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8237 DISCUSSION

Installation of the piled foundations and production modules on Occidental's Piper A platform

S. DUVIVIER & P. L. HENSTOCK

Mr Duvivier and Mr Henstock

It has often been asked concerning Piper whether a faster and cheaper installation could have been achieved with driven instead of drilled piles. While this is a hypothetical question it does raise some interesting points. At the time of the Piper A installation, hammer driving energy was one quarter of that available now. However, even using the latest hammers it is likely that the necessary penetration would not have been reached since pile capacity does not increase in proportion to driving energy. In addition lateral capacity must be considered and since this is largely controlled by steel cross-section at the point of maximum bending moment at or near the mud line, it is often a limiting factor. (Piper required a wall thickness of 7 in. at the mud line).

73. The ultimate resistance of driven piles in the North Sea now seems to have reached a plateau value of about 5500 t with available equipment. Further increases in driving energy are not likely due to costs of plant and the effect of diminishing returns on pile capacity. Drilled piles such as those used on Piper have a far higher potential. An on-site investigation during installation demonstrated an available ultimate resistance of 380 ft penetration piles of 8500 t. Using one of the modern semisubmersible derrick ships which is subject to much less weather downtime than conventional floating vessels, it is possible that drilled piles will become of interest once more in the North Sea, since a few high capacity piles will certainly result in cheaper fabrication costs and might well need no longer to install than a larger number of driven piles.

Mr W. R. Edwards, Occidental Petroleum (Caledonia) Ltd

I had the privilege of working with the Authors on this project. Undoubtedly, it was not the innovative equipment or techniques that were adopted that led to ultimate successful completion, but rather it was the presence, both in the contractors' and in the consultants' teams, of resourceful, adaptive and resilient minds.

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75. A cursory review of Table 4 might lead one to the conclusion that the final cost was almost ten times the original contract. This is, in fact, not so, as many of the derrick ship costs were originally anticipated to be in addition to the lump sum jacket installation costs, as these vessels were to be used to install the platform modules. However, none of the semisubmersible support costs were originally considered, and only about half of the third party costs, resulting in a cost overrun of 4–5 times the original estimate.

76. The operational and technical conclusions (§§ 58–70) are interesting. They were all closely considered in the design of the piling installation programme for the Claymore field platform. The Claymore jacket was completely installed, with piling grouted, in just 28 days during the summer of 1976, a North Sea record unbroken until summer 1979. Also, while the Authors' technical comments on variable wall thickness piling causing driving interval difficulties in soils of varying consolidation are true, I believe that the presence today of giant offshore cranes on semisubmersible vessels, plus piling hammers capable of 750 000 ft-lbf energy levels, allow design flexibilities in platform piling that were an unobtainable dream in 1975. For example, 72 in. dia. × $2\frac{1}{2}$ in. wall thickness piling sections, weighing 300 tons assembled, were set in single units by the *SCV Hermod* in the summer of 1979 on the Tartan jacket installation.

77. Having just completed production and dispatch of over 250 million barrels of crude oil, the Piper platform has now had one of its drilling rigs replaced with a set of modules filled with complex gas-processing and condensate-producing equipment. A new 135 man steel accommodation module has been installed, with expanded facilities for crew comfort; this necessitated placing a 65 ft bolted strengthening doubler around the appropriate jacket leg in the wave zone area, and bonding with special high strength grout. Most recently, a comprehensive, five-year underwater inspection programme has revealed apparent fatigue stress cracks in some members supporting the conductor guide framework at −50 ft elevation. We now have under way with the original jacket designer a programme for installing remedial hangers and some rather complicated four-point clamps to redistribute loads around the affected areas. Thus we find that what many of us supposed to be an 80 day installation programme in 1975 is still very much an interesting and viable civil engineering challenge.

Mr A. Swinney, William Haley & Partners

No doubt the master stroke which brought about a successful conclusion to the piling programme was the introduction of the semisubmersible, which is now accepted practice. Such vessels are constructed for that specific purpose.

79. I notice from the Paper that at the beginning of 1976 only nine primary piles had been driven. The previous summer, I believe, the Menck 7000 hammer had been successfully used in the Forties field. I wonder whether the project management team considered the option of abandonning the drilled piles in favour of purely primary piles driven perhaps to 250–280 ft, or whatever would be required to take these loads (clearly not as much as the 380 ft for the drilled piles). If this was considered, I would be interested to know which were the main factors which brought the project management team to reject this approach and continue with an installation procedure which up to that time must have caused them grave headaches. Would the Menck 7000 have been up to the job?

Dr P. M. Blair-Fish, CJB – Earl and Wright

The Authors are to be congratulated on a frank description of the difficulties encountered during the installation of the Piper A platform. However, offshore platforms need not be as difficult to install as Piper A.

