



**NAUTILUS INTERNATIONAL LLC**

**Coiled Tubing, Drilling & Intervention System  
Using Cost Effective Vessel**

**RPSEA Project 10121-4505-01**

**Task 4 Special Report**

**Technology Qualification Basis Document:  
MEPS SSR for Coiled Tubing Intervention in Deep Water  
Satellite Wells**

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## **1.0 Introduction - Objective, Scope and Goal**

CT intervention in deep water satellite wells normally requires a MODU which is expensive in terms of both day rate cost and opportunity cost and exposes a large crew to offshore hazards. The MEPS Self-Supporting Riser (SSR) system approach facilitates the use of smaller vessels with lower day rate and smaller crew for reduced risk and cost. Technical challenges are primarily optimization of the interfaces between the CT system, the vessel, and the riser.

This document is intended to serve as the basis for technical qualification of the joint use of two existing technologies - a self supporting riser and down-hole intervention with coiled tubing for offshore satellite wells. As such, the document describes the technology, defines how the technology will be used and the environment in which it is intended for use, and specifies its required functions, acceptance criteria and performance expectations. This includes the performance requirements throughout the life cycle of the technology. The technology is summarized in Section 1 and presented in more detail in Sections 2 and 3.

The objective of MEPS-First Oil is to obtain certification of its MEPS SSR, with emphasis on use with Coiled Tubing for down-hole intervention such as plugging and abandonment. The system is being submitted for technology qualification leading to a “statement of endorsement” to show that a reputable certifying agency has reviewed the design and found it to be robust and reliable. The certificate is expected to be in the form of a statement of feasibility for applying the MEPS SSR for down-hole intervention in previously completed hydrocarbon wells in the Gulf of Mexico.

The scope is primarily the combining of two mature technologies – self-supporting risers in support of down-hole intervention using coiled tubing. Production using a flexible from the top of a self-standing riser to a vessel is well-established technology and considered to be a minor variation on the primary scope of coiled tubing intervention.

The goal of Technology Qualification in general is the process of providing the evidence that a technology will function within specified operational limits with an acceptable level of confidence. For the near term in this instance, this includes acquisition of a Statement of Feasibility as the first step toward future completion of a Statement of Endorsement for the MEPS SSR according to DNV’s recommended practice DNV-RP-A203. Future phases are planned to target qualification execution and a final performance assessment that lead to a Technology Certificate for Fitness for Service.

### **1.1 Technology Background and Level of Maturity**

The submitted configuration is an amalgam of two mature technologies. The self-standing riser tower is a well-developed technology used in association with hydrocarbon production in both shallow and deep water including applications in the Gulf of Mexico and other locations. Examples of free-standing riser usage are believed to go back to the 1980’s for Conoco usage in Indonesia and the Placid Green Canyon GoM Block 29 development (removed in 1984), and later the Girasol riser in West Africa, the Petrobras Cascade/Chinook fields in the Gulf of Mexico, Helix use of a free

standing riser for reconstruction of the Typhon field, and the risers installed to capture effluent in response to the Deepwater Horizon incident.

Coiled Tubing for down-hole intervention is well-developed technology commonly used offshore from fixed platforms, floating platforms, and drilling vessels. The interfaces between the MEPS SSR and a coiled tubing system have not yet been demonstrated in practice.

All elements and components are currently available from common usage in the industry. However, even though steel hull buoys are commonly used, the details of buoyancy design for the SSR will vary from common usage, primarily by virtue of the details of the compartment arrangement and a central conduit for attachment to the riser casing.

In the submitted configuration there are new interfaces and interactions between the riser and the wellhead, between the riser and the vessel, and between the riser and the CT system. Function can be optimized and cost can be reduced by future optimization of components used at the interfaces but this is beyond the scope of the present submittal. The referenced documents define these interfaces and provide information from previously completed analysis, fabrication, and testing.

The MEPS SSR is intended for use by established coiled tubing service contractors, any of which can use their standard equipment and operating practices. The operator and/or the coiled tubing service contractor are to designate the MEPS SSR and a vessel of opportunity for specific projects. The primary purpose of the SSR is to bridge most of the water column.

The MEPS SSR differs little from established systems with respect to riser design and components. The topics of novelty and of primary interest for this submittal are the riser itself and interfaces between the riser and the tree or wellhead, between the riser and the coiled tubing system, and between the riser and the vessel from which the coiled tubing is deployed.

### **1.1.1 SSR Technology Maturity**

A self-standing riser is supported by its own submerged buoyancy rather than by a surface vessel or platform. Risers of this type have seen service in the Gulf of Mexico, off West Africa, and in other locations since the 1980's.

A prototype MEPS SSR was installed in 3,500 ft. water depth in 2006 in the Gulf of Mexico on a simulated wellhead. It withstood direct hits by hurricanes and eddy currents and when it was recovered after 5 years there were no significant signs of fatigue or other degradation.

**Fig. 1.1: Installing Keel Joint for Buoyancy Module**



**Fig. 1.2: Buoyancy Module 2 Years after Installation**



The MEPS-First Oil SSR technology is based on public information from previous applications and is based on similar systems that principals at MEPS-First Oil and Nautilus International have implemented or developed. During the past seven years, MEPS-First Oil and Nautilus International have further developed the MEPS SSR through: (1) extensive system design and analysis, (2) basin model tests, (3) system component qualification and manufacturing, (4) installation of a prototype system in the Gulf of Mexico, (5) and RPSEA projects based on the MEPS SSR for well intervention and for extended well testing.

### **1.1.2 Coiled Tubing Technology Maturity**

Down-hole intervention using coiled tubing is now a well-established commodity business throughout the world. Several manufacturers offer catalog standard components including tubing, reels, injectors, CT blowout preventers, and control systems. More than half a dozen international oil field service contractors use this commercially available equipment to compete for intervention projects in offshore hydrocarbon wells. The configurations submitted for TQ is based on established CT service contractors using the MEPS SSR and performing the coiled tubing service activities according to their own practices. The CT contractors provide BOP hardware and other well control equipment and methodologies that are fully acceptable per industry standards and regulatory requirements. The submitted configuration relies on these standard provisions for well control and adds reservoir isolation capability at the seafloor and above the SSR buoyancy.

### **1.1.3 Combined Usage Technology Maturity**

Use of a self-standing riser for workover of offshore wells was developed by Sea Engineering and Conoco for shallow water application in Southeast Asia in the 1980's and early 1990's. The MEPS SSR configuration was further developed and refined by Nautilus and Sea Engineering in preparation for building the prototype. This work

included computer modeling and wave tank tests of the SSR engaged to a semisubmersible in a manner that would facilitate deployment of drill string or coiled tubing from the vessel, through the riser, and down to a hydrocarbon reservoir for a range of currents and surface conditions. Sea Engineering reported that evaluation of the results compiled by the wave tank operator showed that the model tests validated the computer models and that the models performed as expected.

Work by Nautilus International on RPSEA project 1502 extended the concept to deeper water and expanded the range of capabilities, as described herein. Computer model results, wave tank test results, and selected task reports from the RPSEA projects, along with their appendices and engineering documents referenced therein, are incorporated in this submittal by reference.

## ***1.2 Technology Use***

The submitted system is intended to facilitate down-hole intervention for workover or abandonment of offshore wells that are remote from surface structures. Such wells are commonly known as satellite wells. For this submittal it is understood that subject wells have been previously completed and that reservoir characteristics including pressure and fluid types are well known prior to installation of the SSR.

## ***1.3 Environment Where Used***

The basis for qualification is use between the water depth contours of 1000 feet and 5000 feet in the Gulf of Mexico. Hurricanes are the environmental influence normally of highest concern in the Gulf of Mexico. The basis for qualification includes the top of the SSR being installed at least 100 feet below the surface, at which depth analysis has shown that it is not significantly affected by Gulf of Mexico hurricane waves or swells. Also, with the top at least 100 feet deep the SSR is not considered to be a hazard to navigation.

The basis for qualification includes near surface current up to 2 knots, tapering off with depth, and not exceeding one half knot at the bottom.

Currents greater than 2 knots in the GoM are associated with loop and eddy currents whose strength, location, and rate of change of location are regularly charted and forecast. The intent is to install the SSR only in locations not threatened by loop or eddy current during the installation period. The intended installation duration of the CT riser during down-hole intervention work is typically 1 to 5 days, with total installed duration not to exceed 12 days. This duration is well within the present accuracy of predictions.

The effects of current include vortex shedding, which can include Vortex Induced Vibration (VIV) and larger amplitude, longer period movement known as Vortex Induced Motion or VIM, both of which contribute to riser fatigue. The effects are mitigated primarily by the use of strakes on the riser and the buoyancy to reduce vortex shedding. In addition, the tension in the SSR, particularly near the upper end where current is strongest, increases the resonant frequency of the riser, thereby reducing the amplitude

of motion and extending fatigue life. The SSR is intended for short duration installation at locations where the current forecast for that location, with margin, is 2 knots or less.

The MEPS SSR design is based in part on confidential and proprietary met-ocean data provided through DeepStar. The current velocities in Table 1.1 were extracted from that data. The table indicates that the 2-knot design criteria allows margin for short duration installation in locations not threatened by loop or eddy current during the installation period.

