

Neutral Citation Number: [2016] EWHC 2062 (TCC)

Case No: HT-2104-000190

IN THE HIGH COURT OF JUSTICE
QUEEN'S BENCH DIVISION
TECHNOLOGY AND CONSTRUCTION COURT

Royal Courts of Justice
Strand, London, WC2A 2LL

Date: 07/10/2016

Before :

MR JUSTICE EDWARDS-STUART

Between :

FLUOR LIMITED	<u>Claimant</u>
- and -	
SHANGHAI ZHENHUA HEAVY INDUSTRIES LIMITED	<u>Defendant</u>

Mr Sean Brannigan QC (instructed by **Hogan Lovells**) for the **Claimant**
Mr Andrew White QC, Mr Sean O'Sullivan QC, Mr Mark Chennells and Mr Iain Munro
(instructed by **Pinsent Masons LLP**) for the **Defendants**

Hearing dates: 23rd February to 23rd March 2016 & 19th April 2016

Judgment Approved

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Introduction

1. This is a very substantial dispute about the quality of the fabrication of steel monopiles and transition pieces for an offshore wind farm in the North Sea. The Claimant (“Fluor”) is an engineering, procurement, construction, maintenance and project management company registered in England (and is a subsidiary of Fluor Inc, the US multinational construction company). The Defendant (“ZPMC”) is a well-known steel fabricator, based in Shanghai with a major manufacturing base at Changxing Island. ZPMC has an international reputation as a heavy duty equipment manufacturer, in particular ship to shore container cranes.
2. This is a judgment following a trial of liability only. Since one of the main issues in the case is whether or not Fluor’s claims in this action were settled by an agreement made in June 2010, it has been agreed that all questions of quantum, if they arise, should be tried in May 2017. The claim is for about US\$400 million.
3. At the trial Fluor was represented by Mr Sean Brannigan QC, instructed by Roberta Downey of Hogan Lovells, and ZPMC was represented by Mr Andrew White QC, Mr Sean O’Sullivan QC, Mr Mark Chennells and Mr Iain Munro, instructed by Mr Adam Harris of Pinsent Masons. I am very grateful to them all, and their teams, for their detailed and careful submissions and for ensuring that this difficult and complex trial ran so smoothly.

An outline of the project and background to the dispute

4. By the terms of a contract made between Fluor and Greater Gabbard Offshore Winds Limited (“GGOWL”), known as the BOP Contract, Fluor agreed to engineer, procure and construct the foundations and infrastructure to support 140 wind turbine generators (“WTGs”) which were to be installed in the North Sea approximately 26 km off the coast of Suffolk.
5. Each foundation consisted of a monopile (sometimes abbreviated to “MP”), which was a massive steel structure composed of individual “cans” of rolled steel plates which were then welded together to form a cylindrical column, typically 65 m in length, 5-6 m in diameter and weighing between 550 and 700 metric tonnes. Each of these MPs was to be driven approximately 32 m into the seabed. At the top of each MP sat the transition piece (sometimes abbreviated to “TP”), each one of which was approximately 23 m in length and 5 m in diameter. The TP provided the connection between the monopile and the structure above it.
6. Fluor’s plan was to fabricate the MPs and TPs in Shanghai and then ship them to Vlissingen in the Netherlands. Fluor was to establish a staging port at Vlissingen, where it would receive the MPs and the TPs after fabrication, install the requisite electrical equipment in the TPs and then load the MPs and TPs on to special purpose vessels for transportation to the site and subsequent installation.
7. In order to ensure the quality of the welds in the MPs and the TPs the BOP Contract provided for non-destructive testing (“NDT”), one form of which was ultrasonic testing (“UT”). UT can involve several different techniques known as scanning

patterns. I will say more about these later in this judgment, but in outline this involved placing a probe on the surface of the steel which transmitted an ultrasonic pulse through the weld metal being tested. Imperfections in the weld (of a certain type and/or size) would be revealed by an alteration in the signal seen on the operator's screen. For this testing to work properly there has to be good contact between the probe and the surface of the metal being tested. A longitudinal or circumferential seam weld has a curved profile, known as the cap. If the cap is unground, the probe usually has to be placed on the flat surface of the metal either side of the weld. The pulse is transmitted through the weld metal at an angle to the line of the weld seam and also at an angle to the horizontal. This method of scanning - known as scanning pattern E, or E scanning - is efficient at picking up some types of imperfection but others, such as cracks that are transverse to the line of the weld, are more readily picked up by scanning pattern D. For some welds in critical areas, such as the mud line, the specification required the weld cap to be ground flush with the surface of the base metal, and so it was possible to scan these welds by placing the probe on the surface of the weld itself - this is known as scanning pattern D, or D scanning. D scanning is much more efficient at picking up transverse cracks, as the facts of this case have demonstrated with startling clarity.

8. One well-known, albeit fairly uncommon, problem that can occur when welding thick steel plates is hydrogen cracking, sometimes referred to as cold cracking. This happens when atomic hydrogen created by the welding process remains in the weld metal after it has cooled. Being the element with the smallest atoms, at high temperatures hydrogen can diffuse through and out of the lattice of the weld metal relatively easily, but for this to happen the weld metal must be prevented from cooling too rapidly. Hydrogen cracking is fairly rare and when it does happen it is usually the result of some systemic shortcoming in the welding procedure, rather than the result of isolated acts of poor workmanship. Hydrogen cracking typically occurs in a plane transverse to the line of the weld.
9. The NDT procedures in the BOP Contract provided that scanning pattern D was to be used when welds were ground flush and that scanning pattern E was to be used when the welds had not been ground flush. It was Fluor's case in the arbitration that it subsequently brought against GGOWL that these provisions were mandatory and that to carry out a D scan on an unground weld would be a deviation from the terms of the contract.
10. Similar provisions were included in the contract between Fluor and ZPMC, but ZPMC requested and was granted a concession to the effect that it need not perform a D scan on a ground weld if that weld had been previously inspected by E scanning prior to grinding. It was assumed, correctly so far as I can tell, that the process of grinding of the weld cap would not have any effect on the presence or absence of cracks in the welds.
11. However, what was not appreciated was that D scanning was very much more effective at identifying transverse indications - in other words, a signal pattern on the screen that might indicate a transverse crack - than E scanning. So much so that many circumferential welds were passed as satisfactory by E scanning when in fact they contained many imperfections that could be seen on a D scan. As a result of the concession in relation to D scanning on ground welds, relatively few circumferential welds at Changxing were subjected to inspection by D scanning during the early

months of manufacture. However, it was discovered by one fabrication shop in ZPMC early in 2009 that scanning by “riding on the weld” - in other words a form of D scanning - found imperfections that were not seen by E scanning. I will have to discuss later in this judgment the extent to which this fact was more widely known within ZPMC.

12. Thus it was an unfortunate consequence of the UT techniques adopted at Changxing that many MPs contained transverse cracks that had not been detected by the E scanning carried out by ZPMC. However, at the end of March 2009, a Mr Roberts, of RWE¹, discovered transverse cracking in one MP (IGI 04) of Shipment No 1. Unfortunately, the report of this did not reach Fluor until 15 April 2009, by which time Shipment No 1 was already at sea and on its way to Vlissingen. Fluor made arrangements for a testing company called Sonovation to carry out tests on this MP when the shipment arrived at Vlissingen.
13. Shipment No 1 arrived in Vlissingen on 20 May 2009. About a week later some MPs of the shipment were tested by RTD Applus, a testing company engaged by GGOWL, which found transverse cracking on another MP, IGH 06. The upshot of this was that on 3 June 2009 GGOWL issued a non-conformance report (NCR 006) which required Fluor to retest the entirety of the MPs in Shipment No 1 and repair any cracks that were found. It was sent to Fluor by e-mail the following day. The retesting was to be carried out using D scans wherever possible, even if the welds had not been ground. The size of the welds on the MPs was such that the weld caps were relatively flat so that it proved possible in most cases to carry out an effective D scan even though the weld had not been ground flush with the base metal.
14. In due course, similar NCRs, NCR 008 and NCR 009, were issued in relation to the entirety of the MPs in Shipments Nos 2 and 3, respectively, with the result that Fluor, with the assistance of ZPMC, had to embark on a massive operation of retesting the MPs at Vlissingen and repairing any cracks that were found. In order to do this, extensive temporary facilities had to be set up at Vlissingen and the installation of the MPs at sea was delayed. However, both Fluor and ZPMC began to take the view that the extensive retesting required by GGOWL was not only more extensive than their respective contractual obligations but also was unnecessary in terms of the structural integrity of the MPs. By the end of September 2009 Fluor had decided, having taken expert advice, that the further testing and repair should cease and that the MPs of Shipment Nos 1-3 should be installed without further delay, irrespective of whether or not they had been repaired.
15. From then on there was a series of high-level meetings between representatives of Fluor and ZPMC which eventually resulted in an agreement by which ZPMC would assign its claims for the costs of the additional testing and repairs at Vlissingen to Fluor, who would pursue them together with its own claims against GGOWL, and by which Fluor would waive its claims against ZPMC in respect of the additional costs it had incurred as a result of the issue of NCRs 006, 008 and 009. In addition, ZPMC gave a warranty that the unrepaired MPs in Shipment Nos 1-3 would perform

¹ After the BOP Contract had been entered into RWE npower Renewables Ltd (“RWE”) became a 50% shareholder in GGOWL. The other shareholder was Scottish and Southern Energy (“SSE”), whose quality control representative was Parsons Brinkerhoff (“PB”).

satisfactorily in service for 25 years. This agreement was recorded in two letters which were signed by ZPMC in June 2010.²

16. It is on the basis of these two letters that ZPMC contends that the claims made by Fluor in this action were settled. The true construction of these letters, and whether or not Fluor is now estopped from advancing some or all of its contentions in this action, is a major ground of dispute between the parties.
17. At the risk of some significant oversimplification, the principal issues of liability to which this claim gives rise can be summarised as follows:
 - (1) Whether the MPs and/or TPs were fit for their purpose on arrival at Vlissingen.
 - (2) If not, whether that was caused by a breach or breaches of contract by ZPMC.
 - (3) If ZPMC was in breach of contract, whether (and, if so, to what extent) Fluor's claims have been settled by the agreement made in June 2010 as a matter of the true construction of the letters, or whether Fluor is now prevented from advancing some or all of its claims in this action as a result of an estoppel.

In the context of issue (1), Fluor did not advance a claim at the trial that any of the MPs are liable to fail during their 25-year service life.

18. With this introduction, it may be helpful at this point to give a few statistics which provide some indication of the scale of the project.

Some vital statistics

19. ZPMC employs 28,000 people at Changxing. The island has a 5 km deep water coastline, and includes a heavy duty dock of 3.7 km. In 2015 ZPMC was the largest heavy duty equipment manufacturer in the world and owned 26 transportation ships capable of delivering its products all over the world.
20. At the time of peak production on this project ZPMC had 1,000 welders working at any one time. Their work was being checked by about 100 people engaged or employed by Fluor. The work was carried out 24 hours a day, 7 days a week.
21. The fabrication of the 140 MPs and TPs involved 119 km of finished welds. To achieve this the welders made 2,378 km of passes along the various seams.
22. ZPMC's operation at Changxing Island was split between three "branch companies". During the first three shipments, with which this trial has been principally concerned, branch company 1 had approximately 500 welders working on the project, branch company 2 about 900 welders and branch company 3 about 400 welders.
23. 70% of the world's container port craneage is manufactured by ZPMC.

² In both cases the letters were subsequently amended, as I shall explain later in this judgment, but the basic agreement remained unchanged.

24. In the light of these figures, Mr White reminded me, very properly, that one needs to have the scale of the operation constantly in mind in order to put the contemporaneous documents before the court in their proper context. I am very conscious that the selection of documents put before the court, extensive though it is, represents no more than the tip of a very large iceberg.

The conduct of the trial

25. The principal part of the trial lasted for 18 days during February and March 2016, but a further day, 19 April 2016, was taken in order to hear the evidence of two further witnesses. Closing submissions were made on 9 and 10 June 2016. The written closing submissions of the parties, excluding appendices, ran to over 800 pages.
26. Between them, the parties called just over 20 witnesses, and 6 experts. Several of the witnesses called by ZPMC gave evidence through an interpreter and, as a result, I did not find it easy to form any reliable impression about the quality of their evidence, a difficulty aggravated by the fact that nearly all the evidence concerned events that occurred six or more years before the trial.
27. The expert evidence was concluded in three days, which was achieved by adopting a hybrid process of joint examination by the court of the experts of each discipline together with limited cross examination. This worked well and certainly shortened the time that would otherwise have been taken by the expert evidence.
28. There were about 150 ring binders of documents, excluding documents that were in electronic form only. Many of these were translations of documents originally written in Chinese, and in some cases there was more than one translation of the same document.
29. I thought that all the witnesses gave evidence honestly, save in one or two cases which I will mention in the course of the judgment. However, there was a tendency on both sides for witnesses to allow loyalty to their company to influence the evidence that they gave, but this is perhaps unsurprising when the events under inquiry took place so long ago.
30. A difficulty that confronted many of the witnesses called by Fluor was that the case that was being advanced on its behalf at this trial conflicted very substantially with the case that Fluor had advanced in the arbitration against GGOWL in 2011 and 2012. Some of them were subjected to close and no doubt uncomfortable cross examination about the evidence that they had given in the arbitration.

The key contractual terms

31. It is common ground that the relationship between the parties was governed by Purchase Order No 66577000-2-0001 dated 11 April 2008 (“the PO”). The price for ZPMC’s works was agreed at €234,097,500.
32. Paragraph 8.0 of the PO, which was headed “SCHEDULE & REPORTS” provided:

“Progress Reporting

Within 30 days after Purchase Order award Seller shall submit a legible reproducible copy of the Design, Manufacture and Delivery Schedule for all items

detailed in the Bill of Materials of this Purchase Order. As a minimum the schedule shall include the following:

1. Material procurement schedule including Seller's suborder dates, sub-supplier's name and expected material delivery dates.
2. Manufacturing and delivery schedule containing:
 - a. Start of fabrication dates.
 - b. Starting and completion dates of all major steps during fabrication.
 - c. Shipping date(s)
Seller shall submit every 2 weeks thereafter . . . updated progress reports showing actual progress against planned progress dates and shall detail specific or potential problems of which Buyer should be made aware."

33. Paragraph 9.0 of the PO, which was headed "DOCUMENTATION" provided:

"Any review or approval of data or documentation submitted by Seller to Buyer shall not relieve Seller of the responsibility for the accuracy of documentation or data, or compliance with all requirements of the Purchase Order. Buyer confirms that documents will not be subject to repetitive revue [sic] due to subjective reviewer comments."

34. Paragraph 21 of the PO listed other documents forming part of the contract:

- "1. This Purchase Order document
2. Attachment A
3. Attachment B
4. All other Commercial Attachments
5. Attachment C
6. All other documents listed in Attachment C in accordance with the order of precedence listed therein."

35. Attachment B to the PO, "Terms and Conditions of Purchase", provided:

"6. WARRANTY: Seller warrants to Buyer and Owner that all goods and services covered by this Purchase Order will conform with the specifications, drawings and other descriptions supplied or advised by Buyer and will be new, of good quality, fit and sufficient for the purposes for which they are intended as evidenced in this Purchase Order . . . of good materials, design and workmanship, free from defects, and will fulfil satisfactorily the operating conditions specified herein.

...

8. [As substituted by paragraph 4 of the PO]

8.1 . . . Seller shall be liable for and shall defend, indemnify, and hold [Buyer] harmless from and against any and all claims, costs, expenses (including attorney's fees), damages, or other liability, howsoever arising, whether in contract, tort (including without limitation negligence or strict liability of the indemnified Party), or otherwise, out of performance of this Purchase Order in respect of:

- 8.1.1 Failure by Seller to comply with . . . this Purchase Order.

...

8.3 Indirect and/or consequential damages, whatever the cause may be shall be explicitly excluded from this Purchase Order.

31. SELLER'S DOCUMENTS:

...

For each part of the Works, and except to the extent that the Parties otherwise agree that if the Seller wishes to modify any design or document which has previously been submitted for review, the Seller shall immediately give notice to the Buyer. Thereafter, the Seller shall submit revised documents to the Buyer in accordance with the above procedure.

Any such agreement (under the preceding paragraph) or any review (under this sub-clause or otherwise) shall not relieve the Seller for any obligation or responsibility."

36. Attachment C to the PO provided, by paragraph 3:

"The Mono-Piles and Transition Pieces shall comply with the requirements of this PR, its attachments and the documents listed in the following Engineering Document List. The requirements of all the referenced documents within the listed documents shall be applied where applicable. . . .

"Fabrication of Offshore Structures"	760 297 97015
"Structural Steel for Offshore Structures"	760 297 97005
"Structural Welding of Offshore Structures"	760 297 97020

And

9.11 Inspections by COMPANY shall not relieve SUPPLIER of complying with all expressed or implied specifications nor of SUPPLIER guarantee that the materials shall perform satisfactorily under conditions specified in the purchase order. No charge arising out of inspection shall be made on this order until such change has been agreed by COMPANY."

37. I will deal with the particular specifications and codes that applied to this project in the next section of this judgment.

The principal characters

On Fluor's side

38. This is not intended to be an exhaustive list of those who gave evidence: indeed, I will mention some individuals who were not called as witnesses at the trial.

39. **Mr Stephen Dobbs.** He was the most senior representative of Fluor who was involved with the project. He did not give evidence.

40. **Mr Hans Dekker.** He was a senior employee of Fluor who became Project Director on 1 July 2009. He is clearly a very able executive and, in general, I am sure that he is an honest man. However, his evidence before me was tainted by the fact that much of it was directly contrary to the evidence that he gave to the arbitrators in 2012. In relation to his written evidence to the arbitral tribunal, he explained that his witness statements have been drafted for him by US lawyers and that he had been provided with a limited set of documents, by reference to which the statements have been prepared. He said that he had conversations by telephone with the US lawyers and

that he rather naïvely relied on them to get the facts right. He said that the preparation of his witness statements in the current proceedings, by contrast, had been much more thorough, and that he had seen many more contemporaneous documents, with the result that his present evidence was much more reliable and complete than that which he gave in the arbitration. In these circumstances, I consider that his evidence, both to the arbitrators and to this court, must be treated with a considerable degree of caution.

41. **Mr Bruce Hovermale.** He was the Project Director until the end of June 2009. He was replaced by Mr Dekker after the problems emerged with the transverse cracking. I discuss his evidence in cross examination in some detail later in this judgment.
42. **Mr Douglas Fuller.** He was Vice President of Operations, responsible for infrastructure operations in Asia. I thought that he was a careful witness who gave his evidence fairly and honestly. He said that he thought that Mr Guan and Mr Cao were good men and that he had a lot of respect for both of them, and I am sure that he meant it. A particularly revealing aspect of his evidence was when he was being questioned about a passage in his witness statement in the arbitration in which he said that the project was paralysed by the issue of the NCRs. When asked whether he still stood by that statement, he said that he did. That answer was revealing because it was not one that it was in Fluor's interests for him to give.
43. **Mr Russell Ayres.** He was the Deputy Project Director. I thought that he was an impressive, truthful and careful witness.
44. **Mr Jason Estabrook.** He was the Quality Assurance ("QA") Manager in China - in effect, Fluor's NDT specialist. He is qualified to ASNT level III, the highest level of NDT accreditation by the American Society of Non-Destructive Testing. I thought that he was a careful and generally reliable witness, but as with many others his evidence suffered from the severe limitation that most of it was about matters that occurred 6 or 7 years ago. He seemed to have a good relationship with those with whom he worked directly at ZPMC.
45. **Mr David Dove.** He is a welding engineer who clearly knows a great deal about it and feels very strongly about the quality of the welding on projects for which he has a responsibility. However, it was often quite difficult to follow the reasons that he gave for some of his answers in cross examination: but in the event not much turned on his evidence, but rather on some of the contemporaneous reports that he wrote at the time.
46. **Mr Doug Hardie.** He was Fluor's European Regional Manager, Expediting and Supplier Quality Surveillance from 2002 to 2011. I thought that his evidence was not always consistent, but in the event not much turns on it.

On ZPMC's side

47. Again, I will only mention those witnesses to whom I have referred during the course of this judgment. As I have already said, because many of them gave evidence through an interpreter, it was not easy to form a view based on the manner in which they gave their evidence. Some of them were, perhaps unsurprisingly, concerned not to give any evidence that might be thought to damage ZPMC's case. For ease of reference, an organisation chart of the management at Changxing is attached as Appendix A.

48. **Mr Guan Tongxian.** He is the founder and former President of ZPMC. He has clearly built up the company into a very successful enterprise with a worldwide reputation. His regret that ZPMC had become involved in litigation with Fluor was very evident, but he was nevertheless proud of the project. He is now 84 and, although remarkably fit for his age, accepted that his memory of the important meeting on 30 September 2009 was not good. I thought that he was a man of integrity who believed strongly that ZPMC should go to any lengths to deliver a good quality product.
49. **Mr Kang Zuezeng.** Mr Kang succeeded Mr Guan as President on 7 December 2009. Although he signed the waiver and warranty letters in June 2010, his involvement in the crucial events of the project was fairly limited.
50. **Mr Cao Weizhong.** He was Senior Vice President in charge of production planning and manufacturing. I discuss his evidence in relation to some of the important meetings later in this judgment.
51. **Mr Huang Qingfeng (Fred).** At the relevant time he was the Vice President responsible for Quality Control and Assurance. He is currently the President of ZPMC and speaks English very well. His evidence was somewhat contentious, but in the event I do not find that it is of crucial relevance to any of the issues that have arisen in the case.
52. **Mr Gao Feng (Ryan).** He was the Project Manager. He was an English speaker and was the primary point of contact for correspondence between Fluor and ZPMC. He reported to Mr Huang.
53. **Mr Chen Bin.** He was the Quality Assurance General Manager.
54. **Mr Lu Hanzhong.** He was the Deputy General Manager at Changxing.
55. **Mr Li Ruixiang.** He was Mr Lu's opposite number as the Quality Assurance Vice General Manager.
56. **Mr Shen Daming.** He was the Chief Engineer of the Testing Centre, but he did not give evidence at the trial. He appears to have been highly regarded within ZPMC for his technical expertise.
57. **Ms Ma Xiaomei.** She was the Quality Control Manager for branch company 2. She gave evidence in English and, for someone at a relatively junior management level, she seems to have played a fairly prominent role in this project. She was a careful witness and I discuss parts of her evidence later in this judgment.
58. **Mr Liu Qizhong.** He was in charge of marketing and sales for ZPMC and so, as he put it, his involvement in a project usually came to an end when the contract was signed. He gave evidence in English, which he spoke extremely well. His involvement during the project came about through his role as a translator for Mr Guan. I discuss his evidence later in this judgment, particularly in relation to a meeting that he said took place in November or December 2009.

The experts

59. **Mr John Lilley.** Fluor's principal NDT expert, who wrote a joint report with Mr Tim Armitt and Mr Steve Traves.
60. **Dr Richard Dolby.** He was Fluor's principal metallurgy expert, who wrote a joint report with his fellow metallurgy expert, Dr Ted Hamre, and with Mr John Marlow and Dr David Howse, who were welding engineering experts.
61. **Mr John Marlow.** He was Fluor's welding engineering expert who gave evidence.
62. **Dr Lewis Morgan.** He was ZPMC's NDT expert.
63. **Dr John Robert Gordon.** He was ZPMC's metallurgy and welding materials expert.
64. **Mr Robert Teale.** He was ZPMC's welding engineering expert.

The welding carried out at Changxing

The relevant processes

65. At Changxing ZPMC used three welding processes in order to weld the cans. These were:
 - (1) Shielded Metal Arc Welding ("SMAW");
 - (2) Submerged Arc Welding ("SAW");
 - (3) Flux Cored Arc Welding ("FCAW").
66. Arc welding is one of several fusion processes for joining metals. The intense heat required to melt the steel is generated between the welding wire, acting as a positive electrode, and the pieces of steel to be joined - the base metal - acting as the negative electrode. When the welding wire contacts or is in very close proximity to the base metal it forms an electrical circuit through an arc, which has a local temperature in excess of 3,000°C, which melts both the wire and the base metal. The molten pool of weld metal fuses with the base metal which, as it cools, creates the metallurgical bond or weld. During this process it is important that the molten weld metal is protected from gases such as oxygen, hydrogen and nitrogen which can have a detrimental effect on the integrity of the weld. This is done, in part at least, by the use of a flux.
67. The principal welding processes were SAW and FCAW. SMAW was generally used for the initial tack welds, whose function was to hold the steel pieces in place prior to the primary structural welding. For the purposes of this judgment, it is not necessary to say anything more about it.
68. In SAW the positive electrode is a solid welding wire the tip of which is passed under a layer of flux, which is in the form of a powder placed on the surface of the base metal. Some of the flux is melted into "slag" which solidifies on top of the weld metal as it cools. This has to be removed mechanically after each welding pass, but this is not difficult. The procedure is then repeated over and over again until the whole of the joint between the steel plates has been filled by the weld metal. Thus very many passes are required in order to achieve the complete weld.

