No. 16

IHC HOLLAND

OIL REPORT

IHC HOLLAND - OFFSHORE DIVISION - P O BOX 11 - SCHIEDAM

IHC

NEW DEVELOPMENTS

Mr. J. W. Billard

New offshore Consultants Company

J. W. Billard & Associates, Inc. — Offshore Consultants — an affiliate company of IHC Holland, Offshore Division, was recently formed. Mr. Billard was appointed president and chief executive officer. The new company has offices in Greenwich, Connecticut, and in Suite 616 of the Americana Building in Houston, Texas. J. W. Billard & Associates will specialize in international drilling and production operations providing the following services:

1. Provide management and technical personnel for guidance in the organization and management of drilling and producing operations.
2. Coordination of drilling requirements of several operators in an area to minimize mobilization and demobilization costs for equipment, personnel and materials. This service will provide optimum utilization of the drilling unit and all auxiliary services.
3. Provide petroleum engineering services in all phases of drilling and producing operations.
4. Provide guidance in the logistical requirements of drilling and producing operations.
5. Prepare economic analyses of established and potential oil or gas producing properties.
6. Prepare procedures for pollution prevention in drilling and producing operations.
7. Provide guidance in the selection of computer hardware facilities and development of appropriate programs for oil producing operations.

Mr. Billard was formerly Vice President of Union Carbide Petroleum Company. In this capacity he was in overall charge of the company's worldwide drilling, production, and acquisition activities. Prior to joining Union Carbide, he was employed by Amoco International Oil Company as Managing Director of Iran Pan American Oil Company in Teheran, Iran, and as worldwide production manager at Amoco's principal office in Chicago, Illinois. Mr. Billard is a graduate petroleum engineer and has a total of 24 years in the petroleum industry. Now, as president of the newly formed J. W. Billard & Associates, Inc. — Offshore Consultants — he will realize his ideas in the offshore brokerage philosophy, meeting present as well as future needs of the offshore oil industry.

Large Japan-built SEP

Kawasaki Heavy Industries, the Japanese licensees of IHC Holland, delivered recently a self-elevating platform to its owners Kajima Corporation.
The SEP, named *Kajima*, is one of the largest rigs in the world, having a length of 74 metres and a width of 45 metres.
The U-shaped platform, with the open end astern, facilitates construction work at the centre of the pontoon.
The *Kajima* is designed to cover all the civil marine construction projects planned in Japanese waters, including the construction of the Honshu — Shikoku bridge (one of the biggest marine construction projects in the world). The SEP can operate at temperatures down to minus 20 °C. The loading capacity is 2,400 tons, including a 100-ton crane, a crane girder and an MRB — 1500 piling hammer.

The *Kajima* can work continuously. The air-conditioned accommodation for 40 persons has a refrigerated store to provide against supply interruption due to stormy weather. The first job for the *Kajima* is the construction of a sea berth for 300,000 dwt tankers offshore Tomakomai on Hokkaido Island.

New order for IHC Holland-LeTourneau

Petrobrás, the Brazilian state oil company has placed an order for a $ 12 million jack-up mobile drilling platform with IHC Holland-LeTourneau Fabricators Ltd.
The rig will feature a unique hydraulic drive and control system for a continuously engaged and variable speed elevating system, and self-mobilizing 100 ft. leg sections. Construction will take place in the United States, at the Ingleside, Texas, facility of IHC Holland-LeTourneau.
Delivery is scheduled for the third quarter of 1973.
The unit is capable of drilling in a maximum water depth of 320 feet, and has three legs.

Noordwinning Oil-strike

The Noordwinning Group, in which IHC Holland has an interest, has announced the discovery of oil in Block K/13 on the Netherlands Continental Shelf, about 72 miles northwest of IJmuiden.
An application for a production license has been lodged with the Dutch Government.
Other members of the Noordwinning Group are Pennzoil Nederland (operator), AMAX Petroleum Co, Billiton Mij., Hoogovens, Wintershall A.G., Selection Trust Ltd. and Falcon Seaboard.

Appointment

Mr. Kerst Toxopeus LL.D., formerly marketing manager of IHC Gusto, has been appointed commercial manager of the IHC Offshore Division. In his new capacity Mr. Toxopeus is in charge of initiating new ventures of the Offshore Division, promoting joint ventures and in general expanding IHC's activities in the offshore field.

Mr. Kerst Toxopeus

IHC HOLLAND

OIL REPORT

No.16

IHC HOLLAND - OFFSHORE DIVISION - P O BOX 11 - SCHIEDAM

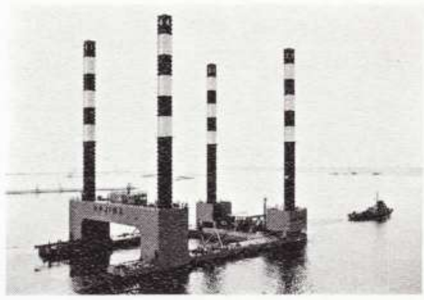
South East Asia:
L. v.d. Veen 84 Jalan Ampang Kuala Lumpur
Malaysia

IHC Holland (Australia) Pty Ltd
37/49 Pitt Street Sydney NSW 2000

New Developments

PAGE 2

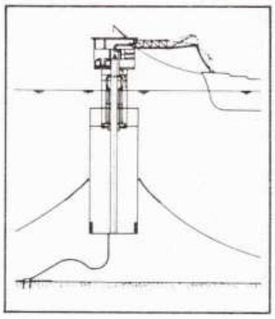
In Greenwich, Connecticut an affiliate company of IHC Holland – J. W. Billard & Ass. Inc. – recently formed an Offshore Consultants office.
IHC Holland's Japanese licensees Kawasaki delivered a SEP with the extreme length of 74 metres to Kajima Corporation.
Petrobrás ordered a $ 12 million jack-up rig with IHC Holland-LeTourneau, USA.
Noordwinning announced oil-strike in Block K/13 North Sea.
Mr. K. Toxopeus, commercial manager IHC Offshore Division.



New design of a floating storage and production unit

PAGE 4

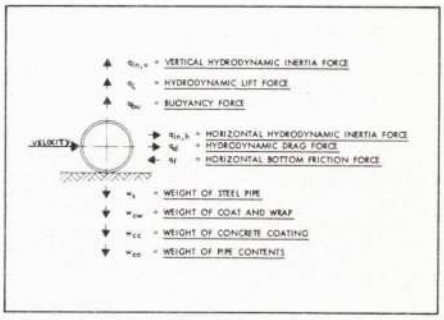
IHC Holland, in collaboration with S.I.P.M., has developed a floating storage and production unit, consisting of three vertical cylinders, mounted one on top of the other.



