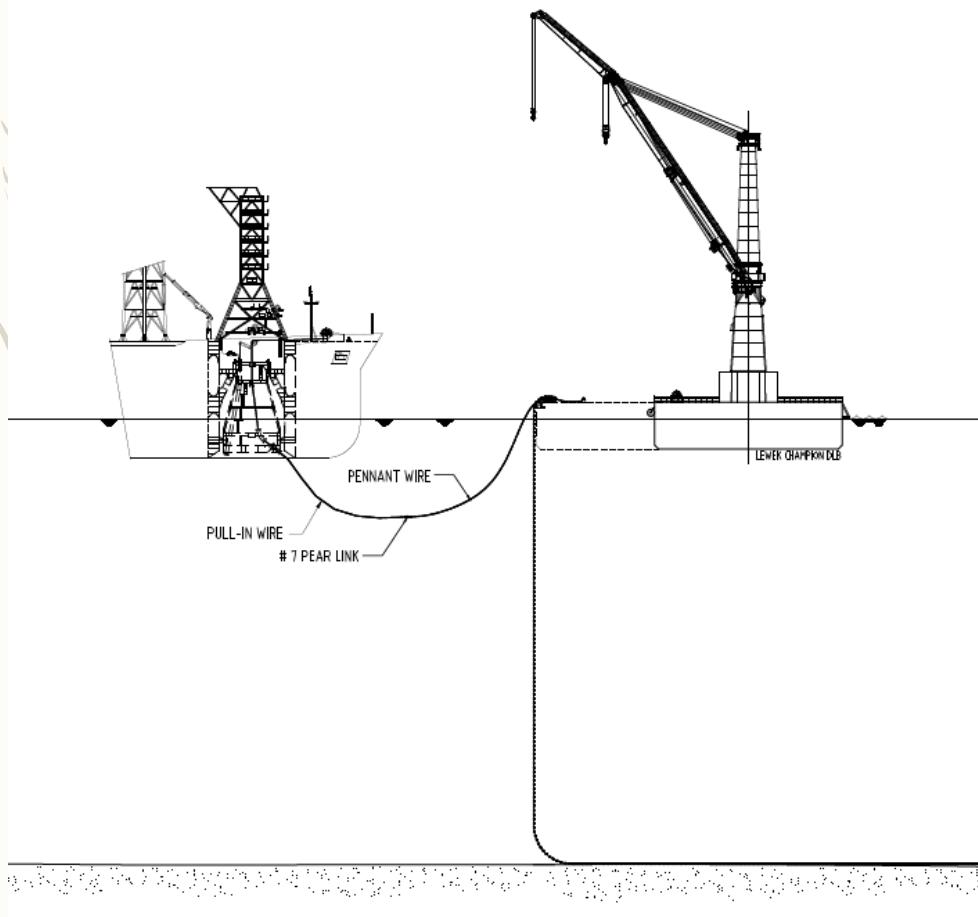
1. LOCATE ANCHOR CHAIN ABANDONMENT RIGGING.
2. DEPLOY LCP AFT CRANE AUXILIARY WIRE WITH ROV HOOK. MONITOR DEPLOYMENT WITH ROV
3. USING ROV, CONNECT CRANE WIRE TO ABANDONMENT RIGGING MASTER LINK
4. ROV TO MONITOR BREAK OUT OF CHAIN FROM SEABED AND INSPECT AS IT IS RECOVERED.



FSO Hook Up

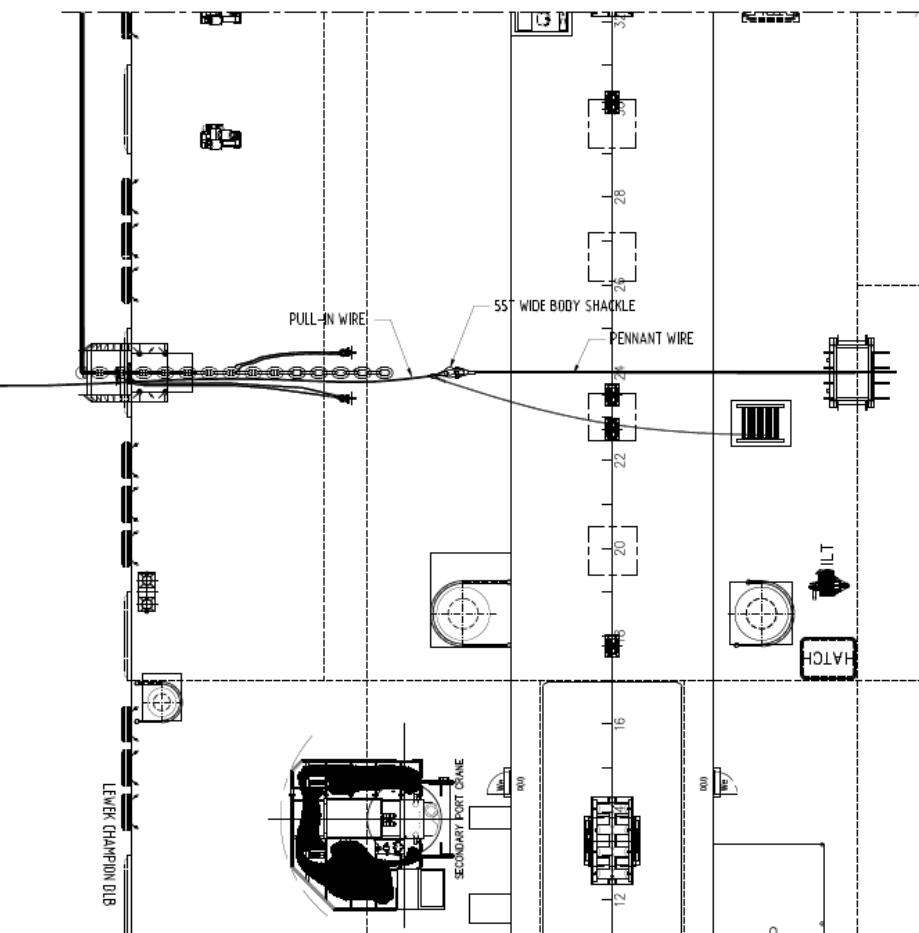
STEP 5 : RETRIEVE PENNANT WIRE

1. DEPLOY THE 5t^e TUGGER WIRE WIH A ROV HOOK.
2. ROV GRABS THE HOOK & SWIMS TOWARDS THE TURRET CENTER.
3. PENNANT END DROPPED THROUGH TURRET CENTRE
4. ROV GRABS PENNANT AS PULL-IN WINCH PAYS OUT
5. ROV MONITOR'S PULL-IN CONNECTION COME OUT OF STOPPER.
6. ROV CONNECTS PENNANT TO AUXILIARY CRANE.
7. HAND - IN THE TUGGER WIRE & RECOVERY THE PENNANT WIRE TO LCP DECK.



STEP 6 : RETRIEVE PULL-IN WIRE

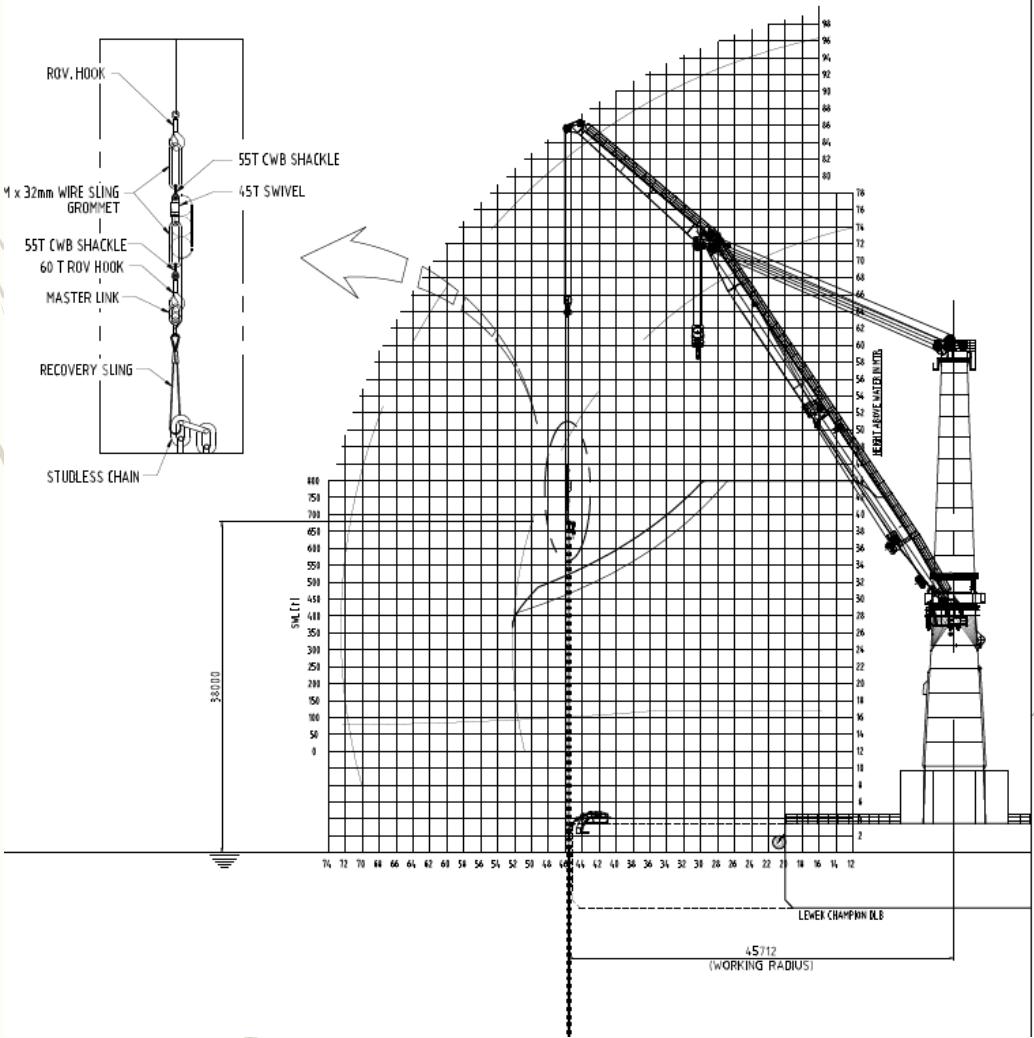
1. PENNANT SPOOLED ONTO TUGGER WINCH UNTIL PULL-IN CONNECTION IS ALONGSIDE END OF CHAIN
2. PULL IN WIRE IS CONNECTED TO THE TUGGER WITH RIGGING CHAIN WRAPPED AROUND THE PULL IN WIRE.
3. PULL IN IS DISCONNECTED FROM PENNANT AND PENNANT REMOVED FROM AREA.