69. Some of the flux powder is not melted and that is then recovered and placed in a hopper for reuse. A frequent criticism made by Fluor of ZPMC's practices when using SAW was that the surplus flux powder that had not been used up in the welding was simply swept up and dumped in the hopper without any attempt to separate it from other contaminants with which it had become mixed. This may explain why there was a higher number of defects in the primary SAW welds than there should have been, but for reasons which will become clear later in this judgment I find that little of any ultimate significance turns on this.
70. In FCAW the flux is contained within a tubular electrode wire and again forms a solid deposit of slag on top of the weld material. At Changxing the wire (or consumable) used at the time was called Supercored 71H, manufactured by Hyundai. Additional protection against contamination by detrimental gases was provided by an externally supplied shielding gas, CO₂ (although it could have been argon, or a combination of CO₂ and argon). With FCAW both the arc and the molten weld pool are not concealed by a layer of flux and so they are clearly visible to the welder, which requires very strong protection for the eyes of the operators.
71. At Changxing Fluor was keen to encourage ZPMC to use SAW for the primary structural welds and FCAW for repairs. When production first started ZPMC sometimes used FCAW for the primary – mainly longitudinal - welds, but Fluor objected to this and, by the end of 2008, nearly all the production welds were carried out using SAW. Repairs were necessary if the subsequent NDT revealed a defect in the weld. If the indications revealed by the probe were above the relevant criteria, then the weld would have to be repaired. The weld material in the relevant area was gouged out and then re-welded (by FCAW).
72. Repair welding differs from the primary or production welding in two important respects. First, because the base metal either side of the area being repaired is joined by the existing weld, the base metal in the area being repaired is effectively rigid so that there is a very high degree of restraint. Second, the length of each weld pass is very short, with the result that one pass follows quickly after the other and the weld metal remains at a much higher temperature throughout the process, albeit for a shorter time overall.
73. It is generally regarded as undesirable for there to be more than two repairs in the same place, and so the third and subsequent repairs in the same place are usually known as Critical Repairs and require a different procedure.
74. In welding operations of the type that were involved in the fabrication of the monopiles and the transition pieces at Changxing, it is good practice to preheat the base metal in the vicinity of the joint before welding. There are three reasons for this (which, for convenience, I take from the first report Mr Teale). First, it lowers the cooling rate in the weld metal and the base metal, producing a more ductile metallurgical structure with greater resistance to cracking. Second, the slower the metal cools the greater the opportunity for any hydrogen present in the weld metal to diffuse out and not cause cracks. Third, it reduces shrinkage stresses in the weld and the adjacent base metal. A number of factors affect the choice of preheat temperature, such as the thickness of the joint, the type of steel being welded and the amount of restraint imposed on the components forming the joint.

75. At paragraph 2.9.4 of his first report Mr Teale said this:

“The application of preheat involves heating the base metal, either in its entirety or just the region surrounding the joint to a specific desired temperature called the preheat temperature. This is done prior to welding. Heating may be continued during the welding process, but frequently the heat input from the welding process is sufficient to maintain the desired temperature without a continuation of the external heat source.

The interpass temperature, defined as the base metal temperature between the first and last welding passes, cannot fall below the preheat temperature. Interpass temperature will not be discussed further in this report.

Fabricators have successfully used gas heating for preheating for many decades. Electrical resistance elements and induction heating equipment are also used for preheat, especially when welding thicker sections. All these methods are acceptable and effective but electrical resistance and induction heating equipment can be easier to control and monitor in the field.”

76. At paragraph 2.9.6 he discussed post heat, that is to say heat applied to the area of the joint after welding has been completed. He said:

“Post heat refers to the maintenance of preheat/interpass temperatures after the weld has been completed to allow increased rates of hydrogen diffusion from the weld to occur. The post heat temperature may be the same as, or greater than, the preheat temperature specified.

Post heat is a technique closely related to hydrogen bake-out. Post heat is a fabrication hydrogen diffusion process usually done during repair on thick sections. In thick section repairs the weld repair will cool rapidly and this is known as “heat sink”. Rapid cooling will cause high restraint. The use of resistance heating mats or induction coils are more effective compared to gas heating torches to help to offset heat sink. Post heating can also be done when ambient temperatures are near 0°C and/or humidity levels are high and HACC is a concern. Post heat is different to PWHT.³ Post heat temperatures are usually less than 480°C and PWHT is above 480°C and more typically above 600°C.

Post heat is not usually a mandatory requirement in codes and standards but can be specified by clients or fabricators, especially on weld repairs with high restraint.”

77. None of this was controversial. I have quoted these extracts from Mr Teale’s first report because they provide a convenient summary of the position.

The specifications and codes that were relevant to the welding on this project

78. On 10 May 2008 Fluor issued Revision 1 of its Specification for Structural Welding of Offshore Structures (Document No 760 297 97020). On 18 June 2008 Fluor issued Rev 0 of Document No A4AX-MSP-SPC-215-0004 “Specification for Structural Welding of Offshore Structures”. It is accepted by ZPMC that this later specification incorporated agreed revisions to the earlier specification (ZPMC’s closing submissions, at paragraph 646), but in fact nearly all the provisions that are relevant to the issues in the case remained unchanged between the two versions. The later document has been generally referred to as “the Welding Specification”.

³ "Post Weld Heat Treatment".

79. Under the heading “General Welding Requirements” in the later document there was a section headed “Temperature Control”, section 2.1.3, which said this:

“Develop temperature control methods and techniques for operations involving preheat, interpass temperature, post-heat, or stress relief temperature control.”

This replaced an identical provision in the earlier specification.

80. However, the Welding Specification was revised and issued for construction in March 2009, although dated 13 February 2009. The corresponding section headed “Temperature Control” now said this:

“Develop temperature control methods and techniques for operations involving preheat, interpass temperature, post-heat, or stress relief temperature control. Maintenance and management of preheat and interpass temperature shall be in accordance with ISO 13916.”

ISO 13916:1996 is a European standard which gives guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature. There is no room for any suggestion that this change could have taken effect before the document was issued in March 2009 and, indeed, as I understood the position taken by Fluor in its closing submissions, it no longer relies on this revision.

81. Section 2.1.11 of the Welding Specification, under the same heading, was headed “Preheat and Interpass Temperatures”. Paragraph A said this:

“Preheat temperature shall be in accordance with the applicable codes except that code recommended minimum preheat temperatures shall be mandatory. Preheat requirements shall apply to all welding, including tack welding and welding of temporary attachments . . . Preheat shall be maintained a minimum of 100 mm on either side of the joint.”

This was in identical terms to section 2.1 K of the earlier specification. Revision 1 of the Welding Specification (issued in March 2009) amended the first sentence of this paragraph so as to read: “*Preheat temperature shall be in accordance with the applicable qualified WPS*”.

82. Paragraph E of the same section of the Welding Specification said that if “Oxy-fuel torches” are used for preheating, the torch tip was to be appropriate for the work, namely a “rosebud” tip and not a cutting or welding tip. The former is what ZPMC used.

83. In section 2.3.3, under the heading “Welding Procedures”, it said this:

“Before beginning work, [ZPMC] shall establish and qualify detailed welding procedures for various materials and components used in structures to be fabricated, in accordance with requirements of Sections 5 and 10 of AWS D1.1. Use of prequalified welding procedures as defined in Section 3 of AWS D1.1 is not permitted.

Written welding procedures shall be prepared and tested in accordance with Section 4 part B of AWS D1.1 and Section 2.3 B of the Structural Welding of Offshore Structures. In the case of conflict the most onerous requirements shall

apply. The procedure qualification report (PQR), including NDT and mechanical test results shall be submitted to [Fluor] together with the welding procedure specification (WPS).

...

For repair of a weld, either the original approved WPS, or one originally submitted and approved as a designated repair WPS, shall be used.”

84. Paragraph G of the same section was headed “Limitations on Variations”. This provided for certain restrictions on changes in essential variables as permitted by AWS D1.1, one of which was that there was to be no increase of more than 50°C in specified preheat temperature, subject to maximum interpass temperature limitations.
85. Paragraph J of this section, which dealt with the repair of welds, included this provision:

“A Procedure to be developed by [ZPMC] [and] shall be submitted to [Fluor] for review prior to use. A repair procedure shall include the following:

1. The method of defining the type and the extent of the defect.
2. Excavation methods for removing the defect and NDE methods to ensure that the defect has been completely removed.
3. Welding procedure employed and NDE methods used to inspect the completed repair.”

These provisions were in virtually identical terms to the corresponding provisions in the earlier specification.

86. Section 3.4.2, under the heading “Workmanship and Inspection”, provided at paragraph 1:

“Each layer of welding shall be smooth and [free smooth and] free of slag inclusions, porosity, excessive undercut, cracks and lack of fusion prior to beginning the next layer . . .”

This provision was relied on by Fluor, but when doing so it usually cited it in part only and omitted the final six words of the extract quoted above. It was pointed out by ZPMC, in my view correctly, that this provision had little or no relevance in the context of hydrogen cracking because that typically occurs during the 48 hours after the weld has been completed and as it is cooling: it is unlikely to happen quickly enough to occur between passes,⁴ particularly in the case of repair welds where the temperature remains high throughout the entire region of the repair weld.

87. There was also a Specification for Structural Steel for Offshore Structures and a Specification for Fabrication of Offshore Structures. However, neither side relied on any provisions of these two specifications beyond those provisions found in the Welding Specification.
88. AWS D1.1/D1.1M: 2006 (“the code” or “AWS D1.1”) is entitled “Structural Welding Code – Steel” and is produced by the American Welding Society and approved by the American National Standards Institute. Mr Teale described it as the “*mainstay of the*

⁴ See the evidence of Mr Lilley at Day 16/101-102.

offshore platform industry for many decades". It was a code with which ZPMC was very familiar and to which it habitually worked. Section 3.5, headed "*Minimum Preheat and Interpass Temperature Requirements*" provided as follows:

"The preheat and interpass temperature shall be sufficient to prevent cracking. Table 3.2 shall be used to determine the minimum preheat and interpass temperatures for steels listed in the code."

The relevant part of Table 3.2, which is headed "Prequalified Minimum Preheat and Interpass Temperature", namely that applicable to steel in Category B of the type used by ZPMC, provided that for FCAW the minimum preheat and interpass temperature for steel where the thickness of the thickest part of the steel at the point of welding was between 38 and 65 mm (inclusive) was 65°C. Where the thickest part of the steel was over 65 mm, the minimum temperature was 110°C.

89. This was the table from which ZPMC derived the temperature of 110°C, which was the preheat temperature that was specified for circumferential welds on the monopiles for plate that exceeded 65 mm in thickness (see the evidence of Mr Marlow at Day 17/101). The minimum preheat and interpass temperature in the relevant WPS was usually expressed as follows:

"10°C [$35 \leq T \leq 38$], 65°C [$38 \leq T \leq 65$], 110°C [$65 < T$]"

where T is the thickness of the plate.

90. Annex I of the code is entitled "*Guideline on Alternative Methods for Determining Preheat*", whose stated purpose was to provide some optional alternative methods for determining welding conditions (principally preheat) to avoid cold cracking. Amongst the factors taken into account in the annex were the anticipated level of hydrogen in the consumable, the hardness of the metal (by reference to the "Carbon Equivalent") and the degree of restraint at the point of welding.
91. Annex I describes the three levels of restraint: low restraint, medium restraint and high restraint. Medium restraint "includes groove welded joints in which, because of members being already attached to structural work, a reduced freedom of movement exists". The high restraint condition applied to welds in which there was almost no freedom of movement for the members joined, "such as repair welds, especially in thick material". Mr Teale accepted this: see paragraph 2.7 of Appendix 2 to his first report (although he considered that the longitudinal and most of the circumferential production welds were in low restraint).
92. Where the consumable was graded as H2 - as in this case - the applicable Carbon Equivalent group was either C or D (Mr Marlow and Mr Teale differed as to which⁵). For plates of thickness between 28 and 75 mm in these groups Table I.2 indicated a minimum preheat and interpass temperature of 110°C and 130°C, respectively, for

⁵ I have some difficulty with Mr Teale's position on this. For a consumable classed as H2, group C had a Carbon Equivalent of < 0.23 and group D of < 0.28. In evidence Mr Teale said that his value was "about 0.23" (Day 17/91), in which case it would not fall within group C but at the bottom end of the range for group D because the symbol used in the relevant table was <, and not ≤. However, given that it made no difference for high restraint conditions, there is no point in exploring the issue further.

medium restraint conditions, and 150°C (for both groups), for high restraint conditions.

93. The thickness of the steel plates used to make the cans for the monopiles was between 55 and 85 mm. For the transition pieces it was between 60 and 75 mm. I understood it to be common ground that all these would constitute thick material.
94. Paragraph 5.4.6 of AWS D1.1 provided that welds having prohibited discontinuities should be repaired using a qualified welding process unless the entire weld was to be removed and replaced. The discontinuities that were prohibited were described in Part C of the code, which dealt with acceptance criteria. I shall discuss this in more detail under the section of this judgment that deals with NDT, but in short if the prescribed form of NDT produced indications in excess of the specified criteria, then a repair was required.
95. The code was accompanied by a Commentary, which was itself a substantial document. In its Foreword it stated that the code was to provide “*general stipulations applicable to any situation and to leave sufficient latitude of the exercise of engineering judgment*” and that the commentary was “*the most suitable means to provide clarification as well as proper interpretation of many of the code requirements*”.
96. Paragraph C-3.5 of the Commentary, headed “Minimum Preheat and Interpass Temperature Requirements” said this:
- “The principle of applying heat until a certain temperature is reached and then maintaining that temperature as a minimum is used to control the cooling rate of weld metal and adjacent base metal. The higher temperature allows more rapid hydrogen diffusion and reduces the tendency for cold cracking. The entire part or only the metal in the vicinity of the joint to be welded may be preheated (see Table 3.2). For a given set of welding conditions, cooling rates will be faster for a weld made without preheat than for a weld made with preheat. The higher preheat temperatures result in slower cooling rates. When cooling is sufficiently slow, it will effectively reduce hardening and cracking.
- . . .
- It should be emphasised that temperatures in Table 3.2 are minimum temperatures, and preheat and interpass temperatures shall be sufficiently high to ensure sound welds.
- . . .
- Based on these factors, the requirements of Table 3.2 should not be considered all-encompassing, and the emphasis on preheat and interpass temperatures as being minimum temperatures assumes added validity.”
97. Mr Marlow’s evidence was that Table 3.2 provided minimum temperatures which, in appropriate circumstances, could be increased by reference to Annex I. That seems to me to be plainly correct. His preference was to use Annex I, but he accepted that that was largely a judgement based on experience (Day 17/102-104).
98. Another standard to which reference was made was Offshore Standard DNV-OS-C401 “Fabrication and Testing of Offshore Structures, April 2004”. This is produced by the well-known Norwegian classification agency Det Norske Veritas (“DNV”). This was the standard favoured by Fluor. Section F was headed “Assembly, Welding,

Treatment and Repairs", of which paragraphs 305 and 307 were in the following terms:

“305 Repair welding in the same area may be carried out twice. Further repairs shall be evaluated in each individual case.

307 Repair welding shall be performed using welding consumables satisfying the hydrogen test requirement given in 118. The preheating and working temperature shall when making shallow and local repairs in special and primary structural elements be raised 50°C above the level specified for production welding and be at least 100°C unless otherwise agreed. The working temperature shall be maintained until the repair has been completed. To ensure sound repair welds, the single repair length shall not be shorter than 50 mm.”

99. Mr Marlow had to confess that he was unable to explain the reference to “*shallow and local repairs*” in paragraph 307 and that he had taken this to apply to all repairs, because increasing the preheat temperature by 50°C for repairs was a practice that he said was “*mirrored by virtually every other application specification that I have ever seen*” (Day 17/114). The point that was put to him by Mr O’Sullivan was that he was putting together figures from two standards that had been arrived at in different ways and then adding them together.
100. However, whilst it looked as if there might be some force in this point, it is not one that I need to resolve because in his closing submissions Mr Brannigan disclaimed any need on Fluor’s part to rely on its original allegation that the welding was to comply with the DNV standard. Fluor is now content to rely on AWS D1.1. This was a sensible and realistic concession.
101. Mr Marlow said that the first passes in a longitudinal weld would be under conditions of low restraint, but the subsequent passes on the other side of the plate would be under conditions of medium restraint. He said that the classification of the degree of restraint was essentially a matter of engineering judgement but, he said, as one gains experience that judgement becomes “*pretty precise*” (Day 17/108). He said that a typical circumferential seam weld would be classed as medium restraint, because although the adjacent plates are held in position by tack welds and the weight of the structures the whole arrangement is not completely rigid. However, as I have already indicated, to some extent Mr Teale disagreed with this since he said that the longitudinal and most of the circumferential production welds would be under conditions of low restraint.⁶ But it is common ground, as the code indicates, that repair welds in thick plate are in high restraint.
102. Table 3.2 is stated as providing minimum values dependent on the type of steel being welded and the thickness of that steel: it is silent about conditions of constraint. If, therefore, the minimum preheat temperature stated in Table 3.2 would be appropriate for a circumferential production weld under medium restraint, one might expect that a higher preheat temperature would be appropriate for a repair being carried out to that weld where the conditions would be of high restraint. Of course, it may be that the welding engineer could take the view that the prescribed minimum temperature for

⁶ However, Mr Teale accepted that as the number of cans welded together increased, so the degree of restraint in the circumferential welds may move from low to medium: Appendix 2, paragraph 2.8.

the ordinary production weld was in fact generous for conditions of medium restraint and so might still be appropriate for a repair weld carried out under conditions of high restraint. But, other things being equal, I consider that a steel fabricator would have to give careful consideration to the question of whether or not the preheat temperature stated in Table 3.2 should be increased for a repair weld in steel of the same thickness.

103. A further consideration, to which I refer in more detail below, is the guidance given by Hyundai, the manufacturers of the consumable, Supercored 71H, who recommended a preheat temperature of between 50°C and 150°C. Dr Dolby said that for high restraint conditions a starting point for the choice of preheat temperature would be at the top end of this range, and Dr Gordon, ZPMC's expert on welding materials and metallurgy, agreed (Day 18/101-4). In my view this was a further factor which supported the choice of a preheat temperature of 150°C where the welding involved repairs in thick plates.
104. But, irrespective of these considerations, it was, I find, the shared view of Mr Marlow, Dr Dolby and Mr Teale that 150°C would have been the appropriate preheat temperature for weld repairs in thick plate (see Day 17/73)⁷. However, Mr Teale's comment on this was that since, as he understood it, the use of a preheat temperature of 150°C did not prevent cracking in ZPMC's August 2015 experiments or when repairs were carried out at Vlissingen, some other factor must have been at work. That is a point that must be addressed: I will do that a little later in this judgment.

The Welding Procedure Specifications

105. As the Specification for Structural Welding of Offshore Structures provides, welding was to be carried out in accordance with Welding Procedure Specifications ("WPS"). These were prepared initially by the Testing Centre at Changxing. Initially a draft WPS would be submitted by the Testing Centre to the technical office at Changxing for review, after which it would be passed to ZPMC's QA department, where it would be recorded in the Project Quality Control Plan ("PQCP") before being submitted to Fluor for approval. Fluor would either approve the WPS or make comments, in which case the WPS with Fluor's comments would be returned to the Testing Centre for further consideration and resubmittal.
106. Before a WPS was prepared ZPMC's welding engineers in the Testing Centre would carry out mechanical tests to verify and support the proposed procedure. They would then produce a Procedure Qualification Report ("PQR"). ZPMC said that sometimes these tests were witnessed by representatives from Fluor.
107. In his witness statement, Mr Lu Hanzhong, who was the Deputy General Manager at Changxing at the relevant time, said that ZPMC was not experienced in the work of this type having not manufactured monopiles or transition pieces before. He said that Fluor was aware of this and knew that ZPMC was relying on Fluor's experience to help it manufacture a product that complied with the contract. In the light of this he said, at paragraph 3.7 of his witness statement:

⁷ Mr Teale's evidence was not wholly consistent on this, because at some points he said that he thought 110°C should have been a sufficiently high preheat temperature (see Day 17/71-72), although it was not clear whether he had in mind primary production welds or repair welds to the circumferential seams.

“As a consequence in most circumstances when Fluor raised comments on any submission we incorporated their comments without questioning them. I recall that when we argued with Fluor about their comments it was when they sought to impose requirements that were not in accordance with AWS D1.1 or requirements which were not in accordance with ZPMC’s common practice.”

108. However, as Mr Teale pointed out, prior to October 2008 neither Fluor nor ZPMC had ever been involved in the manufacture of similar structures, so that both sides were on a learning curve. A crucial factor was that the timetable for fabrication required by the contract was extremely tight.

109. In evidence Mr Lu said this (Day 13/22):

“... although I was, you know, Shen Daming’s boss, but in relation to welding work [and] I was very dependent on his team and I trusted Mr Shen Daming’s team.”

Mr Shen Daming was in charge of the Testing Centre. He appears to have been held in high regard, but he was not called as a witness. Mr Lu went on to say that at the time engineers from Fluor and ZPMC’s engineers would have discussions together (Day 13/23).

110. Mr Lu said (Day 13/18):

“... We are aware that there are cracks in welding then we would apply procedures such as pre-heat, interpass heating, post weld heating, all these kind of ways, basically it using heat to prevent cracks.”

When I then asked him whether in the type of welding that was being done on this project ZPMC would expect to use pre-heat, he said:

“pre-heat should be used.”

In addition, he agreed that if the code required that the pre-heat temperature should be sufficiently high to ensure sound welds, then the procedures must ensure that this happens (Day 13/18). This evidence seems to me to be almost self-evident, and I accept it.

111. In saying this I do not wish to be misunderstood. The fact that a weld may have a crack in it does not mean that there has been a breach of the requirement to achieve an appropriate preheat temperature. It is only if cracking persists in circumstances where the workmanship is good and no abnormal factors are present, that an inadequate preheat temperature is likely to be the culprit. It was for ZPMC to choose a preheat temperature for each welding process so as to ensure, absent some unanticipated and abnormal factor, that there is no cracking if the specified procedures are followed and the workmanship is satisfactory. To that extent, therefore, it is not an obligation that can be discharged simply by the exercise of reasonable skill and care.

112. In my view it follows from this, and from the provisions of the Welding Specification that I have cited, that the onus was on ZPMC to select a preheat temperature that was appropriate to the conditions in which a particular type of weld was to be carried out.

The conditions that ZPMC would have to take into account would include the type of consumable being used, the type of steel being welded, the likely degree of restraint (for example, whether or not the weld was a primary production weld or a repair weld) and the likely ambient temperatures of the workplace (which might be particularly important if the welding was being done outside).

113. As I have said, the preheat temperature prescribed by ZPMC for the primary longitudinal and circumferential seam welds was 110°C for plate thicknesses of 65 mm and above. It was common ground that it was open to ZPMC to increase this preheat temperature of 110°C by up to 50°C on the thickest plates without requiring any authorisation (see Mr Lu at Day 13/24; Mr Teale at Day 17/66; Dr Dolby at Day 18/110, and Dr Dolby and Dr Gordon at Day 18/120 - where both those experts agreed that a similar post-heat temperature could be applied without requiring requalification).
114. Since the degree of restraint of the components being welded may differ, production welding and repair welding may require different WPS⁸. As I have already mentioned, section 2.3.3 of the Welding Specification (revised 18 June 2008) provided that "*For repair of a weld, either the original approved WPS, or one originally submitted and approved as a designated repair WPS, shall be used*". It seems to me that where a particular type of repair will necessarily be carried out under conditions different from the production weld - for example, a different degree of restraint - good practice would require the preparation and approval of a designated WPS for that type of repair. This also reflects ZPMC's obligation and to comply with the requirements of the code in relation to preheating and to develop temperature control methods.
115. I was shown an example of a Weld Repair Procedure that was approved in October 2008,⁹ which contains a fair amount of detail about the removal of the defective weld and the preparation of the repair site, but gives no details of the welding process for the repair. Indeed, paragraph (8) of the document said simply that: "*The WPS used for the welding repair need to be qualified for both the position being welded, the joint configuration being repaired*".
116. The relevant WPS for FCAW welding was approved by Fluor on 15 October 2008. There were in fact several of them because there was a different WPS for each welding position and joint detail. However, so far as maximum and minimum preheat temperatures were concerned, they all contain the same information. The minimum preheat temperature varied with the thickness of the plate and the same figures were set out that I have already given. The maximum preheat and interpass temperature was stated to be 230°C. Against PWHT was inserted "N/A". Nothing was said about the method of preheating or measuring the temperature. The WPS stated that it was "*conformable with the current edition of AWS D1.1 (2006)*".
117. Although the relevant WPS stated that they were for FCAW, it must be remembered that in October 2008 ZPMC was carrying out some of the production welding of the

⁸ Paragraph 5.4.6 of AWS D1.1 provided that welds having prohibited discontinuities should be repaired using a qualified welding process unless the entire weld was to be removed and replaced. In addition, a further WPS was required for critical repairs, being a third or subsequent repair in the same place.

