

FACTS ABOUT

Subsea Rock Installation

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WHAT IS TYPICALLY MEANT BY SUBSEA ROCK INSTALLATION?

Rock has been used for ports and coastal protection purposes for centuries – for dikes and breakwaters, groins and scour protection. During the past several decades the major dredging contractors have become increasingly involved in the development and execution of Rock Installation in marine environments. From the previously used term rock dumping, today the term Subsea Rock Installation is commonly used to reflect the advanced techniques that are being applied, in particular for the offshore oil and gas sector.

Two types of Subsea Rock Installation should be distinguished: One is for shallow water and is typically used for coastal and embankment protection works and for scour protection for the offshore oil, gas and wind energy developments at up to 50 metres of water depths. The other is Rock Installation at greater water depths, usually ranging from 50 to 2,200 metres, and is most frequently applied for the offshore oil and gas industry.

HOW IS ROCK INSTALLATION IMPLEMENTED?

At first the installation of rock was done from shore or by hand from a flat deck barge. In the last century the first mechanical rock dumping vessels were designed, built, tested and used for ever larger maritime works worldwide, for port extensions as well as flood protection structures. These vessels were typically self propelled and outfitted with a strengthened flat deck to load the rock, hydraulically or mechanically operated “shovels”, which were designed to gradually push the rock over the side of the vessel, and a series of anchors and winches for accurate positioning. They were designed to handle a large range of rock sizes, varying from gravel to large boulders weighing many tonnes.

This technique is still used frequently and is referred to as side-stone dumping. Side-stone dumping is primarily used in water depths up to 50 metres, because the accuracy of rock placement from the water surface is limited. The deeper the waters, the more the currents may influence and

disperse the rock, the more difficult it becomes to ensure placement accuracy. With the exploration and development of oil and gas fields in increasingly deeper waters, new rock placement technologies were needed to guarantee accuracy, whilst the workability in more remote offshore locations had to be secure.

HOW DID THE DREDGING INDUSTRY ADAPT TO WORKING AT GREATER DEPTHS?

To keep up with the pace of oil and gas field developments in deeper waters an entirely new solution was developed: A fall pipe, which could guide the rocks from the water surface subsea to much greater depths. By the end of the 1970s a steel, telescopic fall pipe was developed for Rock Installation at water depths significantly exceeding 50 metres. Big diameter steel fall pipes are, however, sensitive to large drag and gravity forces.

In the mid-1980s an improved technique was developed based on a semi-open, flexible fall pipe consisting of a string of bottomless, heavy plastic buckets along two chains. At the lower end of the string a remotely operated, propelled vehicle (ROV) was attached. The ROV was equipped with a sophisticated range of technologies such as camera, survey and positioning equipment. This flexible fall pipe design, in combination with the ROV, installed on a dynamically positioned vessel, was able to achieve more accurate placement of rock by correcting the off-setting caused by currents. The drag forces were lower and therefore the system was less sensitive to rupture. This guaranteed a higher workability as the semi-open and flexible string of buckets is able to adjust its shape to the currents.

In the early 1990s DGPS (Differential Global Positioning System) was introduced in the offshore oil and gas and marine construction worlds: Differential drift of the rock-laying fall pipe vessel with respect to the subsea pipeline or cable could be achieved by dynamic positioning. The success of this technique has proven invaluable as the dredging industry has become more and more involved with the offshore energy industry, working at ever greater depths.

WHAT TYPES OF SPECIALISED ROCK INSTALLATION TECHNOLOGIES ARE USED?

Specialised rock vessels have been developed and their sizes and the technologies that guide rock placement are constantly being improved. These heavy-duty vessels are able to load and transport very large quantities of rock and accurately place the rock at a precise pre-destined location.

In recent years, for very deep rock placement, new technologies for guiding accurate Rock Installation continue to be developed, for instance, subsea acoustic positioning, discharge control, sensors, cameras, profiling scanners, streaming pre- and post-survey techniques and so on. These technologies are steadily growing in importance as the need for Subsea Rock Installation for the offshore industry is expanding.

WHAT CRITERIA INFLUENCE THE CHOICE OF EQUIPMENT FOR ROCK INSTALLATION WORKS?

Factors to be considered include the location and accessibility of the site, the availability of the right quality and gradings of rock, of rock loading facilities, shipping traffic; the profile, length, width, grading and layer thickness of rock to be installed and most importantly the water depth; the type of soil; the water movement such as currents, waves and swell; type of water, salt, fresh or brackish; the ecosystems.