FSO Hook Up

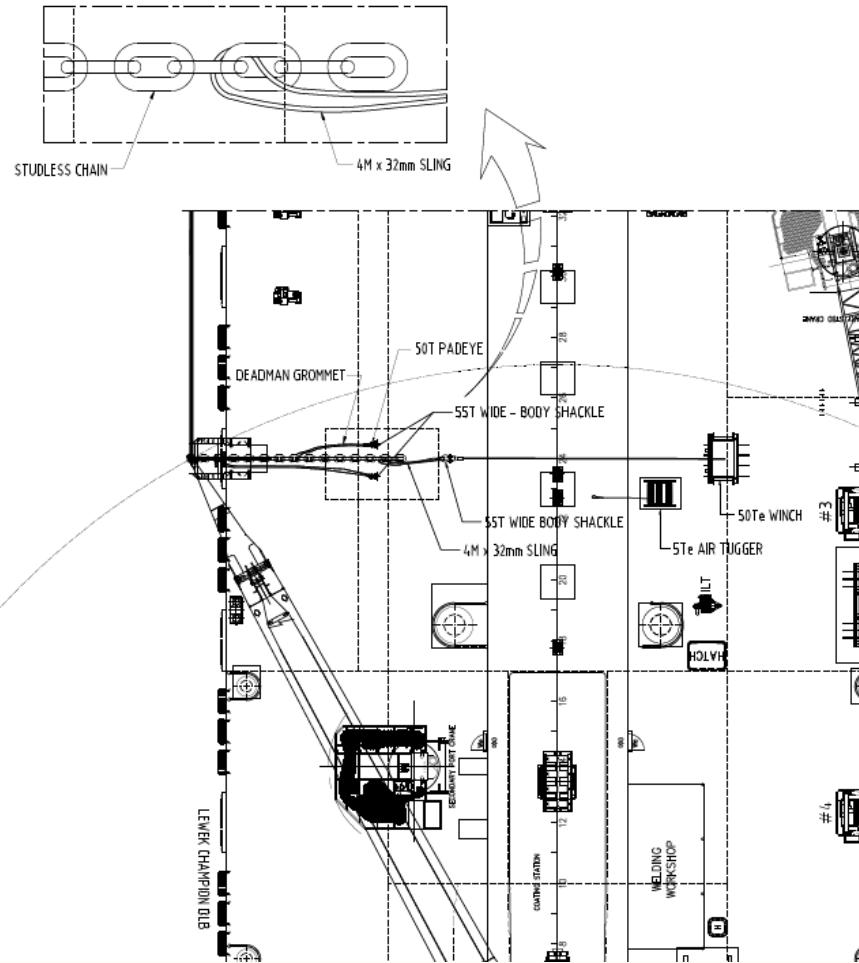
STEP 3 : PAINTING IDENTIFYING LINKS.

1. RECOVER END OF MOORING CHAIN ABOVE DECK
2. PAINT TARGET LINKS AT DECK LEVEL (HANG-OFF INDICATOR)



STEP 4 : SECURING CHAIN ON DECK

1. CHAIN END IS LOWERED ONTO DECK.
2. CONNECT FREE TAIL CHAIN TO 50T WINCH WITH 4M x 32mm WIRE SLING THROUGH THIRD AND FOURTH LINKS.
3. PULL-IN CHAIN UNTIL WINCH TAKES LOAD ALLOWING DISCONNECT OF CRANE.
4. SECURE WITH DEADMAN GROMMET AS AN ADDITIONAL HOLD BACK.