⁹ Trial bundle reference: 4.4/51/1226.

can seams using FCAW so these WPS were probably intended for ordinary production butt welds (as the depicted joint detail suggests). However, that does not mean that they could not also have been used for repairs if otherwise appropriate (this was permissible, as I have already explained).

118. These WPS were revised and approved by Fluor on 8 December 2008. The only material difference that I have noticed between the revised and original versions concerned matters such as the welding travel speed, which was reduced in the resubmitted versions. Relevantly for present purposes, there was no requirement for post heat and no change to the maximum and minimum preheat temperatures and the revised WPS were also silent about the method of applying heat or measuring the preheat temperature.
119. In an e-mail to Mr Fuller dated 30 May 2009, Mr Estabrook accepted that preheating with a gas torch was an approved method. In evidence he explained that this was because the WPS allowed the operatives to heat the metal in any way that they wanted provided that they brought it up to the right temperature.
120. However, in a draft e-mail that Mr Estabrook prepared on the same day on the subject of repair cracking, he wrote this:

“It appears that it may be the pre-heating with a torch that might be the problem. The reason for this is because during FCAW only welding on the long seams we rarely have a problem with the welds. However, when repairs are done they are almost always done with the preheat bands off (except small Changxing workshop). The material is so thick that it may be pulling the heat away too fast - making adequate preheat impossible even if it appears that the preheat is okay. I discussed this with Ms Ma and she said ZPMC has reached a similar conclusion and has made it mandatory for all preheat to be done with the electric bands. Somebody could ask why we did not change our repair procedure if it was found to be inadequate. This is probably something we need to change.”

Mr Estabrook explained that by “FCAW only welding” he meant some welds on the long seams which were carried out entirely by FCAW, although this happened on only about five or six cans that were included in the first shipment. Mr Estabrook said that it was now his belief that allowing the temperature to fall below the minimum temperature specified was probably the main cause of the cracks in the repairs carried out by FCAW (Day 4/93).

121. I have already mentioned that ZPMC’s own welding repair procedures and AWS D1.1 required repairs to cracks to be carried out in accordance with a qualified welding process. I find, therefore, that it was ZPMC’s duty to prepare an appropriate WPS, which would be required to specify preheat and interpass temperatures that were appropriate for repair welds in thick plates. These temperatures would have to be specified taking into account that repair welds would be carried out under conditions of high restraint and, where the plates being welded were thick (in excess of 65 mm), and this would usually require a separate WPS.
122. Having regard to what I consider to have been the shared view of the experts that an appropriate preheat temperature for repair welds using Supercored 71H in plates that were 65 mm thick or greater was 150°C, it follows that ZPMC should have prepared a

WPS for repair welds that specified this temperature. There is no evidence that it did so: if it ever happened and a suitable WPS for weld repairs was prepared, then it is an inescapable finding on the material available that it was never widely implemented at Changxing. Either way, ZPMC was in breach of its obligations in respect of workmanship under the PO.

123. It seems also that when the WPS were being first prepared no one within ZPMC gave any thought to the other point raised by Mr Estabrook, namely the adequacy of applying the preheat with a torch to the same side as that from which the welding was being carried out. Ms Ma had clearly taken it on board, but probably not until well into 2009. However, as I mention below, this point was picked up in December 2008, although the evidence is sparse as to what, if any, action was taken in the light of it.

The draft WPS dated 12 January 2009

124. An issue in the case on which much attention was focused prior to the trial concerns a draft WPS that was submitted to Fluor in relation to a critical repair procedure dated 12 January 2009. Mr Lu said in his witness statement that in late 2008 it was clear that ZPMC was having difficulty in undertaking successful repair welds. He said that ZPMC knew from experience that adding post weld heating had improved the repair success rate on other jobs involving thick plate. Accordingly, he says that he agreed that a critical repair procedure should be submitted to Fluor for approval in which the inclusion of post weld heating would be justified by reference to AWS D1.5 - a code which related to bridges. If that was the case, there is no reference to it in the draft WPS.
125. The draft WPS stated clearly at the outset that it was a procedure that was only to be used when carrying out a repair in the same area more than two times. Importantly, it contained this provision:

“(7) After welding, welds and adjacent base metal shall be heated to a temperature of 230°C minimum to 315°C maximum. The minimum heating time for repair welds shall be one hour for each 25 mm of repair weld depth from the surface, but not less than one hour. Post heat shall use electric band.”

Mr Dove crossed this out and beside it wrote:

“NOT REQUIRED
WOULD REQUIRE
A NEW PQR.”

At the top of the first page of the draft WPS Mr Dove wrote:

“PRIOR TO USING THIS CRITICAL WELDING REPAIR
PROCEDURE, THE CAUSE/REASONS FOR THE POOR WELD
QUALITY NEEDS TO BE IDENTIFIED, & THE
METHOD OF OVERCOMING THESE PROBLEMS NEED TO
BE DETAILED.”

126. ZPMC did not submit a new PQR. Mr Lu said the rejection of the draft WPS was referred to himself and Mr Shen Daming. He said in his witness statement that ZPMC

did not submit a further draft WPS because they “*could not identify any detailed procedure for PQR to test a welding repair procedure*” (paragraph 5.4). What in fact happened was that on 3 February 2009 ZPMC submitted a much shorter critical repair procedure, which omitted paragraph (7) and contained no other reference to post heating. Instead, it retained paragraph (6) of the draft document, which said: “*Welding shall be done as described in the approved repair procedure*”. This can only have referred to the weld procedures that were approved in December 2008.

127. ZPMC made clear in its final submissions that it was no longer any part of its case that it was prevented by Fluor from using post heat (see paragraph 640.3). This, again, was a sensible and realistic concession. Nevertheless, I should for the sake of completeness consider whether or not it had any material effect on what ZPMC actually did.
128. As Fluor has pointed out, there is no evidence that, at any time around this period, Mr Dove was made aware that ZPMC had discovered instances of transverse cracking in circumferential repair welds. Mr Dove visited Changxing from 5-21 January 2009, about two weeks before the discovery of the cracking, and then again between 9-13 February 2009. Of course it is possible that by the time of the later visit ZPMC might have thought that the problem with the cracks which had been found about a week earlier had been resolved, with the result that it was not mentioned to Mr Dove. During the visit in February 2009 Mr Dove seems to have spent most of his time showing round a Mr Ken Mitchell, of RWE,¹⁰ which by then had become an investor in GGOWL. That was Mr Dove’s last visit to Changxing.
129. In his report of that visit Mr Dove commented that the SAW welders had no means of measuring the preheat temperature prior to welding and that inadequate preheating was observed on the circumferential welds. In relation to repairs, Mr Dove noted that repairs were still being made in the up position using FCAW, with the result that in many cases the appearance was unacceptable. He said also that the current repair rate was about 6%, which was also unacceptable. There was no specific reference to any problem with preheating in relation to repair welds: the only reference to this related to the primary production welding, although if the methods of controlling or measuring preheating were unsatisfactory for the primary production welds it may well have been no better when carrying out repairs.
130. In fact, concerns about the adequacy of the preheating carried out by ZPMC on circumferential welds had been raised in mid December 2008 shortly before the issue of the draft WPS. In a report dated 15 December 2008, Mr Zhou Rhuikang made a number of criticisms of the adequacy of the preheating that was being implemented at the Small Changxing outdoor erection site. In the report he said this:

“When we arrived at the site, two large circumferential weld seams were being preheated (picture 1). In addition, 3 welders were performing repair welding at three areas (see picture 2 and 3). The repair weld seen in picture 2 is very long and was being welded by one welder. The repair weld seen in picture 3 is not long; during the interval of welding, I touched it with my hand and it was only tepid. There was no heating operator on site, and neither was there anyone controlling temperature with a tempil stick. So to speak, almost all the repair welding was

¹⁰ In his post visit report Mr Dove said that he had made a tour of numerous workshops with the RWE Welding engineer.

performed without preheat. Later on, an operator was called to heat the scene with a flame torch. Operating in such temperature (less than 10° C) in the open air on thick plates and long weld seams, heating symbolically and carelessly with a torch while the heating operator has no tempil sticks cannot meet with the heating requirement and the temperature would cool down very quickly. Thus, there was basically no preheating for weld repair, not to mention the interpass temperature which was tended to by no one. They said that the schedule was tight and they were shorthanded, and there was not enough heating equipment. I think for short weld seams heating with flame is acceptable, but at least each welder should be accompanied by a heating operator with a tempil stick. For some long repair weld seams, the preheat temperature can never be reached by heating with flame and they must be heated with electric bands. There are three construction teams working on this pile but few people were working. Due to the terrible welding quality, each weld seam has to be repaired more or less, and for some weld seams the repair length can reach almost half the length of the whole weld seam. In January the temperature will be even lower and severe consequences could occur to the quality of repair weld if no measures are taken.

Formal weld seams are heated with electric pads which, however, can be quite slow. To accelerate heating, more electric bands can be added and the heating zone can be covered up with quilts . . . the electric bands are narrow and they can only heat with one side (in some places the racks for electric bands are not properly arranged so the electric bands are positioned too far from the workpiece which results in worse heating effect). The cans are rolling and it is difficult to heat on both sides; two electric bands can be placed side-by-side on the welding zone to heat. In addition, heat loss should be reduced which can be achieved by covering up with quilts . . . Of course, this would require an increase of investment and manpower and the bosses would not be willing to do this, so the leaders' decision would be needed.

...

Next I would like to express my views on preheat temperature: the preheat temperature in our PQR and WPS are determined in accordance with AWS D1.1, when $T \leq 65$ mm, the minimum preheat and interpass temperature is 65°C; and when $T > 65$ mm, the minimum preheat and interpass temperature is 110°C. To prevent the temperature of workpiece from going down quickly after preheating, the initial preheat temperature needs to be higher at 150°C. The preheat temperature required by European standard is even higher, when $T \leq 60$ mm, the minimum preheat and Interpass temperature should be 130°C; when $60 \text{ mm} < T \leq 80$ mm, the minimum preheat and interpass temperature should be 140°C. The British client has already lowered their requirements by adopting the AWS standard rather than the European standard. We might be able to negotiate if we have done a good job in preheating and no cracking has occurred, and yet the current on-site situation is that our preheating is far below the standard and there are many problems - how could they possibly agree in such circumstances? Besides, January has the coldest weather.

...

Our problem now is how to attach more importance to preheating and how to strengthen preheating to ensure welding quality.”

These were remarkably prescient observations.

131. On 4 February 2009 there was a report of transverse cracks in a repair to a circumferential weld. This was investigated by the Testing Centre who confirmed that it was a transverse crack and that it was definitely a cold crack. The report gave guidance regarding on-site repair. These recommendations included pre-heating to no

less than 150°C and the maintenance of a temperature of between 220-300°C post welding for approximately 1½ hours “*guaranteeing ample time to spread the hydrogen*”. This, of course, was not a procedure for a critical repair (in other words, where repairs had already been carried out twice in the same place), but it is of interest that the Testing Centre was at this point recommending a preheat temperature of no less than 150°C and a significantly greater post heat temperature.

132. The report noted that it was clear that the welding preheat work had not been carried out properly. It said that the “*relatively strict weld repair procedure*” that was conducted on the second day should not have led to any transverse cracks and, “*as expected*”, none were found.
133. A project coordination meeting was held on 7 February 2009 attended by, amongst others, Mr Shen Daming and Ms Ma. It said this:

“Due to the cold weather, cracking can easily occur on weld seams. Currently the pass rate for repair is low and the huge amount repair is worrying. The quality of weld repair directly affects production progress . . . After tracking and making analysis by Mr Shen and other welding engineers on the cracks that occurred during weld repair, conclusions have been drawn which indicate that the following four efforts shall be made:

1. Strengthen control on welding process; in particular, the preheat and interpass temperatures must be strictly controlled to prevent transverse cracking;
2. As FCAW wires have a high hydrogen content and wires exposed to the air will contain moisture which can easily cause cracking, they must be timely stored indoors after use.”

134. A further report resulting from the investigations into the transverse cracking was prepared by the Testing Centre three days later, on 9 February 2009, in which it said:

“In order to have good welding repair quality, we hereby reiterate several points. Firstly, each stage in the repair process is critical, especially when the plates are thick and constraining stress is high. WPS and the repair procedure must be strictly implemented during on-site construction. Detailed procedure is attached herein. Secondly, we need to reiterate some matters for your attention. Please ensure preheating temperature and measures before gouging and welding; try to use newly unpacked wires in the repair or at least do not use wires that have been placed in the open air overnight; . . . conduct PWHT after welding; FCAW is recommended for the first repair while manual metal arc welding is recommended for multiple repairs in the same area; especially pay attention to the above matters in outdoor repairs.

In a nutshell, we can overcome difficulties by working together closely and complete the welding and repair work with required quality.”

As already mentioned, “PWHT” stands for post weld heat treatment which involves post heating at a much higher temperature than the preheat or interpass temperature (at least 480°C and typically above 600°C). No one has suggested that ZPMC should have used it here and I consider that the reference to it in this document is probably the result of an error of terminology or in translation (the document in the trial bundle was translated by a linguist at ZPMC’s solicitors) and that it simply refers to ordinary post heating.

135. Unfortunately, the “detailed procedure” referred to was not attached to the copy of the report in the trial bundle. However, the body of the report refers to preheating to a temperature “*not below 120°C before welding*”. Repairs were carried out to seven areas, four of which were repaired with FCAW (but using newly unpacked Supercored 71H) and three using manual metal arc welding. The former repairs were sound. This, therefore, is some evidence that a preheat temperature of 120°C, properly applied - as I infer it would have been since the repairs were being carried out under the supervision of the Testing Centre - was sufficient to prevent hydrogen cracking.
136. The Testing Centre produced a further document on 21 February 2009 headed “*Notice on Reiteration of Matters for Attention in Wind Farm MPs and TPs Welding*”. This emphasised the importance of proper control of preheat and interpass temperatures, but it also made two other points of significance. First, that the preheat temperature was not only to be achieved at least 75 mm from each weld seam, but also at the “rear side” (which I take to mean the other side of the plates from that being welded). Second, it said that during welding “*in order to secure adequate interpass temperature, the rear heating plate shall, instead of being taken down, be continuously supplied with power for heating*”. However, there was no reference to keeping the heat applied for any length of time after the welding was completed.
137. Whilst I consider that Mr Dove’s reference to post heating to a “*temperature of 230°C minimum to 315°C maximum*” being “not required” was unfortunate, because it could be read as indicating that no post heating at all was required, it was in one sense correct because it has not been suggested by any of the experts that post heating to such a high temperature was required (although ZPMC’s August 2015 tests indicate that post heating to such temperatures prevents cracking). As Dr Gordon pointed out, post heating to a temperature equal or below the minimum preheat temperature would be an attractive course to a contractor in the position of ZPMC because it did not require requalification.
138. Ms Ma said in her first witness statement, paragraph 4.15, that:

“It is my belief that in order to avoid confusion in the workshops as to the repair procedure to be used in a particular repair, the critical repair procedure was used for all repairs from 6 February 2009 onwards.”

I am not sure that this takes matters very far because the underlying weld repair procedures, which concerned the first two repairs that were carried out in the same place, were not changed. However, if it were really the case that Mr Dove’s comments had been understood as a general statement that post weld heat (to any degree) was not required, then I would have expected there to be documents issued by the Testing Centre or Ms Ma (in relation to branch company 2) to the effect that applying heat after the completion of a welding repair was unnecessary. No document has been produced which reflects such a procedure being implemented. Although I thought that Ms Ma was a good witness, I think that on this point her recollection is mistaken.

139. My reason for this conclusion is that Ms Ma’s recollection as to what happened is quite unsupported by the contemporaneous documents and reports to which I have already referred together with those to which I refer below. It is quite clear to me that

by early 2009 ZPMC was aware that a better way of applying heat was by the use of heating bands that were applied to the opposite side of the plate to that being welded. Further, it was appreciated that it was beneficial to keep the bands switched on for a couple of hours after the conclusion of the welding or, at the very least, to leave them in place as a form of insulation in order to retard the rate of heat loss in the area of the weld repair. This is quite inconsistent with any reliance on Mr Dove's comments.

140. I am therefore quite unpersuaded that Mr Dove's annotations on the proposed critical weld repair procedure made any material difference to the procedure actually adopted when carrying out repair welds from then onwards.
141. It is worth adding that, by 3 February 2009, the state of completeness of the welding on Shipment Nos 1 to 3 was as follows: approximately 97% of Shipment No 1, about 60% of Shipment No 2 and about 27% of Shipment No 3.

The quality of the welding and the factors which affected it

Some general comments

142. In the first report of Fluor's welding/metallurgy experts (Dr Dolby, Dr Hamre, Dr Howse and Mr Marlow) they said, at paragraph 3.1:

"We have never come across so many defects of such a serious nature in our many years of experience in welding. With respect to good quality and workmanship, the work in Shanghai on shipments 1-3 was significantly worse than normally encountered in steel construction."

In his report in reply, dated 18 December 2015, Mr Robert Teale, ZPMC's welding engineering expert, said, at paragraph 4.5 and 4.6:

4.5 Even Fluor's expert John Marlow stated "*I have never encountered this extent of hydrogen cracking in fabrication in my experience*". Neither have I, which immediately leads me to believe that this just could not be due to workmanship issues.

4.6 Cracking is not a common flaw and transverse cracking is very rare. If there was a significant and widespread problem, it is a clear indication that the cause is way beyond simple issues with preheat, interpass temperature o(r) flux recycling control issues on the shop floor."

143. So, whilst Mr Teale was perhaps seeking to exonerate the welders on the shop floors, he was in agreement with the view that the extent of the hydrogen cracking at Shanghai was unprecedented. In fact, both Mr Marlow and Mr Teale agreed that the cause of the hydrogen cracking was in the nature of a systemic problem rather than just an isolated case by case problem. Mr Teale emphasised that the fact that hydrogen cracking was so rare meant that if it occurred on a systemic basis something must be wrong with the process or the nature of the welding consumables being used: it could not be down to errors by individual welders (Day 17/16). The real difference between the approach of Mr Marlow and Mr Teale was that the former regarded the application of an incorrect or inappropriate welding procedure to be a workmanship problem. That may or may not be right, but in my view in the context of this case that distinction does not matter.

144. Turning to observations that were made at the time, in his witness statement, at paragraph 4.2, Mr Dove said:

“In my view, based on what I saw of ZPMC’s welding in 2008, ZPMC had a total disregard for weld quality. They broke every fundamental welding rule in the book and did not heed or adopt any suggestions/recommendations made by many industrial experts that would lead to a significant improvement in weld quality. In fact, the welding at ZPMC could be described as being ‘out of control’.”

145. Although perhaps overstated, it reflects in part what he said in a report dated 21 January 2009, following a visit to Changxing earlier that month by him and Mr Hardie, Fluor’s European Regional Manager, Expediting and Supplier Quality Surveillance. For example:

“There was an[d] extremely wide variation in weld quality between workshops, ie some welding was of an acceptable standard, whereas other workshops produced an extremely low, unacceptable, weld quality.”

And:

“Inadequate preheating was observed on the thick wall flange fabrication, ie the pyrometer was applied to the heated surface, and not on the reverse side to where the heating was being applied.”

This comment refers, as it says, to the welding of flanges and not to the circumferential welds which have been the focus of investigation at this trial. But it makes the point that where thick pieces of steel were being welded, it was necessary to measure the temperature on the opposite side of the plate to that to which the heat was being applied.

146. The report noted that a testing programme had been introduced for welders and that, of about 300 welders tested, 58 had failed. In addition, it recorded that Mr Hardie was very critical of the SQS welding inspectors retained by Fluor who, he said, had to improve “their proficiency and diligence”. However, in mitigation of that criticism it went on to note that currently those inspectors had been working a 77 hour week and monitoring up to 16 welding stations each, which was unacceptable. Unsurprisingly, it was concluded that more welding inspectors would have to be employed.

147. The report contained the following summary:

“Although significant improvement in the weld quality of the welding on the MPs and TPs has been achieved, there is still an enormous amount of work still to do ie.

Many welders, who produce welds that are barely acceptable, will need additional instruction and guidance on how to improve their welding.

Welders who produce poor welds must be removed.

Welder testing is ongoing.

More good quality welding inspectors are needed.

SQS Inspectors working week needs to be reduced.”

148. A note of a meeting between Mr Dove and Mr Hardie and representatives of RWE that took place on 3 February 2009 recorded that Fluor told RWE that “*Quality is vastly better now than it was in the beginning*”.
149. Whilst one needs to make some allowance for the exigencies of litigation when considering the contents of witness statements, I see no reason to question the criticisms that Mr Dove and Mr Hardie made at the time of their visits to Changxing in late 2008 and early 2009. It is quite clear to me that at the start of this project ZPMC was on a very steep learning curve. Indeed, ZPMC itself accepted as much in a letter dated 12 August 2009, when it said:
- “1. ZPMC expressed regret for welding problems of the first shipment Mono Piles. But ZPMC will go all out to take remedial action and cooperate with Fluor [in] the repairing activities.
2. The loss from the first shipment is due to lack of experience and under estimate, so ZPMC has some responsibility and ZPMC could share partial responsibility.”
150. The position was aggravated by the fact that, for largely economic reasons, ZPMC’s primary resource for achieving output was manpower rather than automation. This observation is not intended as a criticism; it is simply a statement of fact.

The joint statement of the experts

151. The experts were agreed that QIS, who carried out testing at Vlissingen, reported a large number of unacceptable transverse indications and some unacceptable longitudinal indications. The experts believed that a proportion of these were transverse hydrogen cracks.
152. The experts were also agreed that extensive transverse indications would imply a high probability of hydrogen cracks as in this case: see their answer to question 3(a) of the joint statement. They agreed also that DNV-C-401 (2004) Table 5 stated that cracks are not acceptable, regardless of size or amplitude. However, I understood it to be ZPMC’s case that this agreement was either subject to a qualification or was based on a misreading of what the standard actually said.
153. However, it was agreed unequivocally that the indications which were identified at Vlissingen reasonably justified a further investigation, although the experts were of the view that at the same time a coherent recovery plan should have been developed (question 5). I accept this conclusion and agree with it.
154. So far as hydrogen cracking is concerned, the experts noted the following factors as giving rise to hydrogen cracking (question 8):
- (1) The presence of hydrogen introduced by the welding process and the presence of contaminants, such as water, oil, grease and rust (if it contains moisture).
 - (2) A susceptible microstructure.
 - (3) Tensile stress, including both residual and applied stress. It was not in dispute that tensile stress will be highest where there is a high degree of restraint of the materials being welded.

The experts agreed also that increasing weld metal strength increases the risk of hydrogen cracking. Hydrogen cracks generally form within 48 hours after welding.

The individual experts in the disciplines of welding and metallurgy

155. I consider that all of the experts who gave evidence were eminently well qualified to do so. In relation to metallurgy, I found Dr Dolby to be an impressive witness, as was Dr Gordon, although I felt that once or twice the latter came a little close to adopting the role of an advocate (see, for example, Day 18/17).
156. In relation to welding, I thought that both Mr Marlow and Mr Teale were very good experts, each of whom had enormous experience.

Matters agreed by the experts in the course of the evidence

157. Both Mr Marlow and Mr Teale agreed that the extent of the transverse cracking was the result of a systemic problem (Day 17/14). In a similar vein, Dr Gordon said that there appeared to have been a systemic problem with the FCAW repair welds because they were so extensive, and Dr Dolby agreed with him (at Day 18/23).
158. So far as the prevention of hydrogen cracking is concerned, the experts identified three further factors of particular relevance. First, that there should not be an excessive overmatch between the strength of the weld material (from the consumable) and the strength of the base metal. Second, welding consumables should be stored in clean, dry and warm conditions and so as to minimise contamination with water and dirt. Such contamination could be directly responsible for hydrogen in the welds. Third, preheating reduces the rate of cooling of the weld metal and adjacent metal, and this allows a longer time for the hydrogen to diffuse out whilst the temperature is sufficiently high for it to do so. It was agreed that high-energy welding processes, such as SAW (submerged arc welding), generally require less preheat than FCAW (flux cored arc welding).
159. An additional aspect of the role of the consumables that was explored with the experts at the trial was the choice of the flux cored wire used in FCAW repairs. The wire used by ZPMC, Supercored 71H, was described by its manufacturer, Hyundai, as a titania flux cored wire. The notes on usage included the statement:

“Proper preheating (50~150°C) . . . and interpass temperature must be used in order to release hydrogen which may cause cracking in weld metal when electrodes are used for medium and heavy plate.”

160. It was Dr Dolby’s view that in high restraint repair situations you would need a preheat temperature of 150° C - in other words at the top of the quoted range (Day 18/101). Dr Gordon’s response to this was to point out that the tests carried out by ZPMC in August 2015 showed that when preheating to 150°C was carried out, it did not prevent the occurrence of hydrogen cracks. Mr Teale pointed out that he understood that this was done at Vlissingen and it still did not work (Day 17/23). I will have to return to each of these last points.