Pipeline design based on soils and environmental data

PAGE 8

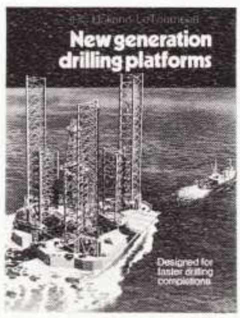
Part II of a paper entitled "How to assess the technical and economic aspects of a deep water pipeline" by Mr. Robert J. Brown, managing director of R. J. Brown and Associates. This member company of the IHC Offshore Division offer total capabilities in the engineering and management of both land and marine pipeline systems.



New generation drilling platforms

PAGE 16

IHC Holland-LeTourneau developed a new generation of self-elevating and self-mobilizing platforms. This New Generation provides efficient handling equipment, a unique hydraulic elevating and lowering system and new operational features to increase drilling efficiency and economy.



Front page

The IHC Holland built offshore crane "Orca" hoisting 800 tons at a radius of 90 ft.

A new design of a floating storage and production unit

By Ir. K. J. C. de Werk

Introduction

It is envisaged that energy requirements in the next few decades will be met from undersea sources and that the exploitation of oil wells will increasingly involve operations in deeper water and at greater distances from coasts.

Where it is necessary to create oil storage facilities in the vicinity of the well, the choice lies between the following arrangements, each of which has advantages and disadvantages:

1. storage beneath the seabed
2. storage on the seabed
3. floating storage on the surface
4. semi-submerged storage

The exploitation of an oilfield may be said to be a temporary undertaking in the sense that it may be terminated if the yield falls or, for whatever reason, the field ceases to fulfil the role allocated to it. This "temporary" aspect is among the factors which go to make up the four principal criteria in the development of a storage and production unit. These criteria are:

Fig. 1

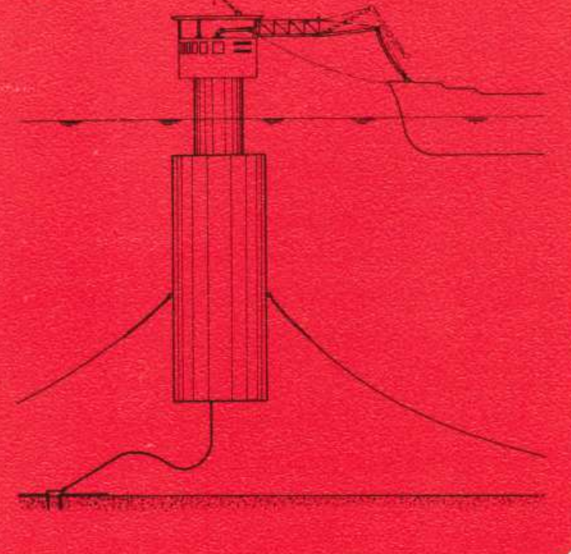
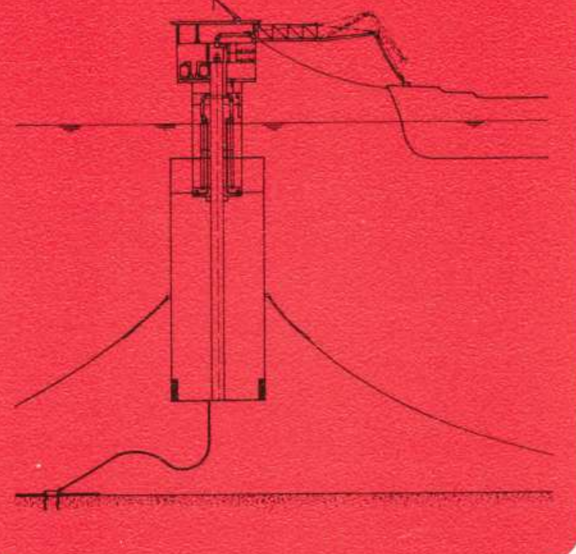


Fig. 2



Mobility: a mobile storage unit has great advantages over a fixed type.

Environmental factors: current, wind and wave forces, and water depth. A unit which, within certain limits, is independent of the conditions at the location affords considerably greater flexibility.
Here it is assumed that the unit meets certain requirements for behaviour in the seaway, and that the water depth at a future location would be equal to, or greater than, the design draught of the unit.

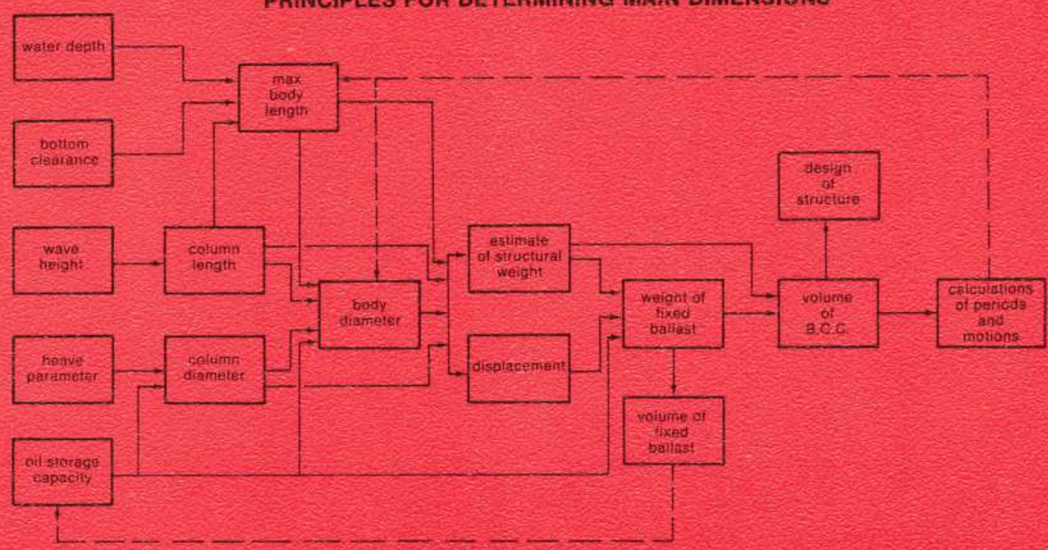
Cargo handling: the movement of the cargo from source to unit and, more important still, from unit to tanker.

Prevention of pollution: the importance of this factor needs no elucidation.

These criteria together add up to a closed storage

Fig. 3

PRINCIPLES FOR DETERMINING MAIN DIMENSIONS



unit which, when in position between seabed and surface, will be relatively unaffected by wind and waves.

IHC Holland, in collaboration with S.I.P.M., has developed just such a storage and production unit. Designated a storage spar, it is of the floating type and is anchored by 6 lines to the seabed.

General arrangement

Fig. 1 shows the general arrangement of the storage spar with a tanker moored to it.

The spar consists of three vertical cylinders, mounted one on top of the other.
The lowest cylinder, the body, forms the actual storage part.
The second cylinder, or vertical column, is situated in the area subjected to the wave forces.
Above the column is a third cylinder, the superstructure, in which are situated the production equipment, the control equipment and the crew's quarters.
On top of the superstructure are a helicopter deck and single point mooring facilities. These will be dealt with later.