81. The plant available to install offshore platforms quickly and efficiently has become significantly bigger and better in the six years since the Piper A jacket was designed. The most powerful hammer now available for the driving of offshore piles is the Vulcan 6300 (Table 5). The Vulcan 6300 has a maximum rated energy that is six times that of the Vulcan 560, around which the installation of the first stage piles for the Piper A platform was planned. The Menck 12 500, which has a maximum rated energy of five times that of the Vulcan 560, was first used offshore in the summer of 1976, just as the installation of the Piper A platform was being completed.

82. Increases in hammer energy enable greater soil resistances to be overcome. Wave equation studies indicate that the maximum soil resistance that can be overcome by the Menck 12 500 or Vulcan 6300 is of the order of 2–3 times as great as that which can be overcome by the Vulcan 560.

83. The lifting capacity and reach of derrick barges has increased since 1973. There are now several derrick barges with a lifting capacity of more than 2000 short tons. Four of these vessels (Heerema's *Balder* and *Hermod*, McDermott's *DB100* and NOC's *Narwal*) have semisubmersible hulls and can therefore stay on station and work in rougher weather than conventional crane-ships. The piles for the Piper A jacket were installed by derrick barges of 600 short ton capacity, a modified semisubmersible drilling vessel with two Manitowoc 4100 ringer cranes of 300 hort ton capacity and two stiffleg cranes of 200 short ton capacity on the jacket. This year (1979), semisubmersible crane vessels with ringer cranes of lift capacity 2000 and 3000 short tons were used to install the Tartan and Murchison steel jackets in the British sector of the North Sea. Single-stage piles of 84 in. o.d. were driven at Murchison.

Table 5

Hammer	Maximum rated energy		Weight, t
	ft-lb	kJ	
Vulcan 6300	1 800 000	2446	386
HBM 4000	1 700 000	2320	222
Menck MRBS 12500	1 582 220	2145	387
HBM 3000 A	1 100 000	1580	188
Menck MRBS 8000	867 960	1177	256
Menck MRBU 6000	774 400	1050	105
Vulcan 5150	750 000	1019	209
Vulcan 5100	500 000	679	181
Menck MRBS 4600	499 070	677	142
HBM 1500	410 000	570	78
Vulcan 560	300 000	408	140
Vulcan 060	180 000	245	115

84. The time required to complete the installation of single-stage piles for a well designed jacket is typically 1–2 months from the up-ending of the jacket to the completion of grouting of the pile/pile sleeve annuli. Early examples of such rapid installations were Chevron's Ninian Southern platform, Occidental's Claymore platform, and Shell/Esso's Brent A platform. With the benefit of hindsight, it is tempting to suggest that, if the foundations for the Piper A platform were being designed today, single-stage piles of larger outside diameter might be installed by the plant now available.

85. For the soils data given in Fig. 2 and the loadings given in Fig. 3, calculations by the α method of API RP2A (1979)[1] suggest that clusters of eight 72 in. o.d. piles driven to approximately 246 ft might be an acceptable foundation.

86. Piles of larger outside diameter are stiffer in bending and therefore distribute horizontal loads to deeper soil strata. Less local thickening of the pile walls is required at mud line for larger diameter piles.