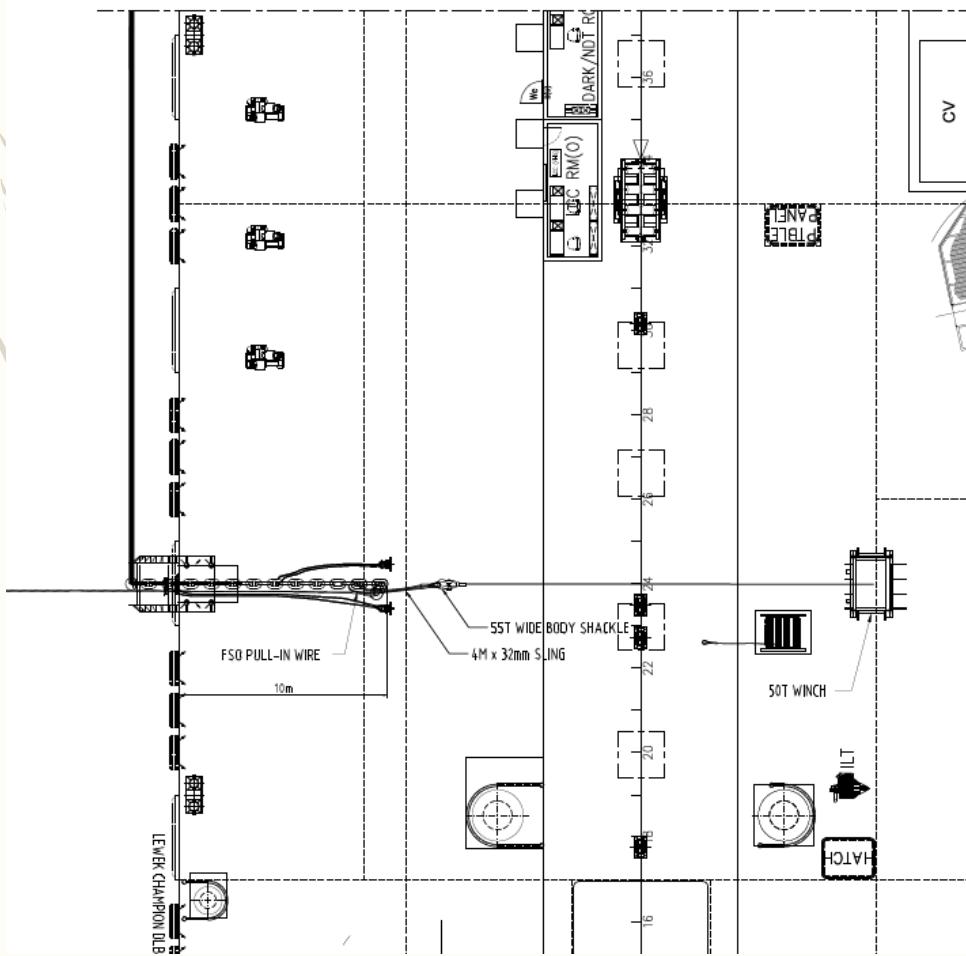


FSO Hook Up

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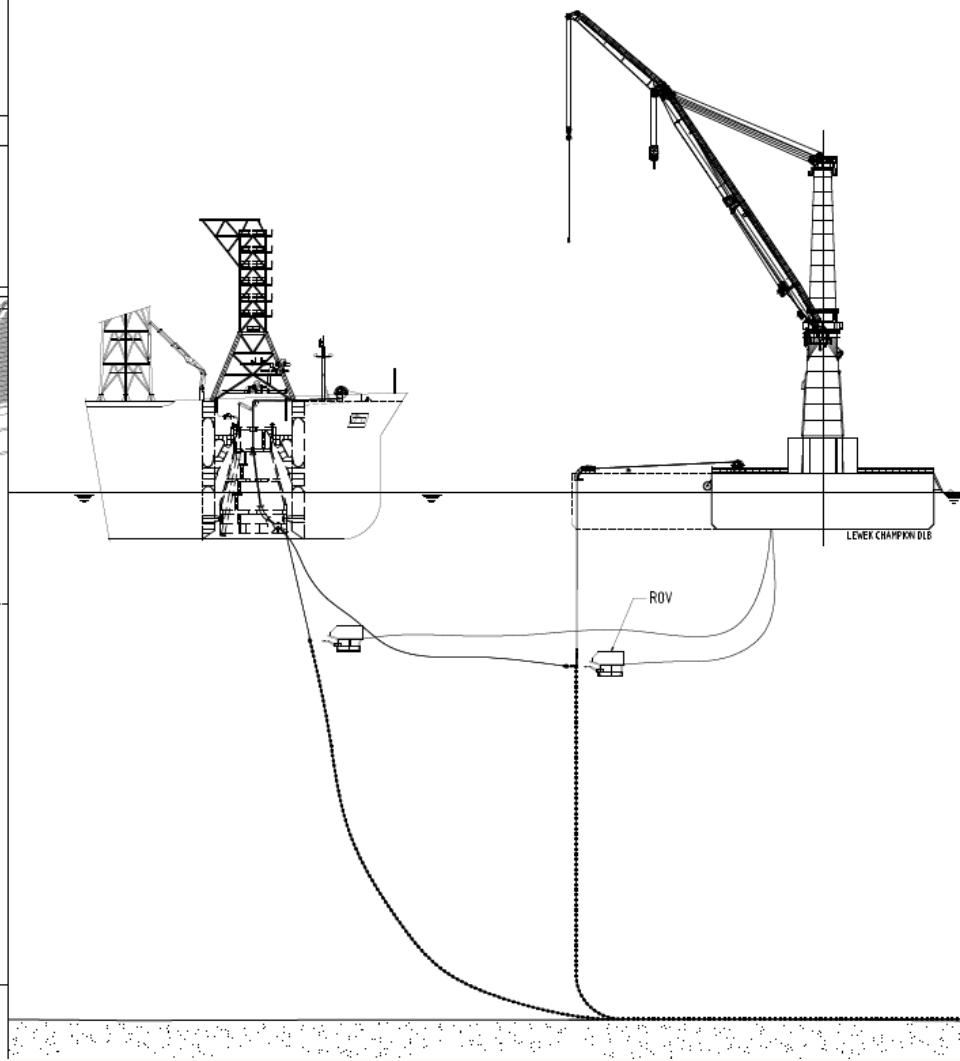
STEP 7 : (CONNECTING CHAIN AND PULL-IN WIRE)

- PULL-IN WIRE IS CONNECTED TO CHAIN WITH PEAR LINK
- SOT WINCH IS CONNECTED TO THIRD AND FOURTH LINKS WITH 4M x 32mm SLING
- HEAVE IN ON SOT WINCH TAKING LOAD
- BOTH DEADMAN ASSEMBLIES ARE DISCONNECTED FROM CHAIN



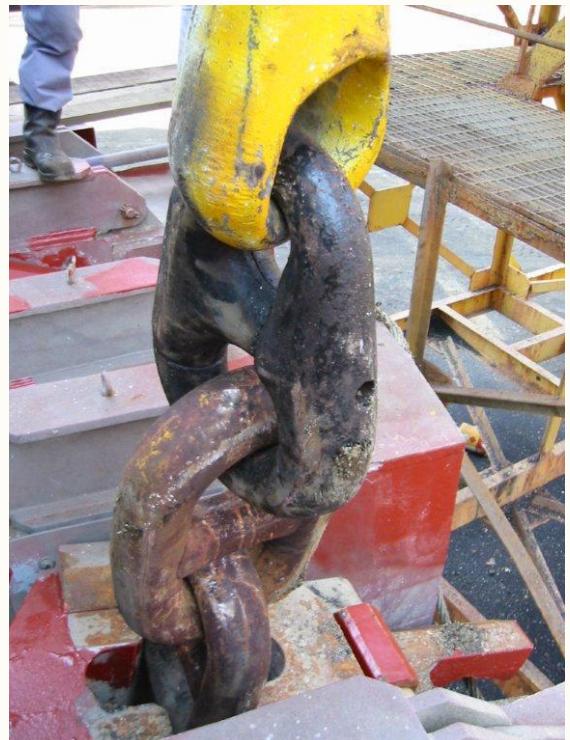
STEP 8 : (CHAIN TRANSFER TO FSO)

- SOT WINCH PAYS OUT PUTTING CONNECTION INTO WATER
- FPSO PULL-IN WINCH RECOVERS WIRE WHILE SOT CONTINUES PAYING OUT
- ONCE LOAD IS TRANSFERRED TO PULL-IN WIRE ROV CUTS SLING AND WINCH WIRE IS RECOVERED BY LCP.
- CHAIN IS PULLED TO HANG OFF POINT IN LCP CHAIN STOPPER.

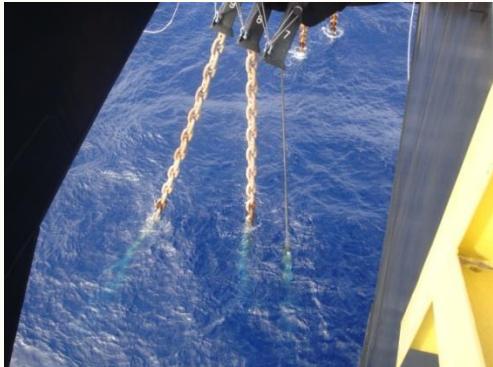


FSO Hook Up (Cont'd)

- CV connects FSO Pull-in wire to the chain & remove messenger wire
- With assistance of crane and A&R wire, CV overboards the chain
- ROV hand-shake the chain to FSO pull-in wire
- ROV disconnects/cut the sacrificial grommet on the A&R wire
- CV recovers A&R wire
- FSO pulls the chain into the FSO chain table.
- FSO secures the chain on the chain stopper.



FSO Chain Tensioning



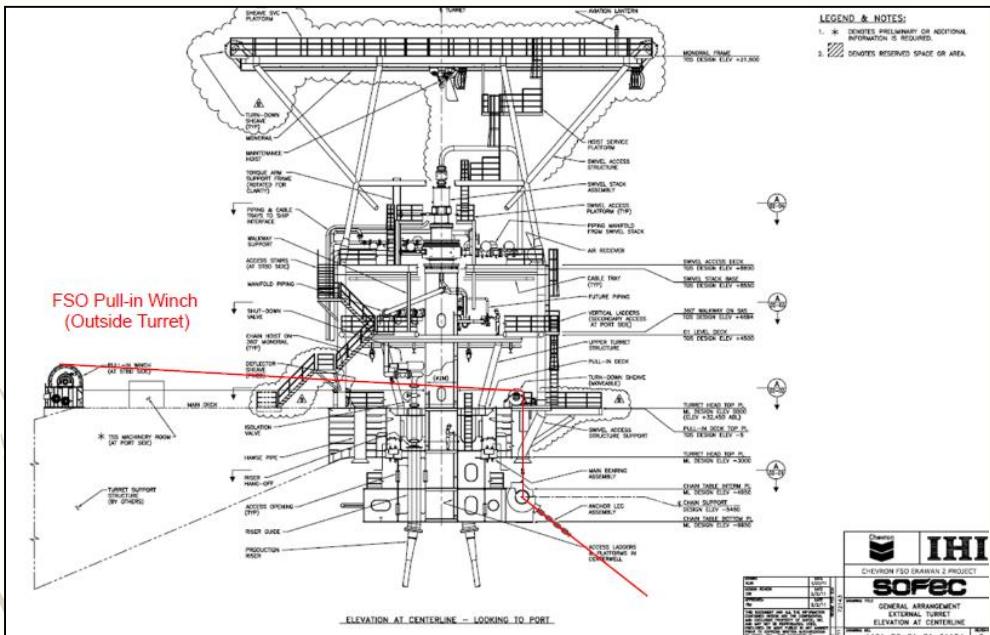
The FSO Chain Tensioning will be carried out in the following sequence:

- Connect the FSO pull-in wire to the Mooring Chain.
- Activate the winch to pull the Mooring Chain to the 1st design tensioning load as specified by manufacturer/designer.
- If the max stroke is reached, cut the excess chain until the 1st design tensioning load is achieved.
- Once the target load is achieved, disconnect the FSO pull-in wire.
- Re-route the FSO pull-in wire to pull the Mooring Chain in the adjacent cluster.
- Redo the steps above to tension all Mooring Chains (first round).
- Repeat the steps above for 2nd or 3rd Round as specified by manufacturer/designer to achieve final chain tensioning.