**Table 1.1: Design Current for Central Gulf of Mexico**

Depth Below Surface (Feet)	Max Loop Current V		Ten Year Winter Storm		One Year Winter Storm	
	ft/sec	knots	ft/sec	knots	ft/sec	knots
0	8.9	5.6	1.6	1	1.3	0.8
164	8.9	5.6	1	0.6	0.8	0.5
328	8.9	5.6	0.3	0.2	0.3	0.2
656	5.6	3.5				
984	3.5	2.2				
1968	0.5	0.3				
2296	0.4	0.2				
8000	0	0				

Ocean surface conditions cause vessel motions, some of which may be induced into the SSR. Vessel motions in response to sea state are specific to different types and sizes of vessels. This TQ submittal is based on the requirement that the vessel not be connected to the riser when sea state exceeds criteria established by computer modeling for the specific vessel type and for the degree and duration of vessel motions that can be coupled into the riser without exceeding the allowable thresholds for fatigue or bending. The submitted configuration includes provisions for routine vessel disconnection from the SSR, and this facilitates disconnection if a weather window is closing or higher seas are forecast. Routine disconnection requires time to pull the tubing, typically one to three hours.

Emergency disconnection, as in the event of a DP drive-off, requires less than a minute and allowable vessel offset is approximately 10% of water depth. For disconnection, a hydraulic connector above the SSR buoyancy is opened to release the vessel from the SSR while shearing gate valves above and below the connector provide redundant shearing of deployed tubing and also seal above and below the connector to isolate contained fluids from the environment.

**Table 1.2 Summary of TQ Envelope Environment**

Factor	Minimum	Maximum or worst case
Surface current	0kt	2kt
Bottom current	0kt	0.5kt
Water depth for installation	1,000ft	5,000ft
Depth of top of SSR	100ft deep	400ft deep
Fatigue life for vortex shedding	20 to 1 margin over intended installation life, nominally 12 days or less, for specific location	
Allowable time/offset-radius to disconnect in the event of DP drive off	Less than 1 minute to close shearing gate valves & release connector	Vessel off station by 10% of water depth
Sea state for CT operations	Calm	As shown by analysis for specific vessels

### **1.4 Required Functions**

Primary functions of the SSR are:

- Extend the well casing from the wellhead or tree to depth near the surface
- Provide for reservoir isolation, including shearing of deployed tubing
- Provide for both routine and emergency disconnection of the vessel

Deployment of tubing, tools, and consumables through the riser and well bore, and well control including CT BOP functions, are the responsibility of the CT contractor who chooses to use the MEPS SSR.

### **1.5 Acceptance Criteria**

From the view point of the Operator, acceptance requires that the system provide a range of features and advantages including:

- Facilitate down-hole intervention in satellite wells using cost effective vessels
- Permit the intervention vessel to depart and return by disconnecting and reconnecting to the riser without need to recover or reinstall the riser

- Meet or exceed all applicable regulatory requirements and industry standards for protecting the environment including provisions for reservoir isolation, fluid retention, and spill prevention associated with coiled tubing intervention
- Meet or exceed all applicable regulatory requirements and industry standards for safety of personnel involved in riser installation, coiled tubing operations, and riser recovery

## **1.6 Performance Expectations**

The combination of an SSR with a coiled tubing system is expected to facilitate workover or plug and abandonment tasks for satellite wells, using vessels that are more cost effective than a MODU, while meeting all regulatory requirements and industry standards for safety and environmental protection. The MEPS SSR is expected to survive anticipated environmental conditions for its place of installation when the riser is left unattended and not connected to a vessel for up to 2 weeks. The SSR is expected to maintain structural and pressure boundary integrity without exceeding the allowable threshold for fatigue when connected to an intervention vessel for a period not to exceed 2 weeks before recovery and inspection.

## 2.0 Technology Specification

Material in this section is primarily excerpted from reports prepared in conjunction with work on RPSEA project 1502. Applicable sections of those reports are incorporated by references.

### 2.1 General System Description

The primary components of the SSR are a subsea shut-in device, specialty joints, body joints of either casing or drill pipe, buoyancy module(s), and a near surface emergency disconnection device with shear and isolation functions. Above the SSR there is an additional riser length of 100 ft. to 400 ft. which connects between the SSR at the near surface disconnect point and is supported near the vessel center of motion by a motion isolation system on the well service vessel. Umbilicals are included for operation of the tree, the shut in device, and the disconnect functions.

The riser can be installed and removed independently from well intervention operations and is suitable for extended periods without attention. Key design parameters for the riser are shown in Table 2.1.

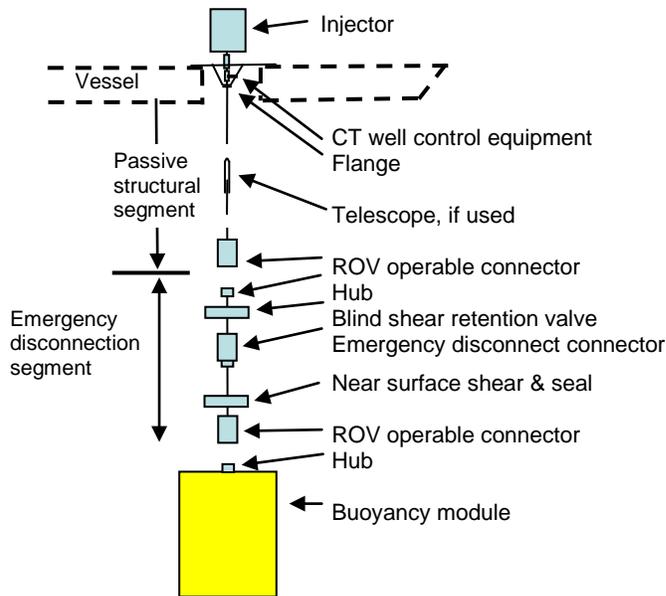
**Table 2.1: Key TQ Envelope Design Parameters for the SSR**

<b>KEY PARAMETERS</b>	<b>NOMINAL VALUES</b>
Casing diameter	6 5/8" drill pipe or 7 1/2" casing
Casing pressure rating	+/-5,000 psi across the casing wall
Nominal joint length	30' to 40' or similar standard length
Specialty joints	Stress joint at seafloor & keel joint below buoyancy
Casing joint connections	Threaded joints
Allowable axial rotation	At least +/- 90° with vessel heading
Seafloor Isolation Device	Redundant blind shear and seal with stored energy and redundant controls
Umbilicals	For tree, SID, and near surface disconnect
Tree interface hardware	Custom to suit specific tree, typically provided by tree OEM for tree installation or re-entry
Upper connection	Connector for riser extension to CT BOP, injector & other surface equipment
Tubing shear locations	In seafloor isolation device above tree and above buoyancy for emergency disconnection
Near Surface Shear & Seal device	Suitable to shear coiled tubing & isolate fluid in the riser as a step in vessel disconnection
Buoyancy type	Rigid hull, pressure equalized
Buoyancy compartments	At least 5 isolated compartments
Buoyancy protection	Dropped object protection integral with top of buoyancy
Mud weight	9 to 12 pounds/gallon or as required for specific tasks
CT hang-off location	In CT BOP supported by vessel at surface
Fatigue life	20 to 1 margin over intended installation life, nominally 12 days or less

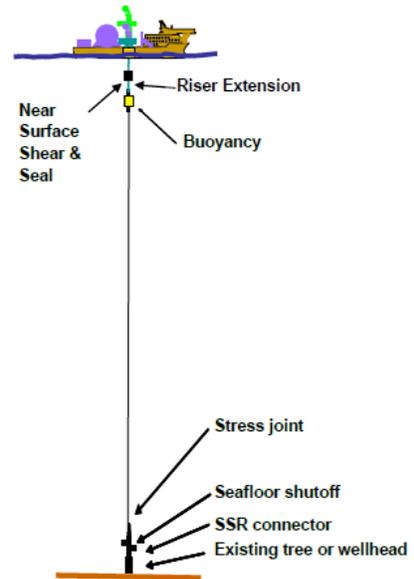
**Table 2.1: Key TQ Interfaces for the SSR**

INTERFACE	NATURE OF INTERFACE
SSR/tree	Bending moment due to current or due to vessel being off station Continuity of well casing pressure boundary Upward force due to tension in riser Gravity load of SID on the tree in the event of structural failure of riser
SSR/vessel	Gravity and tension load of riser-extension on vessel Horizontal force at vessel attachment due to current drag on the SSR Vessel motion introduced into SSR SSR offset due to vessel off-station due to DP malfunction Tension transient in the event of emergency disconnection
SSR/CT system	Mud and tubing in SSR Tubing shear in the event of emergency disconnection

**Fig. 2.1: Typical Riser Extension and Emergency Disconnect**



**Vessel Working Through SSR with Interfaces to Buoyancy and Tree**



**2.1.1 Seafloor Isolation Device (SID)**

A Seafloor Isolation Device (SID) provides reservoir isolation capability at all times during use of the SSR. As described here the SID incorporates the reservoir isolation functions of a traditional BOP, but it is designed to include only essential isolation and re-entry functions so it can be made smaller and lighter for handling by a relatively small vessel. It is intended for use in conjunction with a CT BOP and other well control equipment. The design of the SID includes provisions to maintain reservoir isolation

while any component above it is replaced and this facilitates recovery from component failure or structural failure of the riser or CT BOP. This arrangement is intended to meet all regulatory and industry requirements for safety and environmental protection, with additional features of faster response and improved maintainability that come from locating equipment for functions such as choke and kill near the surface.