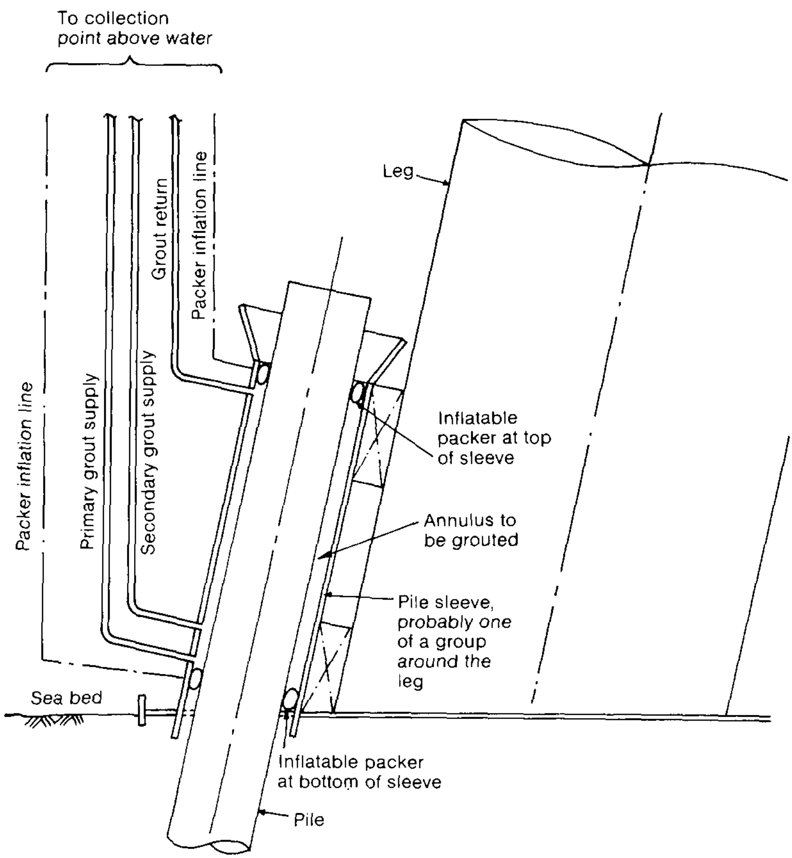

Fig. 18. Scheme A: two-packer surface return system

87. The Paper (§ 33) states that the semisubmersible support vessel had to be winched away from the jacket in periods of very rough weather. Is it possible to quantify the weather and sea state (wind, speed, wave and swell magnitude and period) when it was necessary to winch away from the jacket?

88. In § 13 it is stated that with two primary piles driven per corner and with the deck and temporary drill modules on, the safe wave height was 21 ft. Was leg uplift the potential mode of on-bottom instability?

89. Gravity connectors are normally used to connect followers to each other and to the piles. Were Rockwell connectors used in order to provide a moment connection between followers so as to carry the load of the hammer at the start of driving?

Mr K. C. Mead, CJB – Earl and Wright

My comments concern the grouted connection between the driven pile and the structure. The Authors emphasize the importance of having back-up to the main

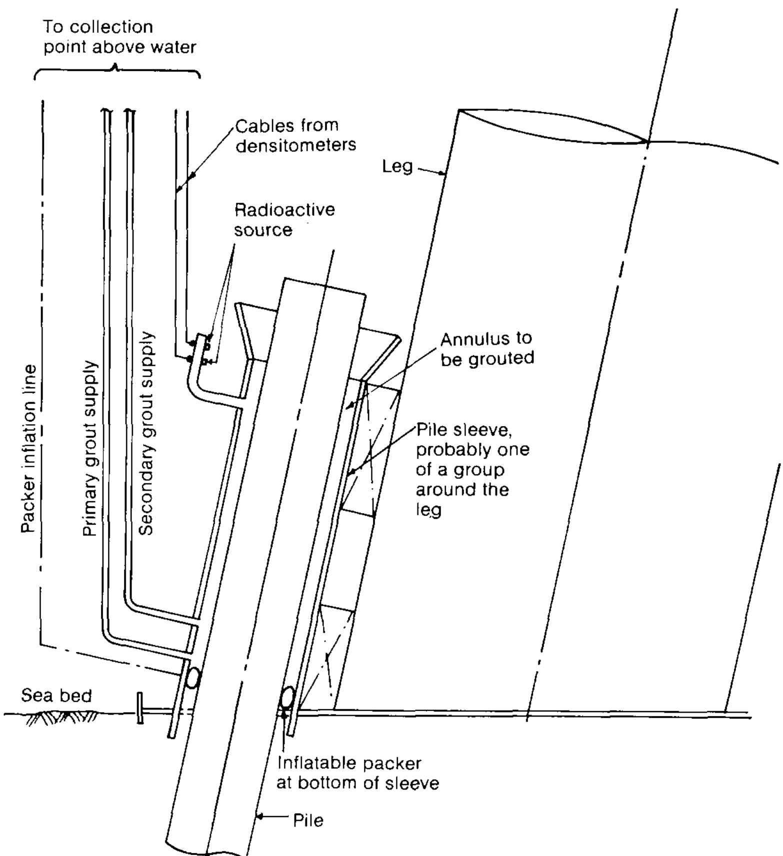

Fig. 19. Scheme B: one-packer remote detection system

components of the grouting system. My company is in full agreement with this, and as platforms move into deeper and more inhospitable waters in the northern part of the North Sea, we also endeavour to ensure that the grouting operations are kept as independent of diver assistance as possible. Failure of components in the grouting system could, if there was not sufficient back-up, involve considerable lengthening of offshore installation time, as repairs would have to be made by divers, often operating in water depths of up to 600 ft. Although the new semisubmersible crane vessels now working in the North Sea should be able to work throughout the summer, the periods in which the divers may work is very dependent on weather conditions, due to the dangers inherent in excessive motion of the diving bell as it is lowered over the side of the crane vessel.