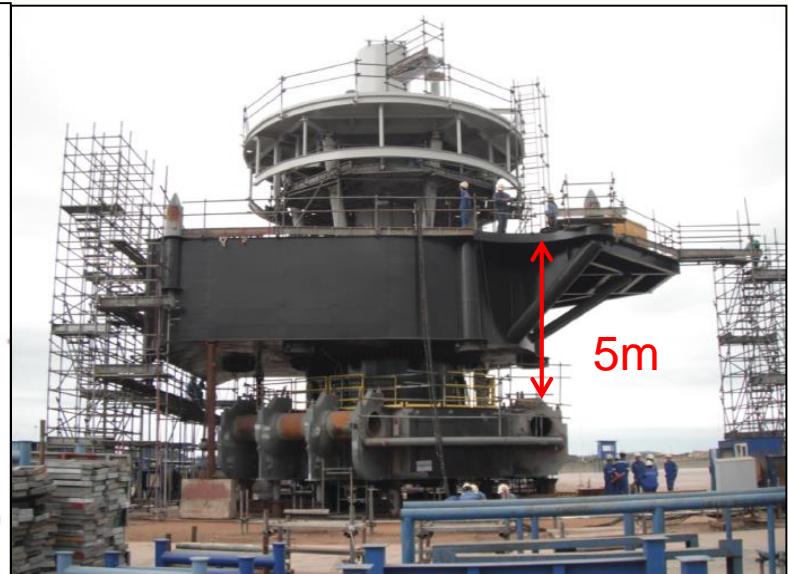
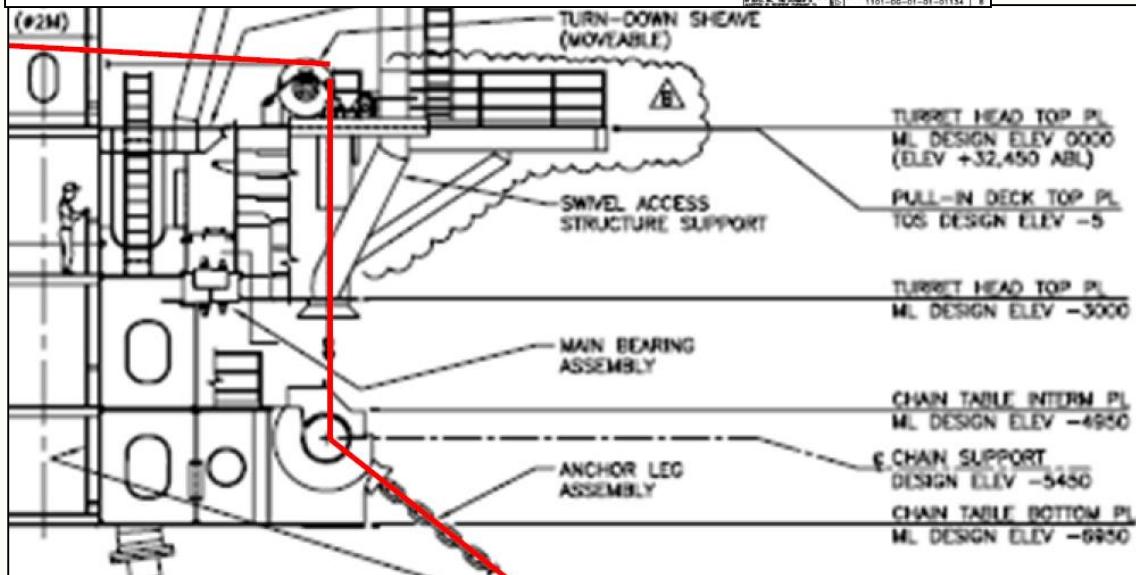
The mooring system to be verified by:

- Load cell on the pull-in winch or
- Measuring the chain angle using inclinometer

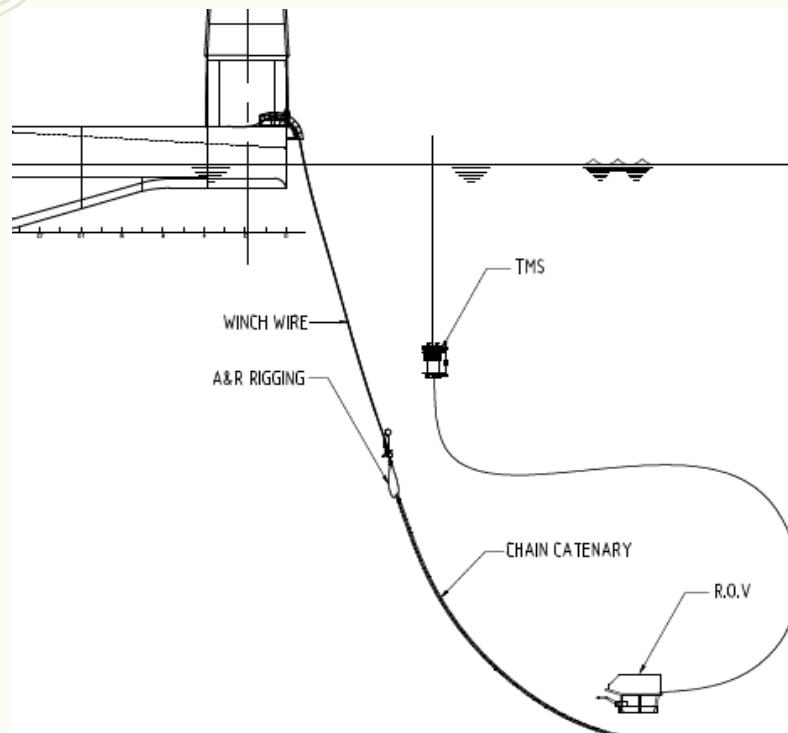
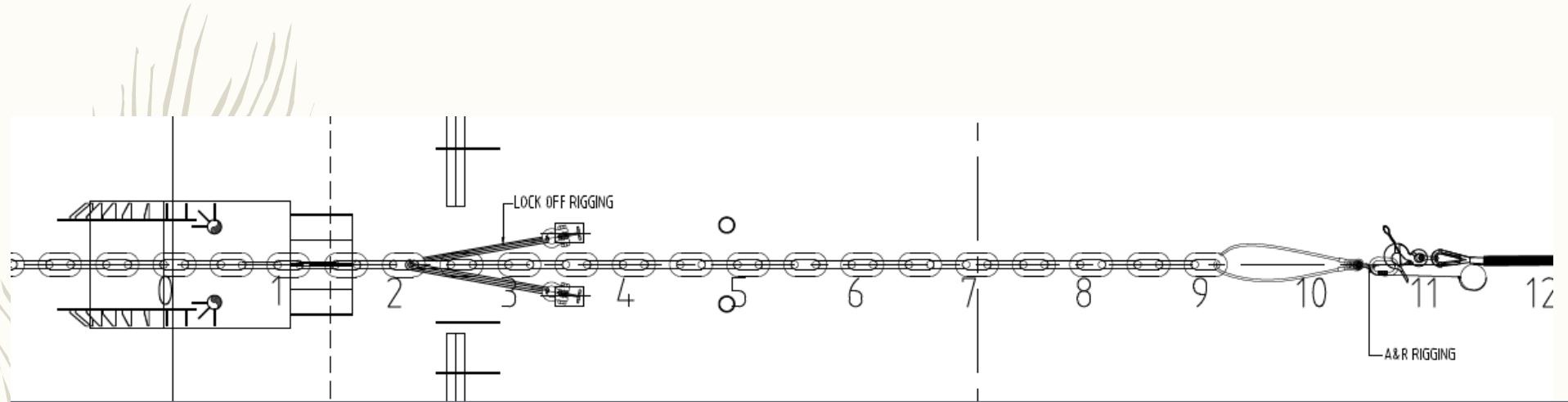