The spar has been designed with a constant draught in both the loaded and ballasted conditions.
This implies that the weight of the cargo of oil must be equal to the weight of the seawater ballast.

Because of the difference between the specific gravities of oil and seawater, not all the compartments destined to hold oil may be filled with seawater in the ballasted condition. Some compartments, the "Buoyancy Control Compartments", remain empty in the ballasted condition but contain oil in the loaded state.

At a very early stage of the design, storage compartments with openings at the bottom, via which seawater could be allowed to enter, were considered. However, in order to eliminate any risk of pollution, this arrangement was abandoned in favour of totally-enclosed compartments. The oil storage capability was and is based on the principle of displacement.

The change in design approach does not affect the principle on which the unit operates, but it does have consequences for the method of dealing with the cargo.

Oil handling

The oil flows from the manifold on the seabed via flexible hoses outside and riser pipes inside the storage unit to the production equipment in the superstructure (see Fig. 2). After degassing and other treatments, the oil is distributed over the storage compartments and the Buoyance Control Compartments.

Every few days a shuttle tanker loads the oil from the spar and takes it ashore. During the transfer of cargo, the tanker is moored by a bow hawser to the spar which, like an SBM, is equipped with a single point mooring. This enables the tanker to swing freely around the spar and to adopt the most favourable position in relation to wind, waves and current.
By bringing in seawater and pumping out the oil, the oil will flow to the tanker, via the unloading system.

Like a single point mooring system, the spar is equipped with a turntable, mounted on the top of the superstructure, and incorporates a retractable unloading boom.

The tanker is equipped with a bow manifold.

The unloading boom consists of four parts:
a turntable, which is partly extended to the superstructure edge.
a part which can rotate in a horizontal plane, but which is fixed during unloading operations
a part able to swing in a vertical plane
a flexible hose

The cargo is transferred via the boom, which has an outreach of about 40 metres.
A loading boom is clearly preferable to a system employing floating hoses.

Principles for determining the main dimensions

The behaviour of a floating structure in waves forms the principle requirement for the design of the unit.

Fig. 4

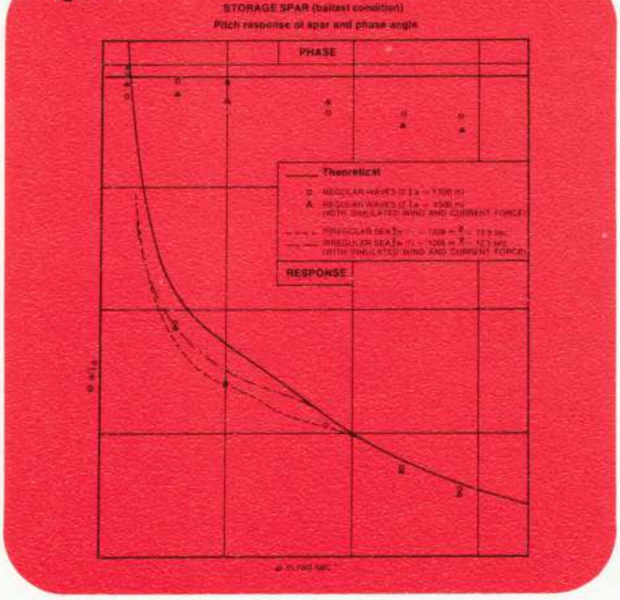
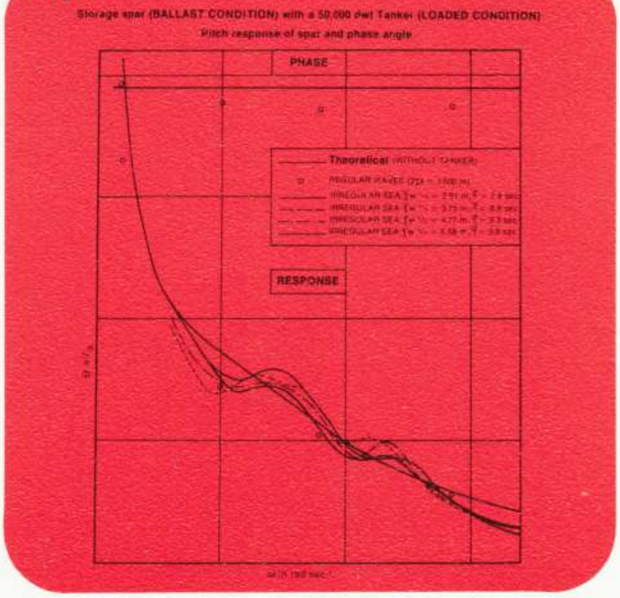


Fig. 5



Generally speaking, two main conditions are envisaged:
First: The tanker must be able to moor and to remain connected to the spar in given operational weather conditions.
Second: In severe weather conditions (normal practice is to take 100-year-storm condition), the spar must remain safely anchored on location without a tanker. See fig. 3.

Starting with the criterion of the wave height, and provided that information is available on the relative vertical motions in that state of sea, the length of the vertical column can be determined.

The underwater part of the column, the water depth and the required clearance between base and seabed together determine the maximum length of the body.
The heave parameter forms an indication for the determination of the column diameter.
The body length having been determined, the storage capacity and the volume required for fixed ballast together determine the diameter of the body.

A design for a floating structure must conform to two laws:
the equilibrium of Volumes
the equilibrium of Weights

The dimensions having been determined, the design must be evaluated until it meets these laws.

A unit designed on this basis will be far from optimal.

The behaviour in seaway depends first and foremost on the shape of the body and the GM value, the metacentric height or the distance between the metacentre and the centre of gravity.
The two variable factors, namely the shape and the GM value, may be investigated in order to optimize the behaviour.
The shape of the unit can be changed in the first place by the choice of another body length.

To establish the GM value, we have to distinguish the two operational states of the unit:
the fully loaded condition
the ballasted condition

In the loaded condition, the centre of gravity may be influenced by removing part of the weight of the fixed ballast from the body and replacing this by oil stored in the vertical column.
In the ballasted condition, we may influence the centre of gravity by varying the position of the Buoyancy Control Compartments.
By these means it is possible to find an optimal alternative from the point of view of behaviour in seaway.

The analysis of the behaviour can be broken down into analyses of the static problem and of the dynamic problem.

The static problem is controlled by the weight and buoyancy of the structure, by the environmental loads of wind and current, and by the anchorline restraints which keep the structure on location.
The dynamic problem is controlled by the unsteady loads, primarily the wave forces and the dynamic response of the structure.

A comparison between the graphs in Figs. 4 and 5, representing the transfer functions for the pitch response of the spar with and without the moored tanker, shows that the oscillating motions of the spar are not affected by the bow hawser force of the tanker.
Model experiments also indicated that these motions are not affected by the anchoring system or by static offset from its zero position.
Another conclusion which can be drawn from the figures is that there is a great similarity between calculation and experiment.
With an analytical method it is possible to calculate the behaviour in any weather condition with suitable accuracy.

