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TRANSACTIONS (TM)

REMOVAL OF OFFSHORE PLATFORMS

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FOREWORD

The Engineering Committee on Oceanic Resources (ECOR) was founded in 1970 for the purpose of providing an international focus for non-governmental professional engineering interests in marine affairs. The organization holds non-governmental observer status within the International Maritime Organization (IMO).

The British Committee for ECOR (BC–ECOR) represents the UK professional engineering interests in ECOR. The members of BC–ECOR include the major professional engineering institutes, some equivalent bodies, and the Department of Trade and Industry, Department of Energy and the Engineering Council as observers.

The Working Group on the Marine Environment was initiated in 1982. After an initial brief consideration of dumping operations, the Group concentrated its efforts on the technical aspects of the removal of oil installations upon completion of their useful lives.

Although originally intended as an ECOR International Working Group, ECOR Council decided that such a subject should be considered in the national context. BC–ECOR pursued its initiative on this basis.

The report produced by the BC–ECOR Working Group (Mr S. Nicholls, Mr N. G. Boyd, Dr F. Ramzan and Mr F. E. Toolan) has been compiled. The three papers presented here are intended to promote discussion on this important subject.

Platform Removal—a Review of the Task

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SYNOPSIS

The legal obligations which may apply when offshore platforms have achieved their original purpose are not yet precisely defined. This paper reviews briefly the present understanding which will affect the fate of these platforms. The paper defines and describes the options that exist and notes the effect of following a particular option. These include complete or partial removal, abandonment and converting to another use. It also discusses the removal of the large concrete gravity structures. The magnitude of the costs of exercising any of the options is noted, together with the difficulty of estimating for events some way in the future.

LEGAL OBLIGATIONS

The BC–ECOR report on abandonment of offshore installations and papers by Hill and Butler presented at the ESC conference in July 1985 discussed in some detail the legal aspects and the UK Government's position concerning platform abandonment. It is proposed only to summarize the understanding at the time of writing in this paper.

Although the Geneva Convention on the Continental Shelf of 1958 required that offshore installations be entirely removed when abandoned or disused, the Law of the Sea Convention of 1982 indicated a consensus for relaxing the requirement. This would require that installations or structures that have been abandoned or disused should be removed to ensure safety of navigation, with due regard to fishing, protection of the marine environment and the rights and duties of States other than the Coastal State under whose jurisdiction the installation falls.

It is anticipated, under the 1982 Convention, that standards for abandonment to ensure safety of navigation should be established by the 'competent international organization', generally agreed to be the International Maritime Organization. The 1982 Convention has yet to be ratified.

THE BRITISH SECTOR

The British Sector of the North Sea, that is to say the sector designated as British for the exploration, development and ownership of hydrocarbon resources, may be divided into three areas: the Southern basin, roughly south of a line drawn eastward from the Humber; the Central basin, south of Aberdeen; and the Northern basin, extending northward from Aberdeen. In addition, British jurisdiction covers areas on the Continental shelf north west of Shetland, West of Scotland, roughly half way across the Irish Sea and the Channel.

The Southern basin of the North Sea contains most of the dry gas fields (and the oldest platforms) and the Central and Northern basins contain mainly oil fields.

John Antonakis, after 18 years of land and coastal based civil engineering, began working on offshore structures in 1962 with the concrete gravity Kish Bank Lighthouse and the Royal Sovereign Light Tower in 1966. Work for the oil and gas industry followed from 1971, concerning steel jackets and topside structures for the North Sea, Middle East and Brazil. He has taken part in a detailed abandonment study and has addressed the technical aspects at the ESC seminars in 1983 and 1985, as well as taking part in discussions with government officials on behalf of the industry. He is chairman of the SUT's Group on Environmental Forces and a member of the I.Mech.E's Ocean Engineering Group. He has served terms on the OETB programmes committee, the ICE Offshore Engineering Board and the council of the BHRA.

SURFACE NAVIGATION

It seems to be generally agreed that a clear depth of about 40 m below LAT will provide safe navigation for the largest surface vessel in existence or likely to be built in the future. It thus becomes obvious that, in the Southern basin, platforms will have to be removed completely because the depth there seldom exceeds 40 m. Fortunately, these platforms will be the simplest, quickest and least expensive to remove and one, in the West Sole field, has already come out.

Even so, the interpretation of 'complete removal' requires further definition. The piles of jacket structures and the wells at all production platforms penetrate the sea bed. If the sea bed is mobile, or likely to scour and expose piles or wells cut off at seabed level (the 'mud line') or if some future operation might be expected to trench below the seabed, then removal might mean cutting to some depth below the mud line.