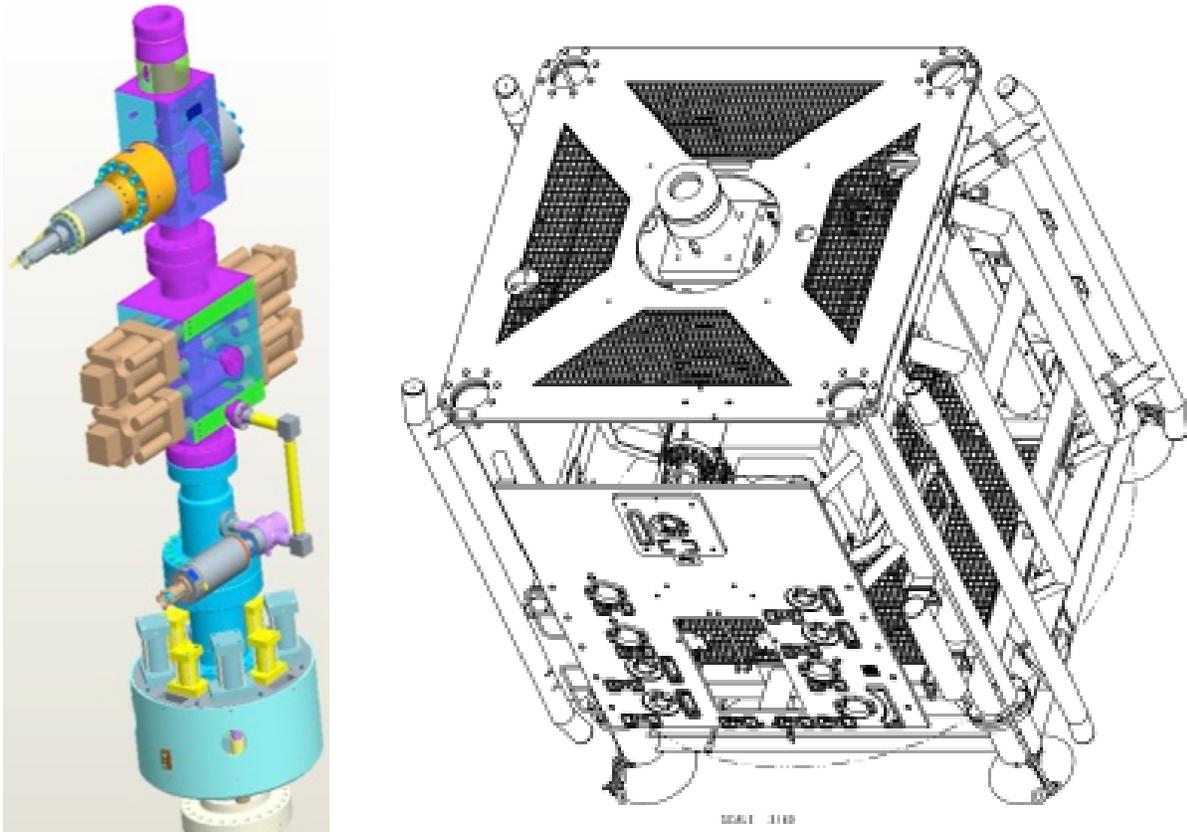
The Seafloor Isolation Device (SID) shall be suitable to connect to a vertical tree, a horizontal tree or a wellhead. Tree connection and control requirements are specific to the manufacturer of the tree and the type and vintage of the tree. The SID is to include an adapter spool below the shears as appropriate to engage a specific tree. The adapter spool shall include provisions for aligning and guiding the coiled tubing tools into the well bore. The adapter spool may be custom built for each job but in most cases the operator will provide a tree running tool or the lower riser package from a completion riser for interface between the tree and the SID. There shall be provisions for ROV override of all remotely operated functions.

Shearing tubing and closing under upset conditions shall be by stored energy that is released in a “fail safe” manner to ensure isolation of the reservoir. Stored energy shall be sufficient for close, open and reclose cycling. Stored energy to operate the SID may be recharged via either the control umbilical or by an ROV.

Depending on the situation at the time of an incident, deployed intervention tubing may be severed both at the SID and near the surface, in which case the tubing above the SID may fall until the SID supports it. The SID shall be suitable to support the tubing in the riser following an emergency disconnection. The design of the SID shall be such that all barriers will remain intact and that the SID will continue to function normally before and after the tubing is removed.

The SID shall include provisions to prevent or remediate hydrate blockage due to gas and moisture at low temperature. There shall be external connection ports by which an ROV can connect for injection of methanol or other fluids, either from the ROV itself or from an umbilical, to clear a hydrate blockage. In some applications there will be gas below the tree, and therefore the SID must provide a suitable interface for re-engaging the riser casing to the SID and entering a methane environment.

**Fig. 2.2: Seafloor Isolation Device as Designed for Task 9 of RPSEA Project 1502**



The SID is to be suitable for all loads introduced by the riser and shall include provisions for bending moments under conditions of design survival current. Tension load capability of the SID and associated elements shall be greater than the tension strength of the SSR joints. Maximum allowable compression load rating shall include the weight of the stress joint assembly above the SID plus joints of riser that might bear on the SID if the SSR were to collapse.

The SID shall consist of field proven components. The function of the SID shall be limited to reservoir isolation, and the device shall be as simple as is practical to enhance reliability and to help avoid unforeseen problems in control logic.

There shall be a hub atop the SID suitable for connection to the stress joint assembly. In the event of structural failure of the SSR, the SID would maintain dual-barrier isolation of the reservoir while the connection between the SID and the riser stress joint assembly is released by an ROV. The riser stub would be removed by lift line.

### **2.1.2 Connector and Retention Valve**

Immediately above the SID, a connector and a retention valve shall be located below the stress joint. The connector and the valve shall be operable only by ROV. For normal recovery of the riser and SID, the SID can be kept closed to retain fluid in the. The retention valve above the SID connector provides backup to retain riser fluids

during contingency operations in which the riser is removed while the SID is left on the tree or wellhead.

The pressure boundary of the connector and the retention valve shall be rated for at least 5,000psi and suitable for the bending moments in the riser under conditions of design survival current or allowable vessel offset.

### **2.1.3 Stress Joint**

Joint(s) suitable for transition from the stiffness of the wellhead equipment to the stiffness of the main body of the SSR shall be located above the connector and retention valve that engage the hub at the top of the SID.

### **2.1.4 Riser Body Joints**

Casing joints shall provide single barrier containment outside of the Coiled Tubing. Pressure rating of the assembled joints, under load as installed, shall be 5,000 psi plus incremental pressure for hydrostatic test of 1.25 times maximum operating pressure, or as may be required by regulations. The joints shall be suitable for maximum tension and bending as determined by analysis for the specific application.

### **2.1.5 Buoyancy**

Buoyancy shall be gas filled steel hull configuration. Buoyancy shall be designed for safety and reliability, ease of handling and installation, low drag, high ratio of net buoyancy to displacement, and low fabrication cost. Dropped object protection and interfacing to the riser extension and umbilicals from the vessel shall be incorporated into the top of the buoyancy. Buoyancy shall be pressure equalized so that the maximum pressure across the hull does not significantly exceed the ambient hydrostatic head between the top and bottom of the module. Gas for de-ballasting shall be supplied through an umbilical and the venting rate shall be sufficient to maintain pressure equalization as the riser is raised or lowered during installation and retrieval.

The buoyancy module hull shall be made of steel and shall be compartmented consistent with regulatory requirements and good naval architectural practice. This includes a requirement that the design allow unintended flooding of any one compartment without compromising the survival or basic function of the riser. Each compartment shall include provisions for venting and filling with gas during installation and operation. Controls for venting and filling shall be isolated to prevent accidental venting of more than one compartment and shall include provisions for ROV override.

Buoyancy module dimensions shall be designed with consideration of installation vessel moon pool dimensions and deck equipment. Buoyancy may be designed with interfaces to moon pool guide rails for deployment and recovery. To the extent practical, piping, valves and appurtenances shall be configured to minimize current drag, to avoid damage during transit through the moon pool, and to avoid entanglement with debris.

The riser and buoyancy modules shall be designed to interface with and support the umbilicals. The umbilicals provide power and control for connectors, valves, the tree,

and the SID and may provide gas flow for de-ballasting and ballasting buoyancy chambers. The buoyancy is to include umbilical connection points for gas and instrumentation lines and shall include provisions for the umbilical to run from above the buoyancy to items below it.