Fabrication, assembly and recovery

The storage spar will be constructed in two parts which will subsequently be joined at the location.

One part consists of the two lower cylinders and the other of the superstructure.
The lower cylinders can be constructed on a slipway or in a drydock. In either case they are constructed in the horizontal position.
The cylinder is built up from a large number of identical sections. Depending upon the facilities at the yard, these can be joined in advance to form larger sub-assemblies, or the cylinder can be built up from single sections.

After launching, the cylinder body is towed into sufficiently deep water to enable the permanent ballast to be installed. While these operations are in progress, the superstructure is built and all the equipment installed.

The superstructure is an independent, buoyant assembly.
Body and superstructure can be towed separately to the location.
There, the body is secured to two anchoring wires, whereupon preparations can be made for the upending procedure.
Fig. 6 gives an impression of the towing and upending phase.

The two lower cylinders (the body and the vertical column respectively) are divided by radial bulkheads to form six oiltight compartments.
This sub-division into longitudinal compartments is necessary for strength and for stability during towing, and is indispensable for the upending operation. During the last-named, it permits filling of the lowest compartments with water and ballasting of the vertical column, which is in the horizontal position at that moment.
When the compartments concerned are completely filled with seawater, the structure settles to a nearly uniform draught over the whole length of the body.
The upper tanks are then opened, whereupon the actual upending procedure is carried out and the structure assumes its vertical position.

The final operation is to join the body and the superstructure. This can be done in several ways.

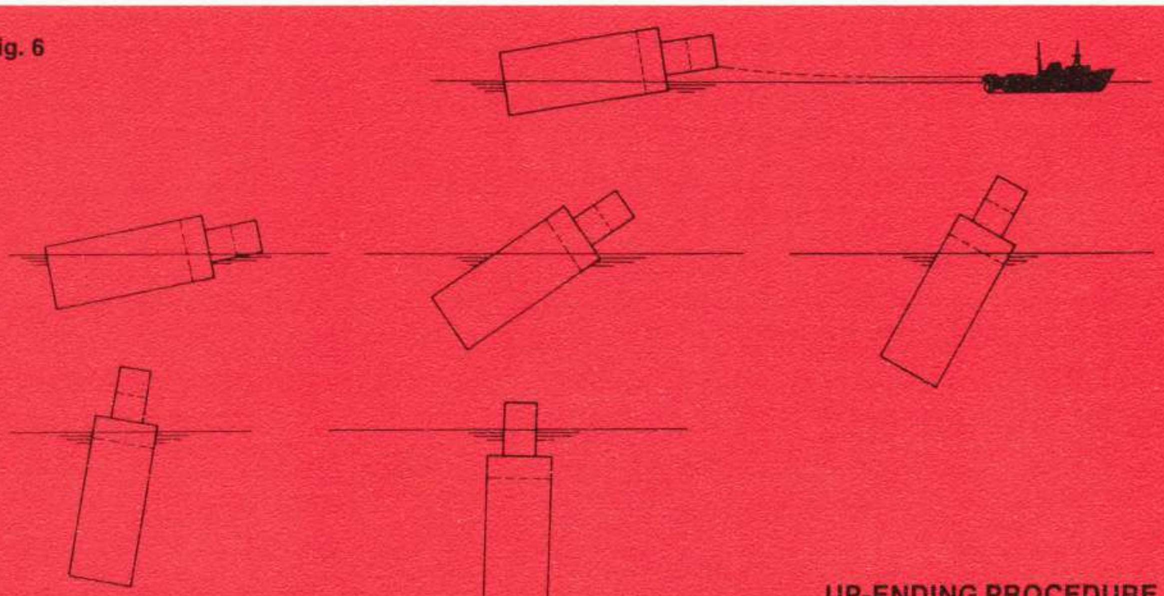
The simplest is to submerge the body vertically to a depth at which the floating superstructure can be towed into position above it with a sufficient clearance. The ballast is then pumped out and the spar rises to meet the superstructure.

For the recovery of the unit, where necessary, the upending procedure is reversed.

Alternative methods of assembly are possible, for example with the aid of the large cranes now widely used in offshore operations.

Towing may be done without fixed ballast in cases where the draught of the unit would otherwise exceed the water depth in the harbour. The ballast must, of course, be placed in the compartments concerned on arrival at the location.

Fig. 6



UP-ENDING PROCEDURE STORAGE SPAR

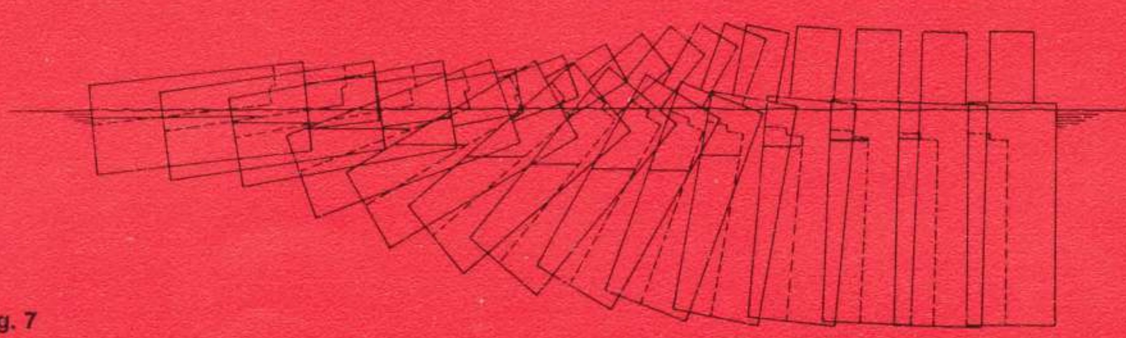


Fig. 7

Deep water pipelines Part II

Pipeline design based on soils and environmental data

How to assess the technical and economic aspects of a deep water pipeline

by Mr. R. J. Brown

Introduction

PART I of this paper described in detail how physical measurements of the soils and the environment were obtained (see Oil Report No. 15).
This data was refined into the expected environment and soils properties for the period of construction and lifetime use. With this information the pipeline can now be designed to assure its stability during both of these periods. When installing by lay barge, the pipeline is exposed to the construction environment in empty state for between one and four months, in which it is suspended from the surface and transits mid-depth before reaching bottom. There is a brief period while it is on the bottom that the pipeline is empty and its exposure includes the currents associated with the lunar tidal conditions. After the pipeline goes into operation, it is filled with oil or gas which makes it heavier. The consideration then is for lifetime design conditions. The pipeline under this condition can be resting on the bottom, spanned above the bottom or buried.

