No. 20

Oil Report

IHC offshore division

DRILLSHIP "HAVDRILL"

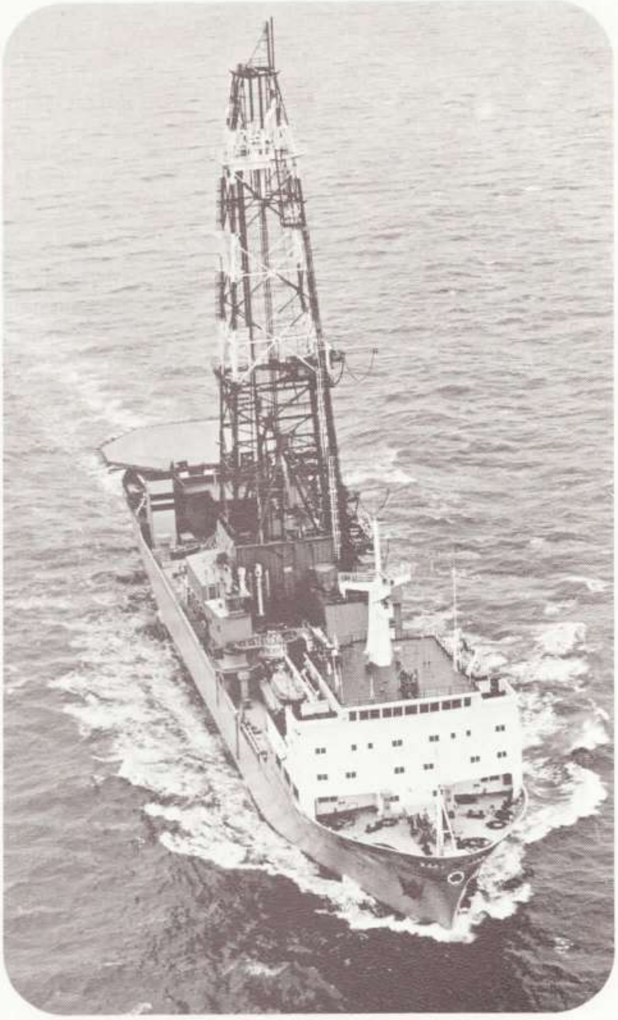
The IHC Holland built D.P. drillship *Havdrill*, delivered to the Nordic Offshore Drilling Company A/S in 1973, is a twin screw vessel fitted with c.p. propellers, five c.p. transverse thrust units and a Honeywell ASK Dynamic Positioning System, incorporating a dual RS 5 accoustic position measurement system and two H-316 real time control computers.
The vessel is equipped to work in conditions varying from arctic to tropical. The hull is strengthened for navigation and operation in ice and the vessel has the following principal characteristics:

main dimensions	149/137 x 21.35 x 12.50 m
design draught	7.32 m
displacement	15,500 t
maximum speed	14 kn

The drilling installations include an IHC Holland heave compensator and an automatic pipe racking system.
Havdrill's design is based on the following criteria:

- high mobility and ability to operate in all climatic conditions ranging from arctic to tropical. Her hull is reinforced to withstand the pressure of ice;
- self-sufficiency;
- operational flexibility by reducing the physical connections between the ship and the sea bed;
- complete mechanization of the handling operations on board

The *Havdrill* is built under survey of Det Norske Veritas for their notation "✠ class 1A1" deep sea drilling vessel – EO-ice class B. The ship has a loading capacity of approximately 7,500 tons enabling the vessel to stay at sea without supplies for a period of about 100 days.



ELSBM on tow to its location

As announced in our previous issue the first Exposed Location Single Buoy Mooring for Shell Expro is now en route to its location, the Auk Field in the North Sea. The ELSBM is seen here passing Rotterdam's famous Euromast. The overall length of the ELSBM is 76 m.

Oil Report

No. 20

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For USA: J. W. Billard and Ass. - 2800 North Loop West - Suite 400 - Houston - Texas 77018 - Tel. 713/681 - 3543 Telex 775301

Drillship "Havdrill"

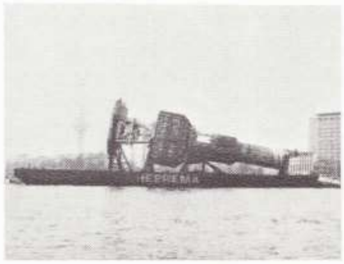
PAGE 2

The dynamic positioned drillship *Havdrill* has been delivered to her owners Nordic Offshore Drilling Company A/S in Oslo.
In the meantime two wells have been drilled for INA NAFTAPLIN, Yougoslavia in the Adriatic Sea. All systems have worked up to the expectations.

ELSBM

PAGE 2

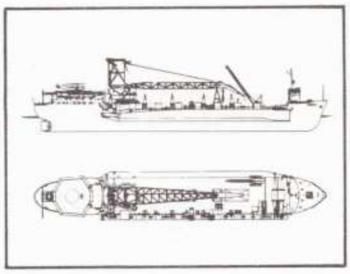
The first Exposed Location Single Buoy Mooring has been transported to a Norwegian fjord, where the launching procedure was executed successfully.



800-ton offshore crane "Orca"

PAGE 4

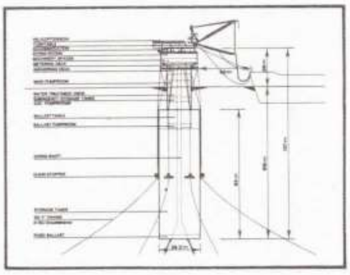
The editor of *Oil Report* took a closer look at the design and work of the combined pipelay/derrick vessel *Orca*. The ship is owned by Netherlands Offshore Company who kindly consented to publish some data on record lifts and provided some of the illustrations.