91. Two systems currently used on offshore steel structures (Figs 18 and 19) make it possible to ensure that the grout annulus is completely filled with uncontaminated cement grout, giving a sound connection between the structure and its foundation. The general method of operation is to close the bottom of the annulus to be grouted (by inflating the packer) and to pump grout into this annular space at a point just above the packer. As the level of grout rises, sea water is displaced. In order to check that the annulus is full and that there has been no intermixing with sea water, it is necessary to check the density of the material at the top of the sleeve. Scheme A differs from scheme B in the way this is done. Conventionally (scheme A), the annulus is closed at the top of the sleeve and the grout is forced along the return line to the surface, where the density may be measured. Scheme B, first used on the Thistle platform in 1976 and again on more recently installed jackets, incorporates a nuclear densitometer near the top of the grout annulus. This densitometer remotely monitors the density of the material flowing through the overflow pipe (Fig. 19). The densitometer comprises a radioactive source (usually caesium-137) facing a Geiger counter across the overflow pipe. After onshore calibration, the variation in the density of material flowing through the pipe can be deduced from changes in the radiation absorption.

92. There are two main causes of failure of grouting systems: inability to inflate a packer and damaged pipework. In both systems outlined above, the grout supply lines are duplicated and, in the event of a lower packer failure, the annulus may be closed by casting a short cement plug. However, damage to the upper packer or return line in scheme A would require the grout at the top of the pile sleeve to be sampled by a diver. In scheme B, by duplicating the densitometers, greater diver independence may be achieved.

Dr R. Hobbs, Lloyd's Register of Shipping

Lloyd's Register is the certifying authority for Piper A and I was fortunate enough to attend site investigation and piling operations on behalf of the Society.

94. Referring to the differences in blowcount records (Fig. 13), I wonder how much these are due to differences in soil conditions and how much to differences in hammer performance. Pile driving behaviour is an important additional site investigation tool, but only when there are enough data on hammer performance to aid interpretation. Stroke, and velocity of ram impact or energy input to pile head should at least be shown.

95. The Authors state (§ 39) that pile drilling was the responsibility of oil-well

men. From experience of drilling and grouting offshore piles throughout the world, I think it vital that civil engineers who are familiar with geotechnics are directly involved in these operations.

96. The Authors also state that drilling mud was desirable. While this may be true from the point of view of maintaining hole stability, it is important to consider the possible detrimental effects of the mud on adhesion between grout and soil.

97. Site investigation carried out at the platform location indicated sand layers not indicated in Fig. 2. These may explain some of the kinks in the driving records (Fig. 13) and some of the problems encountered in drilling and grouting.

98. In the current season Lloyd's Register has covered piling operations on Tartan, Beatrice DAA and Murchison, all of which have piles in clay with design ultimate static capacities approximately equal to those at Piper (i.e., about 45 MN). These were driven with Menck MRBS 8000 and 12 500 hammers, which have rated energies of three and five times that of the Vulcan 560.

99. Two stage (driven and bored) piles like those at Piper were also used at Kinsale Head A and B and at Thistle.

100. There are still some instances where a drilled and grouted pile may be the best solution—for example when piles are installed in weak rock where there is some doubt about the final adhesion achieved for driven piles.

Dr E. C. Hambly, Consulting Engineer

What were the tolerances on the modules and how was the fit controlled? When a comparison is made of two different techniques for offshore construction, requiring a considerable difference in time, how do you estimate cost to the client in terms of the extra borrowing time required for his finance and also for delay in production?

A speaker

Table 3 shows that the piling programme (drilled and driven insert system) took at least from January to July 1976. More recent programmes typically take perhaps a calendar month for the completion of their big diameter driven piling system. I should be grateful if the Authors would give some further information comparing for Piper a drilled and a driven system as against a driven only system.

103. Concerning the suggestion that the diving installations place a limitation on the workability of big semisubmersible construction vessels, when a $100 million barge is built that can work in 10–12 ft significant seas (as compared with a Gulf Coast barge that might stop that sort of work in 4–6 ft seas) it does not cost much to put in a restraint in the interface system which will enable there to be a diving capability to match the workability of the barge. There are barges which, surprisingly, have not had that sort of installation. But soon it will be done with all of them.

Mr W. J. Haley, William Haley & Partners

What interests me is the project management. The platform installation encountered a series of unexpected substantial problems that fully tested the resourcefulness and decisiveness of the project management.

105. The failures of some grout packers and the subsequent attempt to plug the sleeves with grout were overcome by welding the piles to strengthened guides. To make up for this delay the management decided to install the deck support frame in one piece instead of three, hiring a crane ship instead of the planned derrick barge. The worsening autumn weather caused frequent withdrawal of the accommodation barge, delaying further piling completions. Within a month quarters and a helideck were fabricated and installed on the platform, permitting continuous piling operations.

