The Plastics Experts.

HDPE Sea Water Intake Risers for Offshore Applications

Design, Performance and Reliability for OTEC and FPSO/FLNG Systems

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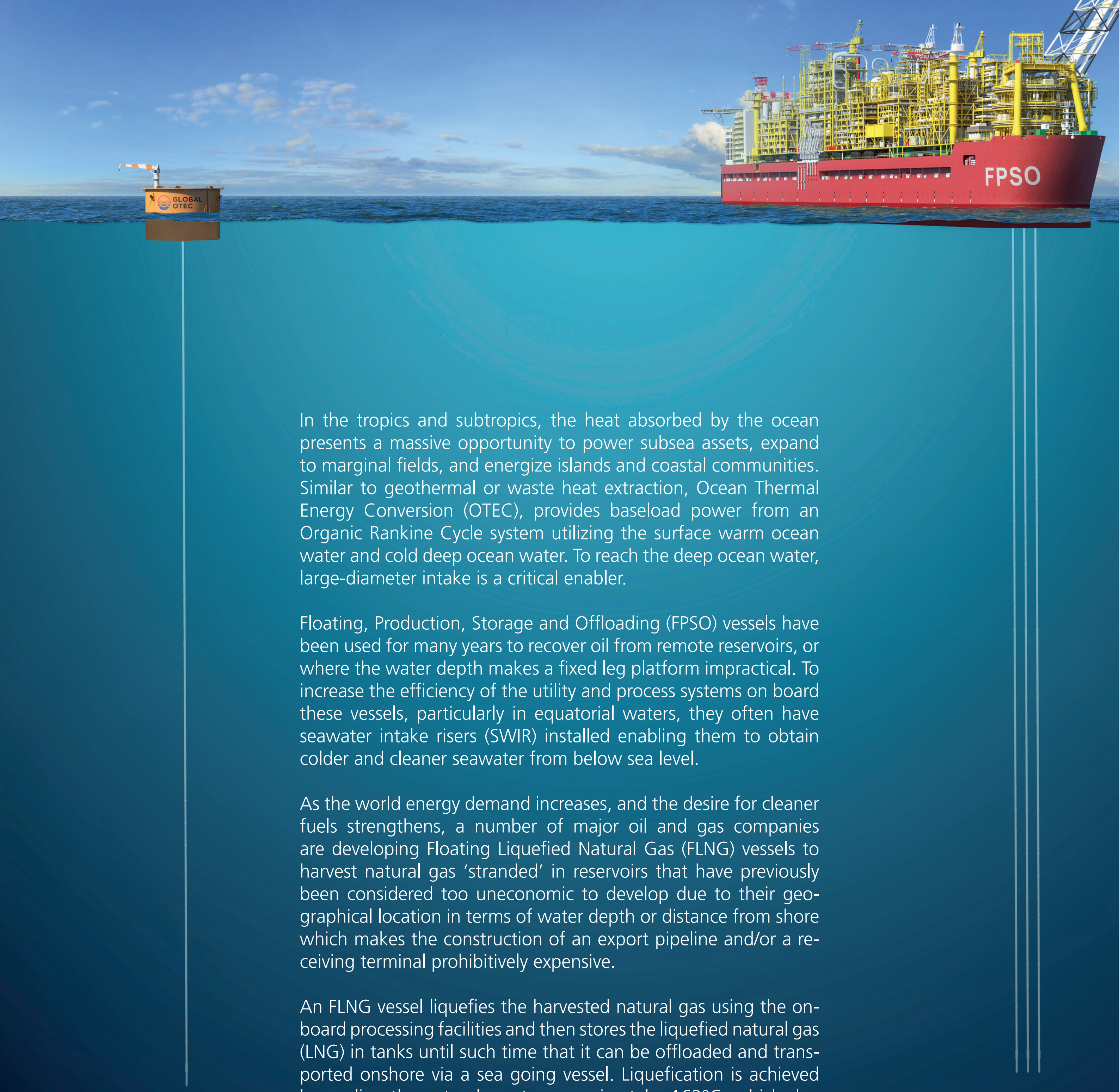
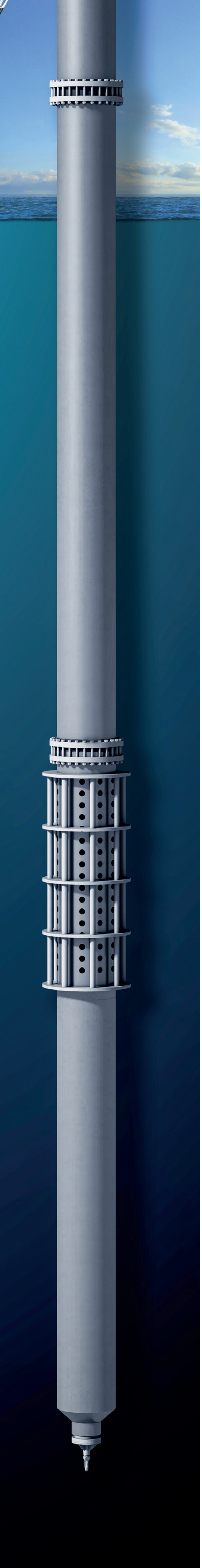


In the tropics and subtropics, the heat absorbed by the ocean presents a massive opportunity to power subsea assets, expand to marginal fields, and energize islands and coastal communities. Similar to geothermal or waste heat extraction, Ocean Thermal Energy Conversion (OTEC), provides baseload power from an Organic Rankine Cycle system utilizing the surface warm ocean water and cold deep ocean water. To reach the deep ocean water, large-diameter intake is a critical enabler.

Floating, Production, Storage and Offloading (FPSO) vessels have been used for many years to recover oil from remote reservoirs, or where the water depth makes a fixed leg platform impractical. To increase the efficiency of the utility and process systems on board these vessels, particularly in equatorial waters, they often have seawater intake risers (SWIR) installed enabling them to obtain colder and cleaner seawater from below sea level.