Hydrodynamic forces on a submarine pipeline

One of the stability considerations is the sliding and pipe lift-off that is associated with the passage of a current over the pipeline which induces both drag and lift (see Figure II-1). This pipeline is similar to the wing of an airplane upon which, because of differential pressure system around the wing, lift and drag forces are induced. The pipeline is a much less efficient airfoil, therefore the lift force is less than that induced by a wing, but the drag force is greater.

A computer program has been developed for indicating the pipe stability with respect to weight, concrete thickness, sliding friction factor which is expressed in terms of current at which sliding will occur. Figure II-2A and II-2B are a typical output for static and dynamic stability. The top portion of the computer output for static stability is a computation of the dry weight, displacement, submerged weight corresponding to different thicknesses of concrete jacket around the pipe. The lower portion of the computer output defines current at which sliding will occur in terms of concrete thickness and sliding friction factor. Figure II-2C is a typical representation of sliding and lift-off instability of a pipeline.

Figure II-1

HYDRODYNAMIC FORCES ON A SUBMARINE PIPELINE

THIS PRØGRAM CØMPUTES AND PRINTS
PIPE PRØPERTIES AND CURRENTS RESULTING IN SLIDING AS
A FUNCTIØN ØF CØNCRETE JACKET THICKNESS AND FRICTIØN FACTØR

GIVEN DATA

ØUT DIAM,IN	DC+W,LB/FT3	DC+WIN,LB/FT3	DCØNC,LB/FT3
20	115	0	190
WALL THICK,IN	THICKC+W,IN	THICKC+WIN,IN	DCØNT,LB/FT3
.5	.1875	0	0

CØNC JACKET THICKNESS INCHES	** PIPE PRØPERTIES ** DRY WT LB/FT	BUØYANCY LB/FT	SPEC GRAV ---------	SUB WT LB/FT
0	113.637	145.364	.781738	-31.7275
1	202.239	175.303	1.15366	26.9368
1.125	213.898	179.242	1.19335	34.6558
1.25	225.685	183.225	1.23174	42.4605
1.375	237.603	187.252	1.2689	50.3511
1.5	249.65	191.322	1.30486	58.3273
1.625	261.826	195.437	1.3397	66.3894
1.75	274.132	199.595	1.37344	74.5372
1.875	286.567	203.796	1.40614	82.7708
2	299.132	208.042	1.43784	91.0901
2.125	311.827	212.332	1.46858	99.4953
2.25	324.651	216.665	1.4984	107.986
2.375	337.604	221.042	1.52733	116.563
2.5	350.688	225.462	1.55542	125.225

CØNC JACKET THICKNESS INCHES	** CURRENTS RESULTING IN SLIDING -- FT/SEC ** FØR A FRICTIØN FACTØR ØF ** .5	.75	1	1.25
0	-11111	-11111	-11111	-11111
1	2.13815	2.47415	2.7149	2.89813
1.125	2.4118	2.7908	3.06236	3.26904
1.25	2.65497	3.07218	3.37112	3.59864
1.375	2.87548	3.32735	3.65112	3.89753
1.5	3.07827	3.56201	3.90861	4.17241
1.625	3.26671	3.78005	4.14788	4.42782
1.75	3.4432	3.98428	4.37197	4.66704
1.875	3.60954	4.17676	4.58319	4.89251
2	3.76713	4.35911	4.78328	5.10611
2.125	3.91706	4.5326	4.97365	5.30933
2.25	4.06022	4.69826	5.15543	5.50337
2.375	4.19734	4.85693	5.32954	5.68923
2.5	4.32902	5.0093	5.49674	5.86772

***** WHEN THE DIGITS -11111 APPEAR IN THE SØLUTIØN IT MEANS THAT THE PIPELINE FLØATS DUE TØ ITS PØSITIVE BUØYANCY AND,CØNSEQUENTLY NØ FURTHER CALCULATIØNS ARE PERFØRMED.

TYPICAL COMPUTER OUTPUT OF
A STATIC STABILITY OF A PIPELINE
FIG. II-2 A

THIS PRØGRAM CØMPUTES AND PRINTS
THE DYNAMIC SPECIFIC GRAVITY ØF A PIPELINE AS A FUNCTIØN ØF
CØNCRETE JACKET THICKNESS AND CURRENT VELØCITY

GIVEN DATA

ØUT DIAM,IN	DC+W,LB/FT3	DC+WIN,LB/FT3	DCØNC,LB/FT3
20	115	0	190
WALL THICK,IN	THICKC+W,IN	THICKC+WIN,IN	DCØNT,LB/FT3
.5	.1875	0	0

CURRENT VELØCITY FT/SEC	** DYNAMIC SPECIFIC GRAVITY ** FØR A CØNCRETE JACKET THICKNESS ØF -INCH- ** 0	1	1.125	1.25
0	-11111	1.15366	1.19335	1.23174
1	-11111	1.14465	1.18443	1.22292
1.5	-11111	1.13553	1.17541	1.214
2	-11111	1.12142	1.16147	1.20021
2.5	-11111	1.10329	1.14353	1.18247
5	-11111	-11111	-11111	1.03466
7.5	-11111	-11111	-11111	-11111
10.5	-11111	-11111	-11111	-11111
13.5	-11111	-11111	-11111	-11111

DYNAMIC SPECIFIC GRAVITY	** CURRENT VELØCITY -- FT/SEC ** FØR A CØNCRETE JACKET THICKNESS ØF -INCH- ** 0	1	1.125	1.25
1.0	-11111	4.12881	4.92527	5.42186

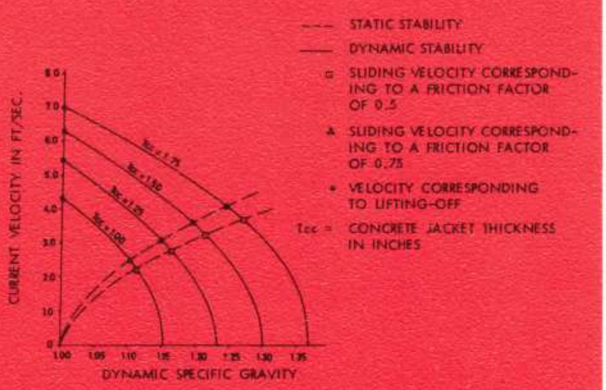
CURRENT VELØCITY FT/SEC	** DYNAMIC SPECIFIC GRAVITY ** FØR A CØNCRETE JACKET THICKNESS ØF -INCH- ** 1.5	1.75	2	2.5
0	1.30486	1.37344	1.43784	1.55542
1	1.29624	1.365	1.42957	1.54747
1.5	1.28751	1.35645	1.4212	1.53943
2	1.27401	1.34323	1.40825	1.52699
2.5	1.25665	1.32624	1.39161	1.511
5	1.112	1.18462	1.25289	1.37775
7.5	-11111	-11111	1.0217	1.15567
10.5	-11111	-11111	-11111	-11111
13.5	-11111	-11111	-11111	-11111

DYNAMIC SPECIFIC GRAVITY	** CURRENT VELØCITY -- FT/SEC ** FØR A CØNCRETE JACKET THICKNESS ØF -INCH- ** 1.5	1.75	2	2.5
1.0	6.28632	7.03155	7.69307	8.84055

***** WHEN THE DIGITS -11111 APPEAR IN THE SØLUTIØN IT MEANS THAT THE PIPE HAS PØSITIVE BUØYANCY AND CØNSEQUENTLY NØ FURTHER CØMPUTATIØNS ARE MADE,ØR THAT THE -DSG- IS SMALLER THAN ØNE.