106. The collapse of the platform stiffleg derrick had seriously affected the safety of the platform. Four insert piles needed placing in order to withstand the winter storm and the weather was by then too rough to anchor the derrick barge alongside the platform, halting piling operations. The management rose to the occasion and initiated a solution that is now standard practice: the provision of a semisubmersible construction vessel capable of anchoring beside the platform in all bar severe storms. Within two months, a standard drilling semisubmersible was converted for this purpose. The lack of the derrick barges' lifting capacity was overcome by capping the followers, the buoyant pile string being then within the lifting capacity of the stifflegs.

107. This history shows that the project management kept on top of events and were decisive. Since I worked on Piper, project management teams have expanded, probably in an attempt to avoid repeating the budget overruns of the early deepwater platforms.

108. In achieving the programme from first oil discovery in January 1973 to oil production in December 1976, the Piper project has been very successful. I am suspicious whether the decisions of the kind that were taken to achieve this programme could be made by a large project team. However, a large project team would hopefully plan contingencies for the 'unexpected'.

Mr W. A. Temple, Mott, Hay & Anderson

Was the contract originally tendered or was it negotiated? If it was on the basis of firm ICE and FIDIC Conditions of Contract, with hindsight would a cost-plus type of system have produced a shorter overall programme?

Mr G. Lowther, Consultant

With regard to the costs, the contract period seems to be a long one. Has there been any allowance for inflation? Shouldn't we be talking in terms of constant purchasing power?

Dr R. Gair, McDermott Engineering London

One of the most important features emanating from the Paper is the degree of responsibility of the individual companies involved. The initial contract was placed with J. Ray McDermott, with fabrication to be performed at Ardersier by McDermott Scotland and the installation by Oceanic Contractors in Brussels. McDermott Engineering London (in 1973 McDermott Hudson) were the principal design consultants for the platform for both the McDermott organization and for Occidental, and produced all the fabrication drawings and installation drawings associated with the project.

112. Bechtel were responsible for the process and facilities design, the design

of the production module steelwork being completed by MEL. Lloyd's assisted in further detailed work for which at that time we did not have adequate facilities. This included the fatigue analysis.

113. The term consultant is used to describe Lawrence-Allison in the Paper. It would be beneficial if the Authors could describe Lawrence-Allison's duties and terms of reference, as they were not responsible for either design fabrication or installation.

114. The design adopted for the Piper platform was developed around the experience gained by McDermott world-wide for launch type structures and upon the tools available at that time for installation of the platform itself.

115. The jacket was a natural extension of some of the larger structures which had been developed for the Gulf of Mexico and the Arabian Gulf. The principles involved building the structure on a flat area of land with access to the sea and providing a suitable transport barge to transfer the jacket from fabrication yard to the final offshore location. McDermott placed their faith in a transport/launch barge larger than those used before: this was Intermac 600, capable of transporting structures up to 18 000 sh tons.

116. Competitors of McDermott were thinking of concrete, self-floating or hybrid structures. This was a substantial breakthrough at that time. Such has been the development and the practical success of this system that the trend has developed for larger launch type structures and consequently larger barges with capacities of 25 000–30 000 sh tons. McDermott are in the forefront of this development, constructing a launch barge with a capacity of 40 000 sh tons to transport a jacket as a complete unit, for placing in a water depth of 850 ft.

117. The most controversial decision was the decision to use a drilled and insert pile. The decision was taken based on the installation equipment of proven ability existing at the time. Menck 8000 and 12 500 and Vulcan 6300 hammers were not available at that stage, and a drilled and insert pile was a natural extension of offshore drilling practice, and used frequently on dock and harbour work and smaller offshore structures founded on poor quality soil strata.

118. It has been suggested that a change to a fully driven pile should have been made in 1975 when the jacket was completed. This would have resulted in the use of the larger diameter piles or more piles driven to a shallow depth. The existing piles would have had to be scrapped and the pile guides and bottle legs of the jacket redesigned, with considerable disruption to fabrication, probably delaying jacket completion by 18 months.

119. Larger hammers are now available which can result in 60 in., 72 in. and 84 in. dia. piles being driven to the 300 ft approx. required for a fully driven solution. This technique was used for the sister platform Claymore.

120. The drilling equipment was fully tested in the Gulf of Mexico before being shipped to Europe for this contract. It had, however, never been used for installation of piles in this manner. Some surprise has been expressed concerning the use of drilling personnel with oil well experience, and that new drilling techniques were required. Few people at the time had installed insert piles of this magnitude, and the specialized tools used, such as that for two-stage grouting and the remote disconnect at the top of the insert pile, are commonly used in that industry. It was therefore logical to employ people with oil well experience. The construction crews employed during drilling were familiar with insert or pinpile installation in other locations. Reverse circulation is not a new drilling

technique and has been used elsewhere in the world. My first personal experience was on the Arabian Gulf in 1970.