As the world energy demand increases, and the desire for cleaner fuels strengthens, a number of major oil and gas companies are developing Floating Liquefied Natural Gas (FLNG) vessels to harvest natural gas ‘stranded’ in reservoirs that have previously been considered too uneconomic to develop due to their geographical location in terms of water depth or distance from shore which makes the construction of an export pipeline and/or a receiving terminal prohibitively expensive.

An FLNG vessel liquefies the harvested natural gas using the onboard processing facilities and then stores the liquefied natural gas (LNG) in tanks until such time that it can be offloaded and transported onshore via a sea going vessel. Liquefication is achieved by cooling the natural gas to approximately -162°C, which due to cost, complexity and efficiency of the process, requires large volumes of seawater and for which it is beneficial to reach and import water of as low temperature as practical from below sea level using SWIR’s.



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WHY sea water intake risers are a critical subsystem?

For FPSO/FLNG applications, process engineers have found it beneficial to use cooler, cleaner and less oxygenated seawater from below sea level for the vessel's cooling, process, utility and water injection systems as it improves the efficiency of the processes whilst mitigating corrosion and fouling within the systems. For FLNG vessels, it is estimated that a seawater temperature reduction of 15-20°C can correspond to an increase in the production capacity of up to 15-20%, i.e. -1°C = +1% MTPA.

HDPE as a technically valid offshore solution?

HDPE has been used successfully for over 50 years in piping systems in various applications such as Water and Natural Gas Distribution, Sewer Network, Petrochemical Piping and Nuclear Power Plants. In 2007 it was estimated that there were approx. 3.6 million tonnes of HDPE piping used worldwide in offshore and onshore applications.

The subset of HDPE resins commonly used for piping systems are 'bimodal' in as much as they have two peaks in the molecular weight distribution giving the optimum balance of mechanical properties for high performance piping systems.

Currently, there are a number of FPSO vessels operating worldwide that utilise HDPE as a key component of the SWIR system. There are several advantages in using HDPE pipe sections for this application, but it is the comparative low weight of HDPE that is considered most advantageous. HDPE has a specific gravity (SG) of <1 therefore, when submerged in sea water, it becomes positively buoyant, which reduces the required crane capacity during installation of the system and also reduces the loads into the hull of the vessel once the system is installed.

Contrasting Deepwater OTEC and FPSO/FLNG in brief

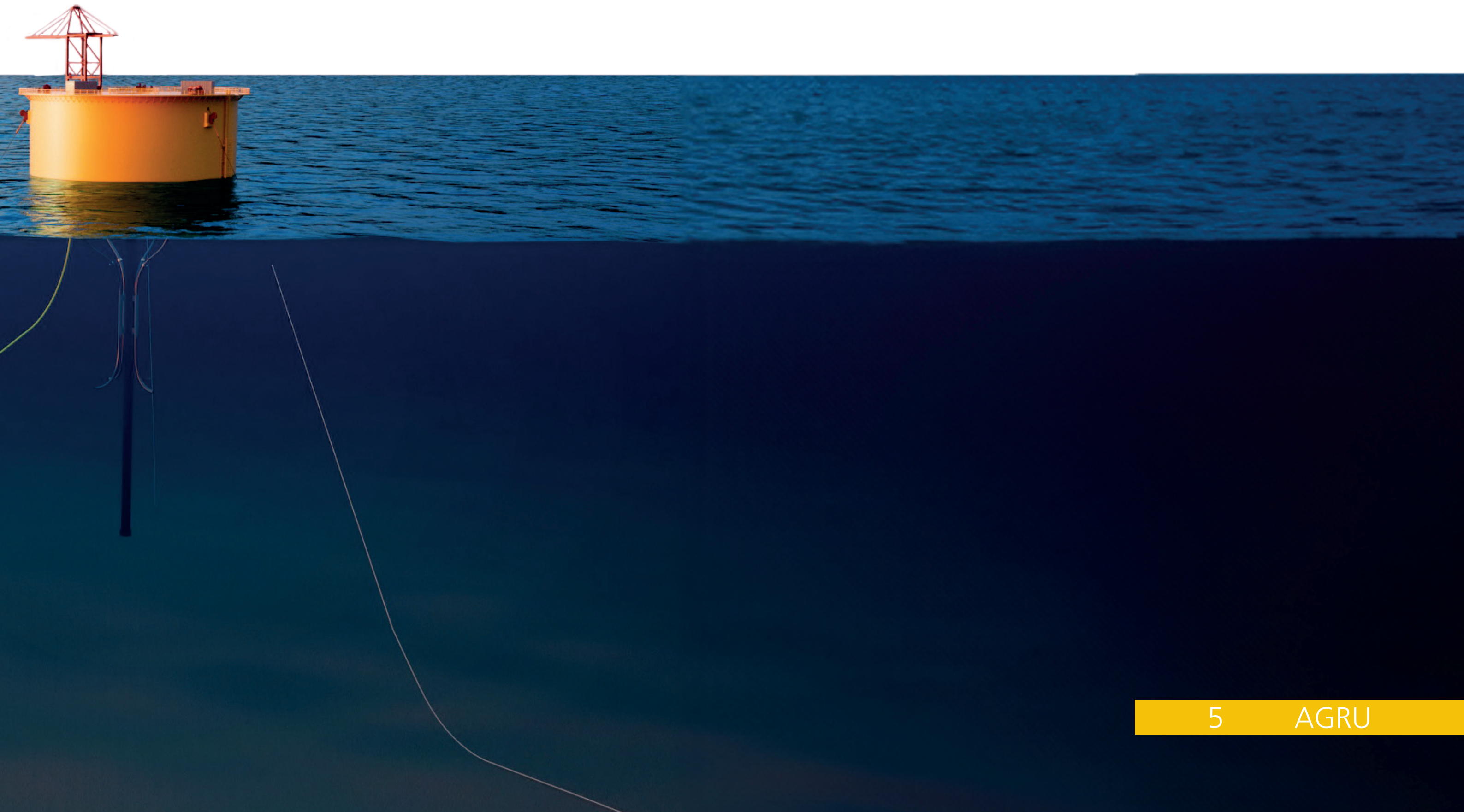
An OTEC system uses thermodynamic principles such as the Rankine cycle to convert heat energy into mechanical work, by using the warm surface ocean water to vaporize and expand a low boiling point fluid (e.g. ammonia) to drive an electricity producing generator. A SWIR is used to obtain cold seawater which cools the vapour to a liquid form, creating a continuous generating cycle.