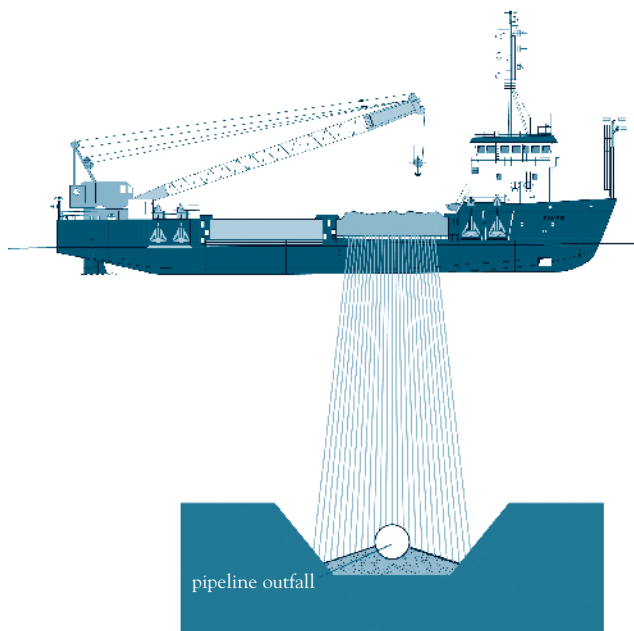
WHAT IS A SIDE STONE DUMPING VESSEL (SSDV)?

The most commonly used vessel is known as Side Stone Dumping Vessel (SSDV). Usually stone is loaded into compartments on the extremely strong, reinforced deck and the vessel sails to its destination, where dozer blades are used to push the rock over the side(s) of the vessel and deposit the stone accurately in the water with the aid of a positioning system.

The most modern SSDVs are sea going and self propelled and may achieve sailing speeds up to 10 knots, making it possible to load their cargo directly at the quarry and eliminating the need for offshore transshipment from supply barges. The SSDVs are used for marine engineering projects all over the world and can handle many different rock types and sizes, ranging from small diameter crushed rock or gravel to large boulders weighing several tonnes each. Even concrete blocks used in breakwater construction or coastal defence projects are being handled by SSDVs. The most modern vessels have dynamic positioning systems which allow safe operation at close proximity to offshore platforms and structures.

WHAT IS A DYNAMICALLY POSITIONED FLEXIBLE FALL PIPE VESSEL?

Another Rock Installation vessel is known as a fall pipe vessel. Dynamically Positioned (Flexible) Fall Pipe Vessels



Side stone dumping vessels (SSDVs) are self-propelled ships that are typically used to install scour protection for offshore wind turbines and offshore rigs, to construct breakwaters or to install rock for subsea pipeline protection.

(DP FFPV) are typically used in water depths exceeding 50 metres. They are either specially designed vessels or transformed bulk carriers which are intended to carry large amounts of rock in their holds. The loading capacities of these vessels vary greatly, from 1,200 tonnes to more than 33,500 tonnes.

Fall pipe vessels are primarily used for offshore projects, for covering pipelines and cables, levelling the seabed or applying scour protection. Rock material is loaded at a port or preferably at a seafront quarry into the hold of the vessel. Fully loaded, the self-propelled vessel travels to the work site. These highly computerised, dynamically controlled vessels can achieve position-fixing within an accuracy of less than half a metre.

HOW IS ROCK DISCHARGED FROM A DP FFPV?

Discharging the rock can be done by transferring the rock by conveyor belts from the hull to the hopper on deck. Alternatively a large crane or excavator can be used to feed the hopper on deck. From the hopper the rock goes through the feeder which controls the flow of rock into the flexible fall pipe. The ROV at the end of the fall pipe is used to manoeuvre the flexible fall pipe and carries all the survey and positioning equipment necessary to allow the crew to accurately place the rock at the pre-determined location. In some cases a free-flying ROV is used to monitor the operations. The newest generation of DP Fall Pipe Vessels can reach water depths of up to 2,200 metres,

six times the height of the Eiffel Tower, and can carry up to 33,500 tonnes of rock.

WHAT ARE SOME APPLICATIONS FOR SUBSEA ROCK INSTALLATION?