TYPICAL COMPUTER OUTPUT OF
DYNAMIC STABILITY OF A PIPELINE
FIG. II-2 B

Figure II-2C



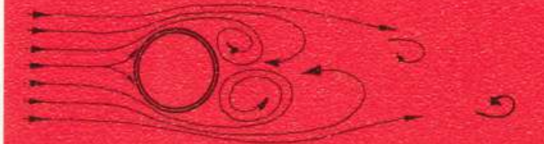
STATIC AND DYNAMIC STABILITY

Spans

Because of bottom roughness conditions, the pipeline, when installed, will have spans between high places of the marine bottom. Analysis of these spans in terms of allowable span lengths is required with respect to the construction and lifetime currents. The analysis of the span length is complicated from the standpoint of vortex formation and shedding, when a current flows across a pipeline. At certain velocities, the vortex shedding can match the natural frequency of the pipe. This situation occurs more frequently than originally anticipated, because of the pipe movement exciting a vortex shedding frequency, which matches the natural frequency of the pipe. One of the complicating factors is that this phenomenon varies with pipe span length. Figure II-3 indicates the sequence of vortex shedding.

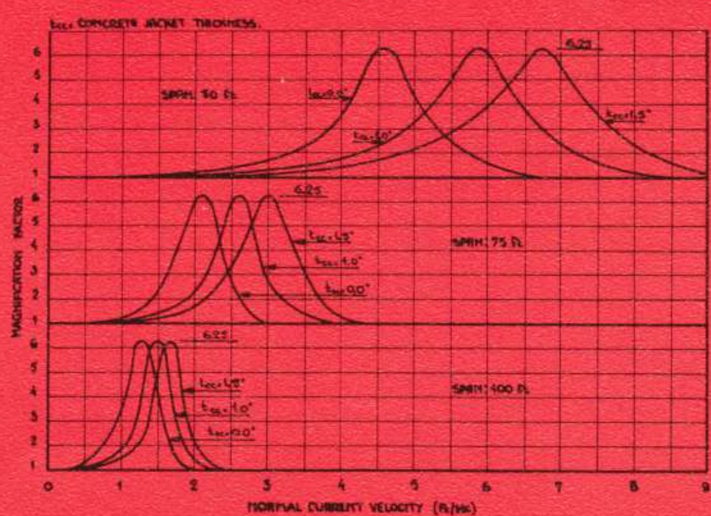
The forces induced by this shedding are alternating, vertically upwards and downwards. The drag forces associated with this shedding are fairly consistent. The approach for solving this problem is to first calculate the magnification of the pipeline stress in terms of span length and velocity. Figure II-4 represents the typical magnification of the bending stresses. Figure II-5A and II-5B respectively indicate the typical output showing allowable span lengths in terms of current velocity. Figure II-5C is the graphical representation of allowable spans based on resonant motion and bending stress.

Figure II-3



VORTEX SHEDDING

Figure II-4



TYPICAL MAGNIFICATION OF BENDING STRESS

THIS PRØGRAM CØMPUTES AND PRINTS
MAXIMUM ALLØWABLE SPAN LENGTHS
FØR A SUBMERGED PIPELINE AS A FUNCTIØN ØF
CØNCRETE JACKET THICKNESS,CURRENT VELØCITY
AND END CØNDITIØNS

GIVEN DATA

ØUT DIAM,IN	DC+W,LB/FT3	DC+WIN,LB/FT3	DCØNC,LB/FT3	C
20	115	0	144	.734
WALL THICK,IN	THICKC+W,IN	THICKC+WIN,IN	DCØNT,LB/FT3	
.5	.1875	0	0	

CURRENT VELØCITY FT/SEC	** MAXIMUM ALLØWABLE SPAN LENGTH -- FEET ** ** FØR A CØNCRETE JACKET THICKNESS ØF -INCH- ** 0	1	1.25	1.5
0	-11111	9999999	9999999	9999999
.5	-11111	288.61	289.996	291.757
1	-11111	204.063	205.044	206.289
1.5	-11111	166.613	167.413	168.431
2	-11111	144.289	144.983	145.863
2.5	-11111	129.055	129.675	130.463
3	-11111	117.81	118.376	119.096
3.5	-11111	109.071	109.595	110.261
4	-11111	102.026	102.516	103.139
4.5	-11111	96.191	96.6531	97.2404

CURRENT VELØCITY FT/SEC	** MAXIMUM ALLØWABLE SPAN LENGTH -- FEET ** ** FØR A CØNCRETE JACKET THICKNESS ØF -INCH- ** 1.75	2	2.25	2.5
0	9999999	9999999	9999999	9999999
.5	293.836	296.186	298.769	301.556
1	207.759	209.421	211.248	213.219
1.5	169.631	170.988	172.48	174.089
2	146.903	148.078	149.37	150.763
2.5	131.393	132.444	133.6	134.846
3	119.945	120.904	121.959	123.097
3.5	111.047	111.935	112.912	113.965
4	103.874	104.705	105.619	106.604
4.5	97.9335	98.7169	99.5782	100.507

***** WHEN THE DIGITS -11111 APPEAR IN THE SØLUTIØN IT MEANS THAT THE PIPE HAS PØSITIVE BUØYANCY AND,CØNSEQUENTLY NØ FURTHER CALCULATIØNS ARE PERFØRMED.THE DIGITS 9999999 MEAN THAT FØR THE VALUE V=0 THE -MAXIMUM ALLØWABLE SPAN LENGTH- HAS NØT BEEN CØMPUTED SINCE IT TENDS TØ INFINITY.