General layout for chain installation at turret & chain tensioning

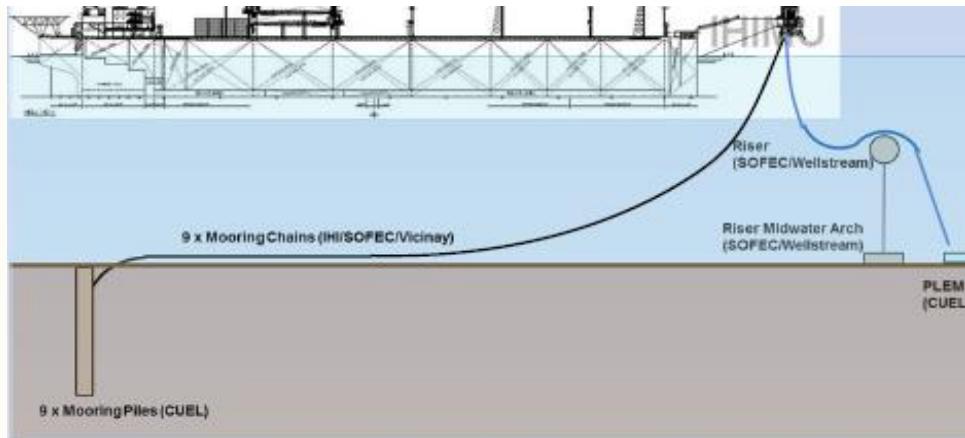
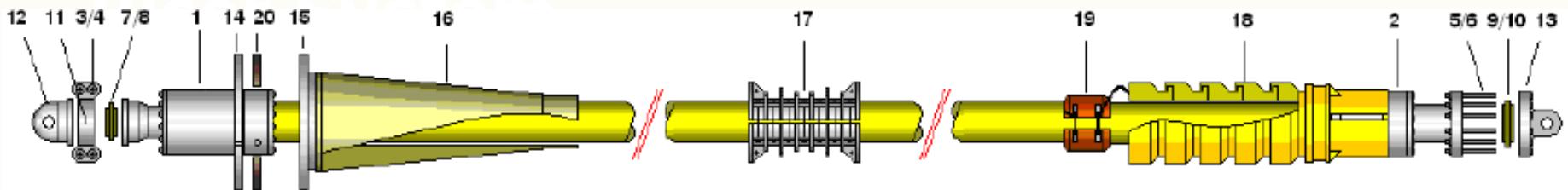


Top Chain Laydown





Riser installation



Lay System – Main Equipment



Under Roller Base

Max Load	: 300te
Maximum Line Pull	: 10te
Speed	: 1000m/hr
Dimension	: 8m x 7m x 1.6m
Weight	: 35te

Tensioner

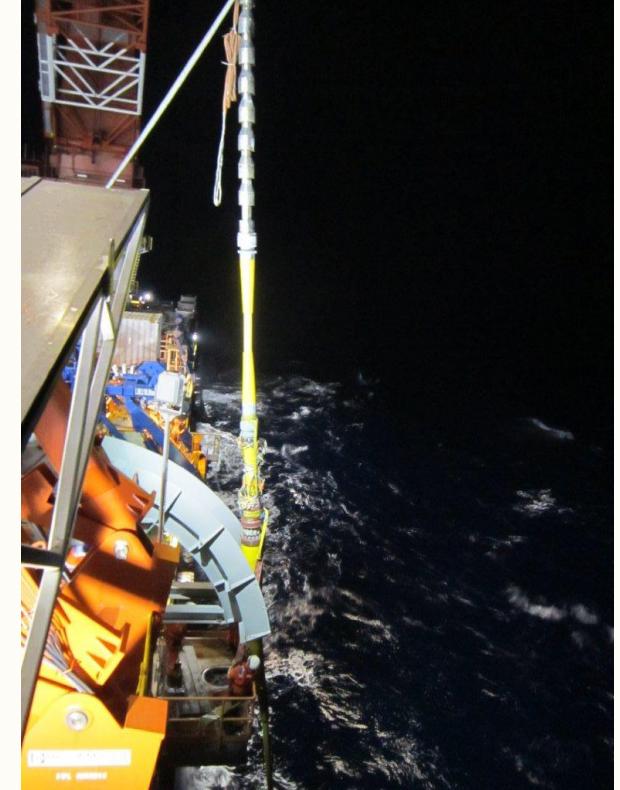
Line Pull	: 40te (four track)
Speed	: 1200m/hour
Footprint	: 6m x 3.5m x 3.5m
Weight in air	: 23Te

Lay Chute

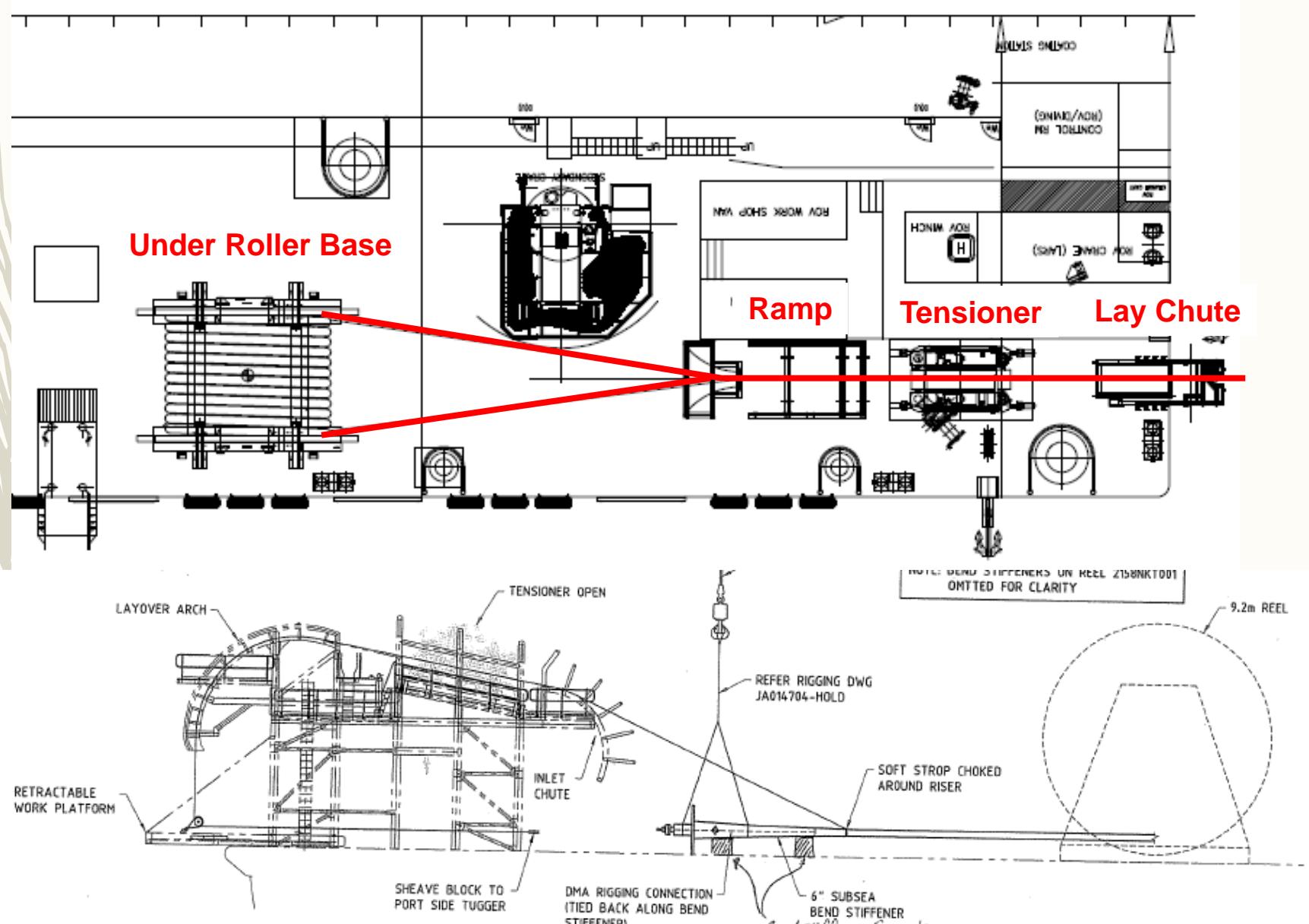
MBR	: 4m
SWL	: TBC

Lay Down Winch

Safe Working Load	: 50te
Length of wire	: 200m



Riser Lay System – Port Stern



Riser Installation

The Riser Installation is typically carried out in the following sequence:

- Attach control heading tug to the FSO stern to control the heading of the FSO.
- Setup construction vessel (CV) within the FSO turret.
- Connect winch wire to the riser pull head.
- Open up tensioner tracks.
- Pay out the riser from the reel.
- Use the crane and winch to place the riser over the tensioner.
- Continue paying out the product until the pull head reach the lay chute.
- FSO team lowers down riser pull-in wire.
- ROV connect the winch wire to the riser messenger wire (from construction vessel).
- CV recovers the riser messenger wire + pull-in wire to deck.
- CV removes the messenger wire and connects the riser pull-in wire to the riser pull head.
- FSO team pulls in the riser using FSO pull-in winch as the riser is being laid (paid out) from the construction vessel
- Riser is hung off at the turret of the FSO
- CV continues to lay the riser until the MWA arch clamp reach the lay chute.