Some instances where Subsea Rock Installation is applied in the offshore oil and gas industry include:

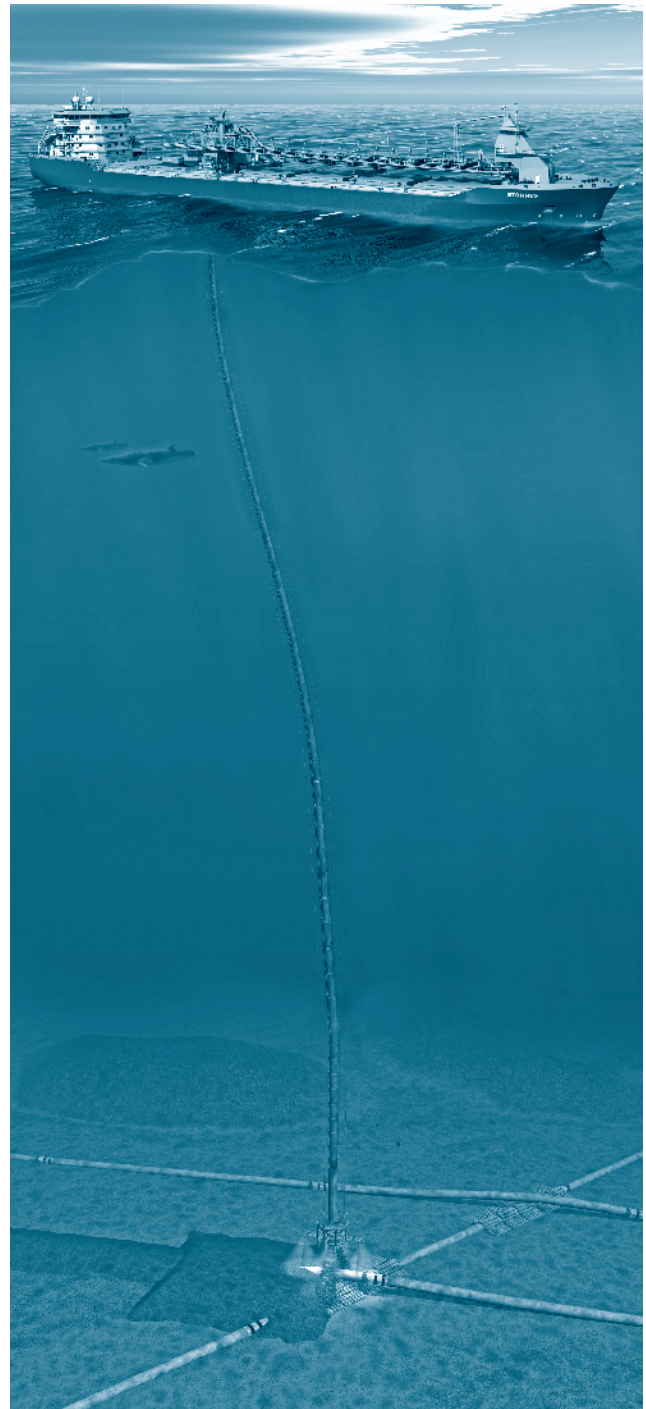
- In the preparation of the seabed prior to pipe or cable laying or platform installation;
- To prevent scouring around maritime structures such as offshore platforms and rigs;
- To protect pipelines against damage from anchors, trawler boards, fishing nets and such;
- To mitigate the free span of pipelines in undulating terrain;
- For offshore ballasting works;
- To achieve axial locking and mitigate lateral or upheaval buckling of the pipeline, e.g., owing to temperature and pressure changes of the pipe; and
- For the physical separation and mutual protection of two or more pipelines or cables in case these cross each other.

HOW IS ROCK INSTALLATION APPLIED IN THE OFFSHORE ENERGY INDUSTRY?

For several decades the dredging industry and the offshore energy industry have worked together very closely. The necessity to stabilise and protect offshore pipelines, cables and other installations such as Gravity-Based Structures (GBSs) for oil and gas or for offshore wind farm foundations is obvious. The global dependence on offshore sources of oil and gas has increased, as has the proliferation of offshore wind farms. Consequently, the necessity for dredging expertise in Rock Installation has also accelerated. Worldwide from Norway and the UK to Sakhalin, Russia to Canada, the demand for pipe laying and stabilising the seabed and pipelines is on the rise.