For the SSR, the most important function of the buoyancy is to keep the riser and all associated components in tension. It must be a design consideration that adequate tension is maintained under the disconnected configuration. Buoyancy shall be adequate to support the riser under the full range of conditions, and nominally 1.2 to 1.5 times the submerged weight of the riser. Tension that the vessel applies to the riser extension will lift upward on the SSR, adding to the effect of the buoyancy. The riser's structural tension capability shall be designed to accommodate the maximum applied tension and to accommodate transients in tension due to non-linearity of the vessel's motion isolation equipment and sudden changes in load and operating conditions.

The design shall include allowance for bending moments between the buoyancy and the riser where they are connected. Bending moment is primarily due to offset conditions in which the buoyancy tends to remain vertical while the riser inclines, and is concentrated just below the buoyancy. The design shall assure that the riser joint immediately below the buoyancy (the keel joint) has adequate strength and fatigue life for the intended application.

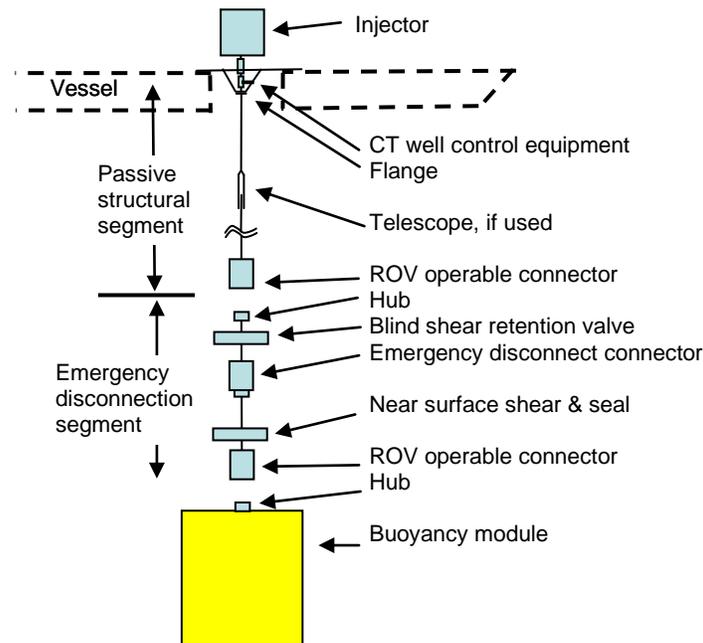
#### **2.1.6 Riser Extension with Disconnect and Isolation**

A riser extension is required to bridge the gap between the intervention vessel and the top of the SSR. The riser extension and the associated umbilicals shall be designed to interface with both the riser and the motion isolation system. The riser extension consists of two segments. One segment includes blind shears and connectors for emergency and routine disconnection of the vessel from the riser. The other segment extends the casing from the emergency disconnection segment up to the vessel.

The riser extension and active components in it shall be suitable for the maximum bending moments, tension and compression loads introduced by vessel motions and the maximum load excursions that may result from emergency disconnection.

The design shall include provisions to prevent damage to the vessel in the event of structural failure of the riser that results in loss of load on the buoyancy and resulting upward force from the buoyancy on the riser extension. Such provisions may include deflection of the buoyancy as it rises or spilling of sufficient buoyancy gas to neutralize the upward force on the riser extension.

**Fig. 2.3: Component Arrangement in Disconnect and Riser Extension**



The riser extension shall be designed to suit applications where the SSR will be submerged at least 100 feet at low tide and may be as far as 400 feet below the water surface, depending on the anticipated current for the specific location. The casing segment of the riser extension may be designed so that the riser installation vessel can hang it on the side of the riser buoyancy. The CT intervention vessel can then lift the riser extension into the moon pool, connect the coiled tubing well control equipment and lower the extension to engage the disconnect provisions above the SSR buoyancy.

The nominal point of engagement to the riser extension shall allow the motion isolation system to operate near its mid-range.

The riser extension should have the same internal diameter as the SSR and be concentric with it. The bore of the riser extension shall drift for the full length of the longest tool string.

The riser extension segment that includes the blind shears and connector for emergency disconnection shall be suitable for installation by the CT intervention vessel. This segment is preferably assembled and tested onshore and installed as a unit.

### **2.1.7 Control Umbilicals**

Umbilicals are required from the surface vessel to the seafloor and to the disconnect device located above the SSR buoyancy. The umbilicals are deployed from reels. The umbilical to the seafloor may be installed at the time of riser installation and secured to the SSR, or it may be deployed from the intervention vessel. The umbilical to the disconnect device is deployed from the intervention vessel.

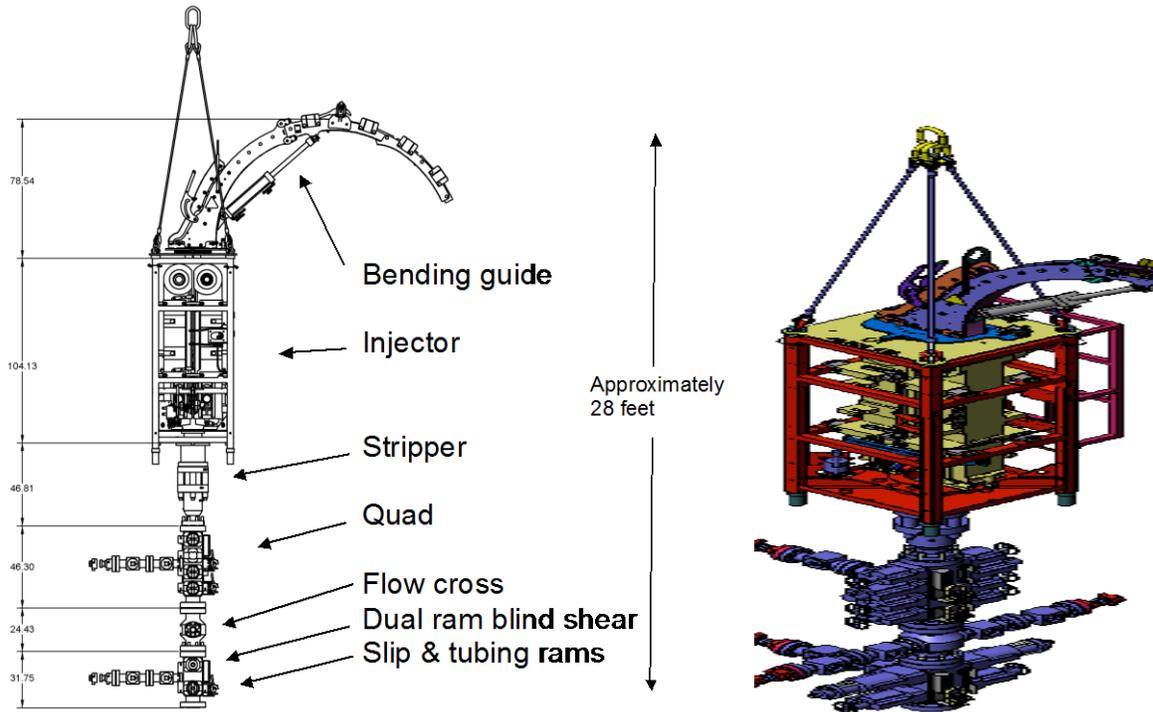
### 2.1.8 Controls for Subsea Equipment

The tree manufacturer provides a panel for control of the tree, normally at the time of tree manufacture and either as part of the tree installation equipment or with a completion and workover riser. Controls for the SID are provided with the SID and are limited to the functioning of the two blind shears and recharging the stored energy on the SID. All active components have provisions for override by ROV.

### 2.1.9 Coiled Tubing System

The coiled tubing system is a standard commercially available system. It includes a CT BOP for well control, tubing on a reel, an injector to deploy the tubing, a hydraulic power unit, and a control cabin. Depending on the size of the vessel, the rated sea state for operations, and the duration of operations, it may be necessary to arrange the reel and injector in a manner to minimize fatigue of the tubing due to vessel motions.

**Fig. 2.4: CT Equipment Stack-up on Deck and in Moon Pool**



### 2.1.10 Vessel Motion Isolation System

A motion isolation system is required when a rigid riser extension is engaged to the vessel. All items supported by the vessel motion isolation system are fixed to the earth when the riser extension is connected to the SSR. The isolation system shall be suitable for use at the moon pool of the intervention vessel and shall maintain tension in the riser extension while supporting the injector, BOP and associated equipment. The load path for tension transients is not through the buoyancy because the buoyancy module connects to the riser at only one elevation. However, the motion isolation system shall

maintain tension and bending transients in the riser extension within ranges found acceptable by analysis. There shall be allowance for vessel heave as great as plus and minus 10 feet, due to an exceptional wave, with no damage to the vessel or the self-supporting riser. Maximum vessel pitch, roll and heave motion for ongoing operations are to be determined by analysis for the specific vessel.

The motion isolation system is to be optimized for a load of approximately 150,000 pounds. Higher load rating is desirable, but energy consumption might be excessive. A load equal to the weight of the injector, surface well control equipment and riser extension, plus allowance for a 200,000 pound breaking strength of the tubing shall be accommodated without damage to the motion isolation system, the vessel or the SSR.

The range of motion and speed of response of the motion isolation system shall be adequate for the maximum anticipated vessel motion in response to an exceptional wave during conditions within the specified range of sea state for down-hole operations. It shall also be adequate to prevent potentially damaging transient loading of the riser extension in the event of emergency disconnection.