While OTEC enables fuel-free power production, the low theoretical efficiency of the thermal cycle, due to the small temperature difference, requires large quantities of seawater. The ocean’s abundance provides the resources for the potential of terawatts of power, provided sufficient intake size and depth are achieved. For OTEC, the design depth depends on local environmental conditions, but generally at least an 800m depth is required. For a single MW-scale OTEC plant, pipes of inner diameters of 1.5m or more are required. The large-scale seawater flows can be directly returned to the ocean, or in some cases, can be re-utilized for other purposes such as additional cooling.

An FPSO/FLNG usually utilises a caisson arrangement to suspend the SWIR which facilitates the installation of a submersible caisson suction pump to import water on board the vessel for distribution to the applicable systems.

A typical configuration for a SWIR system installed on an FPSO would consist of three 20″NB SWIR, 50-100m in length, with a flow rate of 2000m^3/hr per SWIR.

However, due to the increased demands of an FLNG cooling system, the seawater requirements can be a total volumetric flow of between 30,000-50,000m^v/hr by utilising up to 40″NB SWIR’s from depths of 200-500m.



Market Context

SWIR for Offshore Use

The term Seawater Intake Riser or SWIR is used to describe the system currently used for importation of seawater onto an offshore installation such as an FPSO/FLNG.

A SWIR system is effectively a number of flexible pipe sections connected together and suspended from the underside of the FPSO at the seawater inlets in the form of a free-hanging cantilever, enabling the seawater pumps to draw seawater from a specified depth below sea level. Each SWIR is normally fitted with a coarse strainer at the lower end to prevent the ingress of debris or sea life.

Each SWIR system is bespoke to each installation, designed accordingly and subject to a hydrodynamic analysis which considers the vessel response characteristics, the field specific environmental conditions and the flexible hose string properties which can be optimised to suit the required configuration.

In the literature, a SWIR is often referred to as a free hanging aspirating cantilever.

Differences between nearshore / offshore / deepwater

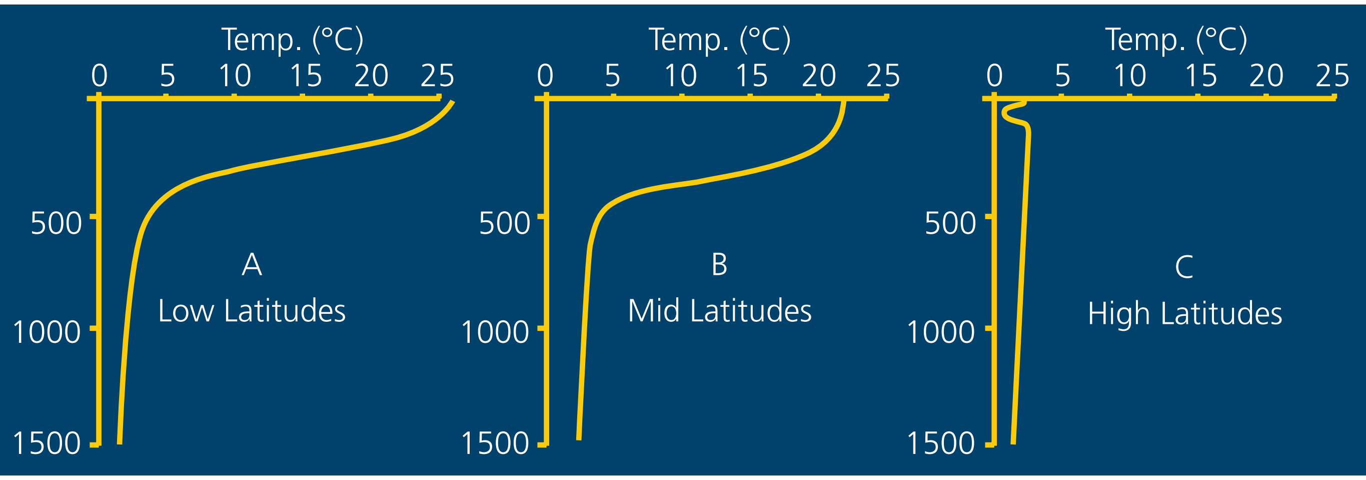
Nearshore, or shallow water, locations often limit the suction depth for the SWIR which in turn limits the advantage of obtaining cooler water below the surface. However, there are a number of FPSO/FLNG vessels operating that utilise short length SWIR for the sole purpose of importing cleaner water from below the ocean surface.

Typical offshore locations for FPSO/FLNG vessels are deeper and enable the suction depth of the SWIR to increase which takes of advantage of the cooler and cleaner water available from below the ocean surface.

In deepwater locations, particularly in the low and mid latitudes, there is a dramatic temperature transient between the depths of 100m-400m which is known as a thermocline.

Energy from the sun is absorbed within the first few centimetres of the surface, but the turbulence created by the waves mixes and distributes the heat to form a fairly uniform temperature profile down to approximately 100m, beyond the depth of this effect, the seawater temperature decreases rapidly.

Consequently, obtaining seawater from below the thermocline is of interest to process engineers who recognise the potential increase in production capacity by importing much cooler seawater.