SPAR floating storage

PAGE 7

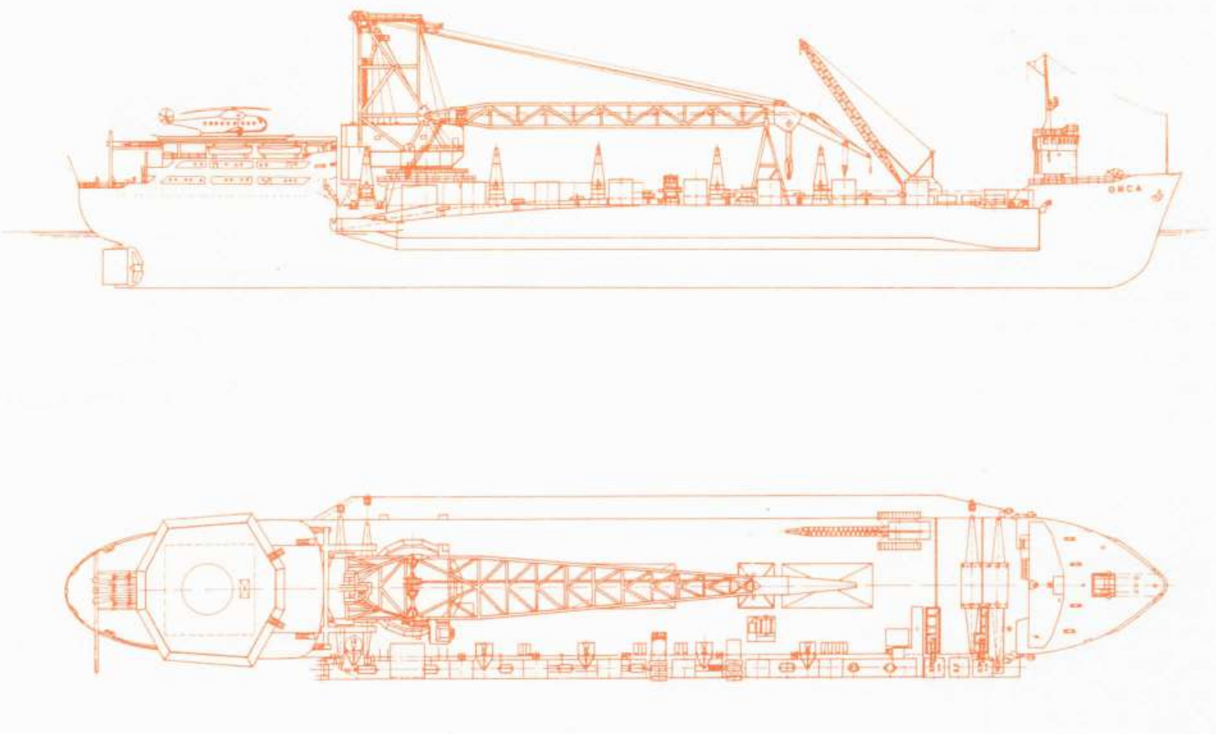
Some considerations on the design of an offshore floating storage/loading facility. The first 300,000 barrel unit of this type for installation in Shell/Esso's Brent field off the Shetlands, is now under construction.



Front page

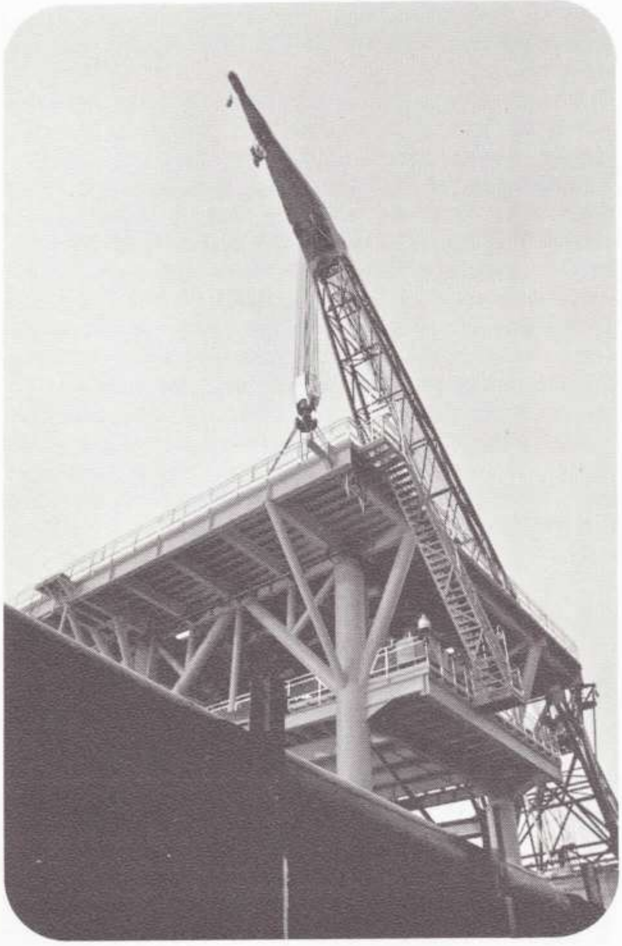
IHC Holland designed and built the 800-ton crane on the pipelay/derrick vessel of Netherlands Offshore Company. Photo by courtesy of N.O.C.

HEAVYWEIGHT LIFTS LOOK FEATHER-WEIGHT LIGHT



Late in May 1973, the multipurpose self-propelled workship *Orca*, operated by Netherlands Offshore Company established a new record for the heaviest over-the-side lift by a revolving crane offshore. It lifted into place the two deck-section modules of Conoco/NCB's 49/17, 8-pile production platform in the South Viking field off the U.K. One deck section weighed 800 tons, the other 750 tons.
The record-breaking operation was completed in less than three hours from the time the seafastenings were cut to installation of the 800-ton deck section on top of its jacket. Within six hours, both deck sections with a total weight of 1550 tons were in place.
Aware that there are other vessels with higher lifting capacities over the stern with their cranes in fixed positions, the editors of OIL REPORT took a closer look at the design of *Orca*. Main objective was to see how this particular sea workhorse had been designed to muscle heavy loads from off the deck of the crane vessel or cargo barge and swing them, if necessary, through 90 degrees into position atop a jacket or platform.
The Swedish ore/oil carrier *Soya-Atlantic* was purchased in 1971 and taken to Boele's yards in Bolnes for conversion into a combined pipelay/derrick construction vessel. The bridge has been moved right forward over the bow to enable the installation of a revolving IHC Holland crane capable of lifting 800 tons at a 90-ft radius, and leaving sufficient deckspace for the vessel to carry large cumbersome loads such as jackets and deck sections without impairing forward vision.