During CT operations, emergency disconnection can be done by isolating the reservoir, severing the tubing (if necessary), sealing the SSR just above the buoyancy and disengaging the riser extension and control umbilical from the top of the SSR as the vessel moves away. (Refer to outline procedure in Section 5 of the RPSEA project 1502 report for Task 5.) The riser extension remains with the vessel. The interfaces and the riser shall be designed to tolerate the change in load when the tubing is severed and the riser extension is disconnected.

## ***2.2 System Functions and Functional Limitations***

The primary function of the system as submitted for TQ is to facilitate down-hole intervention in deep water satellite wells using cost effective vessels. The operator selects a coiled tubing system contractor to provide personnel and CT equipment suited to the particular task at hand. It is the responsibility of the Operator and the CT contractor to verify that the CT system is appropriate and to decide whether to use the SSR to bridge the water column.

Suitable vessels are available for hire in the Gulf of Mexico. Limitations on the installation vessel include adequate stability, ROV system, moon pool and crane for deploying the SID and the buoyancy module(s). The vessel must also have accommodations for the installation crew and deck space for the SSR. It is anticipated that a vessel length of at least 260 feet (79 meters) is required. It may be necessary to outfit the installation vessel with equipment or tools at the moon pool for handling joints and making up threaded joint connections.

Limitations on the intervention vessel include the need for adequate stability, ROV system, moon pool, deck space for the CT equipment and consumables and accommodations for the CT crew. Specialty features such as a flare or classification for hazardous atmosphere may be required, depending on the intervention tasks to be performed. It may be necessary to outfit the intervention vessel moon pool area with a motion stabilizing system to support the coiled tubing injector and the riser extension.

If a single vessel is used for both installation and intervention it must be suited for both tasks. It must be larger to provide adequate deck space and crew accommodations for both riser installation and the CT system, and provisions to resolve any conflicts for access to the moon pool.

Functional limitations on the SSR include limited fatigue life if vessel motions are not adequately isolated and application specific needs for internal diameter and pressure rating. Current is the limiting environmental factor.

Each installation is designed to accommodate current drag and the resulting bending moments by avoiding unnecessary casing weight (to avoid excess drag associated with an unnecessarily large buoyancy module). Drag is also limited by locating some or all of the buoyancy below excessive currents. High currents in the Gulf of Mexico are associated with either loop currents (Gulf Stream flow) or eddy currents that are pinched off segments of the loop that drift across the gulf. The locations of these currents change slowly and are charted and reported every few days. Forecast velocity and location are sufficiently accurate to determine whether there is a risk of associated high current while the SSR is installed for an intervention job, and the SSR configuration shall be planned accordingly.

### ***2.3 Classification and/or Regulatory Requirements***

Final design for applications is to comply with DNV requirements for use with DNV classed vessels and comply with all regulations applicable to reservoir isolations and intervention in hydrocarbon wells in the deep-water provinces of the Gulf of Mexico.

### ***2.4 Applicable Standards and Industry Practices***

Applicable riser requirements of API Recommended Practice 17G are included here by reference.

### ***2.5 Handling and Operation***

The SSR is composed of modules and joints that can be selected and assembled in different ways to suit the specific needs of different water depths, planned intervention tasks, vessels, currents and client preferences. It is intended that each module or joint will be cataloged by unique serial number and stored in a secure yard near docks that can be used for mobilization.

Components appropriate for a specific installation will be taken offshore and used as described elsewhere in this document and then recovered and returned to the storage yard. The conditions of usage of each component will be incorporated into comprehensive records for each serial number. When returned from use each component will be inspected and the history for its serial number will be updated, including duration of installation, environmental conditions during usage and any recorded exposure to extreme or upset conditions. Components used in locations exposed to large tensile or bending loads or fatigue will be subjected to non-destructive testing or scrapped. Buoyancy modules will be inspected for corrosion and refurbished

as appropriate including anode replacement and paint touch-up. Function tests will be conducted on the umbilicals and all active components including the SID, retention valves and the disconnection system. The components that pass inspection will then be returned to the pool from which equipment is drawn for future applications.

Each offshore installation shall be per a project specific procedure that has been subjected to a HAZID assessment. As part of RPSEA project 1502, generic procedures were prepared and a HAZID was performed. The HAZID results are discussed in Section 3.2 below and are submitted as part of the documentation associated with this TQ basis document.

The vessel(s) for SSR installation and intervention shall be rated for DP2. The minimum vessel size is determined by either suitability for the required equipment and crew accommodations or by the required size to work in the available weather window. An ROV system suitable for the installation water depth is required for both installation and intervention.

### **2.5.1 Installation and Retrieval**

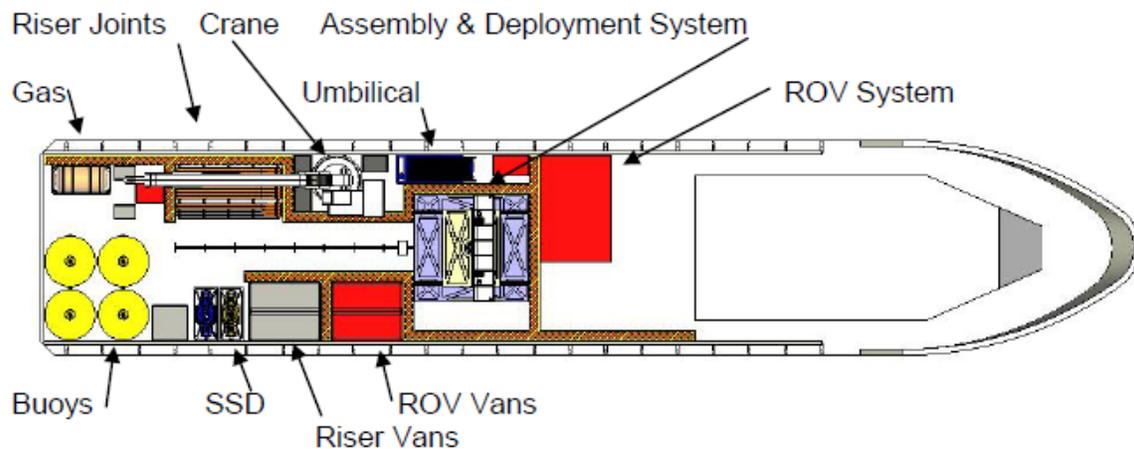
A single vessel can be used to install the riser, do the down-hole intervention, and recover the riser. Alternately two separate vessels can be used, one for SSR installation and one for intervention operations. There is significant opportunity to benefit from vessel specialization since installation is essentially a construction task while down-hole intervention requires significantly different crew skills, safety equipment, consumables and support functions, and possibly provisions for hazardous or flammable gasses.

For installation vessel must have adequate accommodations, a suitable crane, moon pool and ROV, as well as equipment for joint handling and bolting or threading joints. The riser assembly system may include mechanical pipe handling equipment and trolley movement of items such as the SID and buoyancy modules. Overhead lifts are preferably avoided to minimize the risk of accidents due to swinging loads. Guide rails for running and recovering the buoyancy and the SID are needed in the moon pool of mono-hull vessels. Heave compensation will be needed if the vessel crane is used for landing the riser on the tree or wellhead.

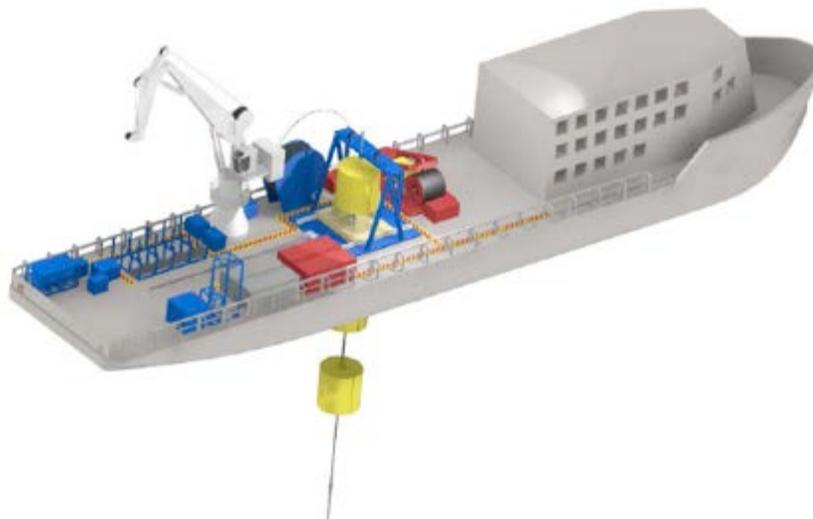
Following installation the riser is subjected to axial load test, pressure test, and function test of active components including the SID. The SSR is retrieved by reversing the installation procedure.

If a separate vessel is used for installation it may stand by during intervention work and then recover the SSR and demobilize. Alternately the installation vessel may either work on other projects or demobilize and remobilize later for riser recovery.