SUBMARINE NAVIGATION

The requirements for safe submarine navigation are, apparently, different and at the time of writing no clear definition has been provided which could apply to the deeper water in the Northern and Central basins and to the continental slope west of Shetland.

It is understood that the Royal Navy has specific guidelines on safe navigation depths for submarines and so have other NATO navies. These will have to be taken into account in planning an appropriate clearance regime. However, this need not preclude abandonment of platforms being treated on an individual basis within general guidelines.

Obviously, where the sum of the permitted clearance depth and the height of any remnant of a platform exceeds the water depth, complete removal will be required.

THE MARINE ENVIRONMENT

The requirement for the protection of the marine environment calls for the removal of any danger of pollutants escaping into the sea, either during the process of abandonment or later on. The actions which will be taken to ensure that the process of de-commissioning and dismantling the facilities will not cause pollution are discussed elsewhere. In addition, any submerged pipelines or storage tanks which may be left must also be purged of hydrocarbons and the effluent disposed of safely.

FISHERIES

If it were not already obvious, North Sea fishermen have made it abundantly clear that platforms or their remnants are an impediment to their traditional trawling activities. It has been suggested, however, that disused platforms or their wreckage might have a benefit for fisheries by providing breeding rounds and therefore increase fish stocks. The artificial reefs created for commercial fishing by Japan and mainly for sports fishing in the Gulf of Mexico are quoted as examples to support a 'rigs to reefs' policy.

However, it is not yet known whether leaving platforms or their remnants in place in the North Sea would lead to an increase in fish stocks, nor to what extent such an increase could compensate for the loss of fishing grounds. It is fairly safe to suggest that if a 'rigs to reefs' policy required that the platform be removed from its original location to a position considered to be more suitable for fish life, as has happened in the Gulf of Mexico, the cost saving over taking the platform to shore or to a very deep water dumping ground would not be overriding.

Much research remains to be done before there is sufficient data for sound and unemotional decisions concerning fisheries. Such research has already started as part of the general programme sponsored by the Department of Energy and by the Industry and the SERC, directed by Marinetech North West.

ABANDONMENT OPTIONS

The various physical options that present themselves will now be reviewed, together with the major constraints and characteristics of each.

A second use

It is possible that another use could be found for a platform, in which case the new user would take over responsibility for maintaining the structures and the navigational aids. I am not aware of such a possibility at the present time and, while it would be foolish to suggest that there are none, it must be unlikely that more than a small fraction of the 40 or so platforms at present in the Northern and Central basins could find another user.

However, even where this is possible, it must be recalled that the structures have a limited life, determined mainly by fatigue damage. Once the designed fatigue life is exceeded, taking into account any change in the loading that the new use may bring, the cost of maintenance will rise rapidly. In the case of steel structures the practical fatigue life is probably of the order of tens of years, whilst the concrete structures may be expected to last for several hundred years in the conditions of the North Sea.

Similarly, the other destructive action on steel structures, namely corrosion, is arrested by cathodic protection under water, most commonly by the sacrificial anode system. Although the anodes can be replaced when they are used up, the cost of doing so is high, especially at depth.

At the end of a second use, the problem of abandonment would return, rather more severely because the older the structure the less certain is its state and integrity.

Abandon

It might be argued that a disused platform could be regarded as another wreck, of which there is already an abundance. Even if his were ever allowed, it is well to recall that such a 'wreck', unmaintained, would eventually disintegrate. In the case of the large steel structures this might occur in an uncomfortably short time.

Once disintegration set in, the structure would be in a dangerous state and very difficult to remove. In other words, all options would be closed.

Partial removal

It has become the convention to use this term to describe the action of slicing the structure at the approved depth and either taking the top slice away or placing it on the bottom, so long as nothing stands proud of the approved depth. However, it is not yet known whether this will be allowed.

Toppling

In this case either the whole structure would be cut in such a way as to cause it to topple and lie more or less horizontally on the sea floor or, instead of removing the slice above the approved depth, that would be toppled to lie alongside the lower part. This is discussed elsewhere. There would, however, have to be absolute certainty that the toppling would be complete, because anything short of completion would be extremely difficult to deal with.

Complete removal

Complete removal of steel structures is discussed in detail elsewhere, but it should be noted that there would be the alternatives of bringing a removed structure back to shore or of dumping it in very deep water.