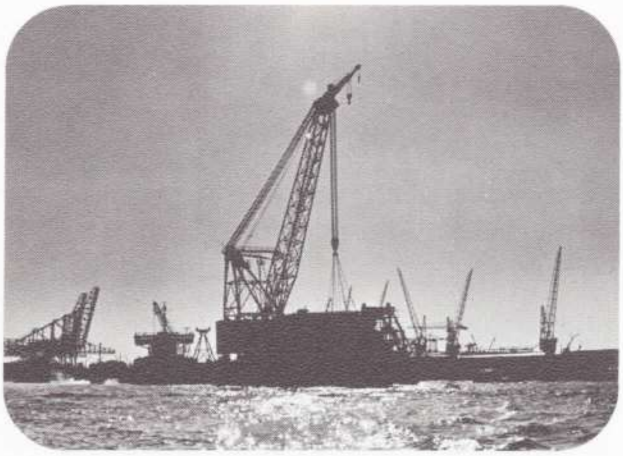
In order that the crane could be operated in any position, the transverse stability of the vessel had to be improved. This was accomplished by fitting wing tanks along both sides, each 12-ft wide and 378-ft long.
The pipe ramp is on the starboard side of the ship and the pipelay equipment includes piperacks, pipe conveyor, line-up station and stalking equipment, welding stations, x-ray and field-joint coating stations, and pipe-tensioners. The pipe ramp along the top of the starboard wing tank is sloped to facilitate lowering the welded and coated pipe to the seabed. Equipment is designed for handling and laying pipe as large as 48-in. outside diameter.
The original turbine steam propulsion plant was removed from the vessel, with the exception of the



propeller shaft, and replaced by a new twin-engined Stork-Werkspoor diesel installation. A total of 9000 hp developed by the two directly reversible marine diesel engines at 520 rpm is transmitted to the fixed-pitch propeller by a pair of clutch couplings and a twin-input, single output gearbox with a reduction of 520 : 104.
Compressed air control of the clutches is by Airflex rotor seals fitted to the after end of the pinion shafts of the main gearbox. High-torsion damping of the couplings is by oil displacement as a result of spring deplection. The couplings are oil-filled making them independent of any oil supply system. The engines drive a pair of 2500 kVA alternators through two clutch couplings and gearboxes.
On location, the main engines can be disconnected

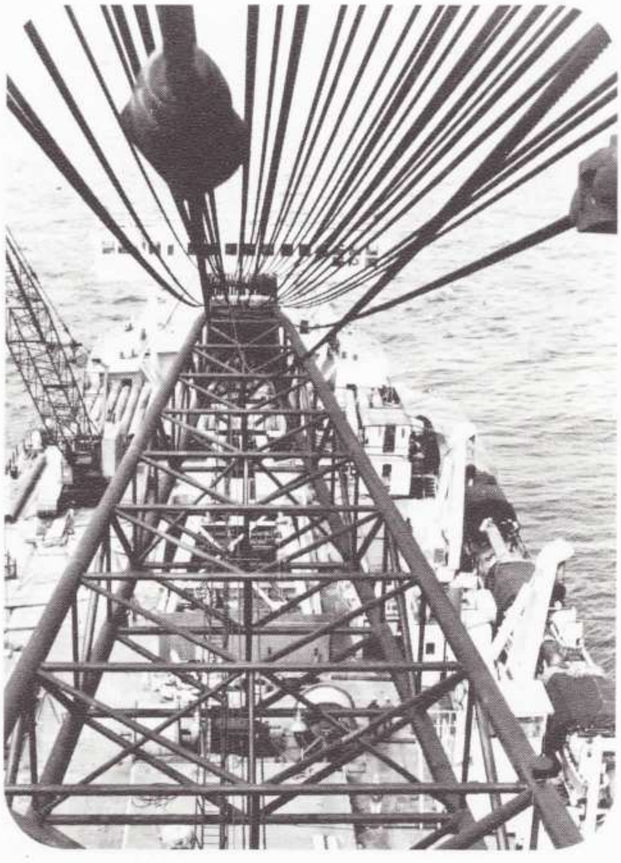
from the propulsion shaft and can be used to drive the alternators providing the power required by the 800-ton revolving crane. Power from the alternators is also tapped to drive the anchor winches, welding machines, pipe tensioners, gantry crane in the hold, and other electrical equipment. This arrangement enables one main engine to be used for propulsion purposes while the other drives an alternator should this power split become desirable.
The space which became available after removal of the old boiler plant and reduction in the size of the engine room was used to enlarge the accommodation to carry some 210 crew members. All quarters are fully air-conditioned. The holds are arranged to carry a cargo of approximately 2 miles of 30-in diameter pipe, and a similar load can be transported on deck. Bunker capacity is sufficient for 60 days consecutive pipelaying or 100 days of platform construction work. A helideck is located aft over the boatdeck.

800 ton IHC Holland crane
The workship *Orca* has an impressive record of offshore work in the North Sea, the Mediterranean and Africa.
The IHC Holland crane to handle the vessel's heavy lifts is a split-boom design with a loading capacity of 800 tons through 360° at a 70-ft radius or 800 tons straight over the sides at a working radius of 90-ft. The tie-down configuration was developed by IHC Holland engineers at NOC's request especially for this crane; it employs a pair of hydraulically-actuated tierods which secure the tail of the crane to pad eyes fixed at deck level. The auxiliary hook is rated



at 100 tons, and the whip line has a capacity of 25 tons.
By providing the crane with an exceptionally high A-frame gantry and a high-capacity swing circle, the design engineers were able to economize in the requirement for heavy, space-wasting counterweight. This also resulted in exceptionally high lift capacities even when the vessel is subjected to both list and dynamic roll conditions. And the high A-frame resulted in better boom suspension, especially when the crane is subjected to sudden shock loading due to sea action. The boom foot is split into two legs nearly 33-ft apart, a boom design which affords high resistance to both side loads and severe dynamic loads imposed by heavy seas.
Since the main crane installed on the *Orca* would be required regularly for maximum and near-maximum lifts in hostile environments, design engineers at the IHC Holland yard paid particular attention to the method used to solidly support the crane substructure. The giant swing-circle gear has a diameter of more than 33-ft; it is designed so that there will be no detrimental increases of the forces acting on its individual components – rollers, bogies, end thrust bearings, etc – by any deflection of the turntable frame.
The swing gear encircles an IHC Holland designed and developed hydrostatic end thrust bearing which is directly attached to the double bottom of the vessel in a manner to withstand the effects of shock loading caused by sea action. The turntable frame is heavily reinforced and is especially designed with extra deep sections to provide the solid support required for capacity lifts.