The effect of the hydrogen content of the consumable

161. Both Dr Dolby and Dr Gordon agreed that the use of the Supercored 71H was a factor that contributed to the hydrogen cracking. There were three reasons for this, the first of which was its relatively high hydrogen content. This was nominally a maximum of 8 ml/100 g¹¹. However, this complied with Fluor's specification and is classified as "low" hydrogen, and so there can be no question of its use being in breach of contract.
162. ZPMC tested a sample of the Supercored 71H during the course of the August 2015 tests and found that the diffusable hydrogen content of a newly unpacked sample was 7.0 ml/100 g. When Dr Gordon wrote his first report he was under the misunderstanding that the Supercored 71H had an H5 classification, and so he commented that "*even a small increase*" - which he took to be 2 ml/100 g - can "*increase the susceptibility to weld metal hydrogen cracking*".
163. An additional factor was that, as both experts agreed, in 2008/2009 the wire was constructed as a folded tube (as opposed to a sealed tube) and was therefore more likely to pick up moisture than a sealed tube, which is how Dr Dolby assumed that the wire would have had to have been constructed if it was to contain hydrogen to a level below 5 ml/100 g (Day 18/36). This meant that particular care would have to be taken in storing and handling the wire in order to minimise its exposure to moisture.
164. Mr Teale said in evidence that there was "*something a little bit special about this consumable*" and "*I think we have a different consumable that has caused the problem*" (Day 17/23). However, it was not clear from this answer whether he was referring to the level of diffusable hydrogen in the consumable or to one of the other factors.

The effect of titanium and boron in the consumable

165. The second reason is that the Supercored 71H contained a high boron content. This increased the susceptibility to cracking (Dr Dolby at Day 18/97, Dr Gordon at Day 18/104, 106). There was some difference between the experts as to the reason for this. Dr Dolby's view was that it increased the tensile and yield strength of the weld metal and therefore was a factor moving in the wrong direction in terms of hydrogen cracking (Day 18/97). In short, he agreed that the presence of boron in the consumable increases susceptibility to hydrogen cracking (Day 18/97-99).
166. Dr Gordon's view was that the presence of boron increases weld metal hardness which in turn increases its susceptibility to hydrogen cracking. His view was that the deliberate addition of boron to weld consumables can significantly reduce the critical diffusable hydrogen needed for weld metal hydrogen cracking (page 46, first report).
167. However, fortunately I do not have to resolve this difficult academic debate since both experts were agreed that the addition of boron to the consumable increases the susceptibility of the weld metal to hydrogen cracking: the precise mechanism for this

¹¹ On this basis it was classified as an H8 consumable, which means that the diffusable hydrogen content is <8 ml/100 g deposited weld metal. Throughout his first report Dr Gordon understood that the Supercored 71H used by ZPMC in the fabrication of the monopiles was classified as H5, because that is how it was shown in the current Hyundai Data Sheet. However, in a correction to his reports he said that test certificates suggested that in 2008/2009 it was an H8 consumable.

does not have any relevance to the issues that I have to determine. There was no indication from the manufacturer of Supercored 71H as to its boron content and it is not, and could not be, Fluor's case that by using that consumable ZPMC was in breach of any term of the contract. However, it is Fluor's case that ZPMC should have been aware of the advice in relation to preheat temperature that I have already mentioned, the implication of which was that in a high restraint situation a preheat temperature at the top end of the range quoted should be specified.

The overmatch between the consumable and the strength of the base metal

168. The third reason is that the weld metal in the Supercored 71H consumable used in the FCAW repairs was stated to have a typical tensile strength of 570 MPa. This was higher than the required minimum tensile strength of 483 MPa for the relevant weld metal classification (E7 in the case of Supercored 71H). The specified minimum tensile strength of the base steel was 470 MPa, so, as Dr Gordon observed, on paper the consumable appeared to be a good choice.
169. In fact, the measured tensile strength of the weld metal from samples taken from repair welds was significantly higher than its stated minimum strength, which, according to Dr Gordon, resulted in an overmatch of about 20% above the specified minimum tensile strength of the base steel.
170. Dr Gordon said that whilst the 20% overmatch would not normally be considered excessive, in this case the increased strength of the metal in the FCAW repair welds could give rise to stresses in excess of 550 MPa, which was the stated yield strength of the weld metal.
171. Fluor's experts made a different point, namely that the yield strength of typical weld repairs made using Supercored 71H, which varied between 494 and 574 MPa, greatly overmatched the base plate yield strength (325 MPa). This, in their view, was a main factor leading to high longitudinal residual stress levels in repairs. In evidence, Dr Dolby said that the Supercored 71H overmatched the base metal in tensile strength by at least 35%, and by 65% in terms yield strength. He described this as "*a massive overmatch*" (Day 18/45).
172. However, in the end, the difference between the experts was one of degree. In his reply report Dr Gordon agreed that the high strength of the FCAW repair welds could have contributed to the transverse weld metal hydrogen cracking. He made the point that the strength of the weld metal was very sensitive to the cooling rate: as the cooling rate increases, so the tensile properties of the weld metal will increase.

Pre-heating

173. As I have mentioned, Mr Teale said that his initial impression would have been that preheating to a temperature of 150°C ought to have been sufficient to prevent cracking. However, his understanding was that a preheat temperature of 150°C was used in Vlissingen without post heat and, as he understood the position, did not work so that there must have been some other factor in play. He said that what was necessary to prevent the cracking was the application of post heat after welding up to a temperature of about 200°C, which is what did work at Vlissingen (Day 17/17-18). By contrast, Mr Marlow said that in his experience of some 25-30 offshore projects it

had never been necessary to apply post heat for offshore structures, and that preheating to a temperature of 150°C was always sufficient (Day 17/19). It was Mr Marlow's view that preheating to a temperature of about 150°C should have been sufficient in Changxing if it had been done correctly. In addition, he thought that poor control of consumables was also a factor. Mr Teale disagreed because satisfactory consumable control had been achieved at Vlissingen without successfully preventing cracking. It was the composition of the consumable - the Supercored 71H - that in his view was one source of the problem (Day 17/23).

174. To an extent Mr Marlow agreed with this, because he said that the consumable had a level of hydrogen that was higher than he would have expected to see and that the flux inside the wire was also likely to attract moisture (Day 17/40). However, his view was that the principal cause of the problem was the fact that the ZPMC welders were preheating with gas torches to the same side of the plate as that from which the welding was to be done (Day 17/45-46). When asked about the tests carried out by ZPMC in August 2015, Mr Marlow said that they suffered from the same problem. A little later, during cross-examination, Mr Marlow said this (at Day 17/50-51):

“When preheating is done from the backside, for example, correctly with electrical heating mats, or with a gas manifold or gas burners, then that heating would be maintained throughout the welding repair process, or the welding process. Whereas if a welder preheats with a torch, he may say, with his Tempilstik, “That has reached 110°C, I can start welding”, one minute that temperature could drop to 40, 50, 60°, because the heat has not soaked through the thick section of material, and that acts as a massive heat sink. It pulls the heat away from the surface.”

175. Mr Marlow agreed that there was no requirement in the procedures that ZPMC had to follow for the temperature to be measured on the opposite face to that to which the heat was being applied: however, he said that if you did not measure it on the opposite face you would get into trouble (Day 17/53). Mr Teale said that the tests carried out by ZPMC showed that cracking could be prevented either by using a very high preheat temperature - perhaps 180° or 200°C - or by applying post-weld heat. However, as he had pointed out in his report, he said that welders could not be expected to work under conditions where the surface on which they were welding was at a temperature of 200°C.
176. Pausing here, whilst I have no hesitation in accepting Mr Teale's evidence about this, it does not really answer the point. If, for example, in order to achieve a required minimum preheat temperature throughout the thickness of the metal of 150°C, it was necessary to have a temperature of the order of, say, 180°-200°C at the surface to which the heat was being applied, then the obvious solution would be to apply the heat to the opposite side of the plate to that being welded. The other difficulty with applying heat to the surface being welded and measuring the temperature at the same surface is the point made by Mr Marlow, which I accept, namely that it gives little indication of the temperature gradient through the thickness of the plate, particularly after the gas torch has been removed.
177. Dr Dolby described the process of heating the surface of the plates to be welded as creating a shallow bowl of heat under the area to which the heat is applied. But he said that if the plates are heated from the side opposite to that from which the welding is being done there has to be a much deeper bowl of heat in order to achieve the

required temperatures at the surface being welded. When put like this, it is obviously correct and Dr Gordon agreed with it. However, Dr Gordon went on to say this (Day 18/16):

“ . . . I think the issue here is not so much how the pre-heat was applied in terms of what was actually required, so there is no requirement to heat from the backside. That might be considered best practice, but it is not actually a requirement. So if you look at the codes and you look at the Fluor specification, both of those are silent in terms of how heat treatment, post or pre-heat should be applied. With that in mind, I think ZPMC adopted a practice that is common and fairly standard throughout the industry, and, you know, the alternative of heating from the backside might be considered better practice but it was not required.”

This, of course, begs the question of what it was that ZPMC was required to achieve. As Dr Gordon rightly points out, both the WPS and the specification were silent about the methods of applying the preheat. Accordingly, for the reason that I have already given, as a matter of principle it was for ZPMC to adopt a method of preheating that would achieve the temperature requirements laid down by the code and, all other factors being satisfactory, would produce a sound weld.

178. What has to be heated is the base metal, which is defined in AWS D1.1, at Annex K, as the “*metal or alloy that is welded . . .*”. Section 5.6 of the code, which is headed “Preheat and Interpass Temperatures”, states that “*base metal shall be preheated, if required, to a temperature not less than the minimum value listed on the WPS*”. It is clear from these provisions that it is all the base metal in the area being welded that has to be preheated.
179. Section 5.6 then goes on to say this:
- “This preheat and all subsequent minimum interpass temperatures shall be maintained during the welding operation for a distance at least equal to the thickness of the thickest welded part (but not less than 3 in [75 mm]) in all directions from the point of welding.”
180. The meaning of this was a source of acute disagreement between Dr Dolby and Dr Gordon. Dr Dolby said that 75 mm in all directions meant that if the plate was 75 mm thick and heated from the front, the required preheat temperature would have to be achieved at the surface on the other side of the plate at the line of the weld. Dr Gordon said that his reading of the code would be that it meant 75 mm “*in either width or length around the repair to be welded, but not necessarily the through-thickness direction*” (Day 18/18-19). In other words, Dr Gordon was saying that the dimension of 75 mm applied only in all directions in the plane of the surface of the plate, whereas Dr Dolby was saying that it meant in all three dimensions. However, at times Dr Gordon did not appear to distinguish between the points at which the temperature would be measured and the points where the required temperature was to be achieved: more than once he said that there would be situations where one could not measure the temperature on the other side of the plate: see, for example, Day 18/25-26, and 27.
181. A similar argument was developed by Mr O’Sullivan in ZPMC’s written closing submissions. Paragraph 681.2.3 said this:

“It makes no sense to read the Code as requiring one to measure the temperature a minimum of 75mm away from the point of welding in a through thickness direction. That could only be done if, for example, the steel was at least 80 mm thick and the repair no deeper than 5mm. Most of the time it would simply be impossible.”

182. In my view, this submission also confuses measurement with the achievement of a required temperature throughout a particular region of the base metal. The relevant paragraph of the code says nothing whatever about the means of measuring the temperature, it is concerned solely with specifying the region of the base metal that has to be heated.
183. Mr O’Sullivan’s ingenious response to this objection in the course of argument was to submit that this was taken into account by the requirement to heat the base metal to a given distance, 100 mm, measured horizontally, from the weld. Implicit in this submission was, I think, an assumption that the greater the area of the surface that was heated, the greater the depth to which the heat would penetrate. But in my view this is doing no more than explaining why there is a “bowl” of heat as described by Dr Dolby. It follows, as a matter of common sense, that if a substantial area of a sheet of metal is heated by a torch applied to one surface, the rate of loss of heat into the surrounding base metal at a given depth will be lowest in the centre of the area being heated - simply because at that point the base metal on either side is also hot so that the heat sink is limited principally to the base metal below the centre.
184. On this point I unhesitatingly prefer the evidence of Dr Dolby, which in effect echoed that given by Mr Marlow. This is for the following reasons. First, the purpose of preheating the base metal is to retard the rate of cooling of the weld metal after it is deposited (as both Mr Marlow and Mr Teale agreed: see Day 17/21-22). It is also clear from the evidence that temperature is the most influential variable in determining the rate of diffusion of hydrogen. It follows, therefore, as the code requires, that all parts of the base metal in the vicinity of the weld must be preheated, not just the surface. Indeed, Dr Gordon said (Day 18/26-27): *“I think as the thickness increases, the heat sink potentially increases so it is important, then, to ensure this you have a broad and long enough area pre-heated to the right temperature”*. He made a similar point at Day 18/28-29. This, I find, was an implicit acceptance of Dr Dolby’s bowl analogy.
185. Second, if “in all directions” means all directions in the plane of the surface of the steel plate, then it is hard to see why the required distance must be at least equal to the thickness of the thickest welded part. Although “thickness” is not defined in this part of the code, both counsel and experts proceeded on the assumption that it referred to the depth of the weld (or the plate, if it was a full thickness weld): see Day 18/26 (Mr Brannigan and Dr Gordon) and Day 18/30 (Mr O’Sullivan).
186. Third, there is evidence that atomic hydrogen is deposited differentially at different depths in the weld. The hydrogen and oxygen present in the air as water become separated into their atomic states by the heat of the arc (see, for example, Mr Marlow, at Day 17/39; Mr Teale at Day 17/67). The atoms of hydrogen are the smallest of the elements and can diffuse through the lattice structure of steel, the rate of diffusion being very dependent on the temperature. In his first report Dr Gordon said that chevron cracks are generally buried in that they do not extend to the surface: page 38,

paragraph 8.2(2). This, he said, is partly the result of the hydrogen gradient in the weld, which decreases close to the surface, and partly because of the reduced residual stresses at the surface. According to Dr Gordon there is a trend for the maximum diffusible hydrogen concentration to be in the central third of the weld, decaying as one moves towards the surfaces. Increasing the pre-heat from 20°C to 100°C produces a significant reduction in the diffusible hydrogen level. All this suggests that there is as great a need, if not a greater need, to preheat the base metal at lower depths in the weld than at shallow depths.

187. Fourth, in my view there is no warrant for limiting the words “in all directions” to all directions in the plane of the surface of the plate at the side being welded. The considerations that I have set out above seem to me to point firmly in the opposite direction. Mr O’Sullivan’s points might have had some force if the code had said that the temperature had to be “measured” at a given distance in all directions from the point of welding, but it does not say that.

Methods of preheating

188. There are at least three methods of applying preheat to the base metal prior to welding. The first is the use of a gas torch with what is known as a “rosebud” head so as to provide a flame over an area. This is often used by the welder and so the heat will be applied to the surface being welded. This was ZPMC’s general practice during the early months of manufacture, and may well have persisted well into 2009. The second is the use of gas burners with several heads which, in an application such as this, would be configured to follow the contour of the surface of the plate. The heat would be applied to the surface opposite to that being welded. I have seen no evidence that ZPMC made any or at least any significant use of gas burners on this project. The third is the use of electric bands or pads, which are usually applied to the opposite surface from that being welded. In an ideal world these would be thermostatically controlled, but those used by ZPMC did not incorporate thermocouples and so they had to be regulated manually.
189. Dr Dolby and his co-experts criticised the use of handheld gas torches because, without close supervision, they could produce regions under the area being repaired that would be significantly cooler than the temperature at the surface. By contrast, they said, if preheat was applied to the surface opposite from that being welded there would be a much more uniform heat distribution through the plate thickness underneath the repair groove so that the heat sink effect would be negligible (Reply Report, page 5). I accept this evidence.
190. In relation to the use of handheld gas torches, it seems to me that the combination of the high dependence on the skill of the operator and the risk of not heating a sufficient volume of the base metal in the plates makes it likely that, in a fabrication operation the size of this one, there would be many instances where the preheating of the base metal prior to welding would be either insufficient or uneven. I consider that this often happened during the first six months or so of fabrication (October 2008 to March 2009, perhaps longer). Aggravating factors during this period - being the winter months - would have been low ambient temperatures (making the base metal much colder) and high humidity levels with consequently greater availability of hydrogen from the atmosphere.

191. A conclusion that preheating was often erratic is, in my view, supported by references in the documents to the difficulties encountered by ZPMC in carrying out satisfactory repairs to welds, concerns about the adequacy of the preheating and references to the steps that should be taken to improve the quality of the preheating and to retain the heat after completion of the welding. For example, in addition to the documents to which I have already referred, there were the following:

- (1) 28 December 2008: a disciplinary notice signed by the Vice President Production and Ms Ma which was issued in relation to poor welding of two circumferential seams where a preheat temperature of only 44°C had been used, instead of the minimum stipulated in the WPS of 110°C. It went on to say that:

“. . . the quality inspection department has emphasised many time(s) that: welding must be performed strictly in accordance with the WPS requirements. If the pre-heat temperature did not reach the WPS requirement, it tends to produce defects and increases welding repair volume . . . ”

- (2) 7 February 2009: minutes of a project coordination meeting presided over by Li Jianghua, the Project Manager, recorded that the project was in “*a difficult situation*”. It was attended by representatives from each branch company and Mr Shen Daming (who was in charge of the Testing Centre). It stated that in cold weather cracking could easily occur on weld seams, that the current pass rate was low and that the “*huge amount*” of repair was worrying. Every effort was to be made to address the issue of repair quality: in particular, there was to be strengthened control over the welding process so that preheat and interpass temperatures were strictly controlled so as to prevent transverse cracking.
- (3) 9 February 2009: an extract from the notebook of Mr Chu Xiangjun, the Production Manager of branch company 3, which was to the following effect:

“Now, when we repair, hang the electric pre-heated plate over the opposite side, the entire process is undergoing heating. 2 hours after welding completed, cut off the electric plate, hugely reduced the production of crack.”

- (4) A report from the Testing Centre dated 10 February 2009 following the discovery of transverse cracks in branch company 3. I have already quoted the relevant passage but, for convenience, I shall set it out again:

“In order to have good welding repair quality, we hereby reiterate several points. Firstly, each stage in the repair process is critical, especially when the plates are thick and constraining stress is high. WPS and repair procedure must be strictly implemented during onsite construction. Detailed procedure is attached herein. Secondly, we need to reiterate some matters for your attention. Please ensure preheating temperature and measures for gouging and welding; try to use newly unpacked wires in the repair or at least do not use wires that have been placed in the open air overnight; try not to make the repair groove too narrow and too deep, and ensure the shape

coefficient; grinding the carburized layer till it turns metallic lustre before welding; properly control the parameters in the welding, adopt multi-layer and multi-pass welding; conduct PWHT after welding; FCAW is recommended for the first repair while manual metal arc welding is recommended for multiple repairs in the same area; especially pay attention to the above matters in outdoor repairs.”

In general, the longitudinal seams on the cans for the monopiles and the work to the transition pieces was carried out indoors. However, much of the welding of the circumferential seams was carried out in the open air - hence the last phrase of the passage quoted above.

- (5) The “Notice on Reiteration of Matters for Attention in Wind Farm MPs and TPs Welding” dated 18 February 2009 that I have already mentioned.
- (6) 21 February 2009: an internal e-mail to Mr Chu noted that:

“In the morning, 57 transverse cracks were found beyond the acceptance criteria in the MP [reference] six circles butt which need to be repaired . . . More than 20 areas found beyond acceptance criteria in T026-3-67 circles butt are all transverse cracks need to be repaired . . . ”

Mr Chu replied emphasising the need to follow the welding process strictly and that the electric heating plate “shall be hung high for the welding and post heating”.

- (7) 23 March 2009: an e-mail from Li Ruixiang, ZPMC’s Vice General Manager for Quality Assurance, asked Mr Shen Daming to carry out a technical analysis into the problem of surface cracks in circumferential welds.
- (8) 25 March 2009: a report addressed to Shen Daming on surface cracks in circumferential seam welds (presumably the response to the previous document) contained the following recommendation:

“Comply strictly with WPS. Use electric heating to preheat each weld seam. The weld width shall be controlled at around 16 mm. After completion of the welding, use non-alkali bulk fabric to wrap the weld surface and vicinity tightly to make them cool down slowly.”

Ms Ma pointed out that these references to surface cracks were to something different from transverse cracks (Day 13/114). Whilst I do not doubt her evidence on this, the point that emerges from these documents is the persisting concern with the need to carry out proper preheating and, in this case, taking steps to retard the rate of cooling after welding.

- (9) 25 March 2009: an e-mail from the Production Manager of branch company 2 to, amongst others, Ms Ma, which noted that the welding pass rate was still the biggest problem with the circumferential seam welds. Ms Ma’s instruction sent on the following day emphasised the need for proper storage of welding materials, pre-heating and other matters. Again, Ms Ma

emphasised in evidence that this was not concerned with transverse cracking (Day 13/117-118). However, it is another example of ZPMC's junior management issuing instructions with a view to improving working methods and, in particular, the need for proper preheating.

- (10) A document issued by ZPMC's Wind Power Project Team to every department and every work team at Changxing dated 22 May 2009¹² said this:

“The current existing phenomena: 1) The work teams do not manage strictly, and do not pay attention to the protection and maintenance of the heating equipment, the heating bands are often damaged cannot be used normally; 2) during can rotation in the can heating process, the heating bands deviate and are not adjusted promptly, the temperature control is not strict; 3) The welders who perform the work do not pay attention to the welding temperature, perform welding casually before reaching the welding temperature and do not promptly report the issue of insufficient temperature . . .”

- (11) 23 May 2009: an internal ZPMC e-mail from Chu Xiangjun, the Production Manager of branch company 3, to the Project Manager and copied to many others, including Mr Liu, Ms Ma and the Testing Centre, contained the following statement:

“In relation to cracks, our company 3 already discovered transverse cracks while shipment 1 manufacture, under the guidance of welding lab, the measures we adopted for procedure are as below, the preheat for repair welding is top priority, the electric heating bands place on the opposite side of the repair welding positions, the electric heated bands are always in the heated status during the whole welding process, after completion of welding, continue the heat for 2 hours; for inspection, perform transverse cracks inspection by probes riding on the welds for all repairs, discovered hundreds of transverse cracks one after another, arrange repair by work teams in the workshop for these cracks . . . Recommend company 1 and company 2 in relation to all repair positions of the welds in shipment 4, perform overall transverse cracks inspection before FLUOR third party random inspection.”

- (12) 3 June 2009: a further e-mail from Chu Xiangjun, which concludes with a request for assistance in the light of the fact that in January and February many of his inspectors had fallen ill through exhaustion and that he had reported the transverse cracks issue to the Welding Research Unit and raised it many times during the daily meetings. Ms Ma was asked about this, and said that although she did not remember those meetings very clearly, she did not think that Mr Chu had raised the question of transverse cracks as often as he suggested in this e-mail (Day 14/10-11).

¹² This document appears in several forms: one variant was headed "Notice 002-2009 of Quality Inspection Department III, Branch Company II, Zhengxing, Shanghai", and subtitled "Regulations on Strict Implementations on Pre-welding Heating and Post-welding Insulation of the Wind Farm Project", and appears to have been written by Ms Ma.

- (13) 16 June 2009: this was of the report of a specialist team set up by ZPMC to carry out an analysis of the cracking problem. The report noted from tracking the course of repairs that when the procedures were properly followed, which included both preheating in accordance with the WPS and post heating in accordance with the Welding Repair Procedure requirements, there was no transverse cracking problem in repaired areas, and that first time pass rates were 88%. It was also noted that inspection pass rates were much higher for first-time repairs than for multiple repairs.
192. The report of 16 June 2009 provides substantial support for the proposition that if preheating was properly carried out and heat was applied after welding, the appearance of transverse cracks could be, if not actually eliminated, very significantly reduced. From what I have seen and heard of the witnesses as a whole, I have formed the view that ZPMC was a company which, at management level at least, had a well entrenched ethic about the achievement of quality, even though its approach was to solve problems by introducing additional manpower and, if necessary, imposing disciplinary sanctions for non-compliant work, rather than by investing in new and up-to-date equipment.
193. A number of witnesses called by ZPMC to whom these documents were put sought either to disparage the qualifications or experience of the authors or to cast doubt on the reliability or apparent meaning of their contents.¹³ I was unimpressed with this. It was, I am afraid to say, an example of loyalty to the company displacing loyalty to the truth.
194. It was common ground that the application of post heat at a temperature lower or equal to the minimum preheat temperature would not require requalification of the WPS, and both Dr Dolby and Dr Gordon agreed that this could have been achieved by the use of electric pads (particularly if they had a thermostat): see Day 18/119-120. However, Dr Dolby had reservations about ZPMC's ability to maintain proper temperature control during post heating over a two-hour period if it had to be done by manual observation. I am quite sure that is a problem that ZPMC would have overcome if they had seen the need for it.
195. Dr Gordon said in section 3.3 of his report in reply, at paragraph 5):
- “In my view, as noted in my first report, there is a greater risk of hydrogen cracking occurring in thick section repair welds rather than normal production welds due to:
- The potential for increased diffusible hydrogen in repair welds due to the shorter time between consecutive weld passes.
 - A high level of constraint in repair welds that can result in very high residual stresses.
 - Increased heat sink that can result in fast cooling rates, which can result in increased hardness and increased strength and reduce the potential for hydrogen to diffuse out of the repair weld.”
196. In their reply report, Fluor's welding/metallurgy experts said, at paragraph 7.1:

¹³ It is unnecessary to lengthen this judgment by citing examples of this. However, several were given by Fluor in its closing submissions, in my view with justification: for example, at paragraph 256, footnote 1033 and paragraph 671.