OTEC Floating Platforms

Continuous Operation

OTEC extracts a small amount of heat from a vast resource and converts it into electricity. Solar radiation is stored by the ocean's surface layers, providing a readily available resource 24/7. Rather than utilizing batteries or other grid-stabilization technologies, the ocean stores energy, and OTEC is able to extract heat convert it to electricity. The process uses heat exchangers, which heat a low-boiling point working fluid. Surface water temperature is decreased about five-degrees Celsius. After the working fluid is expanded through a turbine to generate power, it is condensed back into a liquid with a second heat exchanger and cold deep ocean water. This allows the working fluid to be continuously reutilized in a closed loop, providing power 24/7.

Requirement for large amount of water

The process described above is essentially the same as other thermal power generation cycles. The laws of thermodynamics which govern the process show that as the temperature difference decreases between the hot and cold side, efficiency will also decrease. This is why most thermal plants operate at high temperatures. Since the temperature difference in the ocean is small, the theoretical efficiency is low, however, since OTEC does not require fuel, then if enough seawater can be utilized, power can still be produced economically. As both surface and deep ocean water is required, there is need for intake piping both near the surface and at depth. To reach the deep water, a large-diameter SWIR is necessary.

Cold deep water (600-1,200 m)

As an annual average temperature difference of 20° Celsius is generally required for economic OTEC operation, the optimal sites are where surface water is warm (25°C or more) and deep ocean water is available close to the power offtake.

Deep Ocean Water (DOW) is defined as water deeper than 200m. At that depth, the photic zone of the ocean ends, and the properties of the water change. Without sunlight, the water quickly cools to a depth of about 800m, then more gradually after. Currents, moon-tides, and other factors can all change local outcomes, however, generally, DOW at 1000m depth is 4-5 °C, which provides the necessary counterpoint to surface ocean water at 25°C.

DOW also tends to be more acidic than surface ocean water due to natural carbon sequestration. It has been shown that DOW is more corrosive to some metals, especially aluminium, so care is required in the selection of materials in pipe and heat exchangers. In Japan and the United States, much effort has been made in developing OTEC-optimized heat exchangers made of titanium. In addition, DOW is generally free of bacteria due to the cold temperatures and man-made contaminants so that fouling is significantly reduced compared to surface ocean water.

Today, there are 38 onshore sites with 45 deep ocean water intake pipes around the world utilizing DOW for OTEC, Seawater Air Conditioning (SWAC), Low Temperature Thermal Desalination (LTTD), aquaculture, extractive purposes such as water bottling and cosmetics, and other uses. The majority of these intakes utilize HDPE, with the largest 1.4m-diameter intake in Hawaii at the Natural Energy Laboratory Authority of Hawaii (NELHA). For floating platforms as well, HDPE is expected to be an ideal material.

FPSO/FLNG Platforms

Seawater used for

Predominantly used for cooling of the process equipment on board the FPSO, imported seawater can also be utilised for water injection to maintain reservoir pressure and enhance oil recovery or utilities such as fresh water generation through reverse osmosis.

Process equipment cooling is normally achieved using heat exchangers, devices that transfer thermal energy between two liquids (or gases) at different temperatures without allowing them to mix. They work by passing a hot fluid through a cold one, often separated by a metal barrier, enabling heat transfer by conduction. Therefore, the colder the cooling water, the higher the temperature differential thus maximizing thermal efficiency. Similarly, the cleaner and less oxygenated the cooling water, fouling and corrosion of the exchangers is mitigated.

Dynamic platform motions

An FPSO/FLNG is a floating vessel that is moored to the seabed, and for which there are two main mooring concepts, namely Spread Moored and Turret Moored.

A Spread Moored vessel is one where the vessel is anchored by a four-group arrangement of mooring lines at the bow and stern and which enables the vessel to maintain a fixed orientation in global coordinates and more favoured at offshore locations with benign weather conditions.

A Turret Moored FPSO/FLNG is designed with a single point mooring system consisting of a swivel stack which allows the vessel to rotate so that it can weathervane about the mooring system. This concept enables the FPSO/FLNG to change its heading into the prevailing environmental conditions which reduces the load on the mooring and provides a more optimum offloading orientation.

With both mooring systems, the dynamic motion of the vessel due to the field specific environmental conditions and the impact on the SWIR needs to be assessed.

Oil & gas safety requirements

As with any system, a SWIR needs to satisfy all safety requirements. As the transported medium is seawater, any potential failure of the SWIR will not have a catastrophic environmental impact. Likewise, as the SWIR is located on the underside of the vessel, any potential failure is unlikely to cause injury to personnel.

However, a key consideration is how the SWIR is connected to the vessel. If the connection arrangement is an integrated part of the hull, e.g. an internal caisson, where failure could affect the watertight integrity of the vessel, then the system must satisfy the Class requirements of the vessel. If the connection does not affect the watertight integrity of the vessel, e.g. an external caisson, then Class requirements are not normally applied.

Engineering Constraints

Offshore Challenges

Environmental Loads

Waves

Wind

Curents

Storms

Vortex-induced vibrations (VIV)

When designing a SWIR, it is essential that a hydrodynamic analysis of the system is undertaken to assess the suitability of the design configuration and to determine the loads transmitted into the vessel. The dynamic analysis considers the vessel and SWIR response to the environmental forces acting in the extreme conditions including:

Waves: field specific wave data which can consist of a number of omni-directional wave trains such as; swell, wind waves or a combination of both.

Current: field specific current data which can consist of omni-directional current profiles.

Storm events: the field specific 100 year storm data for waves and currents, also known as the 100 year return period, is a common data set used to assess the integrity of the SWIR within the analysis.

Vortex Induced Vibration (VIV): VIV occurs when a steady flow of water passes a slender structure and forms vortices downstream of the structure. If these vortices become regular and periodic and are close to the natural frequency of the structure, the structure can become excited leading to accelerated fatigue. The VIV effect on the SWIR needs to be assessed as a part of the analysis.

Mechanical and Structural Requirements

Axial loads

Bending stress

Self weight

Fatigue

The output from the hydrodynamic analysis provides the axial loads and bending stresses induced into each of the SWIR components which can then be compared to the allowable values of the components to determine if the selected component is suitable for the application. The allowable values for each component are generally taken from the design standards applicable to each particular project.