Load safety device
From its long offshore experience IHC Holland has become extremely conscious of the need for safety at sea. Since a large number of variables are built into the operation of offshore cranes, engineers spent considerable effort in reducing or eliminating the foreseeable problems. An essential feature of any safety system is the provision of suitable means for indicating the load moment on the hook at any given time. The purpose of such a device is to ensure that the maximum permissible load at a given outreach – or the maximum permissible outreach at a given load – is not exceeded.
The load safety device incorporated into the design of the crane on the *Orca* includes a visual instrument so that the crane operator can see at a glance the actual load moment on the hook as a percentage of the maximum permissible load. It is then the operator's decision whether the crane can be safely topped with the given load. An audible signal will be given when the load moment reaches 95-percent of the maximum permissible load. If this is exceeded by a further 5-percent, the topping and hoisting motors will be automatically blocked.
On the *Orca*, the design of the crane is such that the strain imposed on the topping cable is proportional to the total load moment. Limitation of this – and therefore protection – is achieved by measuring the strain imposed on the topping cable, using a strain gauge incorporated into the system for this purpose. This load safety device played a prominent role in assessing the *Orca's* capability of lifting the near-capacity 800-ton deck module of Conoco/NCB's production platform safely into place.
At the installation site, the *Orca* was positioned alongside the platform jacket and its ten anchors were set out.
The cargo barge carrying the modules was then manoeuvred into position between the *Orca* and the jacket. Seafastenings holding the first and heaviest deck section of 800 tons were removed: the crane hook was attached and the load-moment safety device was checked before the crane lifted the deck section straight off the barge. Whilst the deck section was suspended by the main block of the crane, the barge was towed away and the *Orca* was manoeuvred in towards the jacket by winching in her portside anchors while paying out the starboard anchors.
Within three hours of the cutting of the seafastenings, the deck section was installed on the top of the jacket. *Orca* moved away and the same procedure was repeated for the second deck section, weighing a mere 750 tons.



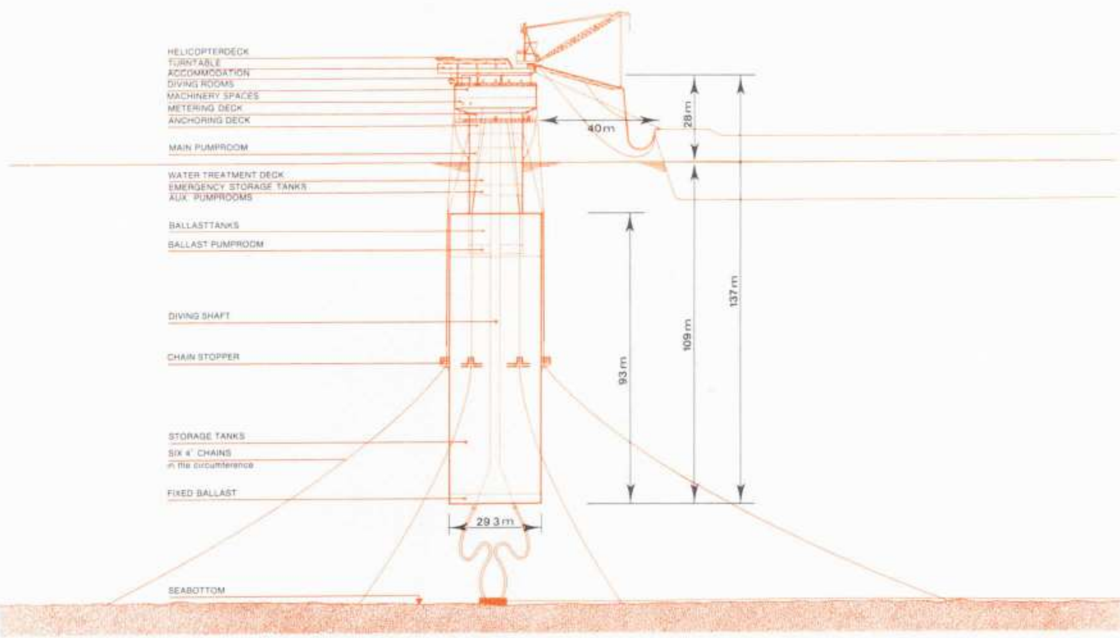
THE SPAR NEW DESIGN FOR FLOATING STORAGE

By J. D. Bax,
IHC Gusto

1. INTRODUCTION

Some years ago it became obvious that spiralling world oil consumption would move the search for oil further offshore. To be prepared for production in deep water, Shell and IHC Holland started development work on an offshore floating storage/loading facility in 1968. The aim was to develop a unit which would enable optimum crude oil production to be maintained from oil fields where the construction of long, large-diameter pipelines was not feasible, i.e. a means by which output from initial wells could be sustained and shutdowns caused by irregular, non-continuous transfer of oil to off-taking tankers eliminated. The SPAR, as the unit is called, ensures this continuous flow of oil by combining storage and tanker loading facilities that will remain operational for a very high percentage of the time, even under rough weather and sea conditions.

After competitive bidding, IHC Holland succeeded in obtaining the contract for building the first unit of this type: a 300,000-barrel unit for Shell/Esso's Brent field off the Shetlands. This will be a joint product of IHC Holland's offshore know-how and Wilton-Fijenoord's ample building capacity, and is scheduled to be installed off Brent in 1974.



2. GENERAL DESCRIPTION

At the Brent field the SPAR will be kept on station by six anchor lines. When in position, the bottom of the SPAR will be about 30 metres above the seabed. In essence, the Shell-IHC Holland SPAR storage unit comprises three cylindrical parts placed one on top of the other; it has an overall height of 137 metres. The lowest part will be 93 metres high with a diameter of 29.3 metres; this will form the actual storage facility. Located above this is a 17-metre diameter cylinder some 32 metres high containing the pumping and other essential equipment. Roughly one half of the length of this cylinder will be below the surface, the remaining 16 metres projecting above it.