**Fig. 2.5: Typical Deck Layout for Mono-hull Installation Vessel with SSR On Deck**



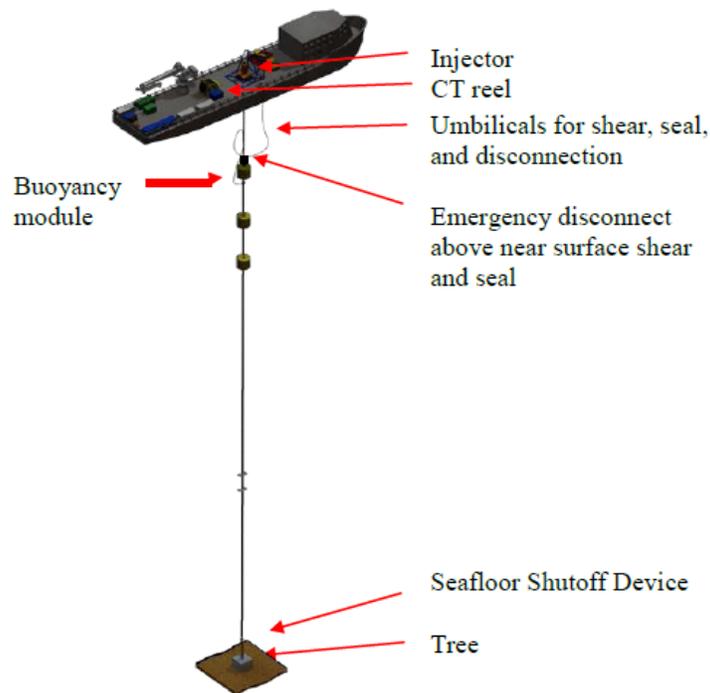
**Fig. 2.6: Mono-hull Installation Vessel in Final Steps of Deploying SSR**



## 2.5.2 Intervention Vessel

Overall requirements for the CT intervention vessel include deck space and deck load for the service contractor's CT and/or wire line and well control equipment, and the motion isolation system. Consumables, typically transported below deck, differ widely different for different jobs. Consumables may include mud, fluids for down-hole injection, nitrogen, chemicals for hydrate remediation, or cement.

**Fig. 2.7: Intervention Vessel with Coiled Tubing Deployed Through Riser**



Deck load is concentrated near the moon pool. This load may include the tubing reel, the injector and associated equipment and the motion isolation equipment. The moon pool may be of modest size, but shall be adequate to deploy and recover the CT BOP and other equipment located in the riser extension and to accommodate the relative motion of a riser extension.

A crane or lowering line shall be suitable for deploying the emergency disconnection segment of the riser extension and may be required to relocate the casing segment of the riser extension from and back to its parking position on the riser buoyancy.

The intervention vessel shall be rated for DP2. The allowable watch circle is quite large when working with the MEPS SSR, which can tolerate vessel offset of up to 10% of water depth.

### **2.5.3 Emergency Reservoir Isolation and Disconnection**

Shearing tubing and closing under upset conditions shall be by energy stored in the SID and released in a “fail safe” manner to ensure isolation of the reservoir. Stored energy shall be sufficient for close, open and reclose cycling. Stored energy to operate the SID may be recharged via either the control umbilical or by an ROV.

Depending on the situation at the time of an incident, the intervention tubing may be severed both at the SID and near the surface, in which case the tubing above the SID may fall and be supported by the SID. The SID shall be suitable to support the tubing in the riser following an emergency disconnection. The design of the SID shall be such

that all barriers remain intact and that the SID continues to function normally before and after the tubing is removed.

The emergency disconnection provisions above the SSR buoyancy include redundant remotely operated shearing gate valves with a remotely operated connector between them. The lower valve is oriented to isolate any pressure in the riser and the upper shear is oriented to retain fluid in the riser extension. For routine vessel disconnection the tubing is recovered before the shearing gate valves are closed. The riser extension above the connector remains suspended from the vessel following disconnection.

## **2.6 Maintenance & Operation Strategy (RPSEA Task 7 Report)**

Equipment used to install the SSR and to conduct CT operations is accessible for repair on deck, and all known failure modes can be repaired without jeopardizing the vessel or the SSR.

The SID is the only active component that is not readily accessible for maintenance during intervention operations because it is installed below the riser. The SID is fully tested after installation. In addition, the SID is specified with redundancy and ROV override capability for all functions and is subjected to onshore preventive maintenance. Valves, controls and other active components are normally used only for testing so wear is limited.

The intervention vessel installs all other active components, including the near surface shear and seal device, the retention valve in the riser extension, and the emergency disconnect connector, all of which are in the riser extension. These components can be recovered to the deck during an intervention. If the controls for the SID fail, the near surface shear and seal device can be used to contain reservoir pressure until the ROV can override the SID. When used with a vertical tree, the tree can be used to isolate the reservoir after the tubing has been recovered or the ROV has been used to override the shear function of the SID. If the SID fails during work through a horizontal tree, the casing length between the coiled tubing contractor's well control equipment and the shear device at the quick disconnection point can be used to inject wire line tools to reset the crown plugs.

Due to the short duration of installation, offshore maintenance of the SSR is not anticipated. Active components in the SSR are designed to existing standards for similar equipment in production systems intended for 20 year life without maintenance. With the exception of the SID the MEPS SSR is a passive structure. Structural failure early in the life of such components is not common. The primary failure modes result from fatigue, corrosion and damage, which tend to be cumulative over long periods.

Each component of the SSR shall have a serial number used to track its service life. A full history including manufacturing records, qualification testing, mobilization dates, location and nature of service and duration of each installation shall be recorded for each serial number. Records are to be updated each time the item is mobilized or recovered, and periodically if the item is idle. Items shall be taken out of service if they fail inspection and cannot be fully refurbished, or if fatigue cycles approach the allowable limit established by the design and records.

After each recovery, all components are inspected and refurbished, de-rated, or scrapped. This allows frequent preventive maintenance onshore in a shop environment and minimizes the need for offshore maintenance.

In 2006 a prototype SSR was installed in the Gulf of Mexico in 1000 meters of water and connected to a conventional wellhead attached to a suction anchor. This unit was in place until 2011 when it was removed and examined with no noticeable structural degradation (see IntecSea Riser Inspection Reports #1 and #2). While installed, the prototype SSR was exposed to two named storms and an eddy current.

**Fig. 2.8: Buoyancy Module in Fab Yard**



**Fig. 2.9: Buoyancy Module 2 years after installation**

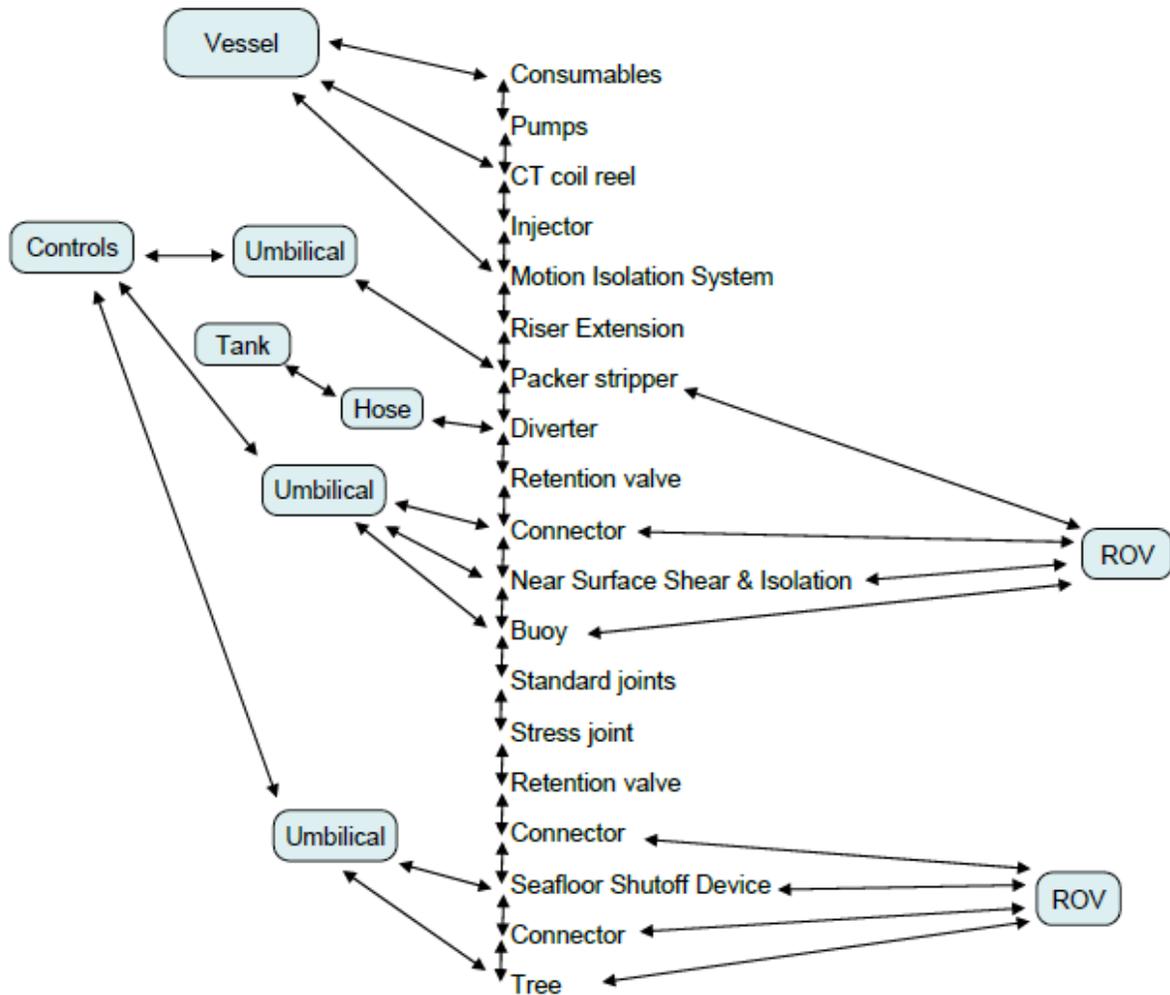


The configuration and maintenance provisions discussed in this section apply to the baseline configuration. Other configurations may be used at the discretion of the down-hole service contractor and the client, and maintainability is one of several considerations when choosing the configuration. A detailed maintenance plan shall be prepared before mobilization and is to list spares and tools needed to maintain, repair, or replace components.