The hydrodynamic analysis also provides the fatigue damage induced into the SWIR components which can be used in conjunction with the relevant SN data to determine if the system satisfies the design fatigue life of the SWIR, which is generally specified by each project.

Depending upon the configuration, the stability of the SWIR can be achieved either through its own self-weight or by means of additional ballast.

Chemical & Biological Exposure

Seawater

The field specific seawater data is often provided for each project, including; temperature, density, salinity etc. which is considered within the design of the SWIR.

The material for each component within the SWIR is selected to ensure it can withstand the marine environment that it will be exposed to during its service life and, where necessary, an appropriate protective coating is applied to the component.

Temperature gradients

The components within the SWIR must be selected to ensure that they are certified for the design temperature they are exposed.

The field specific temperature gradient of the seawater can be used to predict the potential temperature losses through the system against the various operational flow rates.

UV and ageing effects

Once installed, the uppermost components of the SWIR are generally several meters below the waterline and the exposure to UV and ageing effects are minimal. Black HDPE pipes contain 2.5% carbon black, which provides effective protection against UV radiation throughout the entire expected service life of the material. Additionally, HDPE exhibits high resistance to corrosion and abrasion, making HDPE pipes highly durable and resistant to aging effects over time.

Biofouling

Marine growth is known to attach itself to subsea structures, although the depth to which this occurs and the types of marine growth vary geographically. However, attached marine growth changes the surface roughness of the SWIR, increasing the drag factor, which can have a significant effect on the behaviour due to ocean currents.

Consequently, the hydrodynamic analysis would generally consider a clean SWIR and also a SWIR with marine growth attachment to determine the impact on loadings and fatigue.

Where possible, the materials and coating of the components within the SWIR are selected to minimize marine growth attachment.

CHOICE JUSTIFICATION: MATERIAL COMPARISON & SELECTION RATIONALE

SWIR MATERIALS

The selection of suitable materials for a SWIR is a critical aspect of system design, directly influencing mechanical performance, durability, installation feasibility, and long-term operational reliability. This section provides a structured comparison of conventional and emerging material options, highlighting their respective advantages, limitations, and practical suitability within offshore environments. By assessing both standalone materials and hybrid configurations, the rationale for selecting HDPE as the primary riser material is presented within the broader context of SWIR performance requirements.

Conventional Materials

Steel

Steel pipe is used extensively in the offshore and marine industry for low pressure and high-pressure applications. The physical and mechanical properties for most steel grades are well documented within the industry design standards and, as a homogenous material, the in-service behaviour can be well predicted. The main concerns with steel piping in a SWIR application is that it is very rigid and heavy, even when submerged in water. Also, unless appropriately protected, steel pipes are vulnerable to corrosion in marine applications.

Implications for SWIR:

- Poor for dynamic environments; transfers high stress to hang-off.
- Heavy weight increases required buoyancy and installation risk.
- Excellent for short, straight, fixed sections – but not ideal for free spans or long vertical risers.

Rubber

Bonded Flexible Rubber Pipes are used extensively in marine applications due to their flexibility, robustness and corrosion resistance. Being of a composite structure, the physical and mechanical properties are generally proprietary information and bespoke to the intended application. However, with the use of industry standard software, the in service behaviour can be reasonably well predicted. When used in submerged applications, the apparent weight in water is considerably reduced which is advantageous in an SWIR application due to the reduced loading into the vessel.

Implications for SWIR:

- Highly suitable for short jumpers, dynamic tails, flexible joints.
- Not suitable for long risers due to elongation, creep, and limited diameter availability.

Hybrid system

A hybrid system combines different types of pipe elements within the SWIR to utilise the benefits of each element. For example, bonded rubber hose sections may be used at the upper end of the SWIR to accommodate the higher loads and bending that are usually found at the connection to the vessel. The mid sections of the SWIR could be from HDPE, where the loading and bending is not usually as significant, therefore minimising the submerged weight of the SWIR and the loads into the vessel. At the lower sections, bonded rubber hoses or steel sections could be used to provide the SWIR with stability during operation. As with all SWIR design, the final configuration would be dependent upon the hydrodynamic analysis.

HDPE as Offshore Riser Material

HDPE is a homogenous material with well documented physical and mechanical properties that enable the service behaviour to be well predicted.

The use of HDPE as an offshore riser material is becoming more common as a number of the physical and mechanical properties are well suited to the application.

Corrosion resistance

HDPE pipes exhibit excellent resistance to corrosion in offshore environments due to the material's chemically inert polymer structure. Unlike metallic pipelines, HDPE does not undergo electrochemical corrosion and is inherently resistant to dissolved salts, and a wide range of chemicals typically present in marine conditions. This eliminates the need for cathodic protection systems and significantly reduces long-term maintenance requirements. Furthermore, HDPE is not susceptible to microbiologically induced corrosion, which is a common degradation mechanism in steel pipelines operating in subsea environments.

High ductility

At the normal operating temperature of a SWIR, HDPE is a ductile material which provides a good degree of flexibility during operation to withstand the environmental loadings.

Fatigue resistance

It is the ductility of modern HDPE materials that add to the good fatigue properties as cracks quickly become blunted due to the large amount of energy absorbed by the deformation around the crack tip which only allows the crack to grow a short distance before having to be re-initiated. This is advantageous for applications such as SWIR where fatigue due to VIV needs to be considered.

Low weight / buoyancy effects

One of the most advantageous properties of HDPE in SWIR applications is the low weight. When submerged in water, HDPE has a positive buoyancy making it very attractive for long length SWIR applications where loadings into the vessel are a major concern. Due to the positive buoyancy of HDPE, additional ballast weight is often attached to provide the SWIR with stability.