In accordance with the relevant codes and regulations, a proper watertight sub-division has been maintained throughout the SPAR.

A 12-metre high, 26-metre diameter cylindrical superstructure forming the top end of the SPAR incorporates power generating equipment, control equipment and quarters for the crew. Single buoy mooring and offloading facilities, together with a helipad, are incorporated in the turntable located on top of the superstructure.

The SPAR has been designed to maintain a constant draught in both the loaded and ballasted conditions. However, since there is a difference between the specific gravities of oil and seawater, not all of the storage compartments will be filled with water when the unit is in ballast. A number, known as buoyancy control compartments, will remain empty in the ballasted condition but will contain water when the storage unit is full of oil.

The offloading tanker will be moored by a bow hawser to the SPAR which, like an SBM, will be equipped with a mooring on a turnable. This will allow the tanker to swing freely and assume the most favourable position in relation to wind, waves and current.

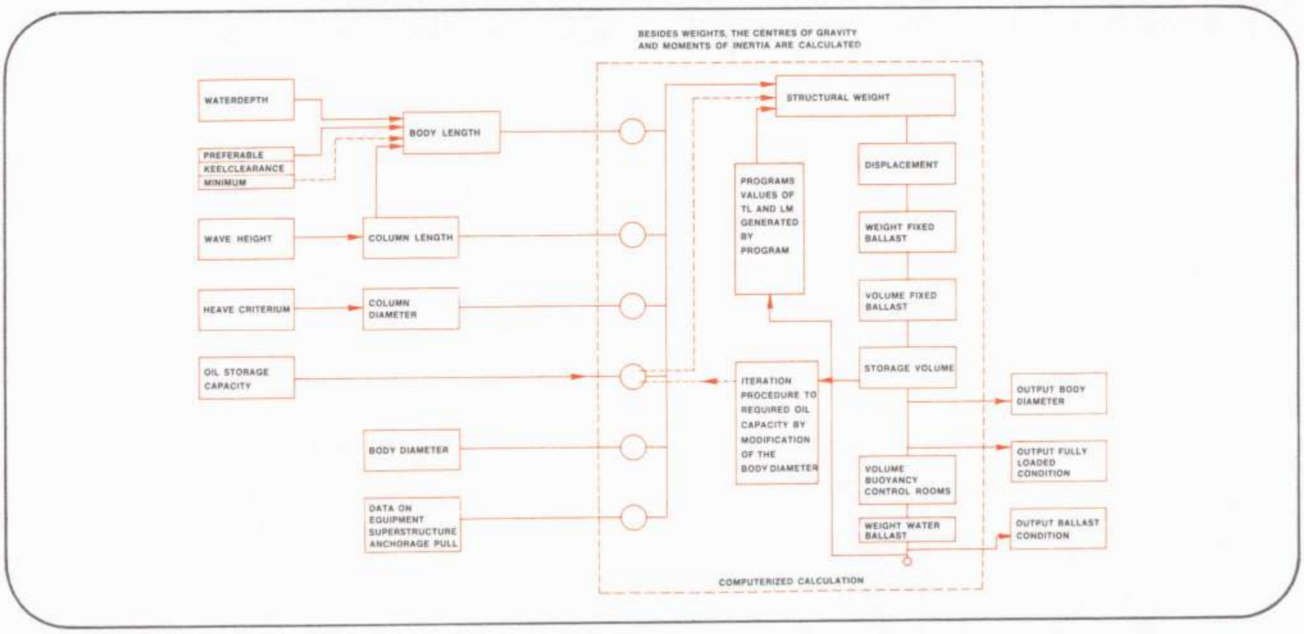
The offloading equipment will incorporate a 27-metre long retractable boom with hoses for direct connection to a manifold on the bow of the tanker.

3. DESIGN ASPECTS

The basic design criteria as established by Shell Expro, as operator for Shell and Esso, for the Brent SPAR are as follows:

- Net storage capacity 300,000 barrels
- Receiving rate 100,000 bbl/day
- Maximum tanker loading rate 5,000 metric tons/hr
- Tanker size, approximately 50,000 dwt/70,000 dwt

The underkeel clearance is specified, account being taken of the anticipated motions of the unit during upending, assembling and, finally, under the influence of wave action when anchored at the location.
Since as great as possible a body length is attractive from the fabrication, transport and upending points of view, the keel clearance should be as small as possible. The column length is essentially dictated by the maximum wave height likely to occur. A length has been chosen that will avoid slamming against the bottom plates of the superstructure.
On the other hand, the SPAR body should be so far under water that, under the maximum sea conditions, the body will not come out of the water and thus be subject to high wave forces.
Finally, the column length should be such as to ensure that under the maximum operating conditions, tanker and body will never collide as a result of their relative movements in the seaway.
This aspect is carefully checked by computer calculations and model tests.
The basic design philosophy demands that the SPAR



- Survival conditions
  Wind data (100 years):
  1 hour mean : 44.7 m/sec
  1 minute mean : 56.8 m/sec
  Maximum gust : 68.4 m/sec

  Wave data (100 years):
  Significant wave height = 17.1 metres
  Maximum wave height = 32 metres
- Maximum operational condition for tanker moored to SPAR

Current	=	0.77 m/sec
Wind	=	20.6 m/sec
Significant wave height	=	5 metres, approx.
Maximum wave height	=	9 metres

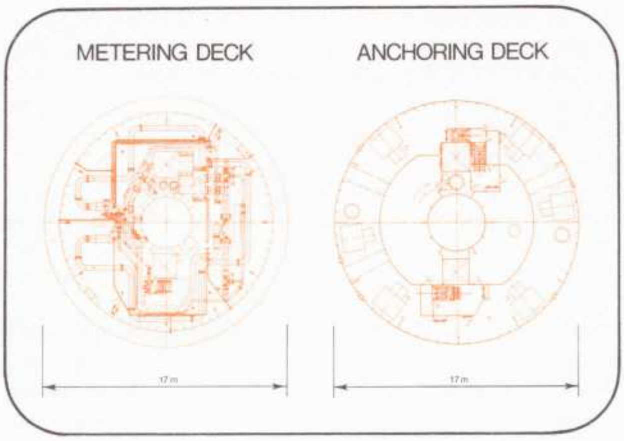
To satisfy the above criteria, the engineering work proceeded generally in accordance with the flow chart shown above.
The water depth at the location and the required underkeel clearance determine the maximum permissible length of the body.