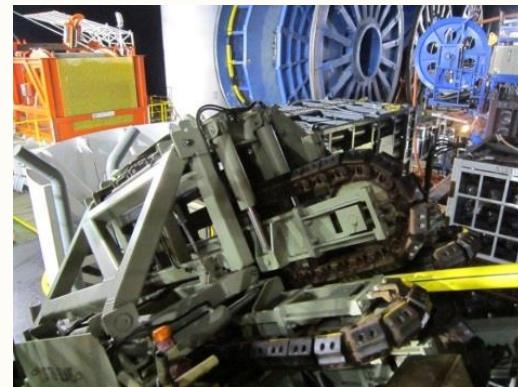
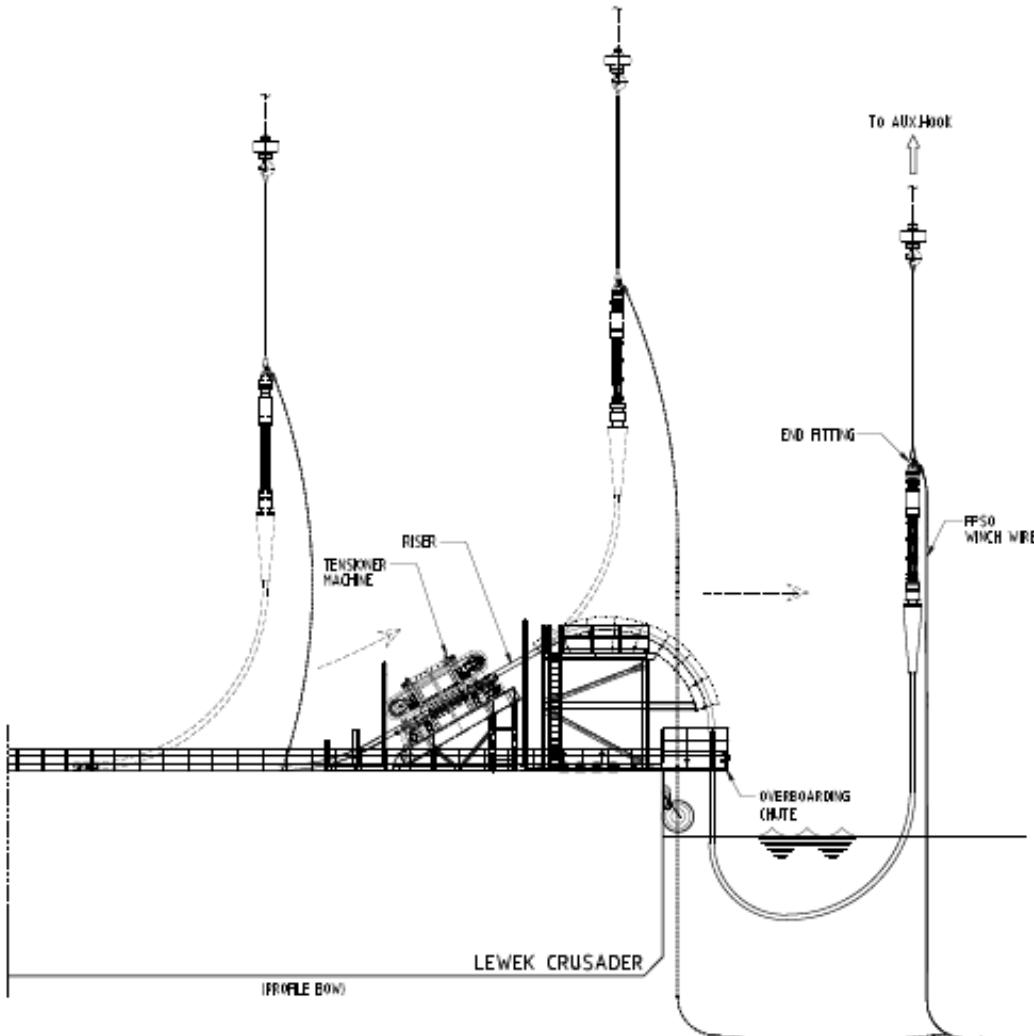
Riser Installation

- 
- Install the MWA clamp on the riser.
 - Lay the riser and land the MWA clamp on the slot of the MWA.
 - Continue lay the riser toward the second end.
 - Using the winch and crane, pay out the riser second end from the reel.
 - Connect the riser laydown head to winch and crane.
 - Open up tensioner tracks.
 - Overboard the riser using the laydown winch and crane.
 - Laydown the riser end near the PLEM using laydown winch.
 - ROV to disconnect / cut the sacrificial grommet on the laydown winch wire.
 - Recover lay down winch to deck.

Riser Installation - Initiation

STEP 7 :

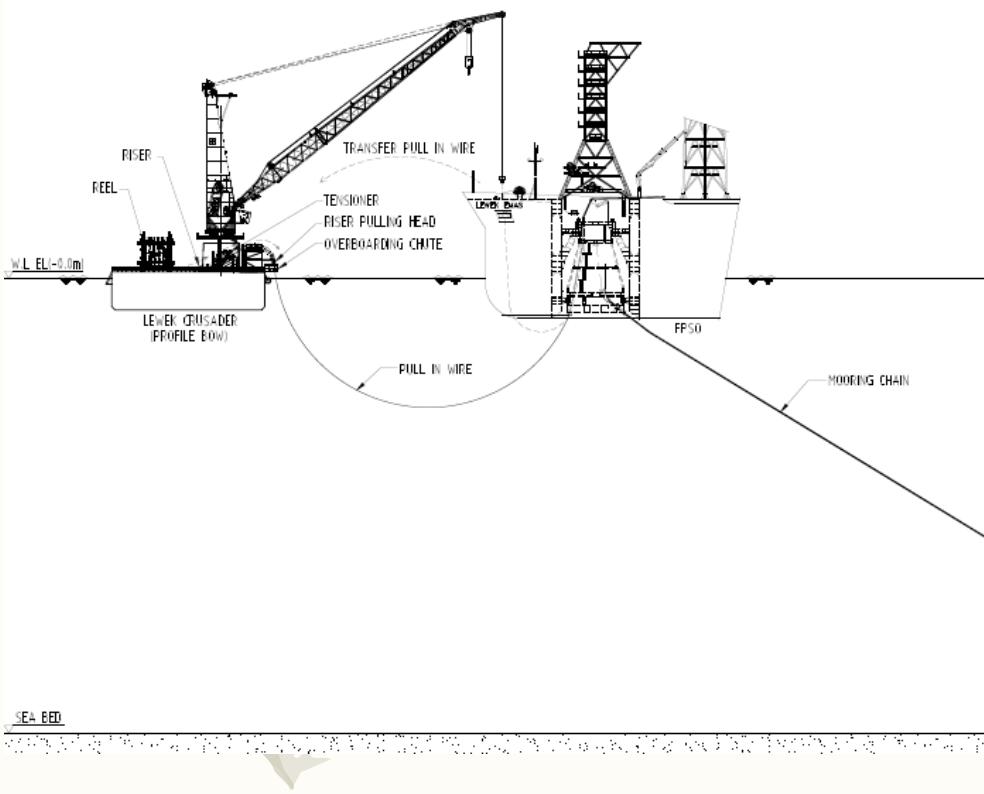
- CRANE LIFTS RISER THROUGH TENSIONER AND OVER CHUTE
- TENSIONER CLOSED
- RISER READY TO DEPLOY