The Oslo Convention of 1972, which applies to specified sea areas of north west Europe, provides that where it is considered necessary to deposit waste in deep water, this should be done at a depth of not less than 2000 metres and at a distance from land of not less than 150 nautical miles. Such areas occur to the north and northwest of Rockall. There is, however, doubt as to how far the Oslo Convention applies to platform disposal.

Since the scrap value of a platform is likely to be very much less than the cost of bringing it to shore and breaking it up, the possibility of disposal in deep water is worth serious consideration. Needless to say the tow to such dumping grounds is long, subject to the usual hazards, and would need to be planned and undertaken with full reliability.

Wreckage

There are two requirements concerning anything that is left on the sea bed. The first, which applies to any location no matter how deep, is that nothing must be allowed to float to the surface at any time in the future. The probability that a tubular member of a steel structure, which was not already open to the sea, becoming detached in such a way that it retained buoyancy must be remote.

However, the consequences, as a hazard to navigation, of such a possibility would be serious. Therefore all such members would be punctured before they were left.

The other requirement probably applies only to the cases where wreckage might be left on the original platform location. In such cases it may be necessary to show that none of the wreckage could move along the bottom, perhaps to arrive at a trawling ground or other place where activity might be desired.

It would not be difficult to determine whether this possibility existed in every case.

GRAVITY STRUCTURES

These structures present a different set of problems to the steel jackets when and if it comes to removal. Seven of the eight presently in place in the British Sector are made of reinforced, prestressed concrete. In these cases, assuming that they had been removed, their disposal would present a major undertaking if they were brought back to an inshore site and the broken concrete and steel would be virtually useless. It would appear that dumping in deep water would be by far the most sensible method of disposal.

The problem of removal from the seabed applies to all gravity structures, whatever they are made of.

All these structures consist of a large base section surmounted by up to four columns which carry a deck and the topside structures and facilities. Construction begins in a inshore berth and is completed in sheltered water in such a way that they remain upright at all stages. In addition, they all float.

A secure foundation for the structure on location is provided by virtue of its own weight but to enhance its security and to afford a measure of protection against any tendency for the bed to be scoured out, 'skirts' or membranes of steel or concrete project below the base to penetrate the seabed.

Once built, the structure, with as much completed topsides as stability considerations allow, is towed to its location and simply flooded-down to settle on the bottom and to drive the skirts into the seabed. The stability limitation is controlling from the time the base becomes submerged, when the benefit of its large water plane area is lost, until submergence is deep enough to restore stability.

The volume enclosed by the base may be used for on location oil storage. Suitable design allows for stresses induced by the temperature differential between hot oil and the cold sea. A control system is provided to ensure that the internal pressure never rises above that of the surrounding sea so that, in the event of minor cracking, oil cannot escape to pollute the sea.

The columns supporting the deck are used to house the ballast and oil storage control equipment, and sometimes conductor tubes and riser pipes may be run inside a column.

Complete removal of gravity structures

From the above description it would seem that this type of structure could be refloated in a simple reversal of the flooding-down procedure, with the aid of pumps for dewatering. Obviously it would be necessary to survey and repair or replace the pipework and valves for ballast control, install a new control system and sever conductor tubes etc. which might be present. It would also be necessary to remove any topside works which amounted in total moment to more than allowed for in the original design.

The following factors would also need to be considered in order to bring the structure clear of sea bed:

1. Friction between the skirts and surrounding ground.
2. Ventilation of the space under the base which is enclosed by the skirts until they are clear of the bed.
3. Grout or mud which may be adhering to the underside.

The difficulty in making these provisions is that the first of them cannot be estimated accurately and the last cannot be estimated at all. The second is calculable but the provision of ducting to ensure that the whole of the underside is ventilated would be extensive and expensive.

It is, of course, possible to make very conservative assumptions about the skirt friction and the amount of material which may be assumed to be adhering to the bottom, and also to calculate the effective weight adduced if the underside were not ventilated. It is then possible to estimate the buoyancy required to lift the structure. This would be greater than that needed to make the structure buoyant once it was clear of the bed and would lead to an accelerating and unstable situation, because once clear the restraining forces would be reduced immediately whilst it would not be practicable to reduce the buoyancy as quickly.

It is emphasized that it is the inability to predict behaviour in these circumstances that is the problem. In an event with which I was concerned 15 years ago, just such a refloating operation was carried out and the unit came clear of the sea bed without any special provisions and so gently that only a measure of freeboard confirmed that it was alive. In that case, however, the water depth was so shallow that if the behaviour had not been so fortunate there could not have been any kind of accident. No engineer would attempt a similar operation upon a major oil platform in the Northern North Sea.