be affected as little as possible by seaway. This means that the area subject to wave forces, the column, should be as small as possible; that is to say, the diameter should be as small as possible (see also page 7). Furthermore, the diameter of the column has a significant bearing on the natural heave period. To minimize the wave action, the specifications required the natural frequencies of all SPAR motions to be detuned in respect to the predominant wave frequencies. The relationship between natural frequency of heave and column diameter can be expressed as follows:

$$T_H = F\,(V,\, g,\, \alpha,\, D)$$

where

T_H = natural heave period
V = submerged volume
α = factor of added mass in heave
g = gravitational acceleration
D = column diameter



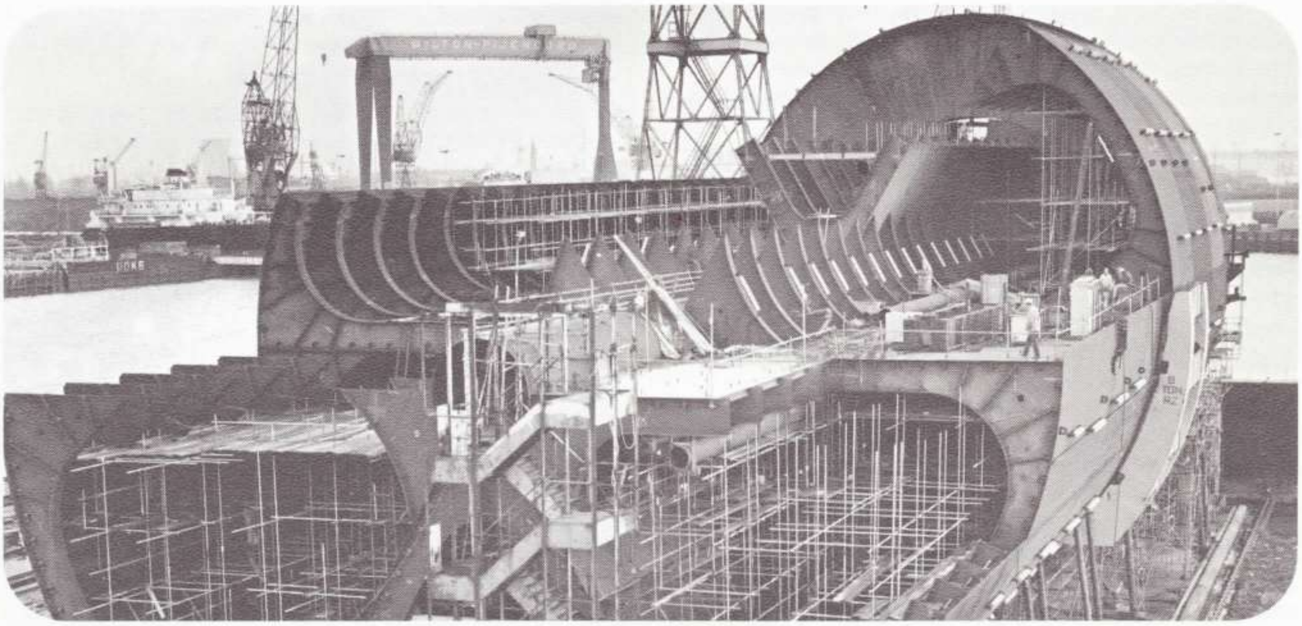
In the case of the Brent SPAR, where T_H must be greater than 30 sec., the above relationship determines the approximate column diameter.
The last remaining main dimension, the body diameter, is determined on the basis of required storage capacity, fixed ballast volume and body length.

It should be noted that the main dimensions thus determined are only preliminary and are in fact used as a first input in an iterative procedure in order to arrive at optimum dimensions.
Firstly, any floating unit has to comply with two basic laws, the equilibrium of volume and the equilibrium of weights.
So the main dimensions have to be adapted in order to satisfy these two basic laws.
Secondly, the behaviour in seaway of the unit specified by the main dimensions must be optimized. Shape and metacentric height (GM) are the most predominant factors influencing this behaviour in seaway.
Shape cannot be varied to any great extent since the main dimensions are dictated by the basic design principles.
The metacentric height, however, allows more freedom; at least the position of the centre of gravity (G) can be varied by altering the weight distribution of the SPAR components.
Computer calculations based on spectral analysis methods, backed up by extensive model tests in the Netherlands Ship Model Basin, are used to arrive at an optimum solution in respect of the SPAR movements in the ballasted condition, in the loaded condition and, last but not least, when the tanker is moored to the SPAR.
The general layout having been determined, attention must be paid to the anchoring system and SBM feature. The anchor system must keep the SPAR safely in place, even under 100-year storm conditions. Moreover, the horizontal excursions of the SPAR due to environmental and mooring forces should be kept within predetermined limits, in view of the submarine hose layout.
Furthermore, the layout must be within practicable limits in order to facilitate installation and pre-tensioning of the anchor lines.
Finally, the height of the point of connection to the SPAR body has to be determined.
As the anchor system has a bearing on the natural movements of the SPAR as well, a height corresponding to the position of the centre of gravity has been chosen in the present design.
Model tests and calculations are used to determine the maximum forces in the mooring line between tanker and SPAR.
Numerous efforts are made to establish the optimun length and elasticity of the bow hawser as these parameters have a predominant bearing on the mooring forces and relative movements between tanker and SPAR.
This last aspect is important in view of the required loading boom length.