HOW IS ROCK INSTALLATION APPLIED TO OFFSHORE WIND FARM FOUNDATIONS?

Basically, three types of foundations have been used so far for offshore wind turbine construction: the conventional monopile foundation, the jacket-type foundation and the gravity-based foundation (GBF). Dependent upon the site conditions, i.e., soil, hydro-dynamics, one type of foundation may be preferred over another. For instance, gravity-based foundations (GBFs) have been used for very large wind turbines, like the wind farm at Thornton Bank off the coast of Belgium. These GBFs are pre-cast concrete structures which are constructed on shore on a quayside and then transported to the installation site by heavy-lift vessels. There they are lowered to the seabed into a prepared foundation pit. The engineered foundation pit is pre-dredged



Flexible fall pipe vessels (FFPV) are primarily operated in very deep water up to 2,200 metres, when covering oil and gas pipelines, levelling the seabed or applying scour protection. An ROV is attached at the lower end of the fall pipe for better positioning.

to its design shape and depth. A gravel layer is then accurately put in place with a DP fall pipe vessel as a foundation layer for the GBF. After positioning the foundation unit into the foundation pit the GBF is ballasted and the pre-dredged pit and surroundings are back-filled with sand and/or gravel.

After installation, whether a monopile foundation or a GBF, the offshore structures need to be protected against



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erosion caused by the action of currents and waves. In most cases gravel and rock are being used to apply a solid and sustainable erosion protection layer. Specialised DP-controlled gravel and rock placement and spreading tools are used to accurately position the gravel and rock layers next to the foundation. Special safety procedures are applied to allow the vessel to operate in close proximity to these structures, often in quite harsh environments.

HOW IS ROCK INSTALLED FOR PIPELINE SHORE APPROACHES?

In many cases oil or gas pipelines need special protection in their near shore approach track. Typically the pipeline is installed in a pre-dredged trench and backfilled with previously excavated material or by means of natural backfill. Sometimes, however, when the excavated material does not meet the requirements to achieve safe cover of the pipeline, engineered backfill material is used. This may include the installation of rock on top of the installed pipeline. This will protect the pipeline against damage and guarantees that the pipeline is safely and firmly installed at its location, regardless of the natural coastal dynamics on the seabed in the surf zone.

DOES ROCK INSTALLATION ENDANGER THE INTEGRITY OF SUBSEA PIPELINES OR STRUCTURES?

The speed at which rock falls through the water column is related to the rock grading and its specific density, although whatever the characteristics, the speed at which rock falls is limited. The falling speed reaches a maximum acceleration soon after the rock hits the water surface. This action can be best compared to falling snow flakes. The impact of rock hitting a pipeline, cable or subsea structure is therefore also limited and does not endanger the integrity of these elements or their concrete covers. During the last decades extensive laboratory and empirical tests and specific physical and computer modelling have been conducted. These have proved that Subsea Rock Installation achieves its purpose and does not harm pipelines or cables. In addition, nowadays, accurate calculations can be made to determine the required rock grading, the rock cover profiles, the impact of falling rock on the structures and the effects on the direct surroundings.

WHAT ARE THE ALTERNATIVES TO SUBSEA ROCK INSTALLATION?

Alternatives to Subsea Rock Installation to protect offshore pipelines or other structures do exist. A common method is to apply a thick(er) armour layer or concrete shell around the pipe or cable, to cover it with flexible (concrete) mattresses or to install the pipeline in an excavated or post-lay trench. To mitigate free spans, a pipeline can also be supported with concrete elements or steel frames. Another option to overcome potential free spanning is to dredge the high spots by “pre-sweeping” to create a more even seabed. Where a pipeline or cable crosses an existing pipeline or cable, concrete mattresses may be used instead of rock placement to avoid damage to either or both.

Good engineering practice used by the dredging community will consider the environmental conditions, technical feasibility and costs in order to select the most efficient and economical solution. The success of Subsea Rock Installation after three decades of use demonstrates that it is a competitive and reliable method to protect subsea structures and ensure their integrity from damages caused by waves, currents and human activities.

FOR FURTHER READING AND INFORMATION

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This brochure is presented by the International Association of Dredging Companies whose members offer the highest quality and professionalism in dredging and maritime construction. The information presented here is part of an on-going effort to support clients and others in understanding the fundamental principles of dredging and maritime construction.