Riser Installation

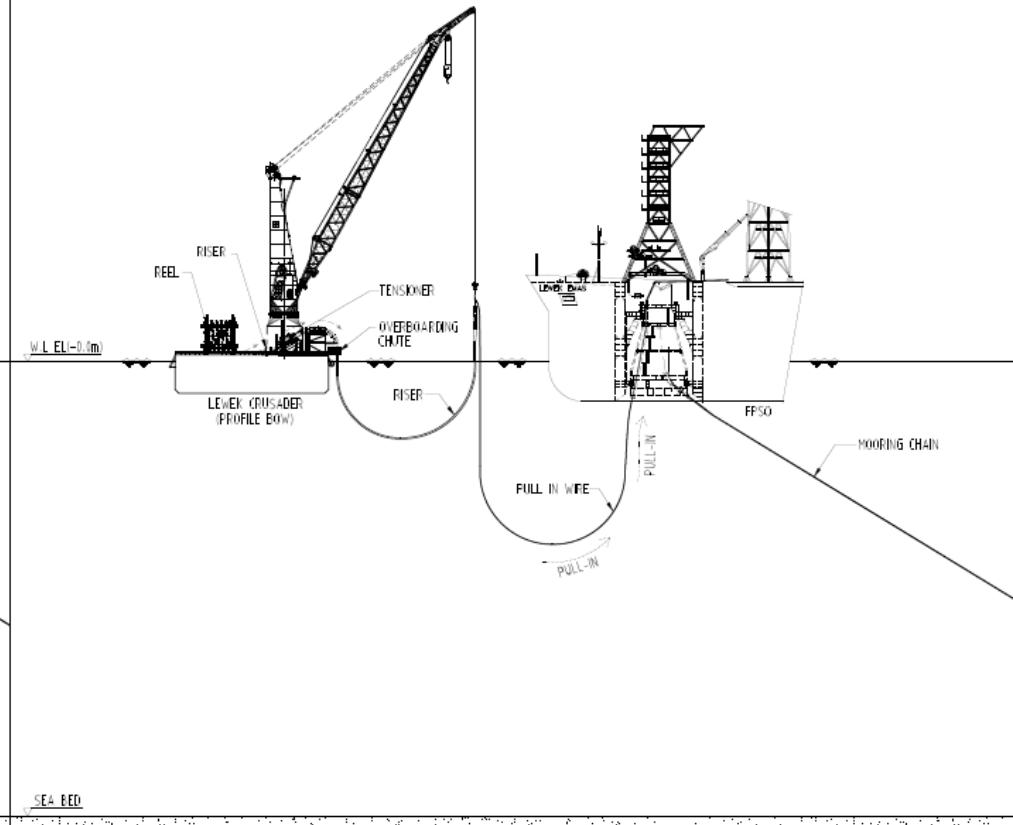
STEP 1 : COMMENCE PULL-IN

- PULL IN WIRE TO VESSEL



STEP 2 : PULL IN AND LAYAWAY

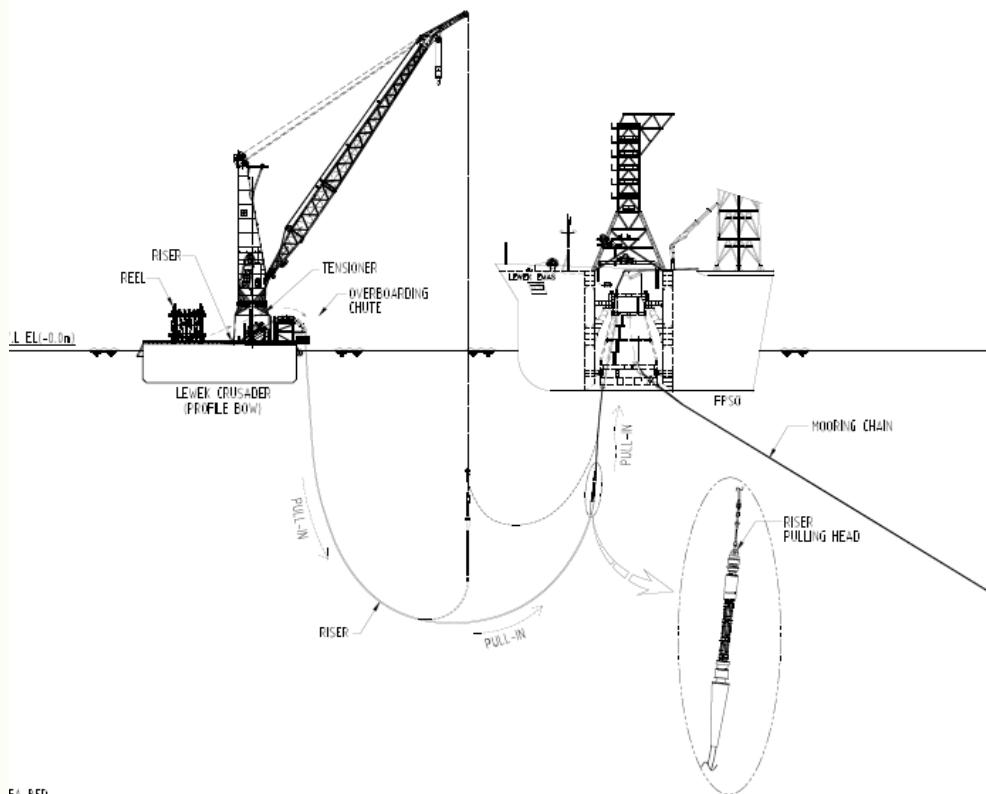
- FP50 HEAD OVER BOARDED



Riser Installation

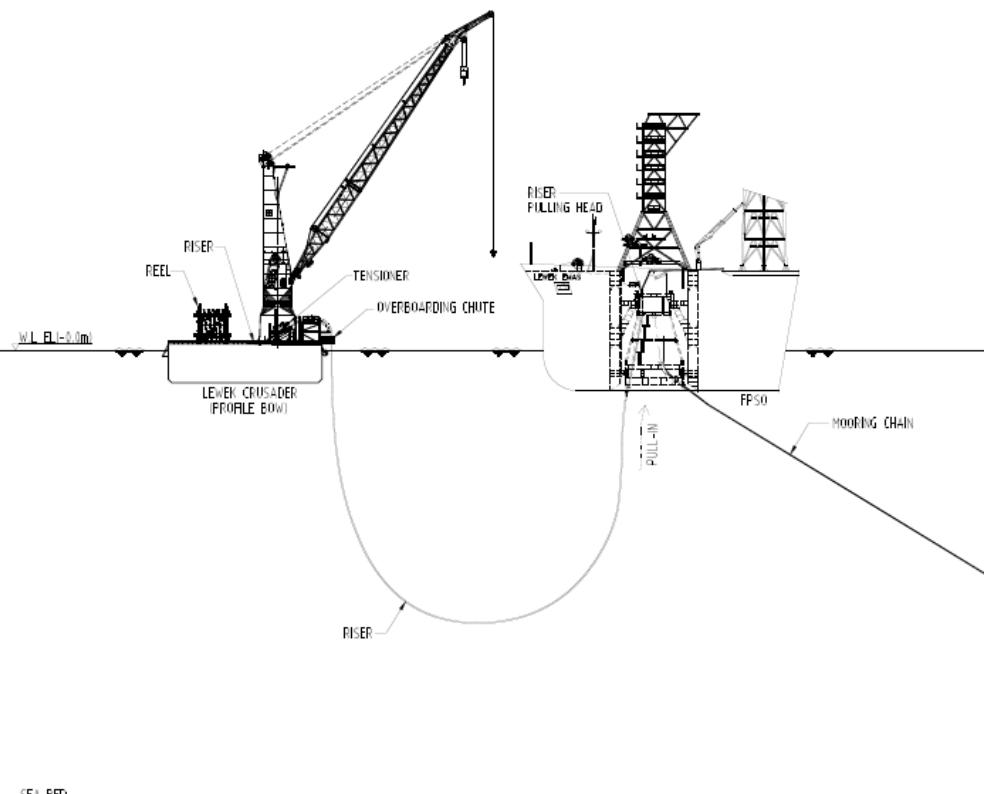
STEP 3 : COMMENCE PULL-IN

- RISER LOAD TRANSFERRED TO FPSO WIRE
- CRANE DISCONNECTED FROM RISER
- FPSO PULLS HEAD INTO FPSO
- FPSO PULLS BEND STIFFENER TO LATCHING MECHANISM