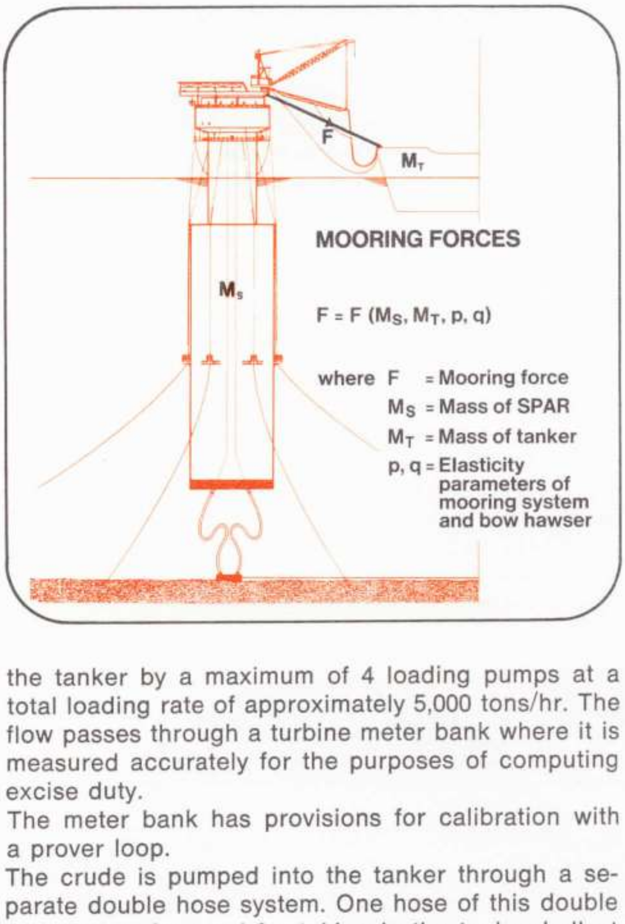
4. OPERATION

Crude flow

Processed crude is received continuously from several adjacent production platforms through a submarine pipeline terminating in a manifold on the seabed under the SPAR.
From this manifold it flows through the submarine hoses and riser system to the filling manifolds of the SPAR, and from these into one of the six identical tanks, entering at the top.
The discrepancy in buoyancy caused by the diffe-



rence in specific gravity of seawater and crude is counteracted by filling the buoyancy control chambers with seawater. When the crude flows down into the tank it displaces the seawater, which leaves the tank at the bottom and flows upwards through a seawater riser into the seawater manifold and, under the influence of gravity, into the skimmers. Particularly at the end of the filling cycle, when the crude oil/water interface approaches the bottom of the tank, the water may entrain traces of crude, which, however, are easily removed by the skimmers. The separated clean water is collected in a header and pumped back into the sea by the water disposal pumps. The oil from the skimmer is collected in a slop tank and pumped back into the filling manifold of the storage tanks by the slop pumps.
Each storage tank – including the emergency storage tanks – is connected by a vent line and a liquid trap to a ring main which exhausts into the air at a safe distance from all other exhausts and intakes.
When a tanker has to be loaded, a tank is connected to the suction manifold and the crude is pumped to



the tanker by a maximum of 4 loading pumps at a total loading rate of approximately 5,000 tons/hr. The flow passes through a turbine meter bank where it is measured accurately for the purposes of computing excise duty.
The meter bank has provisions for calibration with a prover loop.
The crude is pumped into the tanker through a separate double hose system. One hose of this double system may be used for taking in the tanker ballast water, in which case the ballast water flows through the seawater manifold into the storage tanks and crude loading is carried on through the other hose.

Tanker mooring

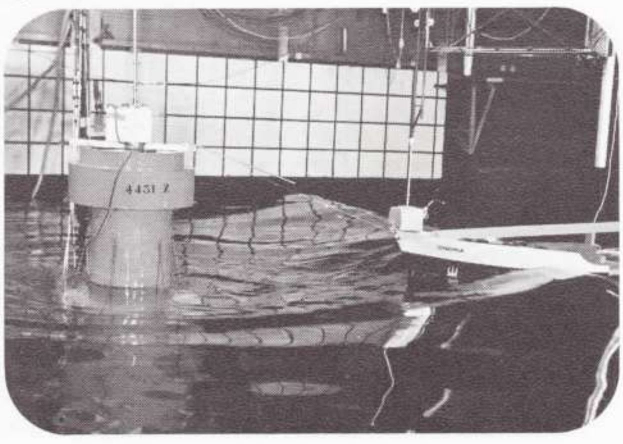
When a tanker arrives, the turntable is rotated in the appropriate direction by the SPAR crew. The rescue boat always available in the field streams a floating polyprop messenger line out downwind.
The tanker picks the line up and starts heaving in on it, until the bow chains, attached to the polyprop, can be made fast in a quick action stopper. The tanker then settles into her berth but continues to apply back thrust by reversing her engines. This thrust will limit the yaw movements of the tanker and therefore the mooring forces in the bow hawser. Furthermore, it will prevent the tanker colliding with the SPAR.
A messenger, attached to the hose ends, is passed with the hawser. The crane operator lifts the crane jib and loading boom from the supports on the turntable, and the crane swings the boom out towards the port side of the tanker bow.
The hoses – which until now have been strapped against the bottom of the loading boom – are released and the tanker crew applies pull on the messenger to connect the hoses to the bow manifold. After connecting the two crude/ballast hoses and the fuel hose used to refuel the SPAR, the crane and loading boom swing movements are locked and the loading boom is set at approximately 20 degrees below the horizontal.
When the tanker settles deeper during loading, the boom remains in a fixed position and all movements are taken up by the slack in the hoses.
If, during loading operations, the tanker should swing around under the action of wind and current, the turntable, because of its large size, will not be able to follow this movement by itself, as occurs on an SBM. Therefore the horizontal angle of the hawser is measured, and when a certain deviation from the central position is detected, an automatic system causes the turntable to rotate until the hawser is again exerting a straight pull.