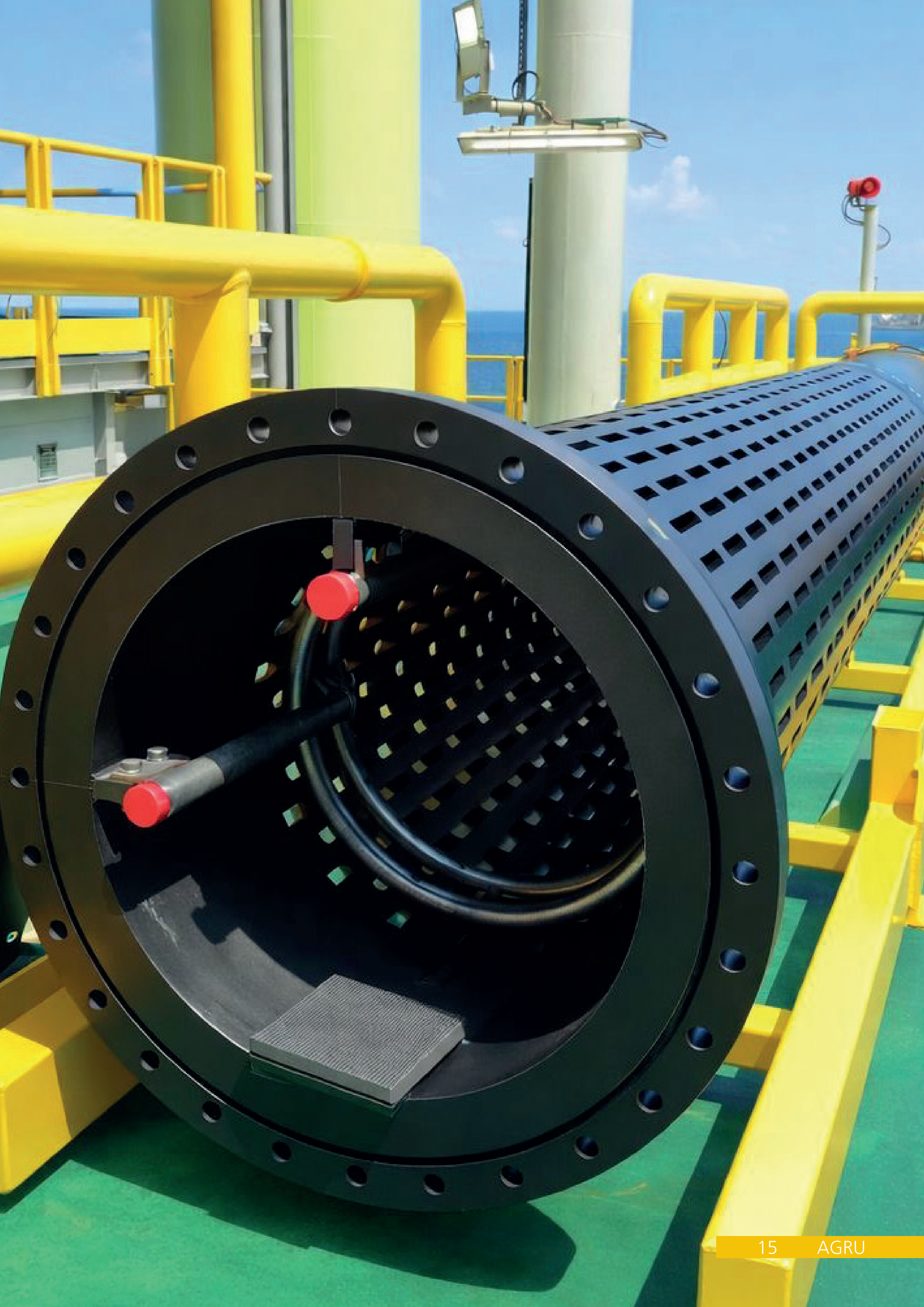
Weldability & system integrity

HDPE is a weldable material with several industry standards available to ensure the quality and integrity of the weld. When executed in accordance with industry standards, the weld provides the same strength to the parent pipe. The weldability of HDPE makes it suitable for SWIR applications where the system installation limits determine the length of each pipe section within SWIR.

Surface roughness

HDPE pipes exhibit a very smooth internal surface, typically characterized by a low absolute roughness of 0.0015 mm. This smooth surface minimizes hydraulic friction and limits the development of deposits or biofilm layers over time, allowing the hydraulic performance of the pipeline to remain stable throughout its service life. Consequently, HDPE pipelines are commonly assigned a high Hazen–Williams coefficient of C = 150, reflecting their low flow resistance compared with many conventional piping materials.

HDPE has a very smooth surface which provides two favourable properties when used in an SWIR application. The Baier Curve provides a generalised relationship between the surface energy of a material and its resistance to bio-adhesion. HDPE has a low surface energy value consistent with weak bio-adhesion according to the Baier curve, and as such resists marine growth attachment. In a submerged application such an SWIR this can be advantageous due to the reduced weight and drag caused by marine growth attachment.



Comparative Assessment Table

Mechanical performance describes how a material behaves under physical loads and environmental influences, and it is a key determinant of suitability for SWIR applications. It can be quantified using measurable engineering parameters such as stiffness, tensile strength, density, flexibility, and resistance to degradation mechanisms. These metrics capture how well a material can withstand forces, deformation, wear, and long-term exposure, and they form the basis for comparing Steel, Rubber, and HDPE in a consistent, objective manner.

PARAMETER	MEANING / RELEVANCE
Stiffness (E-Modulus)	Determines rigidity vs flexibility. Important for bending, ovalisation, wave/current response.
Density / Weight	Impacts handling buoyancy, installation loads.
Tensile /Yield Strength	Resistance to mechanical loads, bending, tensile loads during operation and installation.
Flexibility / Minimum Bend Radius	Critical for installation and operation due to (tie-ins, route curvature) and vessel motion and environmental forces.
Resistance to Failure Modes	Corrosion, fatigue, cracking, abrasion.