STEP 4 : PULL IN AND LAYAWAY

- RISER IS LATCHED INTO FPSO AT BEND STIFFENER
- RISER PULLED THROUGH TURRET
- RISER IS SECURED WITH HANG OFF FLANGE



Riser

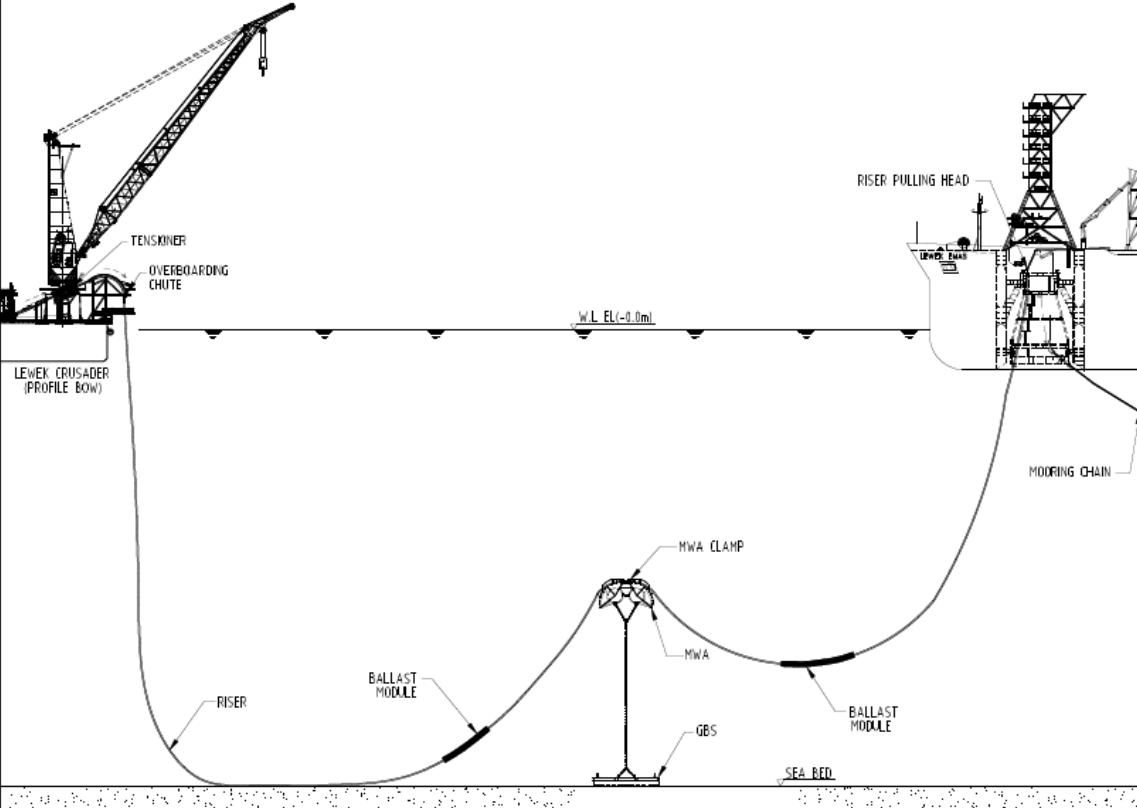
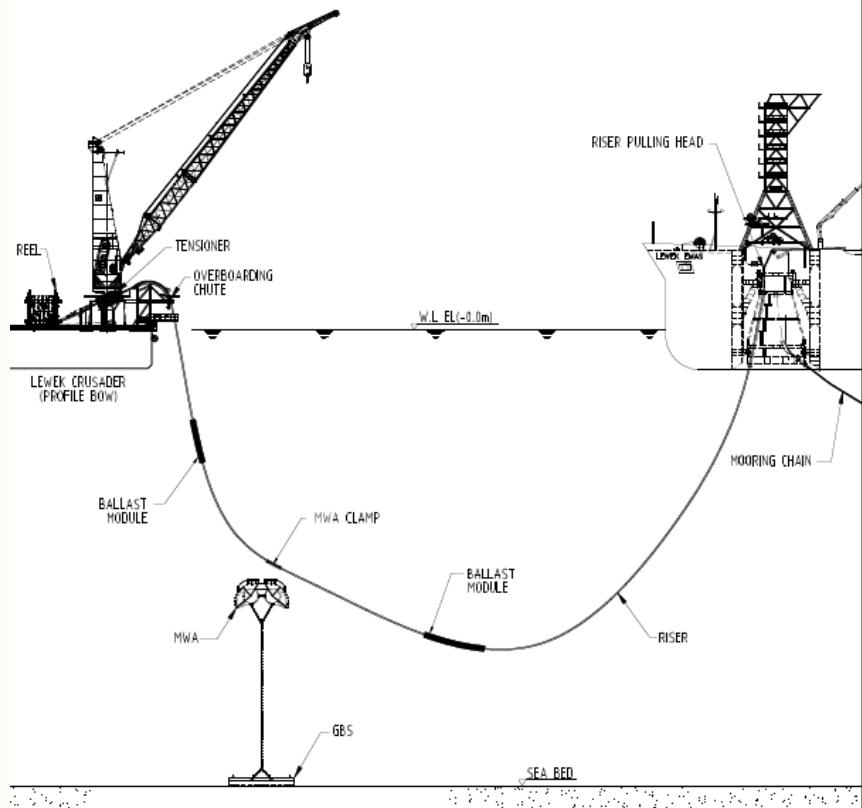
STEP 3 : LAY OVER MWA

- MWA CLAMP IS LANDED IN TO MWA



STEP 4 : LAYDOWN AT PLEM

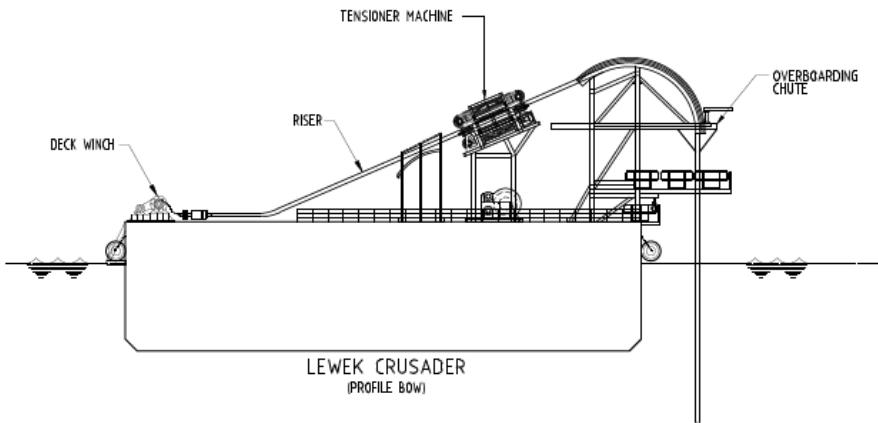
- RISER IS LAID AWAY FROM MWA



Riser Installation

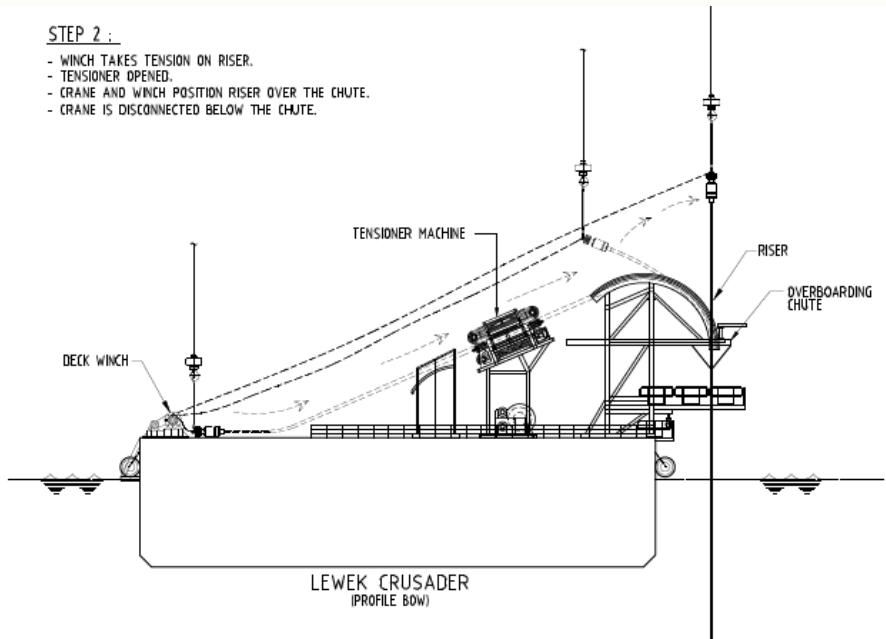
STEP 1 :

- PIG RECEIVER INSTALLED ON PLEM END OF RISER.
- DECK WINCH ATTACHED TO PIG RECEIVER.
- CRANE ATTACHED TO PIG RECEIVER.



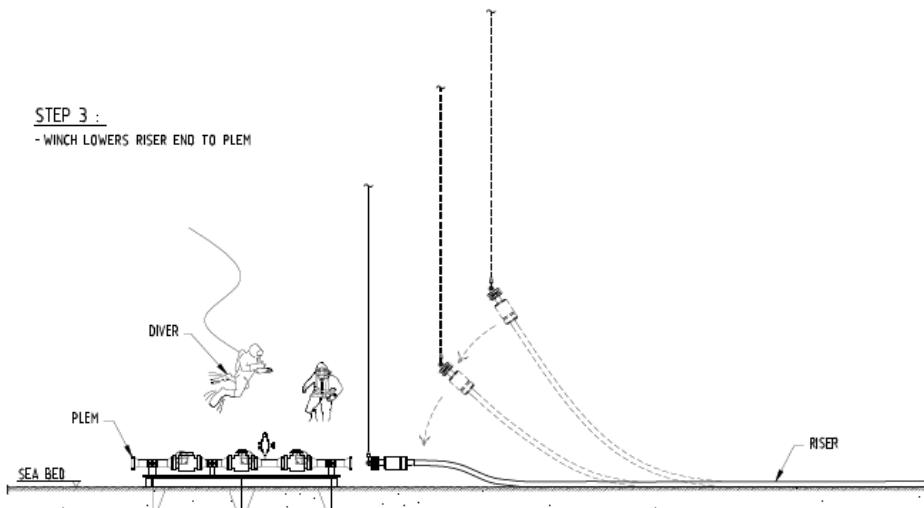
STEP 2 :

- WINCH TAKES TENSION ON RISER.
- TENSIONER OPENED.
- CRANE AND WINCH POSITION RISER OVER THE CHUTE.
- CRANE IS DISCONNECTED BELOW THE CHUTE.



STEP 3 :

- WINCH LOWERS RISER END TO PLEM



Sorry, information pertaining to pile, chain & floating facility installation is
NOT found in my book: “Subsea Rigid Pipelines – Methods of Installation”

J-lay Method of Installation



Controlled Depth Tow
Method of Installation



Surface-tow Method
of Installation

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S-lay Method of Installation



Reel-lay Method of Installation



Stalk-on Method of
Riser Installation



QUESTIONS ???