TYPICAL COMPUTER OUTPUT OF
MAXIMUM ALLOWABLE SPANS
BASED ON RESONANT MOTION
FIG. II-5 A

THIS PRØGRAM CØMPUTES AND PRINTS
MAXIMUM ALLØWABLE SPAN LENGTHS
AS A FUNCTIØN ØF BENDING STRESS

ØUTDIAM,IN	DC+W,LB/FT↑3	DC+WIN,LB/FT↑3	DCØNC,LB/FT↑3	YIELD,PSI
20	115	0	144	60000
WALL THICK,IN	**THICKC+W,IN**	**THICKC+WIN,IN**	**DCØNT,LB/FT↑3**	**PCTYLD**
.5	.1875	0	0	60

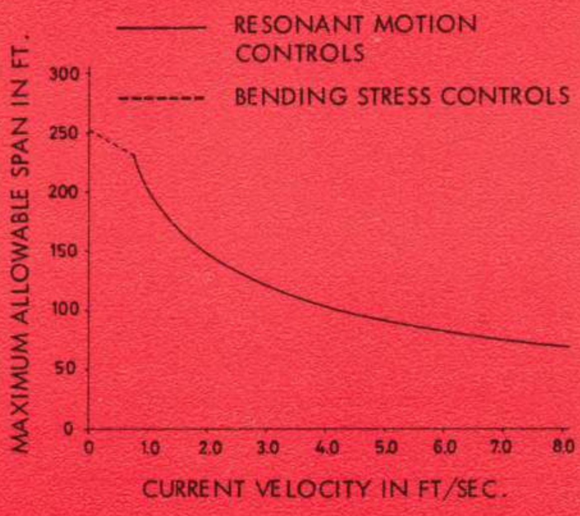
CURRENT VELØCITY FT/SEC	MAXIMUM SPAN LENGTH FEET TCC,IN=0.000	1.000	1.250	1.500
0	-1111	798.363	477.53	371.035
.5	-1111	791.562	455.228	367.276
1	-1111	762.755	465.37	331.464
1.5	-1111	677.457	457.249	353.496
2	-1111	568.432	435.339	348.98
2.5	-1111	474.273	401.577	336.593
3	-1111	402.008	362.684	317.97
3.5	-1111	347.228	324.969	295.612
4	-1111	304.983	291.465	272.29
4.5	-1111	271.652	262.79	249.972
5	-1111	244.775	238.53	229.626
5.5	-1111	222.682	217.994	211.53
6	-1111	204.218	200.509	195.606
6.5	-1111	188.565	185.505	181.632
7	-1111	175.132	172.523	169.353
7.5	-1111	163.48	161.197	158.523
8	-1111	153.278	151.24	148.929

CURRENT VELØCITY FT/SEC	MAXIMUM SPAN LENGTH FEET TCC,IN=1.750	2.000	2.250	2.500
0	313.039	275.159	247.892	227.034
.5	311.11	273.907	246.987	226.337
1	298.909	268.441	243.574	223.899
1.5	275.31	244.933	234.258	218.363
2	290.217	234.205	201.221	205.475
2.5	287.588	247.066	202.034	169.059
3	279.078	245.879	214.48	175.397
3.5	266.465	239.712	214.612	188.195
4	251.259	230.426	210.193	189.646
4.5	234.994	219.189	203.146	186.707
5	218.879	207.02	194.496	181.371
5.5	203.654	194.73	185.021	174.608
6	189.667	182.86	175.315	167.074
6.5	177.012	171.715	165.792	159.248
7	165.647	161.428	156.706	151.463
7.5	155.465	152.023	148.189	143.933
8	146.34	143.466	140.292	136.785

***** WHEN THE DIGITS -1111 APPEAR IN THE SØLUTIØN
IT MEANS THAT THE PIPE HAS PØSITIVE BUØYANCY
AND,THEREFØRE NØ FURTHER CALCULATIØNS ARE MADE.

TYPICAL COMPUTER OUTPUT OF
MAXIMUM ALLOWABLE SPANS
BASED ON BENDING STRESS
FIG. II-5 B

Figure II-5C



MAXIMUM ALLOWABLE SPANS

It is interesting to note that with no currents the static stress in the simply supported beam controls the allowable span length.
When the current velocity across the pipe reaches a certain value, then the vortex shedding and stress amplification controls the allowable span length. This evaluation is prepared after the initial determination of the pipe weight with respect to drag and lift forces with the pipeline resting on the bottom.

Bottom stability

After the currents are established for the period of construction and lifetime, the soils stability of the bottom is determined from the soils erosion factor test mentioned in PART I. There are two considerations for bottom stability:

The first is the erosion characteristics of the soils in terms of the lifetime design current. If it is anticipated that the general bottom will erode, then pipeline burial below this scour depth is required.

The second consideration is the effect of the pipeline as an obstruction, on the soils stability. With the pipeline resting on the bottom, there is a break in the equilibrium condition because of the associated vortices which cause localized erosion immediately downstream of the pipeline. (See Figure II-6 for a typical erosion pattern induced by the vortex circulation downstream of the pipe).

In the cases that indicate a general erosion of the area or localized erosion near the pipeline, stabilization is required. The forms of stabilization can include obstructions set upstream of the pipeline to affect the stream flow across the pipeline. Also various types of spoiler configurations, for modifying the vortex downstream of the pipeline and/or pipe burial can be adopted. The above factors are considered for the bottom stability from the standpoint of erosion of the soil.

Another type of soil failure, which is of equal importance, is the bottom instability in terms of liquefaction

Figure II-6

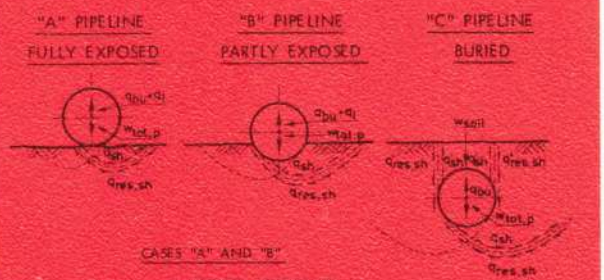
TYPICAL EROSION PATTERN

of the soils. If the liquefaction is a problem the pipeline is to be designed so, that it will remain stable in this heavy density fluid. Figure II-7 indicates the type of soil failures that will occur when the shear strength of the soil is reduced or eliminated and the pipe will move up or down in this heavy density liquid. As described in PART I, the heavy density liquid is estimated by the Atterberg limit tests for clays and by the hydrometer test in coarser grained soils such as sands.

Bottom stability in vicinity of spans

Another element of consideration that is equally important is the bottom soils stability in the vicinity of pipe spans. When the pipe is not resting on the bottom, there is additional negative pressure caused by flow under the pipeline. Figure II-8 indicates the pressure differential diagram around the pipe in which a large negative pressure is induced beneath the pipe. The cause of this negative pressure is the venturi effect that is induced by high currents immediately beneath the pipe. This combination of higher currents plus additional negative pressure causes soils, that would otherwise be stable, to become unstable. This instability is followed by erosion of the soil beneath the pipe. At this point one would assume that this is a good condition, since the entire pipeline system would literally dig itself in. This is correct if the bottom soils are of the same homogeneous consistency. This very seldom is the case. Therefore, as pipeline systems become older, it is noted that span lengths increase over the first several years until the span length reaches its maximum.