“Temperature is a more important factor than elapsed time for the diffusion of hydrogen and it is difficult to be certain that hydrogen build up is a key factor in repair welds.”

197. In evidence, in answer to my questions, it became obvious that the difference in opinion between Dr Dolby and Dr Gordon on the first of the three bullet points was one of emphasis, because both experts accepted that the rate of hydrogen diffusion was a function of both temperature and time (Day 18/9-14), and that temperature was more important than time (see Dr Gordon, at Day 18/116). However, in repair welds the two factors worked in opposite directions: the shorter time between passes provided less time for the deposited hydrogen to diffuse, whereas the higher temperature which resulted from the weld material being put down repeatedly in a confined space would increase the rate of hydrogen diffusion. But one thing that was quite clear is that the higher the temperature and the longer the period for which the temperature was maintained, the greater the rate of diffusion of hydrogen out of the weld material.

Steps that were taken in relation to the use of preheat and post heat at Changxing

198. I have already mentioned the concerns about the application of preheat at Changxing, that on 4 February 2009 transverse cracks were found on the circumferential welds at Small Changxing and that the Testing Centre carried out various tests in order to investigate the cause. One aspect of the process that was tested was the use of the consumables and investigation of the extent to which exposing the consumables to the atmosphere prior to use made a difference. Four of the areas where cracks had been found were repaired with FCAW, using newly unpacked Supercored 71H. The Testing Centre’s conclusion – set out in a note dated 10 February 2009 - was that it was relatively easy to produce good welds, including weld repairs, as long as the procedures were properly carried out. Several aspects of the welding procedure were emphasised, including the need to achieve the correct preheating temperature, not using wires that have been left in the open overnight and carrying out post heating after welding.
199. An extract from the notebook of Mr Chu Xiangjun, dated 9 February 2009, referred to the use of electric pads hung over the side opposite to the surface on which the welding was being carried out which were then left on for 2 hours after welding. This, he noted, hugely reduced the production of cracks.
200. Following the tests carried out in early February 2009, the Testing Centre produced a short report dated 18 February 2009 which contained the following extract:

“Operations shall be in strict accordance with the WPS requirements, with not only preheat temperature but also interpass temperature properly controlled. Electrical preheat method shall be adopted as far as possible for preheat, and it shall be ensured that the preheat enables the area within at least 75 mm from each weld seam (including the rear side and each side of cross joints) in work piece to achieve the preheat temperature and interpass temperature requirements. During welding, in order to secure adequate interpass temperature, the rear heating plate shall, instead of being taken down, be continuously supplied with power for heating.”

201. It is, perhaps, a little surprising that this report said nothing about post heating, although that may be implicit in the last sentence of the passage quoted above. What is instructive is that it refers to achieving the preheat temperature on the rear side of the plates.
202. On 21 May 2009 Ms Ma issued the Notice in the name of the Special Task Group for Wind Power Project entitled "Regulations on Strict Implementation on Pre-welding Heating and Post-welding Insulation of the Wind Farm Project", to which I have already referred. It was addressed to all departments and construction teams. The opening paragraph pointed out that the project involved a large volume of work, with thick sheet metal and requiring a demanding welding quality. It said that:

"The key to the success is the correct use of heat process and a strict control of preheat temperature, and inter-pass temperature, and insulation of post-welding. Improper control of temperature may affect the welding quality, even lead to cracks. Currently instances of no heating before welding and improper preheat temperature still frequently occur. Although the quality department has repeatedly dealt with this deadly chronic problem and penalty is enforced accordingly, yet the effect is minimal. Recently Fluor issues 5 NCR one after another, the impact is appalling, seriously impairing the company's reputation, and this issue has become the gravest deadly problem of this project of ours."

Whilst the language may, to western eyes, have been rather dramatic in its tone, the message was clear enough and demonstrates that ZPMC took the problems very seriously.

203. The notice recorded the fact that welders did not attach great importance to the preheat temperature and were proceeding to weld without checking whether or not the temperature was correct and, further, no insulation was applied after welding (in order to retard cooling). The notice also made these points:

"Heating operator of the electrically (sic) heating team must be individually equipped with a thermometer, after preheat, take initiative to check and determine that the preheat temperature **of both sides of the steel plate** meet with the requirements of the process."

(My emphasis)

And:

"In terms of weld repair (especially carbon-dioxide arc welding repair) one must adopt preheat with electrically (sic) heating method. Once the heat temperature as required by the welding process meets the requirement, notify the quality inspector to confirm, only then, the operator can start repair. During repair process, heating plate shall be kept to be electrically connected to ensure interpass temperature, after repair, the heating plate shall remain to be electrically connected for two hours for heat insulation. Once the insulation time is over, the heating plate shall be electrically disconnected, but not to be removed, let it cool off with the weld beads."

It concluded by setting out a series of punishments that would be imposed on those who did not comply with these "regulations".

204. It is clear from these documents that those in ZPMC who had been charged with investigating the problem of transverse cracks and their causes had identified certain aspects of the process that they regarded as essential to success. However, it is clear also that the instructions in the WPS about the required preheat temperature were not being followed by many welders. As I have already mentioned, when he opened ZPMC's case Mr Andrew White QC emphasised the very substantial size of the operation at Changxing, which was running 24 hours a day 7 days a week. With such a vast workforce, many of whom appear to have been subcontracted labour, it is perhaps unsurprising that unless supervision was very tight and discipline strict ZPMC would find it difficult to ensure that the procedures were properly followed.
205. In the context of the causes of the cracking, it is clear that maintenance of the minimum specified preheat temperature in steel that was more than 65 mm thick (110°C) was seen as an essential condition of success. It is clear also that it was appreciated that this temperature would have to be maintained throughout the thickness of the plate in the region of the weld. That, I suspect, was why Ms Ma and others appreciated that electric heating pads applied to the plate on the opposite side to that which was being welded would be the best way of achieving this. Mr Marlow said that on thick material you had to measure the temperature at the opposite side to that where the heat was being applied (Day 17/50, 52, 130-131). In my view, for the reasons that I have already given, that is obviously correct. Further, I find as a fact that this was appreciated by ZPMC by late May 2009, and possibly 2-3 months earlier. The problem with the use of torches was that identified by Dr Dolby, namely that the "bowl" of heat created under the area of the weld was insufficient to prevent the large mass of the plate acting as a heat sink, thereby drawing heat away from the area of the weld.
206. In addition, there is the question of whether a preheat temperature of 110°C was sufficiently high for repair welds. For the reasons that I have already given, I consider that ZPMC should have adopted a preheat temperature of 150°C.
207. The problem of measurement of the temperature can be crudely illustrated by the simple example of a poker in a fire. If the tip of an iron poker is left for some time in a hot fire, it will probably become red-hot (about 500°C or more). Nevertheless, the other end of the poker will usually be much cooler to such an extent that the poker can be drawn out by hand without discomfort. That is because there is a temperature gradient along the length of the poker: as one moves away from the tip so the temperature of the iron falls. Suppose now that, instead of being placed so that the tip of the poker is in the hottest part of the fire, the poker is placed so that the heat of the fire is applied to a region about 6 cm from the tip. When the poker is withdrawn that will be the region that is red-hot, and the tip will be cooler. Measuring the temperature of the red hot zone does not tell you the temperature at the tip of the poker. If, therefore, with the poker in the same position one wants to heat the last 6 cm of the poker to a given minimum temperature, that temperature must be measured at the tip of the poker.
208. The heating of the surface of the plates on the same side as that on which the welding is to be carried out is like the second example with the poker - where the opposite surface of the plate represents the tip of the poker.

209. Unfortunately, no tests have been carried out in the course of this litigation (at least, none of which I am aware) in order to discover the temperature that the opposite side of a plate, say, 85 mm thick is likely to reach when the surface where the welding is to be carried out is heated by a torch to 110°C. Dr Gordon was asked to what temperature one would have to heat the face of the metal on one side of the plate in order to obtain a temperature of 230°C on the surface of the opposite face. Dr Gordon, albeit with the qualification that he was guessing, said it would have to be over 300°C (Day 18/166). The precise figures do not matter, but Dr Gordon is a very experienced engineer and so I am sure that he was right in a qualitative sense - if not as to the precise number. This suggests that if one side of a plate 65-75 mm thick was heated to 150°C, the opposite face might achieve a temperature of 110°C. Conversely, heating one face to 110°C only would result in a substantially lower temperature at the opposite face and, indeed, a significantly lower temperature at a point 30 mm below the surface - where hydrogen cracking might be expected to occur if a repair was being carried out from the inside of the can (ie. to the larger weld).¹⁴
210. But for one point, therefore, I would have no hesitation in concluding that the problems encountered by ZPMC in achieving successful repair welds was very largely the result of inadequate preheating and the specification of a preheat temperature, 110°C, which was too low. The former was the result of using a torch to heat the face of the plates being welded, rather than heating from the reverse side which is what I find ZPMC should have done. Both factors were aggravated by the use of the 71H Supercored consumable. However, as I have already concluded the latter was not a breach of contract but it did have a consequence of making the selection and achievement of a suitable preheat temperature much more important. The point that remains is whether such a conclusion is consistent with the results of the repairs that were carried out at Vlissingen and the tests that were carried out by ZPMC in August 2015.
211. But before I consider this question, it is necessary to resolve an issue about the location of the cracking, although by the end of the evidence I am not sure that this was really a live issue - at least, to any extent that matters.

The location of the cracking

212. The issue here is whether the hydrogen cracking that was found at Vlissingen occurred in original production SAW welds or in repair welds carried out using FCAW, or a combination of both. There are broadly two aspects to this. As I have already indicated, the primary production welds were, on the whole, carried out using SAW - although during the very early stages of fabrication it seems that in the case of about 5 or 6 cans the seam production welds were carried out using FCAW. It is not in dispute that, almost invariably, the repair welds were carried out using FCAW. It is self-evident that one would not have to carry out repairs unless there were defects in

¹⁴ The longitudinal and circumferential welds of the cans were carried out in two stages: one from either side of the plates. Each weld had a V shaped cross section, but one was deeper and wider than the other. In the case of the circumferential welds, the deeper and wider weld (x2) was usually on the inside. This was criticised by Mr Dove but it suited ZPMC to do it this way, even though many other fabricators may have chosen to have the deeper and wider world on the outside where access was easier. I am not prepared to find that ZPMC's approach was, in principle, a breach of any standards as to workmanship (but of course it required the welding to be carried out properly).

the original welding. It is ZPMC's case that virtually all the cracks that were discovered either on inspection at Vlissingen in the case of Shipment No 1 or, in the case of Shipment Nos 2 and 3, on inspections at Changxing prior to shipment, were cracks in repair welds.

213. If this is correct, then the cause or causes of the defects in the original production welds would not be relevant because they were removed by the process of repair. They are, of course, relevant in one sense, because in the absence of defects in the original welds there would be no need to carry out any repairs. But if the repairs had been carried out successfully and had rectified all the original defects, the cause or causes of the original defects would be no more than a matter of history.
214. Fluor's case originally was that whilst the defects that were discovered in Shipment Nos 1 to 3 may have been attributable to a large measure to repair welds, this was not the case with the subsequent shipments.
215. In a presentation entitled "Greater Gabbard Fabrication Review", dated 22 June 2009, there was a table setting out the results of a 100% retesting of shipment 3 showing the locations of the transverse cracking. Of a total of 623 cracks found, all were in circumferential welds and 618 were in areas that had been repaired. The current thinking at the time (on the part of Fluor) was said to be that the problem was confined to the repair procedure and was not associated with production welding. Unfortunately, very few samples were taken of welds which had cracks; however, five coupons (or samples) which were taken of areas where cracks had been found all concerned repair welds.
216. Dr Gordon noted that hardness tests carried out by Dr Dolby and others on FCAW repair welds produced average hardness values ranging from 196-238 Hv. The maximum hardness values range from 205-245 Hv. It was Dr Gordon's conclusion that the cracking underneath the repair welds in Vlissingen was due to a combination of high hardness in the root of the repair weld and the application of preheat that was too low.
217. Dr Gordon considers that there is no metallurgical evidence to support the allegation that there was extensive transverse cracking in original production SAW welds and this remained ZPMC's case. In its closing submissions Fluor accepted that the majority of the defects discovered at Vlissingen fell into the category of FCAW repair welds "*such that on any view the category is important*" (paragraph 708). This was a change of position that followed the evidence given by the experts. It was also supported by an e-mail from Mr Fuller dated 17 June 2009 in which he said that: "*It appears we have satisfied ourselves here that the problem is in the repair areas. If we do a 100% UT of repair areas using Pattern D we should be able to resolve the quality concerns*".
218. A report by Mr Estabrook dated 14 June 2009 entitled "*Analysis into Non-Destructive Testing on the 3rd Shipment Monopiles*" identified as a cause of the cracking the use of a torch for preheating as opposed to using electrical heating or conduction bands. In his "Conclusions" Mr Estabrook said:

"The main conclusion that can be drawn is that the transverse cracks are found exclusively in areas previously repaired by FCAW and that it is almost certainly

due to a lack of preheat causing hydrogen cracking. The lack of detection by ZPMC's NDT QC and Fluor's QA is likely due to operator performance."

219. Mr Chen Bin said in his first witness statement that the indications that were being identified at Vlissingen were "*very nearly all in the previously repaired areas*" (paragraph 2.6).
220. In the light of this material and the cross examination of the experts I find as a fact that the majority of the transverse cracks discovered at Vlissingen were cracks in repair welds carried out using FCAW. I am not in a position to assess the precise proportion because the limited time available for cross-examination did not permit a picture to emerge to an extent such as to enable a precise conclusion to be drawn. It is sufficient to find that the proportion of defects in production SAW welds was much lower than that for which Fluor had contended. Again, in the light of cross examination, it is now quite clear that those cracks had to be repaired unless and until an Engineering Critical Assessment ("ECA") had been carried out and had shown that the piles were fit for installation in their as delivered condition. The position was encapsulated in the following exchanges between Mr Brannigan and Mr Teale and Dr Gordon. First, at Day 17/165:

"MR BRANNIGAN: Mr Teale, we can agree this, can't we: the one thing you wouldn't do, standing at Vlissingen, looking with horror at the fact you had these cracks, you couldn't just go ahead and install them without undertaking the sort of exercises you have just described?
MR TEALE: That is why I just described it."

Second, at Day 18/201:

"MR BRANNIGAN: I understand that. I think you agree that the one thing, the one purpose you cannot put these things to, whenever they arrive on the dock and you see the cracks in them, you cannot load them out and put them in the ground, can you?
DR GORDON: No."

221. I will have to discuss the contractual implications of this evidence, which I accept, later in this judgment. But its significance for present purposes is that the cracks in the welds repaired using FCAW were, I find, sufficient on their own to justify a programme of investigation and repair which all the relevant experts agreed was reasonably necessary. It is therefore unnecessary to reach any conclusion about whether or not the extent or location of cracks in SAW production welds would, of itself, have had the same consequence.

The repair procedure adopted at Vlissingen

The evidence from the witnesses and the contemporaneous correspondence

222. By 1 June 2009 the MPs from Shipment No 1 had been unloaded and were lying on sand berms. By that time three monopiles had been tested by RTD Applus on behalf of GGOWL and three planar defects had been found in ground welds. Initially, these were not thought to be cracks but one was investigated during the next two days and was found to be a crack. On 4 June 2009 QIS, an NDT company engaged by Fluor,

- began inspecting one of the unloaded monopiles and immediately found transverse cracking. The previous day GGOWL issued NCR 6 in relation to Shipment 1.
223. On 11 June 2009 Fluor sent a letter to ZPMC in which it recommended changing the NDT procedure to the use of D scans wherever possible.
224. By this stage ZPMC had not moved any welders to Vlissingen and Fluor had engaged a local contractor, VDS, to carry out weld repairs and out of roundness repairs. It is not clear from the documents precisely when VDS started to carry out repairs or how many repairs they carried out.
225. However, VDS issued a Welding Repair Procedure for the MPs at Vlissingen on 19 June 2009. This included two procedures for SMAW and one for FCAW. The reason for the second SMAW procedure was that it was for welding from both sides, as opposed to welding from one side only. In each case the preheat temperature was 50°C and the interpass temperature for FCAW was 185°C. There was no post heat. It appears from the DNV welding procedure qualification test that the consumable used was Hyundai 81MAG.
226. In an e-mail to Mr Dobbs dated 26 June 2009 Mr Ayres said that repairs to monopile IGI 05 were 90% complete, that IGJ 02 was 15% complete on gouging and that no progress had been made with IGJ 01, but that it was hoped that a new repair company would start on the following Monday to commence work. In this e-mail he went on to say:
- “We have encountered problems today in IGI05 that will further impact the completion of the repair works. It seems that additional transverse cracks have propagated (sic) underneath the already repaired area’s (sic) which will now require further work. Early investigations indicate the reason for the cracking is “believed” to be coming from very small undetectable cracks in repairs performed from the outside by ZPMC. When heat is applied for the welding repairs, these cracks open up and become a detectable defect.”
227. In his first witness statement Mr Dove said that he and others became concerned that a problem facing Fluor at Vlissingen was that hydrogen already present in the welds in its atomic form recombined to form molecular hydrogen when heat was applied during the course of the repair. This concern appears to have arisen towards the end of June 2009 during the repairs to the first monopile (as indicated in the e-mail from Mr Ayres dated 26 June 2009 quoted above).
228. Between 29 June and 6 July 2009 a Mr Tennant, of Parsons Brinkerhoff, visited Vlissingen in order to inspect the repairs to the monopiles. He produced a short report at the end of his visit in which he recorded that, although completion of the repairs to monopile IGI 05 was said to have been imminent, those repairs were not in fact completed during his visit. He noted that the preheat temperature of 50°C referred to in the procedures as being “*below that required by the DNV standard*”.
229. Mr Tennant noted that the preheating method being used was “induction/electrical resistance” and that in all cases observed the temperature recorded appeared to be between 80°C and 110°C, from which he inferred that gouging/welding operations may have been started before the required minimum preheat temperature was reached.

It is not explained how the adoption of preheat temperatures of between 80°C and 110°C is consistent with the reference to a preheat temperature of 50°C in the written procedures.

230. On 7 July 2009, Mr Ayres had attended a meeting at Vlissingen with various subcontractors and representatives of Fluor. He said in his witness statement that this was part of a comprehensive investigation into the weld repair procedure to be used at Vlissingen. It was concluded at the meeting that all work was to be performed at 150°C, but a note that Mr Ayres made at the time goes on to record this:

“Hydrogen Bake Out
Post-Weld: go up to 200°C for 2 hours, cool down to be determined
...
Reduce consumables hydrogen content.”

231. An e-mail sent the previous day, 6 July 2009, indicated that the previously adopted preheat temperature was 50°C, a fact which derives some support from an earlier passage in Mr Ayres’s note and the visit report of Mr Tennant. However, on the basis of the material presently before the court it is difficult to say whether or not there was a period at Vlissingen during which a preheat temperature of 50°C was in fact used, but there are reports from Delta Heat Services, who carried out some of the preheating, that a minimum preheat temperature of 50°C was applied on some occasions prior to 6 July 2009.

232. On 7 July 2009 there was a telephone conference with Cathleen Shargay, the in-house welding expert with Fluor, who set out a summary of the revised repair procedure that had been discussed. This was as follows:

“1. Apply 150°C preheat throughout gouging and do not cool after gouging (continue preheat right into welding). This applies to all weld thicknesses . . .

2. Preheat should extend over ¼ circumference min. and extend 25 cm min. beyond the edges of the excavations

...

7. Hold preheat after welding for 2 hours.”

233. In response to that e-mail a Mr Mark van den Broek, a Welding and Material Engineer employed by Fluor, said that the seven steps that Ms Shargay had suggested were exactly what had come out of a meeting with the contractors - presumably the one attended by Mr Ayres, except for one point in relation to the post heating. Mr van den Broek suggested that the post heating temperature should be raised from 150°C to 200°C. This is consistent with the reference to 200°C in Mr Ayres’s note.

234. These discussions gave rise to a proposal to adopt a preheat temperature of 150°C and to maintain it for two hours in order to drive off any existing hydrogen before performing the repair. The weld would then be allowed “*to cool slowly from 150°C*”. Mr Dove suggested in an e-mail, sent on 8 July 2009, that this recommendation should be implemented immediately.

235. On 14 July 2009 an internal RWE e-mail recorded that:
- “We believe the current weld repair procedure is giving defect-free welds. Fluor are applying a 150C preheat as mentioned earlier, however they are also applying a 200C PWHT to, though I am not sure of how long or what cooling arrangements.”
236. At a meeting between Fluor and GGOWL held on 16 July 2009, and attended by Cathy Shargay, the new method of weld repair was described as “*pre-bake after gouging and then preheat - post baking for 2 hours*”. It was recorded that the new weld repairs “*have been successful*”.
237. On 19 July 2009 Mr Dove prepared a repair procedure for weld repairs to the monopiles at Vlissingen. This involved the application of 150°C preheat before gouging, which was to be maintained for 2 hours prior to and during welding. After welding the temperature was to be held for a further 2 hours at 150°C to 200°C. The preheating was to be carried out using induction coils located on the opposite surface to that being welded. A similar procedure was adopted in Changxing the following month.
238. It was not until mid July 2009 that ZPMC sent operatives to Vlissingen to assist with the weld repairs: 22 arrived on 16 July and a further 22 on the following day. However, there were difficulties - such as obtaining passports and visas and finding accommodation - in redeploying a Chinese workforce from Shanghai to Vlissingen at short notice, so the delay does not necessarily reflect any lack of willingness by ZPMC to take some responsibility for resolving the problems. At any rate, according to Mr Ayres they started work on 19 July. According to the witness statement of Mr Chen Bin, the number of welders and other operatives was subsequently increased to 169.
239. A WPS (for FCAW) and a welding procedure qualification report for repair works at Vlissingen was prepared by ZPMC in August 2009. This required a minimum preheat and interpass temperature of 150°C where the base metal was more than 65 mm thick (but still at 65°C where the thickness was between 38 mm and 65 mm). The maximum preheat and interpass temperature remained at 230°C, and post heat was to be at 150°C for 2 hours.

The evidence of Mr Teale about the preheat temperature adopted at Vlissingen

240. Mr Teale said, in his first report (at paragraph 6.1) that initially Fluor qualified three WPS, one using SMAW and two using FCAW, but these specified a preheat temperature of only 50°C. The reference given for this is a presentation dated 22 June 2009 entitled “Greater Gabbard Fabrication Review”, which contained a reference to the flux cored consumable used in the repair procedure as requiring a preheat temperature of 50°C in order to perform properly. He went on to say that Fluor was forced to increase the preheat temperature to 80°C, then to 100°C as the cracking continued. He said that eventually it was increased to 150°C.
241. Mr Teale then said this, at paragraph 6.2:

"It is also significant to note that even when Fluor did increase their repair preheat value in Vlissingen first to 80°C, then 100°C, and then to 150°C, none of these preheat values stopped repair weld cracking. It was only after the addition of Post Heating that the new cracking was contained."

242. In relation to this paragraph, Fluor's experts, in their report in reply, said this (at paragraph 3.10):

"We have seen no evidence of this suggested progressive increase in preheat from 50°C through 80°C and 100°C to 150°C, and Mr Teale does not refer to any. Fluor started with preheat at 50°C, and when that was found to be inadequate, the preheat was increased directly to 150°C as far as we are aware. In any case, we are unsure what the relevance of Mr Teale's statement is as it refers to Fluor's experience, not ZPMC's."

243. So far as I recall, this point was never discussed during the course of the expert evidence and so the source of Mr Teale's information remains obscure. In a note that Mr Fuller prepared on 7 July 2009 he wrote:

"We need to know
- What temperatures do you preheat for excavation process.
- We have heard 50°C, 100°C, 150°C, 250°C."

Coincidentally, this was the very same day as that on which Ms Shargay made her recommendations as to the weld repair procedure and provided an answer.