## ***2.7 Interfaces & Boundary Conditions***

Interfaces and SSR loads are discussed here. Key interfaces include those between the SSR and the vessel, the CT system and the tree. Interfaces are summarized in the illustration below.

**Fig. 2.10: SSR Interfaces**



### 2.7.1 Interface between the SSR and the Tree

The SSR is connected to the tree or wellhead for continuity of the pressure boundary and to anchor the buoyancy module. This connection loads the tree and wellhead in tension and bending. Maximum tension load on the tree occurs during axial tension load testing of the SSR. While installed, the SSR maintains sufficient tension on the tree connection to prevent bending moments from buckling the stress joint or adjacent riser joints. The site specific design shall include analysis of the tree and wellhead to establish that the applied tension and bending loads will not exceed the safe working load rating of the tree and upper well casing.

## 2.7.2 SSR Structural Loads

Design analysis for each specific installation shall verify that all riser joints and joint connections are suitable to withstand applied loads, primarily:

- Positive or negative SSR internal pressure specific to the well, the location in the water column, and the intervention task being conducted
- Tension applied to the casing by the buoyancy and by the vessel
- Bending due to current drag or vessel offset
- Axial torsion due to vessel heading changes
- Dynamic loads such as vortex induced vibration and vortex induced motion that contribute to fatigue

## 2.7.3 Pressure and Fluid Barriers

The requirement for dual boundaries shall be respected at all times. The tree valves isolate the reservoir during riser installation, testing and recovery. While the riser is installed the SID provides redundant capability to isolate the reservoir in the event of upset conditions above the SID. The SID provides a level of protection not normally available during conventional workover from a fixed platform, TLP or other facility that has surface trees.

The riser is fully tested and reservoir pressure is known before the tree valves are opened. Conventional industry accepted practices are followed during operations with intervention tubing deployed inside the riser. In the event of upset conditions the reservoir can be isolated at any one or all three of the isolation locations: the SID, the shearing gate valves in the emergency disconnection segment, or the CT BOP.

Retention valves prevent loss of contained or residual fluids during normal or contingency recovery of the riser extension and the SSR.

## 2.7.4 SSR Interface to Intervention Vessel

The baseline interface between the SSR and the intervention vessel includes a riser extension to engage the top of the SSR, an umbilical to control emergency disconnection and either a heave compensated crane or motion isolation equipment to support the riser extension and reduce the effect of vessel motions.

### ***Riser Extension***

A riser extension is required to bridge the gap between the intervention vessel and the top of the SSR. The riser extension and the associated umbilical for disconnection shall be designed with consideration for interfaces with both the riser and the motion isolation system.

The nominal point of vessel engagement to the riser extension shall allow the motion isolation system to operate near its mid-range. The riser extension preferably has the same internal diameter as the SSR and is concentric with it.

A disconnection segment with connector and isolation and retention provisions is included between the riser extension and the SSR buoyancy. The bore of the riser

extension, including the disconnection segment, shall drift for the full length of the longest tool string.

### ***Vessel Interface and Motion Isolation System***

Motion isolation is required when a rigid riser extension is engaged to the vessel. All items supported by the vessel motion isolation system are fixed to the earth when the riser extension is connected to the SSR.

The motion isolation system shall not introduce horizontal forces or bending moments into the SSR significantly beyond those needed to overcome current drag and maintain SSR verticality. The motion isolation system shall maintain nearly constant tension in the riser extension as the vessel heaves and as the equipment load varies, as for instance when tubing is run or pulled. The tolerance in applied tension will be seen as variation in SSR tension, and must therefore be small enough to not exceed the maximum allowable tension in the SSR or introduce compression into the SSR. The riser design shall accommodate this cycling with adequate SSR fatigue life. Axial resonant frequency of the riser shall not be close to the frequency of vessel heave motion. Analysis for a specific vessel shall determine the allowable range of resonant frequency and the maximum practical tolerance in motion isolation based on required SSR fatigue life and maximum tension.

The vessel must be allowed to change heading for changes in wind or sea state. The vessel interface connection shall include provisions to avoid excess torsion in either the SSR or the motion isolation equipment during vessel heading changes. The design shall allow heading changes of up to 90 degrees. Greater change in degrees of heading may be allowable and will depend in part on water depth and riser design.

### **2.7.5 SSR Loads Due to Intervention Equipment**

Pressure excursions constitute the primary influence of the coiled tubing system on the SSR. The relevant pressures, which may be either greater or less than water pressure external to the SSR, shall be determined for each specific application and shall be verified to be within the rating of all SSR components prior to use.

## ***2.8 Manufacturing & Quality Assurance***

Components that are not available from catalogs at this time are primarily the SID and the buoyancy. Other system elements can be selected from product lines that are routinely produced under industry accepted manufacturing and quality control standards.

The SID is a unique combination of shearing gate valves, connectors and controls that individually are field-proven catalog items. The SID shall be designed and built by a recognized provider of BOP and well control equipment. Competent oversight shall be provided to assure that applicable practices and standards are met.

Buoyancy modules shall be fabricated by a yard that has extensive experience in fabrication of buoys or hulls of similar size and rating and has engineering, quality control and documentation programs that are widely accepted in the industry.

Competent oversight shall be provided to assure that applicable standards and regulations are met.

Comprehensive acceptance tests and system integration test are required. The test shall demonstrate, to the extent practical onshore, that the components function as intended when connected or otherwise interfaced to other system components.

## **2.9 Required Expertise**

The system as submitted requires cross discipline expertise. Relevant areas of expertise considered necessary to understand the technology consist primarily of:

- Mechanical engineering
- Naval architecture
- Metallurgy
- Offshore operations

## **2.10 Existing Evidence to Support Qualification**

Available evidence includes computer analysis results, wave tank test results, and records associated with a prototype SSR that was designed, analyzed, fabricated, and installed in 3500ft water depth in the Gulf of Mexico. Data held by IntecSea from related projects is available as evidence to support the qualification process.

Further engineering is addressed at length in Project 1502 Task Reports and a Final Report prepared for RPSEA project 1502. These reports are included by reference. Representative examples of other available documentation are listed at the end of this document. Engineering and prototyping completed to date are listed sequentially below under bold headings.

### **Prototype Design, Analysis, Fabrication, and Installation**

As part of a related project initiated in 2006, a prototype MEPS SSR was installed in the Gulf of Mexico in 1000 meters of water and anchored to a conventional wellhead attached to a suction anchor. This is the basic configuration of the MEPS SSR. Engineering modeling and analysis included:

- Finite element analysis of riser strength,
- Modeling for response to waves, swells, and current, and
- Fatigue analysis.

The prototype was installed, left unattended for 5 years, and then recovered and examined. While installed, this SSR survived two named storms and an eddy current. Examination following removal found no indication of structural degradation. IntecSea Riser Inspection Reports #1 and #2 include results of the examination. These encouraging results suggest that the SSR is suitable for commercial application.

The prototype MEPS SSR was tested only in the disconnected configuration. Testing with the MEPS SSR connected to an intervention vessel is included in the plan for the next phase of work with RPSEA.

**Fig. 2.11: Vetco H-4 Wellhead Anchor for Prototype Riser**



**Fig. 2.12: Suction Pile Was Used to Anchor Well Head**



### **West Africa MEPS Riser Studies**

A MEPS SSR was defined and analyzed for use in one West African field in particular and others in general. Configurations examined included 9-5/8" single casing riser in about 2000meter water depth. The engineering records include:

- Functional rationales, design requirements and selections for SSR drilling and completion equipment particular to the unique features and functions of the SSR
- Components and system integration including
  - Preliminary specifications for riser joints and specialty joints
  - Detailed, descriptive list of the components in the riser system
  - Draft design basis document
  - Buoyancy calculations
- Computer simulation models of the SSR and partial analysis results, including effects of West African current, squalls, and swells.