Figure II-7



CASES "A" AND "B"

$w_{tot,p} < q_{bu} + q_L \longrightarrow$ VERTICAL INSTABILITY

$w_{tot,p} > q_{bu} + q_L \longrightarrow$ PIPELINE STABLE, PROVIDED THAT $q_{sh} < q_{res,sh,ult}$

w_{soil} = WEIGHT OF OVERBURDENING SOIL (LBS/FT)

$w_{tot,p}$ = WEIGHT OF PIPELINE & CONTENTS (LBS/FT)

q_{bu} = BUOYANCY OF PIPELINE (LBS/FT)

q_L = LIFT OF PIPELINE DUE TO CURRENT (LBS/FT)

q_{sh} or q'_{sh} = SHEAR FORCE IMPARTED TO SOIL (LBS/FT)

$q_{res,sh}$ or $q'_{res,sh}$ = SHEAR RESISTANCE OF SOIL DUE TO APPLIED SHEAR FORCE (LBS/FT)

CASE "C"

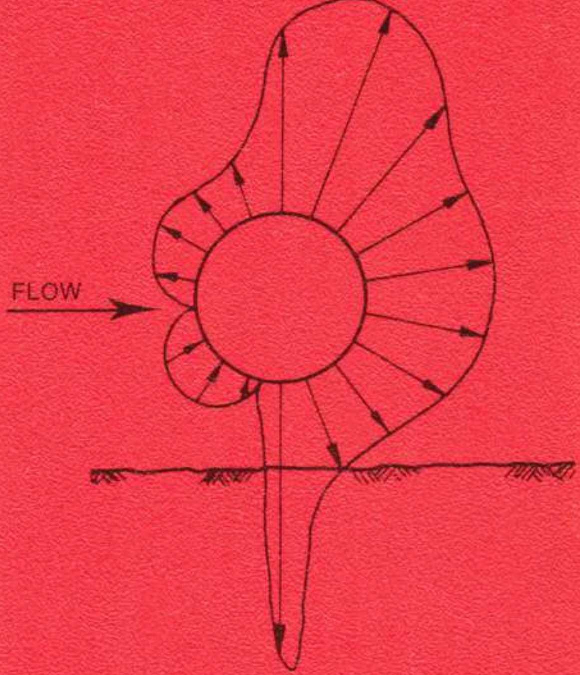
$w_{tot,p} > q_{bu} \longrightarrow$ PIPELINE STABLE, PROVIDED THAT $q_{sh} < q_{res,sh,ult}$

$w_{tot,p} < q_{bu} < w_{tot,p} + w_{soil} \longrightarrow$ PIPELINE STABLE, PROVIDED NO LIQUEFACTION OCCURS

$w_{tot,p} + w_{soil} < q_{bu} \longrightarrow$ PIPELINE STABLE, PROVIDED THAT $q'_{sh} < q'_{res,sh,ult}$

SOIL FAILURES BY REDUCED SHEAR STRENGTH OF SOIL

Figure II-8



PRESSURE DIFFERENCE AROUND THE PIPE

The factors that limit the span lengths are such items like, a change in the cohesive properties of the soil or reaching rock or very stiff clay soils. This is the reason that it is normally recommended that surveys be completed during the years immediately following the installation to determine this increase in span length. For example, for a pipeline laid on the bottom, after five years of operation, it was found that for every 15 feet installed, 1 foot was spanned. Initially, the value was for every 35 feet installed, with 1 foot spanned.

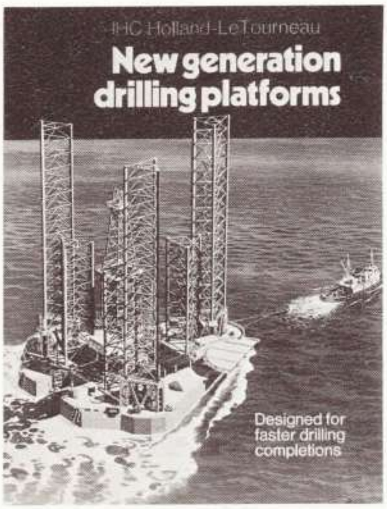
The important factor here is that the span lengths do not reach the critical absolute maximum at which overstressing and pipe fatigue failure occurs.

Conclusions

The state-of-the-art has been developed that permits complete analysis and design of the pipeline for the periods of construction and lifetime use. This analysis is similar to that for the engineering required for a bridge or building, in which the environment and soils conditions are determined and the structure is designed to be stable during both the period of construction and for lifetime expectancy.

This article on design consideration follows Part I which discussed the environmental analysis and which was published in issue no. 15 of this magazine.

NEW GENERATION DRILLING PLATFORMS



Two well-known identities in marine structures formed IHC Holland-LeTourneau Marine Corporation in 1971 to develop and manufacture offshore drilling platforms for more efficient drilling and relocation operations. They are IHC Holland, world leader in shipbuilding for more than a century, and Richard L. LeTourneau, known throughout the petroleum industry for his major participation in the development and application of self-elevating platforms since 1954 and now self-mobilizing platforms.

When you arrive at the drill site, your regular drilling crew places the unique hydraulic system in operation and in record time elevates your New Generation platforms smoothly and prepares to drill

The additional leg sections you need for the water depth at the drill site have been stored on deck in a vertical position. Your regular crew moves them into position, connects them and elevates the platform to a stabilized drilling position.

Versatile self-mobilization equipment takes over

The New Generation approach provides efficient handling equipment operated by your regular crew for fast, safe positioning and connecting of leg units in economical section lengths—up to 100′ and more. The tedious, time-consuming, expensive cutting and welding of numerous short leg sections are eliminated.

New Generation hydraulic system gives precise, continuous jack-up control

The infinite and higher speed variations of the IHC Holland-LeTourneau continuous hydraulic elevating and lowering system for the platform permit precision adjustments under load. Bottoming and stabilizing the footings under adverse conditions are accomplished more easily with the New Generation hydraulic system.

After spudding in and you want to handle drill pipe, casing, B.O.P. stacks and other heavy equipment, the New Generation platform provides more convenience, capacity and flexibility than conventional platforms

From the beginning, the objective of the drilling-oriented IHC Holland-LeTourneau design team has been to develop a new generation of platforms incorporating new operational features to increase drilling efficiency and economy.

The driller has more work area on deck

The open deck is planned for drilling operations, with more open deck for efficient, orderly organization of drill pipe, supplies, handling machinery, auxiliary equipment and controls or other things you may want to do.

The derrick provides a larger racking area

The derrick designed for the New Generation platform has the capacity for more and longer sections of pipe and casing—speeding drilling operations and cutting labor time.

When you need to relocate, your regular crew will have you afloat and under tow with minimum standby time

The self-mobilization equipment of a New Generation platform is operated by your regular crew to disconnect the leg sections. Each leg section is moved to its designated storage and transport position on deck by the versatile and powerful handling machinery. Depending on the water depth, you can tailor leg lengths to fit your requirements—economically!