121. The Paper describes (§§ 40 and 41) the real difficulties which were found on location; the soil foundations must be among the poorest for any North Sea platform. The drilling programme consequently had to be modified to suit the conditions. Two-stage grouting was essential because of the real possibility of hydraulic fracture of the soil, described in the Paper as losses to formation of the grout.

122. The calculations performed to ascertain safe wave heights of the structure at various stages during installation were all performed by MEL, and hence the sequence of events which led to placing of the module support frame and the drilling modules were at our recommendation.

123. The safe wave heights were all calculated on the basis of the piles being grouted to the sleeves. On one occasion, because of packer failure, the necessary grout bond to transmit axial load could not be achieved. Welding of the pile follower to the top pile guides was therefore required. Some surprise has been expressed concerning this course of action. The pile guides were designed to transmit the self weight of the pile and all the installation equipment used when installing the primary piles. The welding off of the piles to the guides was not therefore as ludicrous as it would appear, but obviously not as efficient as the grouted connection.

124. The launch flotation and up-end of the jacket went reasonably efficiently but the installation of the piles was not the smooth procedure it was hoped to be. A detailed confidential report was prepared by the engineers working on site, who reached conclusions similar to those outlined in the Paper. It should be remembered that it was not envisaged that installation would continue through the winter period. Many of the ancillary items such as grout lines and air inflation lines were designed as temporary connections, to be removed on job completion, and were damaged due to the severe weather.

125. Problems with the grout packers have been overcome by introducing sliding sleeve valves which allow grout plugs to be set if packer failure occurs. A series of grout nipples can be introduced along the pile sleeves such that if failure occurs during grouting then standby methods can be used. Our current designs have also used the grout detection system marketed by AERE Harwell, which can eliminate the need for the upper packers and the use of pile wipers as a back-up in the event of failure of the lower packer.

126. The conclusions reached by the engineers were put into effect by MEL on all subsequent structures. In 1976 a jacket using the same foundation concept as Piper was installed in the Norwegian sector of the North Sea. It had 16 insert piles, four in each corner. The same installation equipment was used as on Piper. Advance planning by MEL included the use of a self-contained quarters and helideck during installation, and the construction of additional storage facilities for piling and drilling mud such that a complete pile could be installed without the assistance of a derrick barge.

127. The structure was launched in May 1976. All the primary piles were driven and grouted up, all insert piles completed and the installation modules removed by November 1976. All production modules were installed and permanent drilling modules and the drilling of conductors started by Easter 1977.

128. Rapid advances in derrick barges used offshore were also reflected in the module design, where initial thoughts had centred around 1000–1200 sh

ton lifts. Capacity was later extended to 1500–2000 sh tons by MEL and was felt to be somewhat of a risk at that time (1974) as very few derrick barges of that capacity were available. I feel that this is reflected in the installation costs, where it is interesting to note that the bulk of the monies for fabrication and installation did not go to McDermott but to other offshore contractors, with lift vessels of greater capacity than McDermott had available at that time. Barges of 2000 sh ton and 3000 sh ton lift capacity are commonplace in the offshore industry in 1979.

129. Occidental Piper has in many ways broken new ground, particularly in the use of suitably equipped semisubmersible units as back-up vessels during installation and hook-up of offshore structures. Semisubmersible units are now used extensively throughout the North Sea. The logical conclusion would be to use such vessels as crane barges for all-year-round installation. To date, only McDermott and one other contractor operate such vessels in the offshore construction industry.

130. Lessons can be learned, often after bitter first hand experience, and problems can be resolved by putting such experience into practice. Such has been the development of new hammers and derrick barges that very few drilled and insert piles are used in the North Sea. This does not signify that with proper planning the system cannot prove to be a reliable alternative, given the correct soil conditions.

Mr C. Z. Erzen, Raymond Technical Facilities Inc., New York City

The Paper is an excellent exposé that should be referred to repeatedly by every management group that assumes the responsibility of installing a platform similar to Piper A.

132. It appears to me that the most effective way to eliminate delays and other difficulties during the installation of a platform would be by changing the entire system of the platform rather than trying remedial measures to correct mishaps as they present themselves in the application of a wrong system for deep water platforms.