### **RPSEA Project 2501 Riser Models and Analysis Results**

A MEPS-style SSR for well tests in the Gulf of Mexico was defined and analyzed for representative cases. Particulars included:

- 7" single casing well test riser, with SID, and flexible pipe flowline to a vessel
- About 5000 ft. water depth
- Evaluated against Gulf of Mexico loop current and DP drift-off

### **RPSEA Project 1502 Riser Models and Analysis Results**

A MEPS-style SSR for coiled tubing intervention on existing subsea trees in the Gulf of Mexico was defined and analyzed for representative cases. Particulars included 6-5/8" drill pipe riser with SID.

### **Representative examples of available documentation**

1. IntecSea/Billy Davis – Riser inspection report #1
2. IntecSea/Billy Davis – Riser inspection report #2
3. Nautilus/RPSEA Project 1502 – Task 8 Final Report – HAZID Report
4. Nautilus/RPSEA Project 1502 – Task 5 Final Report – System Architecture & Design
5. Nautilus/RPSEA Project 1502 – Task 7 Final Report – Operational Planning Report, RPSEA PROJECT 08121-1502, Coiled Tubing Drilling & Intervention, Using Cost Effective Vessels, DOCUMENT NUMBER: 1502-004
6. Keith K. Millheim, Nautilus International LLC and Geir Aune, MEPS-First Oil Ltd. “Self Standing Riser Offers Alternative to Conventional Deep Water Approach for Developing Marginal Deep Water Oil and Gas Resources”, SPE Paper #15235, IPTC 2011 Conference, Bangkok, Thailand.
7. Nautilus/RPSEA Project 2501 Final Report

## **3.0 Quantitative Functional Requirements & Expectations**

### **3.1 *Targets for Reliability, Availability, and Maintainability***

Targets for reliability, availability and maintainability are stated simply as being equal to or better than the levels available by previous approaches to down-hole intervention in deep water.

#### **3.1.1 Operational Reliability**

The SSR has 2 primary modes of operation. In one mode the SSR is left installed and unattended either before or after down-hole intervention. In the second mode the SSR is engaged to a surface vessel to facilitate entry into the well bore or for production testing.

In the first mode the SSR is expected to survive the design current profile and duration with 99.99% confidence for a period of up to 12 days. In this mode the SSR is not connected to a surface vessel and there is no significant pressure differential across the casing of the SSR.

In the second mode the SSR is expected to provide extension of the casing pressure boundary up to a surface vessel for a period of up to 12 days, during which there is 99.999% confidence that SSR failure will not result in life threatening damage to the vessel or the release of reservoir fluids to the environment.

#### **3.1.2 Availability**

Following installation and successful load testing in tension, pressure testing of boundary integrity and function test of the isolation and retention devices, the SSR is expected to be available for a period of at least 12 days with a confidence level of 99%. Mean time for the SSR installation vessel to repair the SSR is expected to be no more than 1 week.

#### **3.1.3 Maintainability**

It is expected that SSR component maintenance will be done onshore between offshore applications. There is no planned maintenance requirement during a 12 day installation period. Offshore maintenance is limited to repair of failures that prevent completion of down-hole intervention work, and is performed by recovering the failed component for repair or replacement. ROV backup is provided for actuation of valves and connectors. The coiled tubing equipment, including devices for handling the tubing and the CT BOP for well control, are installed at the surface where they are readily accessible for maintenance.

### **3.2 Safety, Health and Environment Requirements**

The HSE target is to have no significant risks beyond what is generally accepted for similar activity. In several regards the approach presented herein will reduce risk as compared to prior practice. Examples include a greater number of reservoir isolation devices, fewer personnel at the job site, and less equipment exposed to extreme weather conditions. An important advance inherent in the concept is that with quick disconnection from the SSR the vessel is free to maneuver almost immediately in the event of a vessel emergency.

Onboard operations include only minimal departure from established practice. Fluids shall be stored in suitable tanks onboard the vessel. High-pressure systems shall be built from commercially available equipment without modification. Only commercially proven hydraulic components and fluid systems shall be connected to the production and intervention systems. All fluids onboard shall be as commonly used and transported in the industry.

RPSEA Project 1502 included discussions with subject matter experts for consideration of risk, safety, and contingency issues. This included examination and evaluation of:

- Salient failure modes and effects for the SID
- Generic operational procedures including safety provisions
- Departures from established practice for well entry and well control during down-hole work
- Provisions to manage contingency or upset conditions
- Provisions to ensure successful operation, such as hydrate prevention and equipment redundancy that facilitates uninterrupted control during maintenance and repair activity.

For the submitted configuration, 24 senior industry experts from oil companies, service contractors, engineering firms, and consultants considered the risks in a formal HAZID using the Chevron HAZID format and a facilitator from Chevron. Results of the HAZID are included in the Task 8 report for RPSEA project 1502, which is included here by reference. No unacceptable issues were identified, and action items that could be worked at this stage of the design were resolved by changes to the RPSEA Task Reports that will serve as design basis documents for future detailed design engineering.

#### **HAZID RESULTS**

The Project 1502 Task 8 SSR HAZID Report was prepared by the HAZID facilitator, who was in turn recommended by Chevron. The 44 items identified by the HAZID exercise are listed in Section 3.0, page 19, of Project 1502 Task 8 SSR HAZID Report. The risk-ranking matrix is included in Appendix 1 of the Task 8 report. Procedures documented in the Project 1502 Task 7 Report served as the basis for the HAZID exercise. These reports are included in this TQ submittal by reference.

As stated in Section 1.8, page 15, of Project 1502 Task 8 SSR HAZID Report:

- A thorough and comprehensive HAZID of the SSR system with respect to particular operations has been undertaken.

- The team members assembled for the HAZID were able to provide valuable input into the design through the HAZID process.
- No significant HSE issues were identified that would prevent the SSR system design from moving forward.
- Failure modes/Hazards were identified which could result in significant downtime and associated costs to the operation.

As stated in Section 4.3, page 25 of Project 1502 Task 8 SSR HAZID Report:

- The vast majority of identified hazards were associated with downtime and cost consequences and were ranked in the range 7 to 10 on the Reliability and Efficiency Matrix. This indicates that the design is relatively robust with respect to the identified risks. It must be stated though that the risks ranked above were based upon a short duration operational scenarios. The short duration operational scenarios have a significant effect on the likelihood of the identified hazard events occurring. Therefore it must be noted that although the risks were generally considered to be low this does not preclude the requirement for undertaking the actions identified by the HAZID team at the discretion of the SSR Project team.
- All the environmental events were identified as low risk due to the nature of the type of fluid which could be released to the environment.
- The only pure safety issue identified during the HAZID exercise concerned the handling of equipment on the deck of the vessel and this was ranked as a 5 which requires further action to be taken.

As stated in Section 5, page 26 of Project 1502 Task 8 SSR HAZID Report:

“The overall conclusion of the SSR system design HAZID is that the review by the HAZID team is considered to be comprehensive and in general the design at the concept stage meets the proposed design intent. The mitigation provided by either the proposed recommendations or follow up actions will enable many of the hazards or problems identified in the HAZID to be either removed or mitigated during the next stage of the design process.”

### **3.3 Functional Expectations**

It is understood that the SSR will be installed in accordance with results of analysis based engineering design specific to each application and that, after recovery, each component will be inspected before it is used again. While installed it is expected that the SSR will:

- Survive under local conditions of current and sea state without inspection or maintenance while unattended for up to 12 days
- Provide extension of the well casing up to an intervention vessel for a cumulative duration of up to 12 days
- Provide isolation between the environment and the interior of the casing during intervention activity
- Provide for reservoir isolation under both routine and upset conditions

- Provide for disconnection between the intervention vessel and the SSR buoyancy under both routine and upset conditions, and
- Facilitate down-hole intervention in the well by engagement to commercially available coiled tubing equipment.

### List of Acronyms/Abbreviations

BOP	Blow-out Preventer
CT	Coiled Tubing
DNV	Det Norske Veritas
DP	Dynamic Positioning
DP2	Dynamic Positioning 2
FPU	Floating Production Unit
HAZID	Hazardous Identification Study
MEPS	Modular Exploration Production System
MODU	Mobile Offshore Drilling Unit
PSI	Pressure per square inch
ROV	Remotely Operated Underwater Vehicle
SID	Seafloor Isolation Device
SSR	Self-Supporting Riser/Self-Standing Riser
TLP	Tension Leg Platform

### List of Appendixes/References

1. IntecSea/Billy Davis – Riser inspection report #1
2. IntecSea/Billy Davis – Riser inspection report #2
3. Nautilus/RPSEA Project 1502 – Task 8 Final Report – HAZID Report
4. Nautilus/RPSEA Project 1502 – Task 5 Final Report – System Architecture & Design
5. Nautilus/RPSEA Project 1502 – Task 7 Final Report – Operational Planning Report, RPSEA PROJECT 08121-1502, Coiled Tubing Drilling & Intervention, Using Cost Effective Vessels, DOCUMENT NUMBER: 1502-004
6. Keith K. Millheim, Nautilus International LLC and Geir Aune, MEPS-First Oil Ltd. “Self Standing Riser Offers Alternative to Conventional Deep Water Approach for Developing Marginal Deep Water Oil and Gas Resources”, SPE Paper #15235, IPTC 2011 Conference, Bangkok, Thailand.
7. Nautilus/RPSEA Project 2501 Final Report