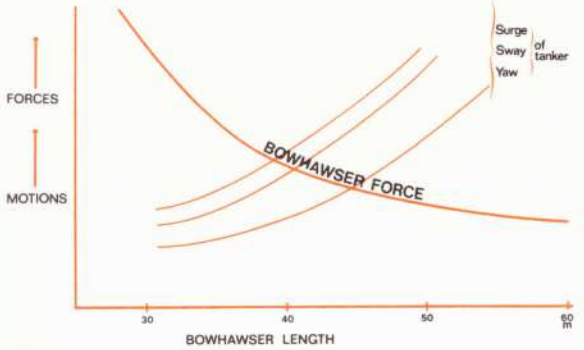
Maintenance of submarine hoses

The SPAR will be reasonably stable in seaway, and no highfrequency motions will occur. This implies that the submarine hoses between the bottom manifold and the SPAR will not be subjected to heavy motions either.
Nevertheless, the utmost care has been taken to provide ample maintenance provisions. A diving bell which can be lowered through the central well of the SPAR has been incorporated. This will enable divers to be sent down for inspection of hoses, etc.
In the event of a hose requiring replacement, a complete hose string will be pulled through the central well into the SPAR, where the faulty hose will be replaced by a new one. This procedure eliminates costly and time-consuming diving work.

5. ANTI-POLLUTION FEATURES

In the design, the utmost attention is given to the features which reduce the risk of oil spillage during operations.





Relation between bowhawser length and mooring forces resp. motions

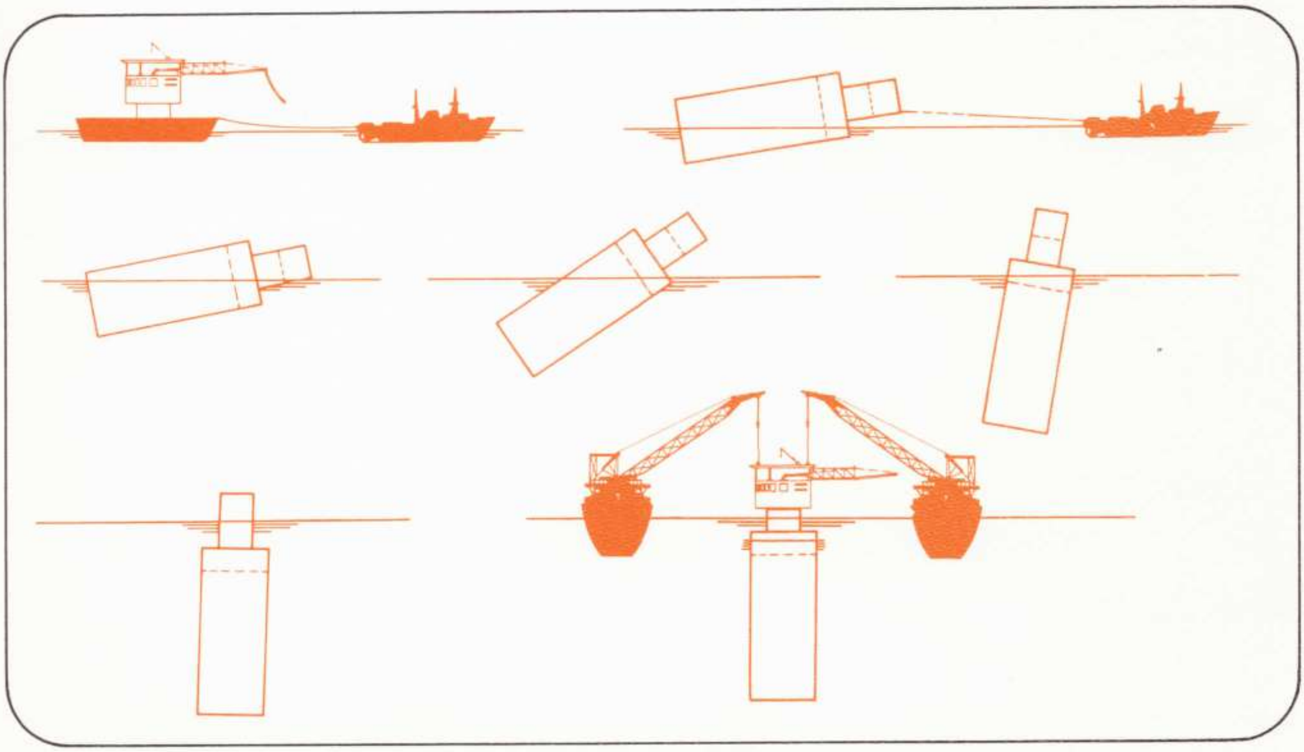
In the first place, the anchoring system is designed to keep the SPAR in position even during the most adverse weather and sea conditions.
Secondly, the storage is kept so far under the waterline that, in the event of a collision between tanker and SPAR body, the storage part cannot be damaged.
To minimize any risk of collision, the tanker continuously applies back propulsion.
Thirdly, the SPAR body is divided into watertight compartments, so that, in the unlikely event of a collision, the damaging of two adjacent compartments will not cause the SPAR to sink.
Moreover, a separate safety system is incorporated, measuring the tension of the bow hawser at the connection to the turntable. This system will initiate emergency action should the tension suddenly decrease, indicating a parted hawser.

The pumps are then stopped automatically, the valves on the loading boom are closed and the boom hose connector releases the hoses automatically.
Finally, slop and emergency storage tanks are used as a general collection point for the skimmed oil and any that may be collected in the central shaft, deck drains and pump-out connections on deck, and to deal with any situation where there is a danger of the field flow having to be interrupted. This situation may arise if all filling valves are closed accidentally or if a power failure occurs, stopping the water disposal pumps.
The emergency storage tank is kept as empty as possible by the two slop pumps, discharging into the filling manifold.
Thus a completely closed crude system is achieved, eliminating the danger of any pollution.

6. CONSTRUCTION, ASSEMBLY AND INSTALLATION

The construction of the Brent SPAR will take place at two locations.
The substructure, the actual storage section, will be built horizontally in a building dock at the Wilton-Feijenoord yard, and the superstructure, including turntable, will be fabricated by IHC Holland
Upon completion of these two components, the substructure will be towed horizontally to a deepwater location in a Norwegian fjord, where it will be upended by controlled flooding.
The superstructure, transported by barge, will be mounted by a heavy duty crane on top of the substructure.

The connecting of all systems of the above two parts and the commissioning of all systems will be done in the smooth waters of the fjord.
Finally, the completed SPAR will be towed vertically to Brent, where it will be anchored and where the submarine hoses linking underwater manifold and SPAR will be installed.



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