244. In his second witness statement Mr Chen Bin said (at paragraph 6.5) that documentation that ZPMC received from Fluor after monopile IGJ01 had been repaired by local sub-contractors indicated that that had been many repeat repairs. However, his statement is silent about the repair procedure that was adopted by these sub-contractors.
245. All in all, I can find no evidence whatever to support Mr Teale's suggestion that cracking occurred at Vlissingen when a preheat temperature of 150°C was used. Equally, there is no evidence that a preheat temperature of 150°C was used at Vlissingen without some post heating at a similar temperature, or at least a retarded process of cooling. It is therefore impossible to draw a conclusion from this as to whether cracking at Vlissingen was prevented by the use of a higher preheat temperature, 150°C, or the use of post heating, or a combination of both.

ZPMC's August 2015 tests

246. In August 2015 ZPMC carried out a series of tests to study the cause of the transverse cracks. The conclusion drawn was that the test results showed that a lack of post heat was the main cause of transverse cracking. Fluor was given no notice of the proposal to carry out these tests, although ZPMC did have them witnessed by representatives from Lloyds Register, AGS and TUV NORD - all of whom are well respected testing agencies.
247. The tests were performed on a full size simulation pile. They consisted of gouging out sections of a circumferential weld and then carrying out weld repairs. Without

going into the procedure in any detail, repairs were carried out using no preheat and with preheat - at temperatures of 50°C, 110°C, 150°C and 175°C. These were carried out with and without post heat at 230-315°C for 2 hours. No detailed experimental procedure is included in the report, so what was done must be derived from the results and the description of the process given in the narrative parts of the report coupled with the photographs. The photographs attached to the report show that the depth to which the welds were gouged (according to notes in chalk on the plates) was between about 40-45 mm and the cavity excavated was between 35-40 mm wide and about 200-225 mm long.

248. Section 5.2 of the report of the tests, headed “Cracking Reasons”, said this:

“Transverse cracks found in the experiment were typical hydrogen induced cracking. The contributory factors mainly include: diffusible hydrogen content and its distribution, stress and material hardening microstructure. In terms of repair weld, because the welding repair area is small, the weld is short and the cooling rate is high. When conducting welding repair, the specified preheat temperature can be reached fast. Once welding repair is conducted, as it is semi-auto welding, inter-pass temperature can be very high, and the repair welding can be finished quickly. However, when repair welding is conducted in winter, as the constraint stress is large and cooling rate is high, residual stress and repair weld diffusible hydrogen cannot be released easily after welding, which can easily induce transverse crack.”

249. The report noted that the “amount and dimension of crack” decreases as the preheat temperature increases. It concluded that although preheat temperature increase is helpful in preventing formation of transverse cracks, it cannot effectively inhibit the occurrence of such cracks. By contrast, the application of post heat between 230-315°C for two hours prevented transverse cracking.

250. Photographs in the report showed that the preheating was done by torch and to the same side (the inside of the pile) as the weld repair. There are photographs showing the preheat temperature being measured at a point fairly close to the weld, again from the inside of the pile. There is no suggestion that there was any attempt to measure the temperature on the outside of the pile. Indeed, one would not have expected them to have done so, because, as Dr Gordon explained, the purpose of the tests was to replicate the procedure adopted at Changxing. The statement that the preheat temperature was reached “fast” suggests to me that the base metal may well not have been preheated to the prescribed temperature for its full thickness.

251. Although ZPMC was somewhat reluctant to admit this at the trial, it is perfectly clear that the intention behind these tests was to demonstrate that if the critical repair procedure that was rejected by Mr Dove in January 2009 had been adopted, transverse cracking would not have occurred in the circumferential welds.

252. Whilst on the face of it this work looks as if it might be a compelling piece of evidence, in the absence of any clear record of the procedure followed I regard it as being of somewhat limited value. There is no evidence that the preheat temperature on the opposite side to the face being welded was ever measured, let alone checked so as to ensure that it achieved the prescribed temperature. The plates of which the pile was made were 60 mm thick, so since the depth of the weld repair was of the order of

40 mm the prescribed preheat temperature would have to be achieved for the full thickness of the plate. In this context it is of interest that when a preheat temperature of 175°C was adopted (and measured on the same side as that being welded) there were no cracks.

253. While the tests show that, had the critical repair procedure put to Mr Dove in January 2009 been adopted for all repairs (and not just critical repairs), much if not all of the transverse cracking would have been avoided, they do not show the converse. In other words, the tests do not show that a preheat temperature of 150°C, if properly achieved, would have been insufficient to prevent cracking. All they show is that when the preheat was applied by a torch from the same side as the welding, and the temperature measured on the same side, a measured temperature of 150°C was not sufficient to prevent cracking.
254. One cannot know with certainty what would have happened if the preheat had been applied from the opposite side of the plates but the temperature of the steel had been taken on the same side as the welding. However, the repair welding carried out under supervision by the Testing Centre at branch company 3 in Changxing in February 2009 suggests that a preheat temperature of 120°C, if properly applied, was sufficient to prevent hydrogen cracking. Further, the absence of cracking in the August 2015 tests when a preheat temperature of 175°C was adopted (measured at the surface being welded), suggests that the lower temperature that would have prevailed at a depth of, say, 30-40 mm, was in fact sufficient. This suggests quite strongly that if the preheat had been applied to the opposite face of the plates and a temperature of 150°C had been recorded on the face being welded, there would have been no cracking.
255. For these reasons I consider that the August 2015 tests provide no satisfactory evidence that a preheat temperature of 150°C, properly applied, would not have been sufficient to prevent transverse cracking. On the contrary, they provide some basis for concluding that, if applied to the opposite side of the plate from that being welded, a preheat temperature of 150°C might have been sufficient.

My conclusions as to the causes of the transverse cracking

256. In spite of the substantial body of oral evidence, both from the parties and the experts, and the many thousands of documents that have been put before the court in this case, I have come to the conclusion that the cause of the transverse cracking in the repair welds on the circumferential seams of the monopiles is fairly self-evident. It was a combination of the factors set out below.
 - (1) The failure to devise a separate WPS for FCAW repair welds to the circumferential seams having regard to the high restraint present. Such a procedure should have at least prescribed a preheat temperature of 150°C and probably, in addition, the application of post heat up to the same temperature. The existing WPS could have been revised to provide for this without the need for requalification.
 - (2) Even if the proposed procedure had provided only for a preheat temperature of 150°C (and no post heat) such preheating, if properly applied, would have eliminated most if not all of the transverse cracking.

- (3) The failure to achieve, on a consistent basis, the preheat temperature of 110°C actually prescribed. This problem was particularly prevalent when the preheat was being applied by torch. However, it is clear that where the preheat was applied by electric heating bands, these were not always properly kept in place. However, I am not satisfied that a preheat temperature of 110°C, even if properly applied, would have eliminated transverse cracking altogether. However, I have little doubt that it would have reduced its incidence significantly.
- (4) The use of Supercored 71H, which had a hydrogen content which was too high for this application and a significant boron content. This in itself was not a breach of any obligation owed to Fluor: however, ZPMC should have paid proper attention to the manufacturer's recommendation to adopt a preheat temperature of between 50°C and 150°C - the latter being the appropriate temperature for welding in conditions of high restraint.
- (5) The fact that many of the circumferential welds of the monopiles in Shipment Nos 1 and 2 were carried out in the open air during winter, which increased the rate of cooling of the weld metal thereby providing less opportunity for the hydrogen to diffuse out. In these circumstances, ZPMC should have been particularly aware of the importance of achieving the specified preheat temperature throughout the base metal (and not just at the surface).

257. Mr Dove's rejection on 28 January 2009 of the proposed critical weld repair procedure did not excuse or relieve ZPMC from its obligation to devise an appropriate WPS for non-critical weld repairs. Indeed, there is ample evidence that ZPMC did not rely on Fluor in this regard in that on many subsequent occasions the Testing Centre proposed post heating for weld repairs and clearly did not regard itself as prevented from doing so.

Non Destructive Testing ("NDT")

What is NDT?

258. By way of a definition, I can do no better than quote from paragraph 26 of Fluor's NDT experts' report:

"Non-Destructive Testing is the term used to describe a test or series of tests that can detect welding or in-service flaws without damaging the component under test. This can be achieved by the use of ultrasound, magnetic fields, penetrating fluids and x-rays or gamma-rays, to name but a few. The flaws, that could potentially compromise the integrity of the component, can be either surface breaking or buried within the welds or parent material. Ultrasonic testing is similar to that used on pregnant women to check the age and health of the baby."

259. In this project the primary method chosen was ultrasonic testing. Much of the description which follows is based on the helpful explanation in the report of Dr Morgan, the NDT expert instructed by ZPMC. The method involves the use of a probe that is placed on the surface of the metal being welded, or sometimes on the weld itself, which, by means of a short pulse of ultrasound, can detect imperfections

or irregularities within the body of the weld or the adjacent base metal. Dolphins use a similar system, but at a much lower pitch, to detect obstacles and prey. Because ultrasound is at a very high frequency it can be pointed at a particular target more easily than sound. Indeed, the beam is treated as if it were a straight line like a well-focused beam of light from a torch or a lighthouse.

260. The probe is connected to a small screen which is carried by the operator. It is important to appreciate at the outset that what the equipment detects is an alteration in the signal that is reflected back from the material being tested. If there are no flaws in the metal being examined the operator will see two spikes on the screen: the first is the signal emitted (the “send” pulse) and the second is the echo from the back of the steel plate, which represents a discontinuity. The distance between the two spikes on the screen represents the depth of the metal being examined. If the weld contains a flaw, the operator will see two signals in addition to that given by the send pulse: an echo from the flaw and a second echo (from the part of the pulse that misses the flaw) from the back of the steel plate. The distance between the spike from the send pulse and the spike representing the echo from the flaw indicates the depth of the flaw.
261. It will be apparent from this description of the process that certain types of imperfection will be more readily detected than others. For example, if a torch is pointed at a mirror placed face on in the dark, the reflection is easily seen. However, if the mirror is turned sideways on, the observer may see little more than a faint reflection in the form of a line representing the edge of the glass. It is much the same with ultrasound. An additional factor is that the strength of the signal diminishes with distance, partly because it is diverging and therefore reducing in intensity and partly because some of it is absorbed by the medium through which it is passing.
262. Accordingly, there are different types of scanning pattern available to the operator, the choice of which will depend on the type of flaw which he¹⁵ is particularly interested in detecting.
263. The presence of air in the material being examined will show up as a discontinuity. Accordingly, the probe is usually placed on a water or oil based liquid, known as a couplant, so as to eliminate or reduce the effect of any irregularities in the surface of the metal on which the probe is placed. If it is necessary to have the beam at an angle, the probe is placed on a metal wedge in which case the couplant will be placed between the wedge and the surface of the metal.
264. As I have mentioned, the profile of a typical butt weld takes the form of an irregular bulge - the weld cap - above the surface of the base metal. In many places the presence of the cap does not matter, but in regions where stresses are likely to be particularly high it can present a point of weakness (such as a crack inducer) and so it has to be ground flat. The welds for which this is required will be specified in the design. Where welds have been ground in this way it is possible to place the probe on the weld itself. This is often referred to in the documents as “*riding on the weld*”. It is technically known as scanning pattern D (or D scanning).

¹⁵ In the interests of brevity, I will use “he” or “him” throughout; in any event, it seems that the great majority of NDT inspectors were men.

265. Scanning pattern E (or E scanning) involves directing the beam at an angle with the probe placed, on a wedge, on the surface of the base metal beside the weld. In addition to the beam being directed at an angle to the horizontal, it is also directed at an angle to the line of the weld. Whilst this method is efficient at picking up flaws that are parallel to the line of the weld, it is not so good at detecting transverse flaws which are orientated so that they are, in effect, edge on to the line of the beam (as in the example of the mirror turned sideways on). E scanning is done from both sides of the weld seam and usually at two or three different angles to the horizontal. In this way the operator methodically works his way along the line of the weld seam, scanning one side for a certain length and then the other.
266. As I have said, D scanning involves moving the probe along the surface of a weld which has been ground flat. It is much more efficient at detecting imperfections that are transverse to the line of the weld. D scanning can also be used, albeit much less reliably, on a weld which has not been ground but has a reasonably flat surface. Alternatively, the weld can be partly ground to improve the efficiency.
267. There are also other patterns of scanning: A, B, and C. B and C scanning play no part in the present dispute and so I can leave them on one side. A scanning was described by Dr Morgan, but it is not necessary for me to say anything about it in this judgment.
268. The size (or amplitude) of the UT signal is used to give a measure of the size of the flaw, but there is a complication. As I have said, like the beam from a torch, the ultrasonic beam becomes weaker as it travels further from the probe. Accordingly, the device has to correct the signal amplitude to accommodate the distance from the probe to the flaw. This is done by means of a Distance Amplitude Correction (“DAC”).
269. For this purpose, a test piece of steel is taken and holes are drilled in it at different depths. These simulate the presence of a flaw. Each hole is scanned and a mark is made on the screen at the peak of the signal. The process is repeated for each of the holes. A curve is then drawn linking the peaks and this becomes the DAC curve. When the operator starts scanning finished welds any difference in the response to the signal, known as an indication, is compared with the DAC at the same point and the signal size is assessed as a percentage of the level of the DAC curve at that point. The UT specification for a particular project will provide acceptance criteria in terms of a percentage of the DAC curve. For example, it may provide that any indication in excess of 50% of the level of the curve is to be investigated further and, if confirmed, is to be treated as a defect and will normally have to be repaired.
270. UT scanning is an art as much as a science. When the operator sees an indication on the screen he will usually move the probe about in order to optimise the signal response and thereby gain a better idea of the nature and extent of the potential defect. The ability to categorise accurately the nature of the defect observed is largely acquired by experience.
271. As Mr John Lilley, and his fellow NDT experts instructed by Fluor (Mr Armitt and Mr Traves), pointed out in their first report, at paragraph 66:

“The amplitude of the response from a flaw depends on many factors including the flaw size, the flaw type(s), the flaw orientation relative to the ultrasonic beam and

the manner in which the UT is conducted. The ultrasonic responses from different types of defect are different and this permits defects to be characterised, e.g. as cracks, lack of fusion or other forms of welding defect. Defects can be complex in nature, either individually or as a combination of co-existent defect types, and the process is somewhat subjective. Some defects however, such as transverse cracks, are straightforward to characterise.”

272. In relation to NDT, the two principal issues that arose at the trial were, first, whether ZPMC should have used, and would have been entitled to use, scanning pattern D once it became clear that there was a problem with weld repairs and, second, what are the contractual consequences if the chosen scanning pattern fails to discover cracks in the welds?

The UT procedure and the relevant codes

273. The initial UT procedure prepared by ZPMC was based on AWS D1.1 Tubular Structures Welding Code, but during the latter part of 2008 there were lengthy discussions between ZPMC and Fluor about which standard was to govern NDT. From an early stage Fluor made it clear that UT should be carried out in accordance with the Offshore Standard DNV-OS-C401, not AWS D1.1.
274. By the end of November 2008 ZPMC had been persuaded to agree to the application of the DNV standard. It was agreed that ZPMC would retest all the circumferential welds in accordance with the DNV standard, but that any longitudinal welds that had already been tested in accordance with the AWS code would not have to be retested. It is clear that Mr Estabrook of Fluor was heavily involved in the drafting of the revised procedure.
275. However, there is one provision in the revised procedure that is disputed by ZPMC. It concerns the acceptance criteria. These are set out in Table 3 in paragraph 16 of the procedure. It is as follows:

“16.3 Acceptance criteria see Table 3, Structural Category ‘Special’

Table 3 Ultrasonic testing acceptance criteria of Offshore Standard DNV-OS-C401, April 2004 Edition			
Indication ¹⁾²⁾³⁾	Structural Category		
	Special	Primary	Secondary
Echo height above Maximum length ⁴⁾ mm	50% of reference level t/3 or maximum 10	100% of reference level t/2 or maximum 10	100% of reference level t or maximum 20

Cracks are not acceptable regardless of size or amplitude.

- 1) Indications which the operator based on experience, knowledge of the welding method and joint geometry deems likely to be cracks, lack of fusion or lack of penetration may be unacceptable regardless of echo amplitude and length. In such cases an independent examination by another operator shall be performed.
- 2) If only one side of the weld is accessible for examination, all indications with a length $>t/4$ and exceeding 20% of the reference curve for the special

category and 50% otherwise, may be regarded as cracks, lack of fusion or lack of penetration unless otherwise proven. In such cases an independent examination by another operator or by different methods shall be performed.

- 3) For longitudinal defects where the indications intermittently are above and below the acceptance level, the type of defect shall be determined when the areas exceeding the acceptance level are repaired. If the defect is found to be crack, lack of fusion, lack of penetration or slagline(s) the whole defect length is unacceptable regardless of echo amplitude.
- 4) Length is defined as distance between points where the echo amplitude reach or pass the stated percentages of reference level.”

“t” refers to the thickness of the metal being welded.

276. ZPMC takes issue with two aspects of this table. First, it contends that the structural category should have been Primary, and not Special. Second, there is a dispute as to the meaning of the words “*Cracks are not acceptable regardless of size or amplitude*”. Fluor submits that this means what it says. ZPMC submits that it applies only where there has been an indication above the prescribed level that turns out to be a crack, in which case it is unacceptable.

277. The DNV standard contains the following provisions in Section 3B, Non-Destructive Testing (which, at paragraph 208, is defined as “*visual inspection, radiographic testing, ultrasonic testing, magnetic particle testing, penetrant testing and other non-destructive methods for revealing defects and irregularities*”):

“**101** Prior to commencement of fabrication the contractor shall submit a plan for NDT, NDT procedures . . . For acceptance by the purchaser.

. . .

104 Methods of NDT shall be chosen with due regard to the conditions including the sensitivity of the method and the method’s ability to detect defects likely to occur as a consequence of the chosen welding process

. . .

201 NDT shall be performed in accordance with agreed written procedures that, as a minimum, give detailed information on the following aspects:

. . .

401 The extent of NDT shall be based on type and level of design stresses and on the importance of the connection in question. The welds shall be assigned inspection categories equal to the highest structural category of the two components.

. . .

Aspects that shall be considered in determining the extent of NDT are:

. . .

- technique

. . .

402 Unless otherwise agreed, NDT shall normally be carried out to an extent not less than required in Table B1 . . .

. . .

403 If a consistently low NDT failure rate is documented, the extent of NDT inspection required for elements within structural category primary may be reduced, but shall not be less than poor Inspection category III

. . .

405 Frequent repairs shall result in increased extent of NDT. The extent of NDT shall be increased in a manner such that all relevant defects are discovered in the areas of concern

and that representative sampling is carried out on all welds. When the weld quality level has been restored, the extent of examination may be reduced in agreement with the purchaser
406 If severe defects (i.e. cracks and other planar defects or excessive slag lines) occur repeatedly, all welds made with the same welding procedure during the period in question, shall be examined full length.

Frequent occurrence of excessive porosity can be indicative of inadequate handling of welding consumables. If inadequate handling is confirmed, the welds made during the period in question shall be investigated by adequate methods for hydrogen induced cracking.

413 *Ultrasonic testing*

Ultrasonic testing shall be performed according to approved procedures. The procedures shall be established according to recognised standards.

...

417 For evaluation of flaw indications a reference curve shall be established. The curve shall be plotted on the instrument screen. Imperfections, which produce a response greater than 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity and location of all such imperfections and evaluate them in terms of the acceptance criteria. All defects exceeding the acceptance criteria shall be reported unless more stringent requirements are agreed.”

278. Table B1 is headed “*Minimum extent (in %) of non-destructive testing for structural welds*”. There are four test methods identified: visual, magnetic, radiography and ultrasonic. For different types of joint a minimum percentage is given for each test method, save that in some cases this is shown as “Spot”, meaning approximately 2% to 5%. A note to the table says that “*ultrasonic examination shall be carried out for plate thicknesses of 10 mm and above*”.
279. Reading this section of the standard as a whole, therefore, it is apparent that it differentiates between the test method, being the type of NDT adopted, and the extent of the inspection, being the percentage or a proportion of the number of welds that have to be inspected. The extent of the NDT is to be specified after taking into consideration the various aspects mentioned in the standard. In this context, I do not consider that the various different UT scanning patterns can be classed as different methods of NDT: for the purpose of the standard, they are UT. In its closing submissions ZPMC accepted that the word “method” when used in the standard refers to the form of NDT (see paragraph 714.5.1 of ZPMC’s closing submissions).
280. Table B5 in the DNV standard is virtually identical to table B3 in the agreed UT procedure that I have set out above.

The meaning of the words “cracks are not acceptable regardless of size or amplitude”

281. As Dr Morgan explained, the operator is searching for any signal which might be over the threshold level. He then describes what would happen as follows:

“Then you investigate the signal (you characterise it). You stop the probe and point it at the place where the signal was found. You then twist and rotate it around that position to get the maximum signal size (which is noted) and observe how the signal changes as you move the probe, to see if it has the characteristics of common flaws and whether it is crack-like. Having decided the type of flaw, it must then be assessed against the project criteria, most particularly measuring the flaw’s length, (in a tightly specified manner), to decide if it is to be rejected.

...

These two stages are often not distinguished in witness statements and expert reports that I have read. If a witness says that the signal was above threshold when he investigated it, he is not necessarily saying it was above threshold when he did the search scan. It may only have been above threshold when the probe was rotated and the signal maximised during the “investigation”. (The “search” scan will always have a smaller signal than the maximum found when investigating).”

282. If one applies this approach, the operator might find a signal below the threshold which prompts further investigation in the manner described by Dr Morgan. That further investigation may suggest that the flaw is a crack, but the signal always remains just below the threshold. On Dr Morgan’s approach, therefore, that crack can simply be ignored. I appreciate that this is probably an artificial scenario, but I have created it in order to test the hypothesis.
283. However, during the course of the evidence Dr Morgan modified his position to some extent because he agreed with Mr Lilley when he said that the operator should investigate *"any indication that is clearly visible on the screen that may look, in the operator’s experience, as though it may come up higher if the probe is optimised"* (Day 16/21-22).
284. Otherwise, the difficulty with following Dr Morgan’s logic would be that it appears to ignore the words *"regardless of . . . amplitude"*, because the signal has to be of a particular amplitude in order to reach 20% of the DAC curve. To respond only to those indications in excess of the threshold is not to disregard the amplitude.
285. There was disagreement also about the meaning of these words (in the table setting out the acceptance criteria):
- “Indications which the operator based on experience, knowledge of the welding method and joint geometry deems likely to be cracks, lack of fusion or lack of penetration may be unacceptable regardless of echo amplitude and length. In such cases an independent examination by another operator shall be performed.”
286. To my mind, these words are reasonably clear. They say, first, that flaws giving rise to indications which are likely to be cracks, lack of fusion or lack of penetration *"may be unacceptable regardless of echo amplitude and length"*. Second, that if the operator using his experience and professional knowledge thinks that what he is seeing is likely to be a crack, lack of fusion or lack of penetration, then he should seek a second opinion from another operator. I agree with Mr Lilley and his fellow experts that if the operator is certain that what he is seeing is, for example, a crack, then he can reject the flaw forthwith without needing to seek an independent examination by a second operator. Dr Morgan, in his reply report, appeared to suggest that an independent examination by a second operator was required in every case where the first operator thought that he had found a crack, irrespective of how confident he was about it.
287. Linguistic analysis apart, the approach taken by Fluor’s experts seems to me to be sensible. The usual purpose of requiring a second opinion is to provide clarity in circumstances where there is uncertainty in the mind of the first examiner. But if the first examiner is quite certain about what he has seen - assuming that he is sufficiently

experienced, seeking a second opinion is an unnecessary luxury which is unlikely to be commercially justified.

RFI 34

288. The revised NDT procedure provided that scanning pattern D was to be used when welds were ground flush, and scanning pattern E when the weld cap was not ground flush. For circumferential welds the minimum prescribed extent of NDT was 100% of the weld; for the longitudinal welds it was 20%.

289. By RFI¹⁶ 34 (Rev 1) dated 1 December 2008, ZPMC asked:

“Based on ZPMC’s experience, there is no need to do UT after grinding, because the grinding is only the work for the surface of weld. So, we think that only MPI should be done according [to] the specification after grinding, and UT can be done before grinding. Please confirm our understanding is correct..”

ZPMC then ticked the box that said that the RFI was being submitted for “Contractor Convenience”.

290. The response, dated 3 December 2008, was as follows:

“Agreed. All welds to be UT examined & repaired. Where grinding is required (as table) then MPI at 100% shall be performed as a further check for crack detection.”

MPI stands for Magnetic Particle Imaging.

291. The consequence of this concession was that ZPMC would never have to perform a D scan on a weld that had been ground if there had been an E scan before grinding. Fluor must have assumed that the E scans would pick up any relevant flaws. With the benefit of hindsight, it can be seen that this request was inappropriate and its approval unwise. Nevertheless, from a contractual point of view it left ZPMC free to choose whether it carried out UT before or after grinding. If that had the consequence that cracks were missed that would otherwise have been detected, which is in fact what happened, that is a matter in respect of which of itself Fluor has no recourse against ZPMC. As I have mentioned before, whether or not a particular circumferential weld was to be ground was a matter for the designer. It had nothing to do with any UT considerations.