An obvious solution to the problem would be not only to ventilate the underside but also to provide an overpressure sufficient to account for conservative assumptions of skirt friction and adhering material. Such pressure would be limited by the strength of the base and of the skirts themselves but, once clear of the sea bed, the overpressure would dissipate immediately. Then the structure could be dewatered in a reversal of the flooding-down sequence and towed away.

Clearly, in each case, very detailed engineering work would be needed to find the most economical and reliable method. In addition the activity itself will be costly.

Partial removal of concrete gravity structures

Platforms of the Seatank, Condeep or Andoc types, in which the columns are slender, could be amenable to partial removal or toppling. The columns could, with existing technology, be cut at the safe navigation depth to fall to the base below. Whether the whole topsides could be allowed to fall with the columns would depend upon the configuration. It would be easier to topple a one or two column structure than one with three or four columns and be sure of leaving a safe navigation depth.

If the base had stored oil, it would seem to be a prerequisite that it be purged thoroughly because it would surely be damaged by the falling columns.

The method of cutting the reinforced concrete columns remains to be determined. It would be possible to drill a pattern of holes, not quite through the walls, from the inside, and to charge them with explosive, but a more likely method, when and if developed, might be a specially designed linear shaped charge placed around the outside.

Summary

I have been on record before as suggesting that the large concrete gravity structures will either be quite easy to remove completely or else very difficult indeed. Much detailed study is required before one can know which it is to be. However, if any platforms are candidates for being left where they are, these concrete structures, through their expected longevity in North Sea conditions, must have a strong claim.

COSTS

The estimates of the cost of partial removal, toppling and complete removal of all the platforms in place in the North Sea, made by and for the Operators in response to a Department of Energy request in 1982, are now widely known. Table I shows a summary of such estimates as analysed by UKOOA, with average figures also shown.

The magnitude of the estimates, for complete removal in particular, emphasises the need to consider alternative options and methods carefully. It is common ground between Government and industry that the costs incurred at the end of each platform's original purpose should be kept to a minimum, consistent with proper regard to the other relevant interests.

Meanwhile, the initial estimates are already being subjected to a continuous process of refinement. My company took part in a costing exercise for an Operator which contributed to the total figures and, in common with all others similarly involved, appreciated that the limits of confidence which could be placed upon the estimates were uncertain. There are many reasons for this, which in total amount to the fact that there is as yet no experience of removing, partially or completely, a major platform in the environment of the Northern North Sea.

Some particular observations, in no particular order, can be made:

1. Complete removal of large steel structures by conventional means would require the use of heavy floating crane barges for up to two seasons at an unspecified time in the future. Hire rates will be a major cost centre and will depend upon the market at the time.

2. There are still some matters of research and/or development required before the method of removing the larger steel structures can be confirmed with assurances of safety in sufficient detail to allow cost estimates to be refined. The same remark applies to the gravity structures.

3. The cost estimates for toppling the larger structures are probably the most tentative. It is common ground that any method involving the forecasting of the collapse of structural members in the correct sequence requires the most detailed engineering. In general, such work remains to be done.

4. Purging, dismantling and removal of the topside structures requires no new technology and can be costed with the greatest accuracy. Although heavy crane barges and flotels would be required, they would be needed only for a month or two.

TABLE I: Costs estimated in 1982, collated by UKOOA

Area	*Type and number*	*Method*							
		Topple			*Partial*			*Complete*	
	Steel	All (£M)	Aver. (£M)	Saving (%)	All (£M)	Aver. (£M)	Saving (%)	All (£M)	Aver. (£M)
North	14	600	43	70	1320	94	34	2015	144
Central	18	695	37	66	1464	81	29	2049	114
South	99							1157	12
	Gravity								
North and Central		265	33	69	265	33	69	859	107
Totals		**2717**			**4206**			**6080**	

The costs exclude auxiliary structures but include well abandonment. The average figures and the percentage saving on complete removal were derived by the author.

In conclusion, the estimates made in 1982 may be regarded as a first approximation. The sheer magnitude of all the figures has drawn attention to the need to investigate all options and methods in full detail. The cost of such investigations will be of similar proportion to the cost of abandonment, as is the cost of engineering a platform to its construction and installation. Every incentive is required to ensure that such work is done, and done in good time.