Mechanical Performance

Criterion	Steel	Rubber	HDPE
Criterion	Steel	Rubber	HDPE
Flexibility	Poor	Excellent	Very good
Stiffness	Very high (too rigid)	Very low	Low
Tensile Capacity	Excellent	Moderate	Moderate
Weight	Very heavy	Light-Moderate	Light
Corrosion Resistance	Poor (requires coatings/CP)	Excellent	Excellent
Wear/Abrasion	Poor	Good	Excellent
Suitability for long length	Poor	Poor-Moderate	Excellent
Suitability as Dynamic Riser	Poor	High	High

Installation Complexity Summary

Installation complexity reflects how easily a material can be transported, handled, and assembled under project specific conditions, particularly in offshore environments. It is quantified by factors such as handling weight, jointing methods, achievable installation rates, curvature tolerance, and the need for specialised equipment, all of which directly influence schedule and cost. Additionally, offshore feasibility—such as the ability to install long continuous strings via float out—further differentiates materials and significantly impacts overall project efficiency.

Criterion	Steel	Rubber	HDPE
Weight Handling	Difficult	Easy	Very Easy
Jointing	Complex (welding)	Moderate	Simple(fusion)
Long string installation	Poor	Not Applicable	Excellent
Float-out to site	Rarely	No	Yes (industry standard)
Overall rank	Worst	Medium	Best
Overall LCC Ranking	Worst	Middle	Best

Lifecycle costs

Lifecycle costs capture the total financial impact of a piping material over its entire service life, combining both upfront investment and long-term operational requirements. CAPEX reflects the initial expenditure for materials, fabrication, transport, fittings, and installation, while OPEX accounts for ongoing maintenance, pumping energy, and replacement frequency. Because these cost drivers vary significantly between materials, lifecycle analysis provides a more accurate comparison than initial purchase price alone.

- **CAPEX** = Material cost + fabrication + fittings + transport + installation
- **OPEX** = Maintenance + energy losses (pumping) + replacement frequency
- Cost drivers differ strongly by material.

Criterion	Steel	Rubber	HDPE
CAPEX	High	Medium	Low
OPEX	Very High	Medium-High	Very Low
Lifetime	20-40 years	+20 years	100 years
Maintenance	High	Medium	Minimal
Overall LCC Ranking	Worst	Middle	Best

Risk Profile

As the medium is seawater, any potential failure of the SWIR will not have a catastrophic environmental impact, likewise, as the SWIR is located on the underside of the vessel, any potential failure is unlikely to cause injury to personnel, therefore, the severity of a failure would be primarily the Dissatisfaction of the Customer and Loss of Production Capabilities.

Risk Aspect	Steel	Rubber	HDPE
Mechanical Failure	High	Low	Very Low
Corrosion Risk	Very High	None	None
Fatigue Risk	High	Low	Low
Operational Impact of Failure	High	Medium	Low
Overall Risk	Highest	Medium	Lowest

HDPE SWIR System Architecture

Buoyancy & Stability Concepts

High-density polyethylene (HDPE) pipes have a slightly positive buoyancy in seawater due to the material's density, which typically ranges from approximately 950–970 kg/m³, compared to seawater with a density of about 1025 kg/m³. As a result, empty or lightly filled HDPE pipelines tend to float when installed offshore. To ensure stable seabed placement and prevent uplift from hydrodynamic forces, ballast systems are typically applied. These ballast elements increase the overall submerged weight of the pipeline, allowing the pipe to remain submerged.

Fatigue reduction strategies

For seawater intake risers, fatigue reduction in HDPE pipelines is primarily achieved through design measures that limit cyclic bending. Due to wave and current action, riser sections are exposed to continuous dynamic loading; therefore, the use of proper ballast distribution and buoyancy control is essential to stabilize the pipe and reduce oscillatory movement. In addition, gradual curvature at the riser connections helps avoid localized stress concentrations where cyclic bending is typically highest.

Intake Screens & Deep-Sea Interface

Function of intake screens

The main function of the intake screen (or strainer) installed at the lower end of the SWIR, is to prevent the ingress of any debris or sea life larger than 20-25mm. The seawater pumps themselves are usually fitted with a further strainer to prevent the ingress of smaller particles that could damage the pump.

Flow optimisation

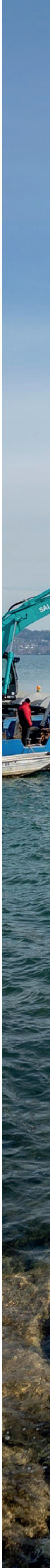
As with any restriction in fluid flow, a pressure loss is created but which should be minimised to maximise the efficiency of the pump. Therefore, the flow path through the intake screen needs to be optimised such that the SWIR is suitably protected but with minimal pressure losses. The optimisation process is often undertaken using Computational Fluid Dynamics (CFD), a simulation method using numerical analysis to analyze, model, and solve problems involving fluid flows.

HDPE integration concepts

AGRU has developed HDPE intake screen systems specifically designed for integration with large-diameter HDPE seawater intake risers. By manufacturing both the intake screen structure and the riser interface from HDPE, the system provides a fully corrosion-resistant and material-homogeneous solution that eliminates galvanic interfaces and simplifies long-term maintenance in aggressive marine environments.

Maintenance considerations

HDPE seawater intake pipelines offer exceptionally low maintenance requirements due to their inherent resistance to corrosion, abrasion, and chemical attack in aggressive marine environments. Unlike metallic systems, HDPE does not require cathodic protection, internal coatings, or periodic corrosion mitigation measures, significantly reducing long term operational intervention. When combined with a controlled chlorination system for biofouling prevention at the intake structure, the pipeline system maintains stable hydraulic performance and minimizes marine growth within the intake infrastructure.

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Installation and

Fabrication & Pre Assembly

To minimise hot work offshore during installation, the SWIR system is generally designed as a modular system, whereby all connections are made using cold work methods, for example bolting and latching. Furthermore, to minimise the need for special transportation, the component design is such that each element, and all the associated installation tools, can be transported using standard offshore containers. This generally means the length of each flexible pipe element is less than 12m in length. Pending any installation limits offshore, for example, crane height and/or capacity, the flexible pipe element length may need to be optimised accordingly.