Increasing the extent of NDT where there are frequent repairs

292. This is the issue raised by paragraph 405 of DNV C401. For ease of reference, I shall set it out again:

“Frequent repairs shall result in increased extent of NDT. The extent of NDT shall be increased in a manner such that all relevant defects are discovered in the areas of concern and that representative sampling is carried out on all welds. When the weld quality level has been restored, the extent of examination may be reduced in agreement with the purchaser.”

¹⁶ "Request For Information".

293. This issue is of importance because as I have explained, certain types of transverse crack produced a UT echo which was well below the acceptance criteria when E scanning was adopted, but gave an indication that was unacceptable when tested by D scan.
294. I agree with ZPMC that increasing the “*extent of NDT*” does not mean changing the NDT method to be adopted. Such an interpretation does not fit with the terminology used in the standard. In evidence, Fluor’s NDT expert, Mr Lilley, did not accept this. He said that if one read through the standard the word “method” was sometimes used to refer to the form of NDT but at other times it referred to the “*way in which NDT is applied, the technique*” (Day 16/71). He may have had in mind the reference to “methods” in the last sentence of paragraph B 406; however, that seems to me to be using “methods” in the sense of the type of NDT. On this point, therefore, I do not agree with Mr Lilley.
295. However, as Mr Lilley pointed out, paragraph 405 makes it clear that the object of increasing the extent of NDT is to ensure that all relevant defects are discovered in the areas of concern - in this case the circumferential welds. The problem here is that, since the NDT requirement for the circumferential welds was already 100% UT, there was no scope for extending it using scanning pattern E. In the case of repairs, there was a similar problem in that the extent of the UT required was only in the immediate area of the repair – so there was no scope for extending it.
296. However, for the reason that I have already given, I do not consider that altering the UT scanning pattern amounts to a change of method. Indeed, in one sense Mr Lilley agreed with this, as the following exchange (at Day 16/74) shows:
- “MR JUSTICE EDWARDS-STUART: Mr Lilley, in this context, looking at paragraph 104, could you just give me, off the top of your head, three methods of NDT? Just name three methods.
MR LILLEY: there is radiography, ultrasonics and magnetic particle.
MR JUSTICE EDWARDS-STUART: Right. Is scanning pattern D a different method from scanning pattern E, in your view?
MR LILLEY: I would call it a technique.”
297. Dr Morgan accepted that, for example, increasing the number of probe angles may be considered an increase in the extent of the NDT, although it would depend on the procedure (Day 16/82).
298. The question is whether changing or adding a scanning pattern can be regarded as increasing the “extent” of NDT. Suppose, for example, that ZPMC became concerned at the discovery of cracks in repairs to circumferential welds that were not being picked up by E scan. It could then, in my view, increase the scanning by carrying out an additional D scan on, say, all welds that had been ground flush in order to confirm the findings of the E scan already carried out. I can see no reason why that should not be considered an increase in the “extent” of the NDT since it would not involve changing the method or the agreed procedure. Its only effect would be to override the concession granted by RFI 34. I consider that that is what ZPMC should have done once it was apparent that D scans carried out by “*riding on the weld*” were discovering cracks that were not being revealed by E scanning.

299. The language of the first sentence of paragraph 405 is in mandatory terms: the verb “shall” appears twice, and the definitions in the standard make it clear that when the verb “shall” is used, it denotes a mandatory requirement (see paragraph D 101). It seems to me, therefore, that paragraph 405 should be construed in a manner that, so far as possible, allows proper effect to be given to its obvious purpose.
300. For these reasons, I consider that, in principle, it was not only open to ZPMC to increase the extent of the NDT by adding a requirement for D scans to be carried out in addition to E scans but also that, under paragraph 405, it was obliged to do so if that was necessary to ensure that “*all relevant defects are discovered in the areas of concern*”. However, there is an important qualification: in this event the D scanning to be carried out would have to be in accordance with a technique laid down in the agreed written procedures. Dr Morgan said that a contractor would require the customer’s consent to such a change if he was “*changing his process*” (Day 16/83); but, by implication in my opinion, an increase in the extent of the NDT that did not require a change to the agreed process would not require the consent of the customer. Therefore, once it became apparent to the operators in branch company 3 that cracks could be discovered by “*riding on the weld*” that were not revealed by E scanning, they should have taken the immediate step of carrying out D scans to all ground welds (notwithstanding the concession confirmed by RFI 34) and at the same time raised the matter with higher levels of management within ZPMC. Failure to do the former was a breach of paragraph 405 of the DNV standard and the latter a breach of ZPMC’s workmanship obligations under the PO.
301. In this context Dr Morgan said also (at Day 16/30):

“We have a D scan standard and an E scan standard. If it is acceptable to the E scan and rejectable to the D scan, my feeling is that under the basis of good working practice, good engineering practice, you should take the conservative sensitivity . . . Which is with the D scan, indeed.”

This, to my mind, must be correct. Further, it suggests that in a situation where frequent repairs were required a contractor who was aware of this difference in sensitivity of the two types of scanning pattern should, wherever permitted by the agreed procedure, increase the extent of the scanning by the use of D scanning in order to ensure that all relevant defects are discovered.

302. In relation to welds that had been ground flush, this would not present a problem because the agreed NDT procedure for such welds was D scanning. However, this was not permitted where the weld had not been ground flush, because in that event the procedure provided that E scanning was to be used.
303. As I have already mentioned the Purchase Order contained a warranty that the monopiles would be “*of good . . . workmanship*”. ZPMC submitted that this obligation amounted to “*no more than a warranty that reasonable skill and care has been used in carrying out those specified or described work processes*”¹⁷. This submission was made by reference to paragraph 3-084 in Hudson’s Building and Engineering Contracts, 13th Edition, where the authors say:

¹⁷ Paragraph 745 of its closing submissions.

“In the absence of any special term or direction in the contract specifying the manner in which the work is to be done, there is an implied condition in all contracts for work and labour that the described work will be carried out carefully and skilfully or, as it is sometimes expressed, in a good and workmanlike manner.”

304. I do not accept this submission. It is a warranty that the work has been carried out with reasonable skill and care (see also paragraph 331 below).
305. Paragraphs B101 and 104 of DNV-C401 impose a duty on the contractor to prepare NDT procedures and submit them to the employer, using methods of NDT that have due regard to the relevant conditions, including the sensitivity of the method and the method’s ability to detect defects likely to occur as a consequence of the chosen welding process.
306. In these circumstances it seems to me that it is an incident of the duty to exercise reasonable skill and care in carrying out the prescribed processes that the contractor will bring to the attention of the employer any shortcomings in the methods of NDT or procedures chosen which have become apparent and to propose alternative procedures of which the contractor is or ought reasonably to be aware that will enable a type of defect that has become apparent to be detected. Of course, it would be a matter for the employer to agree or withhold agreement to the proposal.
307. If, where frequent repairs were being carried out, ZPMC became aware of the occurrence of cracking that was not always being detected by E scanning, but which could be detected by D scanning, then in my view, in addition to the steps set out in paragraphs 298 and 300 above, it became obliged to submit a proposal to adopt a different method of NDT or, alternatively, different UT procedures so as to identify the cracks. Its failure to do so was a breach of its workmanship obligations under the PO because it should have acquired the relevant knowledge if branch company 3 had reported the fact.
308. Although this is a conclusion that I reach as a matter of construction of the contract, it derives some practical support from the evidence of Mr Li Ruixiang, who was the QA Vice General Manager at Changxing. At Day 14/48, he gave this answer:

“If company 3 clearly knew at time that their NDT testing method was outside the scope of the contract, and if they clearly knew that company 2 and company 1 were not using such scanning method, then I think they should raise this issue as a specific issue, as a specific subject.”¹⁸

There would be no point in raising this issue with the other two branch companies unless it was anticipated that some action would be taken in the light of it.

Did ZPMC know that transverse cracks could be detected by D scanning?

309. Although this is posed as a single question it contains, in my view, two separate elements. The first is to respond to Fluor’s allegation that ZPMC should have told it about the need to implement D scanning in order to detect the transverse cracks, or at least most of them. The second aspect arises because knowledge of an inspection or

¹⁸ This is discussed more fully in the next section

fabrication problem within ZPMC may, as an incident of workmanship or good practice, trigger an obligation to take steps to raise the matter with Fluor with a view to changing the agreed procedures.

310. Each element may give rise to a separate answer. In relation to the first, the knowledge required must be knowledge that is capable of being imputed to ZPMC as a company. Where actual knowledge is concerned, it is trite law that it is only the knowledge of employees at a certain level that will be imputed to the company. What that level may be will depend on the circumstances. Fluor did not suggest that in this case some form of constructive knowledge would suffice.
311. However, in relation to the second element, knowledge of a more junior employee, such as a foreman, may be relevant because it may trigger a chain of reporting within the company. With these points in mind I turn to the evidence.
312. In an extract from the notebook of Mr Chu Xiangjun, the Production and QC Manager of branch company 3, dated 9 February 2009, it was noted that *“Adopting straight welding seam UT inspection on base material is unable to detect, must ride over the welding seam then only be able to detect”*. This followed a request from Mr Chu a few days earlier asking if Mr Shen Daming could visit *“Small CX”*¹⁹ to find out the cause of the repeated appearance of transverse cracks on FCAW repairs. The extract from Mr Chu’s notebook is clear evidence of the fact that in branch company 3 it was known at junior management level that D scanning (or a variant of it - if it involved *“riding on a weld”* that had not been fully ground) was able to detect cracking that was not picked up by E scans. It is not clear from this entry whether Mr Chu was referring to cracks in primary production welds or in repair welds, although from the wording of the entry the former looks more likely.
313. There is an undated and unsigned internal ZPMC document (but is dated by the metadata as created on 22 May 2009), which, according to Mr Cao Weizhong (at least, at one point), was written by a Mr Yan Hua, a manager in ZPMC’s QA department. In this document he said:

"Investigation and analysis in relation to **the causes for transverse cracks** of the wind power project

The wind power project, **from the commencement of large production in last November to present, this problem has always existed**. Through long term statistics and observation, **the transverse cracks mainly exist on repair positions. Recently, the supervisor increased the strength of onsite inspection, the frequency of discovering transverse cracks increased, therefore raised doubts to our inspection quality and product quality**.

However, through technical analysis and analysis of the onsite quality inspection and NDT staff's experiences, the main causes are as follows:

1. Insufficient preheat. This is the currently common belief of the supervisor, welding technicians and general staff. Indeed, the issues of proceeding welding without preheating, insufficient preheat temperature were discovered onsite many times, there was also the issue that the preheat position did not match the welds;

¹⁹ "Small CX" stands for Small Chanxing which was the area of Changxing Island where Branch Company 3 was located.

2. No temperature keeping after welding. According to the procedure requirement, temperature keeping should be performed on the welds after welding. While welding, the electric heating band cannot be reached, should be placed near the welds, but these requirements were not strictly implemented.
3. Issue of CO2 welding. Most of the places where transverse cracks occurred were the positions of CO2 repair welding. The CO2 welding wires itself may have issues, whether low in hydrogen (did not reflect in the quality warranty letter). In addition, CO2 onsite were not taken back to the consumables room in the evening to perform temperature keeping, heating process, left in the workshop overnight, very easy to be damp. The baking system was basically strictly implemented on the electric welding rods, therefore, the electric welding rods repair welding positions basically did not occur transverse cracks.
4. Issue of welder's welding. Some welders in order to be fast, did not implement the WPS requirements, increased electric current and voltage, causing energy input increased, the penetration bigger and wider, the fusion metal filled too much, causing problems of stress and defects exist in the welds etc.. When repairing the nearby positions, these defects which should be postponed in occurrence occurred immediately in the welds.
5. The increase of the chance to discover electronically transverse cracks also related to the inspection method. **According to the requirements of the drawings and procedure, we only performed transverse scanning by riding on the welds for the welds which require grinding under the drawings, and performed transverse scanning of 15 degree or 10 degree from both sides for other welds. When FLURO [sic] performed transverse scanning by riding on the welds for all welds, naturally the chance to discover transverse cracks increased."**

(My emphasis)

314. In my view, four points are apparent from this document:

- (1) The problem of transverse cracking was in the belief of the writer, a persistent one, that is from November 2008 onwards and occurred mainly where there had been repairs.
- (2) A recent increase in the extent or thoroughness of the scanning had revealed many more cracks.
- (3) D scanning was only required on welds which were required to be ground, and that is what ZPMC did.
- (4) The reference to "transverse scanning" carried out by ZPMC in the second sentence of the final paragraph must be a reference to E scans (because D scans are not done from both sides). This is to be contrasted with the "transverse scanning" said to have been carried out by Fluor by "*riding on the welds for all welds*".

315. It is reasonably clear to me that this document shows that the author was unaware that any of ZPMC's fabrication units had discovered transverse cracks in early 2009 by using D scans. If, as stated by Mr Cao (and there is no evidence to contradict him),

the author of this document was a manager in ZPMC's central QA department, then it is reasonable to infer that those who worked in that department were not aware in early 2009 that D scans were more effective than E scans at detecting transverse cracks of the type that arose at Changxing. Indeed, the inference from the last paragraph - whether right or wrong - is that this was only discovered by Fluor.

316. In cross-examination Ms Ma said that she first became aware that people employed by ZPMC were using D scans in May 2009, which was when Fluor's inspectors started using D scans in branch company 2 (Day 13/58). I have no reason to think that she was not telling the truth.
317. Fluor relies on an e-mail dated 23 May 2009 sent by Mr Chu Xiangjun to (or copied to) a number of employees of ZPMC. They included: Sun Mingfeng, Zhou Jinhua, Tian Hongliang, zhucz, lingjy, chencs [full name unknown], Lu Hanzhong, Ma Xiaomei, Cao Guiming, Liu Jianbo, Shen Daming, Li Jianghua, Zhang Ming, Tang Yung, Feng Zhiwen, Cao Yi. It said this:

"5. In relation to cracks, our company 3 already discovered transverse cracks while shipment 1 manufacture, **under the guidance of the welding lab**, the measures we adopted for procedure are as below, the preheat for repair welding is the top priority, the electric heating bands place on the opposite side of the repair welding positions, the electric heating bands are always in the heated status during the whole welding process, after completion of welding, continue to heat for 2 hours; **for inspection, perform transverse cracks inspection by probes riding on the welds for all repairs, discovered hundreds of transverse cracks one after another, arrange repair by work teams in the workshop for these cracks; For the repairs of more than twice, request to use welding rods to perform repair welding (basically did not discovered cracks of welding rod welding, but low efficiency). Recommend company 1 and company 2 in relation to all repair positions of the welds in shipment 4, perform overall transverse cracks inspection before FLUOR third party random inspection.**"

(Mr Brannigan's emphasis)

318. This is consistent with the extract from Mr Chu's notebook that I have already quoted, in that it is saying that branch company 3 was using D scans from a very early stage. It is not clear quite what was said to have been done "*under the guidance of the welding lab*", but that seems to refer to the measures that were taken to improve the welding procedure (rather than the inspection technique).
319. On 3 June 2009 Mr Chu sent an e-mail to Mr Yan Hua, the final paragraph of which was as follows:

"Mr Yen, please assist appropriately, initially Small Changxing's Quality Inspection was under my strict supervision, exhausted in doing this project, many of the quality inspectors had fallen ill, at the end of January, beginning of February, **I reported this transverse cracks issue to the Welding Research Unit, I had also raised this issue many times during the daily Wind Farm Power Project meeting, did not get sufficient attention**, I had tried my best. I led Company 3's Wind Farm Power Project team(s), forget about reward money, just hope that will be separately treated, not to be punished and criticized."

(My emphasis)

320. This was clearly a plea for clemency (although I am not entirely clear why he thought he needed it) and, without wishing to cast any doubt on the integrity of the author, he would have had an understandable interest in making the point that he had raised these issues before but that no one had taken any notice. Fluor invites the court to draw the inference that not only did Mr Chu report the occurrence of cracking at the daily meetings, but also that he reported the fact that branch company 3 was finding those cracks by using D scans, not E scans. Ms Ma was asked about this e-mail and whether she remembered Mr Chu raising the issue of transverse cracks on many occasions at the meetings. She said that maybe he had raised it “*but I don’t think so many times*” (Day 14/11). She went on to say that she just had a vague memory of it which, seven years after the event, is hardly surprising.
321. Apart from Mr Chu’s reference to mentioning the issue of transverse cracking at daily meetings, there is no evidence at all from the documents disclosed by ZPMC that anyone within ZPMC outside branch company 3 was aware of the fact that D scans could detect transverse cracks that were not picked up by E scans. Fluor invites the court to infer from the various references to the discovery of transverse cracking from January 2009 onwards that this cracking must have been discovered by the use of D scans and that the management of ZPMC knew this. These two things are certainly possible, but in my judgment neither is an inference that the court can draw with any degree of confidence.
322. What I find telling is that, subject to one possible exception which I will address below²⁰, there is no evidence whatsoever that, until at least early April 2009, any of those who were engaged by Fluor to monitor the NDT carried out by ZPMC realised that branch company 3 was finding transverse cracks by using D scans in situations where the prescribed technique was an E scan. In his first witness statement Mr Estabrook said, at paragraph 40, that he was sure that ZPMC was only using E scans, at least after early December 2008; he said that he usually walked around the various welding shops “*more or less every day*” and would frequently see operators doing NDT, but that he now cannot remember what type of scanning they were doing. He said he would have seen if he had looked closely, but he was concentrating on whether they had the appropriate equipment and appeared to be using it in the right way.
323. In March 2009 a Mr Richard Edwards, of RWE, visited Changxing and produced a report dated 27 March 2009. On 6 April 2009 he sent an e-mail to Mr Estabrook and Mr Ayres by which he forwarded an e-mail that he had sent internally within RWE earlier that day. In the earlier e-mail he said this:

“Vince has asked me to forward to you both this e-mail that I sent to him on Thursday. Basically it summarises my enquiries with DNV since the issue of our report of 27th March, on NDT and acceptance standards. It concludes that; on what we have seen, we cannot have confidence in the current ultrasonic inspections performed by ZPMC and SGS. Therefore, without revised procedures and 100% re-inspection we should conclude that there are sub-surface flaws present in these components (monopiles and transition pieces) that do not comply with the standard.”

²⁰ The incident of 20 January 2009.

The other e-mail referred to in the passage quoted above was an internal e-mail sent by Mr Edwards to others within RWE on 2 April 2009 (“the Edwards e-mail”). In that e-mail he said this:

“The bottom line is that for all of: UT sensitivity (including corrections for transfer loss), defect evaluation and sizing, defect removal, scanning and detection for transverse flaws (chevron cracking, our interpretation of the DNV code and our expectations based on other EN and ISO inspection codes [are] required to be applied on this project. I can expand on the detail further if required, much of which is covered anyway by our last report but in a nutshell ZPMC and Fluor should be:

1. Testing with angle probes at DAC + 14 dB and evaluating anything that breaks the DAC line.
2. Measurements/corrections for transfer loss should be carried out and applied
3. sizing the length of defects should be done using the 6 dB technique, which means basically all of its length
3. when excavating flaws lack of fusion and slag defects must be completely removed even if the bits at the ends are very low amplitude. The only way to check this is to grind the surfaces of the excavation and carry out MPI.
4. **Transverse scans should be carried out from the weld cap provided the surface is smooth enough**, which it should be on normal submerged arc welds of this size and in the case of what we have seen at ZPMC after the welds have had a proper visual inspection and have been dressed or repaired so they conform. This is another practical reason for doing the MT prior to the UT.

(My emphasis)

My recommendations would be:

1. ...
2. Modify the ZPMC and SGS UT NDT procedures to reflect requirements above and retrain/instruct operatives as appropriate
- ...

Without the above I cannot see anyway that GGOWL will be able to have confidence that the butt welds on the MPs and TPs are free from sub-surface flaws.”

324. In his witness statement Mr Ayres said that, beyond recognising that Mr Edwards was criticising the way ZPMC was carrying out the NDT, he did not really understand this e-mail because it was too technical. He said that he left it to Mr Estabrook to investigate the issues that Mr Edwards had raised. However, since it quickly became clear that Mr Estabrook’s investigations were taking up a lot of his time, Mr Ayres then decided to ask Mr Dove to investigate the problem and sort it out.²¹ In his witness statement served in the GGOWL arbitration, Mr Ayres said that he was very surprised at the suggestion that the NDT procedures were inadequate.²²

325. In his witness statement Mr Estabrook said this, at paragraph 50:

“I took exception to his criticisms, and spent a lot of time in April and May 2009 refuting them. As well as setting out my own views in numbers of e-mails, I roped in support from outside experts including Ohlen from DNV, and American expert called Bill Blanshan, and later an English expert ASNT level III called Dr Ian

²¹ At paragraphs 4.2 and 4.3.

²² At paragraph 33.

Thomas. Eventually Dr Thomas produced a report on 6 May 2009 concluding that our procedures complied with DNV code.”

326. In evidence Mr Estabrook said that he rejected the criticisms made by Mr Edwards because he firmly believed that “*the procedure we had conformed to the requirements of DNV-OS-C401*” (Day 4/143). However, in his witness statement in the arbitration Mr Estabrook said that by early May 2009 he had instructed Fluor’s quality assurance inspectors to perform D scans on unground welds in Shipment 3; but he did not instruct ZPMC to change its procedure.²³
327. It is quite clear from this evidence that when it was first suggested that D scanning should be carried out on unground welds where it was possible to do so, this was strongly resisted by Mr Estabrook. I find that, until he received the Edwards e-mail on 6 April 2009, Mr Estabrook was unaware of the fact that D scans might detect the existence of transverse cracks that were not seen with an E scan. Whilst I find it understandable that a person in Mr Estabrook’s position may not have paid close attention to which scanning pattern was being used in branch company 3, and therefore remained unaware that they had started to use D scanning on the cap of the welds, it is less easy to understand how it was that seemingly none of the NDT inspectors engaged by Fluor noticed that some fabrication shops within ZPMC were using D scans in situations where the agreed procedures required the use of an E scan. The only possible explanations are either that D scans were not used very widely in branch company 3 or that the Fluor inspectors were not very thorough in checking what was going on or, possibly, a combination of both.
328. In their third witness statements, Mr Li and Ms Ma each said that they were unaware that branch company 3 had been carrying out D scans on repair welds from early 2009. The only evidence that begins to contradict this is the statement in the e-mail by Mr Chu (who was not called as a witness) that he mentioned the issue of transverse cracking at the daily meetings, but I have already dealt with this.
329. In relation to the first element, the burden of proof is on Fluor to establish that ZPMC’s management was aware of the fact that transverse cracks were being found by D scanning that were not being found by E scanning. On the basis of the evidence, it has not been shown that knowledge of this spread outside branch company 3 until early or mid May 2009, by which time it was known to Fluor also. In the context of this project, I do not consider that the knowledge of Mr Chu, the Production and QC Manager of branch company 3, can be regarded as the knowledge of ZPMC. In the organisation chart for the Wind Farm Project, which was attached to the witness statement of Ms Ma (attached as Appendix A), he appears at the lowest level of management - which was the production and QC management in each of the three branch companies. On the Quality Assurance side, there were three intermediate levels of the hierarchy above this and below the level of Vice President.
330. For these reasons I am not prepared to find that ZPMC as a company knew before May 2009 that many transverse defects in the circumferential welds could not be detected by E scanning - the agreed procedure - but only by “riding on the welds”, that is to say by using a D scan procedure on welds that had not been ground flat.

²³ At paragraphs 112-113.

Accordingly, ZPMC was not in breach of any contractual obligation to disclose those matters. Whilst it is possible that ZPMC's knowledge of this preceded that of Fluor (although I do not find this is a fact), any difference was probably measured in days and not weeks and would therefore not have been relevant as a matter of causation.

331. However, in relation to the second element of knowledge I reach a different conclusion. An obligation of good workmanship, or to ensure that the work will be carried out skilfully and carefully is not an obligation simply to take reasonable steps to ensure that such a standard of workmanship is achieved, but actually to achieve it. A breach of good workmanship which remains unrectified is a breach of contract irrespective of the level in the corporate hierarchy at which it occurs. Indeed, in a contract such as this one it is for the most part the fitters and welders who do the work contracted for, not the general managers and vice presidents.
332. I have already concluded that if ZPMC's shop managers became aware of the occurrence of cracking that was not always being detected by E scanning, but which could be detected by D scanning, they should have reported this up the line. In my view this would at least have required ZPMC to bring the matter to the attention of Fluor and, probably, to submit a proposal for the adoption of a different method of NDT or, alternatively, different UT procedures so as to identify the cracks. In this context I agree with Mr Li that if the production or QC management in branch company 3 knew that the NDT testing procedure that they were having to adopt in order to detect cracking was not in accordance with the agreed procedures, and if they knew that the other two branch companies were not using such scanning method, they should have raised the matter with their superior management. If that had happened, it would have been the duty of the superior management to raise the matter with Fluor and, as I have already found, to submit an appropriate proposal for the modification of either the procedures or the methods of NDT. I consider that a failure to do so would have been a breach of ZPMC's workmanship obligations under the PO.
333. In fact, in the light of the many reports and contemporaneous documents to which I have referred, I find that the production management in Branch Company 3 was aware from early 2009 that D scans on unground welds could detect transverse indications that were not picked up by E scans. Accordingly, it should have reported this to senior management within ZPMC and the failure to do so, or to do so in a manner that ensured that the point was understood, was a breach of ZPMC's workmanship obligations under the PO.