133. Unfortunately, the present day deep water platforms are nothing but enlarged versions of the shallow water platforms which were designed and built 20 years ago in the USA and later in the shallow waters between Holland and the UK for the production of natural gas. The description of the Piper platform reveals exactly the same steps taken: the transportation of the jacket on barges, uprighting it at the site, driving the piles through the sleeves, mounting of the hull, and finally placing of the modules. These reveal no innovations, such as a change in physical build-up of the platform or the installation process. It appears that the delays are due to the size and weight of these structures and the magnified effect of weather on structures of such dimensions. Therefore, it is worth thinking of how the size effect may be reduced by taking advantage of the buoyancy of the structure and reducing the delays due to weather by carrying part of the hull and pile driving equipment on it together with the jacket so that when the jacket is uprighted and placed in position, the equipment will be at a height not to be disturbed by waves. In such an operation, half of the piles may be transported with the jacket in their guides, and therefore the pile driving operation may start directly from the top of the hull as soon as the jacket is set on the bottom, provided that the jacket under its own

weight may withstand waves up to 40 ft or even more. When such a structure is conceived, the following may be eliminated: transportation of the jacket on a barge; a pile driving barge anchored alongside the jacket in order to drive the primary piles; transportation of the hull after the placement of the jacket; and provision of living quarters for the personnel on a separate barge.

134. The design concept described above does not eliminate the transportation and placement of the machinery on deck. After the structure has been secured to the bottom, a Manitowoc crane and other equipment may be placed on deck, enabling the modules to be placed on deck and skidded into position without the aid of any floating equipment.

135. In 1974 I conceived and designed an offshore platform as described above for a depth of 600 ft, north of Shetland Islands (Fig. 20). The structure was intended to be transported together with its hull, uprighted at the site, and then set with its 15 ft dia. torus on the bottom, distributing the loads to the foundation before the piles were driven. The modules could then be placed on the hull with the aid of a heavy duty crane fixed on deck.

136. It would be interesting to hear the Authors discuss their ideas on how the design concept may be changed in order that many of the delays encountered during the installation of the Piper platform may be eliminated.

Mr Duvivier and Mr Henstock

The Piper A project consisted not only of jacket and module installation, but the laying and connection of 100 miles of 30 in. pipeline, the construction of

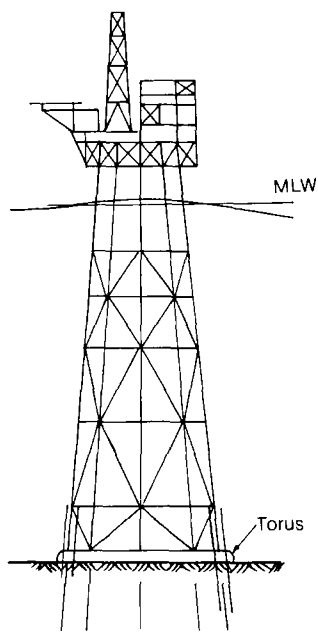

Fig. 20. A proposed North Sea platform for the Thistle field region

onshore terminal facilities in the Orkneys, and the hook-up of production facilities on the platform. From discovery of the field to production of the first oil took just four years. The fact that pile installation was behind schedule allowed a high level of completion to be reached in the production modules by the time they were installed in 1976. This reduced enormously the hook-up work which was substantially complete in three months. For more recent platform installations, significantly less time has been taken to install the piles as lessons of offshore working have been assimilated, but the hook-up of facilities (which is very man-hour intensive) has generally taken much longer, resulting in a similar overall installation period.

138. **Mr Swinney** mentions that the use of the Menck 7000 might have allowed a change to driven piles during installation. Such a solution was not practical once the jacket had been fabricated since it would have involved substantial alterations to the design. Furthermore, it is unlikely that the Menck 7000 would have produced the necessary driving energy.

139. **Dr Blair-Fish** raises a similar point in his contribution except that he poses the question of whether a driven pile foundation would have been adopted nowadays. Such a solution would now be likely in view of the increases in hammer capacity and derrick barge size.

140. Operating conditions for the semisubmersible support vessel (§ 87) were controlled primarily by wind speed. Insurance requirements decreed that, providing the anchor winches could reach stall out during test without anchors slipping, a wind speed of up to 50 mile/h could be tolerated without moving away from the jacket. Before this wind velocity was reached, however, all other operations such as crane or supply boat operation had to stop. It was found therefore that though the cut-off point set was somewhat arbitrary it did represent a good practical limit, since personnel movements became dangerous due to the wind force and connecting bridge movement at that level.

141. The safe wave height (§ 88) referred to in § 13 was governed by foundation axial capacity in compression.

142. The Rockwell connectors (§ 89) were designed to be used only at the connection between pile and follower. Since this was always well inside the jacket leg, no bending capacity was needed.

143. **Mr Mead** describes the method of grout monitoring developed by the Atomic Energy Research Establishment, Harwell, which appears to be a significant improvement on earlier systems and is now being used on several jackets. A point to be noted, however, is that although this system works well now, at its first trial at Thistle many of the gauges failed due to leakage. This is another example of the problems of innovation in the North Sea environment.