Offshore Installation Concepts

Vertical deployment

The SWIR system is generally deployed using a similar technique to a drill string, that is, the first flexible pipe section is held in a vertical position while the next section is lowered into place by the on-board vessel crane and connected to the first section. The two connected sections are then lowered into the water by the vessel crane until the second section can be held to enable a third section to be connected, and so on until the desired length is achieved. It is desirable to utilise the on-board vessel crane for the installation (and recovery for maintenance and inspection) of the system as opposed to an external heavy lift crane which can be expensive to charter. Therefore, the capacity of the on-board vessel crane can be a consideration in regard to the installation weight of the SWIR which is a function of the material, diameter and quantity of flexible pipe sections.

Towing

Long HDPE pipeline strings can be efficiently transported to their offshore installation location by marine towing, taking advantage of the material's buoyancy and flexibility. The prefabricated pipeline sections are welded onshore or nearshore into long continuous strings and then towed on the water surface or in a controlled submerged configuration using tug vessels.

Controlled flooding

The S-curve sinking method is a controlled installation technique commonly used for large-diameter HDPE marine pipelines. In this approach, the prefabricated pipeline string is gradually submerged by controlled flooding of the pipe with seawater while the pipe transitions from a floating condition at the surface into a stable S-shaped curvature during descent to the seabed. The controlled flooding process allows precise regulation of buoyancy and bending stresses, ensuring that the pipeline remains within allowable strain limits throughout installation.

Offshore Handling

Risk Mitigation

Weather windows

As with any offshore operation, a risk assessment needs to be undertaken prior to execution. One of the main risks during installation of the SWIR are swinging loads due to vessel motion and/or wind. Therefore, for the installation of the SWIR, a period of calm weather would need to be identified as would a low underwater current to avoid any unwanted drag on the partially deployed SWIR during installation.

Redundancy concepts

The two main components that provide the seawater intake capability on an FPSO/FLNG vessel are the Seawater Intake Risers (SWIR) and the Seawater Lift Pumps (SWLP) and, generally, there will be one SWIR for each SWLP. By comparison, the SWIR is a much less complex piece of equipment in as much as there are fewer components, no moving parts and no power demand, so consequently the maintenance requirements are minimal. The SWLP however is a more complex piece of equipment and will have a regular maintenance programme based on number of hours service and which would normally mean a redundancy requirement for the pump so that while one pump is being maintained, there is no loss of sea water capacity.

To achieve this the project would normally specify the required number of pumps as N+1 where N is the number of pumps required to deliver the design flow rate of seawater. Therefore, the redundancy requirement for seawater intake capacity of the vessel is driven by the SWLP as opposed to the SWIR.

Quality Assurance and control

Quality assurance and quality control (QA/QC) procedures for HDPE seawater intake pipelines are typically implemented in accordance with the requirements of EN 12201 and ISO 4427, which define material properties, manufacturing tolerances, testing requirements, and traceability for polyethylene pressure piping systems. These standards ensure that HDPE pipes meet stringent criteria for mechanical strength, long-term pressure resistance, dimensional accuracy, and material consistency. Manufacturing quality control includes raw material verification, melt flow index testing, dimensional inspection, hydrostatic pressure testing, and continuous monitoring of extrusion parameters. Field welding and jointing of HDPE pipelines are carried out in accordance with the guidelines of the DVS – Deutscher Verband für Schweißen und verwandte Verfahren, which define procedures for butt fusion welding of thermoplastic pipes. QA/QC procedures include qualified welding personnel, calibrated welding equipment, documented welding parameters, and systematic inspection of weld beads.

Seawater Intake Risers are rapidly becoming the quiet workhorses behind deep-water FPSO, FLNG, and OTEC systems. Their ability to tap colder, cleaner, low-oxygen water now shapes everything from cooling efficiency to LNG output and long-term operating cost. But beneath every successful SWIR system lies one decisive factor: the material it's built from.

Traditional metallic and rubber solutions struggle to keep pace with the industry's shift toward deeper, larger, and more dynamic intake systems. Steel brings weight, stiffness, corrosion, and fatigue risk; rubber flexibles offer movement but not the diameter or longevity modern projects demand. In contrast, HDPE stands out as the material that unlocks the full potential of SWIR technology. Its low weight and positive buoyancy ease installation. Its ductility and fatigue tolerance support long free spans. And its corrosion immunity and smooth hydraulic behaviour cut life-cycle cost while boosting performance.

As offshore assets push into deeper waters and higher flow requirements, HDPE-centric SWIR systems are moving from innovative to inevitable. A 50-year durability, combined with weldability and modular construction, aligns perfectly with offshore project horizons, while decades of successful deep-ocean HDPE intake deployments in OTEC, SWAC, and desalination demonstrate their scalability.

Ultimately, the future of SWIR systems will be determined not by concepts or configurations, but by choosing the right material for decades of demanding ocean exposure. HDPE provides the reliability, predictability, and cost efficiency required for next-generation ocean-energy and offshore cooling solutions. As the need for deeper, colder, and cleaner seawater grows, HDPE-based SWIRs will shape how the industry delivers high-performance production – and how it accelerates the shift toward sustainable ocean-energy technologies.

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Accelerate the shift to durable, low-maintenance offshore solutions. Adopt advanced polymer engineering to secure long-term reliability in seawater intakes, OTEC platforms, and FPSO systems.

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Authors:

Dr. Ian Craig
EmsteC
ian.craig@emstec.net

Ben Martin
Global OTEC
ben.martin@globalotec.co

Mario Vukelja
AGRU
vum@agru.at

Markus Ebster
AGRU
ebm@agru.at

For more information please contact AGRU or your nearest distributor:

agru Kunststofftechnik GmbH
Ing. - Pesendorfer-Straße 31
4540 Bad Hall, Austria

T. +43 7258 7900
F. +43 7258 790 - 2850
office@agru.at

agruworld
www.agru.at