144. **Dr Hobbs** mentions the need for close monitoring of pile driving behaviour since this provides additional information on soil conditions. The Authors agree with this and feel that the mere counting of blows is insufficient. On Piper only blow counts were recorded but the substantial difference in these at various locations could not have been due solely to hammer performance and must represent variation in soil conditions.

145. **Dr Hambly** asks about the tolerances on module installation. The lateral position of modules was governed by flanges bearing against the skid rail. The difference between skid rail gauge and flanges was a total of 4 in. and this represented the tolerance. In practice this was found to be too large if the pipework within modules was allowed to continue up to the interface, since

a 4 in. dogleg could not be incorporated in the short distance between the modules.

146. The second question must surely be a matter of opinion and of the individual case involved.

147. **Mr Haley** indicates how management teams have increased in size and scope since the first North Sea installation. At the time of the Piper project, relatively few people were involved in taking decisions. This led to good flexibility in approach and fast decisions. Mistakes were made but some outstanding successes were achieved. Given the size and scope of current project management teams, it is likely that many of the mistakes would not have been made, but the provision of quick on-the-spot decisions which was most important on Piper would have been greatly curtailed.

148. **Mr Temple** asks about the contract format. At the inception of the project there really were only two contractors capable of carrying out the work. One was fully involved in other work and this resulted in a negotiated contract being let to the other contractor, who was McDermott. The contract was lump sum but with an allowance for force account or daywork rates to be adopted after a certain duration of bad weather. Changes in conditions led to re-negotiation and amendments to the contract, which to all intents and purposes became a cost plus system after the weather downtime limit had been reached. FIDIC or ICE conditions were not used.

149. **Mr Lowther** is correct in stating that allowance should be made for inflation in definitive estimates; however, the figures given in Table 4 are indicative and are not intended to provide a basis for future costing.

150. **Dr Gair** has made a useful and interesting contribution stating the viewpoint of the contractor, who in this instance was responsible for the design as well as the complete construction of the works. The main point raised by him is the role of the various parties involved, and in particular that of Lawrence Allison.

151. Occidental negotiated a contract with McDermott's for the emplacement of a jacket at Piper A. In addition, other contracts were let for the construction of a terminal at Flotta and for the laying of the offtake pipeline. The extensive programme meant that Occidental's construction division required assistance to supervise and co-ordinate the entire works. Consultants were employed to assist in the work and Lawrence Allison were required initially to review all construction drawings produced by McDermott, check the various components and suggest improvements. During installation Lawrence Allison acted as the company's representative offshore, directing and co-ordinating the several derrick barge and support vessel contractors, and for the hook-up and subsequent works provided a full project management function.

152. One of the most controversial aspects in this type of work is the question of what is the right type of organization. The contractor who has a lump sum contract feels that supervision by a third party interferes with his contract obligations and rights, whereas the client wishes to have a full information service and control of the operations as they proceed. There is a further factor involved in that all structures now require independent certification and as a result all records and constructional details have to be collated and passed to the certifying body. When this is added to the use of several specialist contractors for operations such as survey, diving, pipeline, hook-up and transport, it does become necessary to have an overall management body.

153. The course that should be avoided, however, is the all-too-frequent practice of having several layers of management.

154. In this situation the client has an organization which is mirrored and amplified by the project management contractor and also matched by the design and construction contractor. As a result paperwork proliferates and decisions cannot be taken rapidly.

155. **Mr Erzen** questions the basic concept used and asks whether a different concept might reduce delays. His own solution is a type of self-floating jacket. Though this method has several advantages, as Mr Erzen has stated, it has not been widely adopted. The main reasons are

(*a*) dry dock required for fabrication;
(*b*) elaborate floating and up-ending system needed;
(*c*) flotation tanks are redundant after installation but cost a lot to fabricate;
(*d*) structure is subject to damage during tow.

The overall result is a more costly and elaborate structure which has less flexibility in the design for alterations in topside weight. The Authors view is that for the foreseeable future conventional designs will continue to be refined and improved as experience is gained, and for depths up to 600 ft and possibly more the jacket type structure, barge-launched, is likely to remain the best choice. In certain areas where the foundation conditions are suitable, concrete or steel gravity structures may prove attractive. Real innovations will be limited to a few areas such as subsea completions and schemes to reduce hook-up costs. The latter may be achieved by single-piece installation of the topside facilities using a special transport barge and transfer system.

Reference

1. American Petroleum Institute. *Recommended practice for planning, designing and constructing fixed offshore platforms.* API, Dallas, Texas, 1979, API RP2A, 10th edn.