The incident of 20 January 2009

334. On 20 January 2009 Mr Yuan Zhiyong, who was the team leader of the NDT inspectors in branch company 3, sent the following e-mail to Mr Chu:

“Today, the total length of the weld seams for which the UT testing was performed is 43,748 mm and 3 areas, measuring 470 mm in total, need to be repaired. Supervising Engineer randomly inspected 12 repaired areas on M 48-12 - M 48-17-1 prepared by Zhu Chunjing team and transverse cracks were found thereon. Gouging was arranged and MT testing will be performed tomorrow. I really could not stop them doing the gouging. Zhu Youngjun and Fang Min wanted to do gouging and grinding themselves. In the end nothing could be done so Meng Guangdong and Li Yujun had to bring the gouging gun. After gouging, Fang Min

did the grinding by himself. I will pay more attention to this in the future. I heard that Big Changxing did not even allow supervising engineer to perform spot check. Please find the daily pass rate in the Daily UT tracking record for the UK Wind Farm Project.
...”

Unfortunately, this e-mail was not disclosed to Fluor until 18 December 2015.

335. The essential content of this version of events is challenged by Fluor. However, no material has been put before the court that suggests that Mr Yuan might have had any reason to be untruthful. However, I bear in mind that the language used by ZPMC employees in messages of this sort can sometimes be a little over dramatic. For example, whilst this e-mail might give the impression that Mr Fang might have done both the gouging and the grinding, I am quite satisfied that he did not do any gouging. Gouging needs special training, whereas grinding - using what in this country is called an angle grinder - is an operation that can be carried out by anyone with a sufficiently steady hand, particularly if the machine being used is relatively small, which was probably the case here given the nature of the operation. Mr Fang described the machine used by ZPMC as a “sand wheel machine” (Day 19/68). That sounds to me like an angle grinder.
336. In his witness statement, which was served at a very late stage in the proceedings, and well after the trial had started, Mr Yuan said that Mr Zhou and Mr Fang had identified potential transverse cracks “*by riding the probe over the weld seam on top of the repair weld*” (paragraph 17). Although this is possible, given that there is evidence that this was being done at the time in branch company 3, there is no mention of it in his e-mail.
337. Fluor says that neither Mr Zhou nor Mr Fang are named as inspectors in the Manufacturing Data Book for the relevant pile. In response to the witness statement served by Mr Yuan, Fluor held a telephone call with Mr Fang. A Mr Tom Smith, of Hogan Lovells, participated in the call with Mr Hans Ho, of Fluor, acting as an interpreter. The call took place on 3 March 2016. According to Mr Smith’s note of the call, the accuracy of which I have no reason to doubt, Mr Fang said that he had been a team leader of the night shift at Small Changxing from January 2009 to April 2009 (however, this was contradicted in evidence when he said that the nightshift did not have a separate team leader because it reported to the leader of the day shift: Day 19/43). His primary work in January 2009 was working on the transition pieces. His role was to oversee the visual inspection of the welding processes in order to ensure that ZPMC’s work followed the proper procedures. He said that he did not work alongside Mr Zhou, because he led the day shift. He said that he had no involvement with NDT inspection, although he was qualified in China to Level II. He said that although the name of Mr Yuan Zhiyong sounded familiar, he had no clear memory of him.
338. This last statement by Mr Fang proved to be palpably untrue. It was evident that he knew Mr Yuan quite well: on at least one occasion in 2015 they had had dinner together when they went out with some other colleagues. Indeed, it emerged that in fact Mr Fang had spoken to Mr Yuan on the morning before the telephone conversation with Hogan Lovells. In cross-examination he agreed that he had told Mr Yuan in a later conversation on 9 March 2016 that SGS were complaining that he, Mr

Fang, had not carried out his duties in accordance with the required procedure and that, as a result, he might have damaged the reputation of his employer, SGS.

339. It also emerged during the cross-examination of Mr Fang that he had previously worked for four years in a job that required him to perform a range of different kinds of NDT, including ultrasonic testing. He was well aware, for instance, of the difference between a longitudinal defect and a transverse defect.
340. In his witness statement Mr Fang said that he did not know that there were transverse cracks in the welding carried out by branch company 3 in early 2009, and that he did not carry his own NDT equipment because he did not carry out any NDT. He said that he would not have been able to identify a transverse crack by reference to the image on a UT monitor.
341. In his third witness statement, dated 7 March 2016, Mr Hans Ho exhibited the examination reports for the monopile MP 48, welds 12 and 17-1, which are those referred to in Mr Yuan's e-mail. These show that on 8 January 2009 weld 12 was inspected by ZPMC using what seems to have been E scanning (with beam angles of approximately 45°, 60° and 70°) and seven defects were found, all of which were described as slag defects. These were therefore rejected. On 20 January 2009 the same points along the weld were re-examined using the same method and were recorded as acceptable. The latter examination described the welds as being both FCAW and SAW, which appears to confirm that they were repairs. That report was countersigned two days later.
342. So far as weld 17-1 is concerned, the only examination report is dated 20 January 2009 in which no defects are reported and the weld was passed. The weld was described as SAW, suggesting that there had been no repairs.
343. The examination reports, therefore, do not provide any support for the existence of 12 repaired areas on these two welds. If the welds were re-inspected on 20 January 2009 following ZPMC's earlier inspection that day and cracks were then found, it becomes difficult to see how ZPMC could have signed off the report two days later as it appears to have done. The e-mail does not say that Mr Fang and Mr Zhou found the transverse cracks: rather, the fact that they were mentioned by name whereas the "Supervising Engineer" was referred to only by title, tends to suggest that they were not the same people.
344. I consider it unlikely that Mr Yuan would have made up the involvement of Mr Zhou and Mr Fang altogether, but it seems to me to be more consistent with the inherent probabilities of the situation that they were involved in the investigation of the defects, rather than in their discovery. Indeed, it was not put to Mr Fang that he discovered the defects himself by "riding on the weld" (although, in fairness to him, Mr O'Sullivan was by then cross-examining against the clock).
345. In fact, a document identified by ZPMC in its closing submissions (which I do not recall being referred to during the trial), which clearly referred to the same welds as Mr Yuan's e-mail of 20 January 2009, strongly suggests that it was ZPMC itself that discovered the cracking in the repair welds. In a short report dated 25 January 2009, an entity described as "Small CX Inspection Department" (although probably a draft prepared by Mr Yuan) said this:

“In respect of the small CX part of the wind farm project, during the UT inspection on the weld seams, transverse cracks are being found in the repair areas successively, see figure 1. The first time is that the supervisor detected defects in the length of 20 mm for repair on MO32-14 circle weld produced by Zhu Chunjing construction team on 12 Jan 2009 and during the UT (horizontal scanning) on the repair, transverse crack was found with the depth of 30 mm. Because of this, small CX strengthened preheat and post heat to eliminate transverse cracks (must use electric heating to preheat the weld to 110°C and welding shall be conducted after inspector has inspected and confirmed. The interpass temperatures shall be controlled above 230°C. Repaired surfaces should be ground smooth and transitioned smoothly into the adjacent base metal or weld. After welding, electric heating should be continued for 1 hour. After that, the welding area should be covered with chrome free mat for the welds to cool down slowly to the ambient temperature). Based on aforesaid, Zhu Chunjing construction team repaired 12 areas on MO48, and then found transverse cracks on all of these 12 repaired areas by UT.”

346. In another version of the same document, which was produced by Fluor, the first few lines appeared rather differently. They were as follows:

“For the Xiaochangxing branch of the Greater Gabbard Wind Farm Project, in the weld UT detection process, transverse cracks have been discovered at the repair points, as shown in Figure 1. The first time was on 12 January 2009, during the random inspection on the MP MO32-14 CW completed by Zhu Chunjing’s construction team, a length of 20 mm was repaired. After the repair, the UT inspection horizontal scan found a transverse crack with a depth of 30 mm.”

347. Unlike the former version there is no indication as to who performed the “horizontal scan”, which I take to be a reference to a D scan. Although ZPMC submits that the report shows that the UT was undertaken by SQS, and not by ZPMC, I am not persuaded that this conclusion can safely be drawn.
348. If some transverse cracks were found in the two welds, which on balance seems to me to be likely (because I can see no reason for Mr Yuan to invent it), then I can understand that Mr Fang and Mr Zhou - if this happened at the changeover of the shift - would have been keen to know whether the indications were in fact cracks. I do not find it unlikely that they would have put pressure on ZPMC to carry out the excavations of the welds straightaway, if necessary by threatening to do it themselves. Again, I see no reason why Mr Yuan should have made up the allegation that Mr Fang did the grinding if it was in fact untrue. For Mr Fang to do this might not have accorded with the procedures, but I find it hard to see how he could be criticised for his eagerness to discover the nature of the defects. It seems far more like an excess of zeal, rather than culpable wrongdoing.
349. In reaching these conclusions I take limited account of the evidence given by Mr Yuan. Like that of Mr Fang, it was very unsatisfactory in certain respects: in particular, his explanation of an incident which he described in an e-mail dated 31 January 2009, in which he said this:

“There is still a transverse crack in the repair area on T003-02 at Gaokua workshop. The construction team erased the mark and marked a false location, and after re-inspection tomorrow afternoon, the supervisor will be asked to confirm.”

350. When confronted with this Mr Yuan embarked on a detailed explanation (from memory) which I found neither convincing nor plausible. First, I consider it very unlikely that he could remember in such detail an incident that occurred more than seven years previously. Second, I found parts of his explanation to be implausible. For example, when asked what would have been re-inspected, he replied “*the repair spot*”. When it was then suggested to him that those carrying out the re-inspection would not have known where the real defect was - because it had been falsely marked - he said that the entire circumference was re-inspected and the true repair spot was then found (Day 14/121). But of course this would only have happened if the team carrying out the re-inspection had been told that the mark indicating the crack was in the wrong place, which would defeat the point of marking a false location in the first place.
351. ZPMC relied on Mr Yuan’s e-mail of 20 January 2009 in order to submit that Fluor, through its inspectors SGS, was aware of transverse cracking in the welds in early 2009 and of the fact that D scanning could detect such cracks in circumstances where E scanning could not. I reject both aspects of this submission. First, knowledge of some transverse cracks in two circumferential welds on one occasion would not, in my view, be expected to put an independent testing contractor on notice that there was a widespread problem with such cracking throughout the site. Second, for the reasons that I have now given the evidence does not establish clearly who in fact found the cracks, or by what means, although I consider that they were probably discovered by ZPMC using a D scan.
352. I have to say that the detailed argument that developed around the incident described in the e-mail of 20 January 2009 was in my view little more than a storm in a teacup. It is an unfortunate consequence of our adversarial system, with its focus on the trial, that minor issues such as this can be blown up out of all proportion to their relevance with the result that disproportionate resources are devoted to resolving them.

The allegation that ZPMC should have informed Fluor about the cracking

The provisions relied on by Fluor

353. I have already set out the paragraph in Section 8 of the Purchase Order upon which Fluor relies. This is a section which is concerned with shipment and delivery and which requires ZPMC to submit reports every two weeks until delivery which were to show, amongst other things, actual progress against planned progress dates and which were to “*detail specific or potential problems of which [Fluor] should be made aware*”. Reading this clause in its context makes it quite clear that it is concerned with problems relating to programme and delivery dates.
354. In my judgment it is only where there is an actual or potential problem in meeting a delivery date that the obligation to report under this section arises.
355. In his witness statement Mr Ayres said that from October 2008 he implemented weekly meetings so that ZPMC’s progress could be monitored closely and that problems could be dealt with as soon as they arose. He said that it was much more effective to meet with ZPMC face to face rather than to communicate by e-mail (paragraph 3.5).

356. At paragraph 3.24, Mr Ayres said this:

“ZPMC’s welding was not perfect and the welds did not look pretty, but I considered the issues to be snagging items and I had no idea that the welds contained cracks. If I had known this, I would have investigated them prior to the shipment departing (as we later did with Shipment 3), not least because they had all the necessary equipment and infrastructure in Shanghai and very little in Vlissingen.”

357. Clause 5.26.3 of AWS D1.1, on which Fluor also relies, provided that prior approval of the Engineer was to be obtained for “*repair of major or delayed cracks*”. Fluor contends that ZPMC was in breach of this clause. Fluor asserts that ZPMC’s decision “*to repair transverse cracks*” without informing Fluor and obtaining their prior approval was a breach of this clause (see paragraph 682 of Fluor’s closing submissions). I have heard no evidence as to what is meant by the expression “*major or delayed cracks*”: however, it seems to me that it refers either to individual cracks that are major or to cracking that is delayed. But this is not a case about major cracks, it is about a very large number of small cracks. It is also not a case about delayed cracks, which I take to mean cracks that would not be in existence at the time when NDT is carried out 48 hours after completion of the relevant welding. If cracks formed within 48 hours of welding, then in principle they should be detected by the contractual NDT procedures and so there would be no need for any specific provision in the code. In the absence of any evidence that clause 5.26.3 bears some different meaning, I consider that it does not apply to the facts of this case.
358. Clause 5.4 of the agreed Weld Repair Procedure, which formed part of the Quality Control Plan, provided that ZPMC was not to attempt to repair any longitudinal or transverse cracks until a thorough investigation had been conducted and approval to repair had been obtained from Fluor. This seems fairly unambiguous and, in particular, it is not limited to cracks of any particular magnitude.
359. ZPMC submits that this procedure was replaced by a Weld Repair Procedure that was issued by Fluor on 20 October 2008. Paragraph 8 of that procedure said that the WPS used for a weld repair needed to be qualified for both the position being welded and the joint consideration being repaired. However, I do not consider that this addresses the point raised by clause 5.4.
360. The answer seems to me to lie in the provisions of the Inspection and Test Plan - Structural, Revision 7, which was issued in December 2008. This provided that Fluor’s inspectors (SQS) were entitled to witness some types of operation and so ZPMC had to give them notice when that operation was to take place. If the SQS representative did not appear, then the operation could proceed. However, other types of operation were ones that were not only to be witnessed by Fluor’s SQS, who had to be given 1 days’ notice, but also could not go ahead without being witnessed. These were designated W/H (“witness hold”). Weld repairs other than to cracks were designated M, meaning that they had to be monitored, but crack repairs were designated W/H.
361. It seems to me that this procedure was intended to reflect the requirement of clause 5.4 because, since cracks could not be repaired without the repair being witnessed by a representative of Fluor, it meant in practice that the repair could not go ahead unless

Fluor's representative was prepared to approve the repair procedure. So it was not Fluor itself, but Fluor's representatives on the shop floor - in other words Fluor's SQS - who had to approve the weld procedure. When Mr Estabrook was asked about this procedure he said that it all depended on ZPMC giving the proper notification, which it did not always do. However, when this happened Fluor complained about it and, if the failure to notify involved a W/H operation, the result would be the issue of an NCR.

362. For these reasons, I consider that Fluor's reliance on clause 5.26.3 of AWS D1.1 and clause 5.4 of the Weld Repair Procedure is misconceived. So far as the alleged failure by ZPMC to notify Fluor under Section 8 of the Purchase Order is concerned, in my view the obligation to notify under that provision arises only if there is a problem that would imperil a forthcoming shipping date or some other critical project milestone. This would require knowledge by employees of ZPMC at a sufficiently senior level such that their knowledge could properly be imputed to ZPMC as a company.

Knowledge giving rise to an obligation under section 8 of the Purchase Order

363. I have already concluded that neither ZPMC, as a company, nor Fluor had any knowledge prior to early May 2009 of the possibility that cracks could be detected using D scans which were not identified by E scanning. The first indication - so far as Fluor was concerned - that this might be the case came with the e-mail from Mr Edwards on 6 April 2009. But, as I have already described, Mr Estabrook disputed the conclusions reached by Mr Edwards and was determined to refute them.
364. However, the prior question is: when did ZPMC, as a company, first become aware that it had a serious problem with transverse cracking in repair welds?
365. Relevant communications within ZPMC include the following:

- (1) An entry in the Li Ruixiang's notebook for 14 of January 2009 refers to: "*Groot lay on ship appeared [XX] cracked. Welding cracks problem, how to deal with it*". In evidence, Mr Li said that this referred to another project: he said that the vessel mentioned was a 4,400 ton pipe laying vessel (Day 14/44-45).
- (2) On 31 January 2009 Mr Chu sent an e-mail entitled "*Progress in Small CX*" to a large number of recipients in ZPMC, which included Mr Lu and Mr Liu Jianbo, the Changxing General Manager. Under the heading "Difficulties", this said:

"5. Performing UT for transverse cracking inside the repaired welds is a key factor that is constraining the progress. Contact Mr Gu Fuming today and ask for technical support."

Ms Ma said that she could not say whether or not she would have read this e-mail at the time, since it concerned branch company 3.

- (3) Mr Chu sent a further e-mail on 3 February 2009 that was addressed or copied to many of the same people, except Mr Liu Jianbo, in which he noted:

“Quality: Transverse cracks often appear on FCAW welds. Mr Shen, please go to Small CX to help find out the cause.”

- (4) Two days later Mr Chu sent another e-mail to a similar group, but this time including Mr Liu Jianbo, in which he said “*inside the repaired welds often exist transverse cracks, bothering progress*”.
- (5) At a Project Coordination Meeting held on 7 February 2009 it was recorded that:

“Due to the cold weather, cracking can easily occur on weld seams. Currently the pass rate for repair is low and the huge amount of repair is worrying. The quality of weld repair directly affects production progress. There are still over 50 m of weld seams that need to be repaired for Shipment 1 and we must hurry up in weld repair.”

It is not clear whether this is a reference to cold or hydrogen cracking, or is a reference to the type of cracking referred to the report cited at (11) below.

- (6) On 18 February 2009 the Test Centre circulated a notice containing dos and don'ts to prevent the “*formation of defects such as cracks*”. A copy was sent to both Mr Lu and Mr Li.
- (7) In February 2009 there were internal reports from Mr Yuan to Mr Chu of branch company 3 of cracking being found on a regular basis.
- (8) Between 17 and 19 March 2009 a number of e-mails were circulated within ZPMC with the title “*URGENT!/WELD DEFECTS NOT BEING REPAIRED FOR FIRST SHIPMENT*”, some of which were copied to Mr Hans Ho, Mr Ayres and Mr Estabrook. So at this point Fluor was being kept in the picture by ZPMC.
- (9) On 23 March 2009 there was an e-mail from Mr Li to, amongst others, Mr Huang, the Vice President, and Mr Lu. This was entitled “*The crack problem of the Greater Gabbard Project*” and said that monopiles were frequently subject to crack problems of circumferential welds. It said that SQS staff found a 15 m long surface crack on a circumferential weld.
- (10) On 25 March 2009 there was an e-mail from Mr Zhang Haisheng, the Production Manager, branch company 2, which was copied to both Ms Ma and Mr Lu and stated “*welding pass rate still biggest problem hindering increase in production of circumferential seam welds*”. The reply from Ms Ma on the following day referred to “*circumferential seam surface cracks*”. Ms Ma explained in evidence that her understanding at the time was that these surface cracks were not the same thing as transverse cracks (Day 13/114-116).
- (11) On the same day the Inspection and Welding Procedure Office produced a report entitled “*Report on Surface Cracks in Circle Seams for Wind Farm Project*”. The report makes it clear that the cracks in question were the product of cyclic loading (caused by temperature difference between day

and night) which produced unacceptable stress concentrated at a “gully” in the weld seam. It contains no reference to cold or hydrogen cracking.

(12) On 15 April 2009 Mr Hovermale sent an e-mail to Mr Dekker and Mr Fuller in which he said the “*transverse cracking of welds is new to us*”.

366. It is clear from the e-mails sent by Mr Chu in January and early February 2009 that it must have been known within ZPMC’s middle management that there was a problem with transverse cracking in circumferential welds within branch company 3.
367. But at a wider level, and as time went on, there is also no doubt that ZPMC was having a general problem with the frequency of weld repairs and their quality, and there is also no doubt that Fluor was made aware of this in the run up to the first shipment. However, in spite of the early references to transverse cracking in branch company 3, I do not consider that it is fair to conclude that in, say, March 2009 there was any general awareness within ZPMC that there was a significant problem with transverse cracking - as opposed to other types of crack or defect - that merited special attention in the context of delay to the forthcoming shipment.
368. Shipment No 1 left Shanghai on 4 April 2009 - two weeks later than the original shipment date. However, there is no documentary evidence of any complaint by Fluor that it was not being kept aware of this delay or the reasons for it. Indeed, an exchange of e-mails around 19 March 2009 between Fluor and ZPMC shows that the need to meet the shipping date (then 20 March 2009) was not to prevail over the need to achieve proper weld quality.
369. However, it was known from December 2008 that cracks had been found in the flange welds, but those welds were in very thick sections and the problem was not thought to be of general application (see the evidence of Ms Ma at Day 13/55-56).
370. There were some fairly widely circulated reports in March 2009 of surface cracking in circumferential welds, but I accept the evidence of Ms Ma that this was seen to be a different problem (Day 13/110-116).
371. On the material before the court I am not prepared to find that, prior to the anticipated shipment date of Shipment No 1, there was a clear understanding at middle to senior management level within ZPMC that there was a widespread problem with transverse cracking which was likely to cause delays to the schedule. By contrast, it is clear that there was widespread concern at the extent of weld repairs generally and the difficulty that ZPMC was having in producing acceptable repairs. In my view the court must be very astute not to attribute to people on the ground knowledge that is rather more easily identified with the benefit of hindsight. The edifice of knowledge that Fluor seeks to erect is in my view based on foundations that are too slender to support it.
372. Shipment No 2 left Shanghai on 6 May 2009. By this time Fluor had become aware of the Roberts report and the discovery of a hitherto undetected transverse cracks in a monopile that had been shipped in Shipment No 1. But, as I have already explained, the initial reaction within Fluor, led by Mr Estabrook, was to dispute the suggestion that this might be a serious problem. It was not until about a fortnight after Shipment No 2 had left Shanghai that the full extent of the problem began to be appreciated.

373. For all these reasons I consider that Fluor has not proved its case that ZPMC was in breach of any duty to notify Fluor of any problems under section 8 of the Purchase Order.

The issue of NCRs 006, 008 and 009

The events of April and May 2009

374. GGOWL's involvement with NDT at Changxing really began with the Edwards e-mail (of 2 April 2009 and to which I have already referred), in which, amongst other things, Mr Edwards said this:

“Transverse scans should be carried out from the weld cap provided the surface is smooth enough, which it should be on normal submerged arc welds of this size and in the case of what we have seen that ZPMC after the welds had a proper visual inspection and have been dressed or repaired so they conform. This is another practical reason for doing the MT prior to the UT.”

Mr Estabrook's response, typed into the e-mail, was as follows:

“Incorrect. There is absolutely no requirement whatsoever to scan the surface of the weld cap according to DNV OS C401. Scanning is performed to pick up all indication in all planes in the weld.”

375. Mr Estabrook, through his comments typed into the e-mail, disagreed strongly with any suggestion that the UT and NDT procedures being followed by ZPMC (and SGS) should be modified; on the contrary, he wrote: “*ZPMC has performed the UT in accordance with approved procedures and in accordance with DNV OS C401*”.
376. Very shortly after receipt of this e-mail Shipment No 1 left Shanghai.
377. On 15 April 2009 Fluor was sent a copy of a report by a Mr Roberts, of RWE, following inspections that he had carried out at Changxing between 18 and 24 March 2009²⁴. The report recorded that on the final day of the inspections transverse chevron cracking (in fact, in a subsequent telephone conversation between Mr Hovermale and Mr Reilly this description was changed to “transverse cracking”) was found in a weld on monopile IGI 04.
378. Mr Hovermale agreed in evidence that Fluor wanted to rebut the findings in this report so as to avoid any demand by GGOWL for further testing at Vlissingen (Day 6/120). To this end, Mr Fuller, Mr Ayres, Mr Ho and Mr Estabrook wrote a joint seven page memorandum dated 29 April 2009 addressed to Mr Dekker in order to clarify the quality requirements for the welding on the project and how those requirements were being implemented and monitored. It concluded as follows:

“Based on the above facts, it is our opinion that the weld quality inspection process on the project meets specifications, is healthy, and is providing the specified quality for the project.”

²⁴ No explanation has been provided as to why it was not until three weeks after the visit that this report was prepared and passed to Fluor and ZPMC.

379. Mr Hovermale, who was at the time the Project Director, agreed that the conclusion of this report reflected Fluor's view at the time (Day 6/121-122). In addition, he said (at Day 6/133) that he did not want anyone to know about the earlier change of standard from AWS to DNV in relation to NDT:

“because it might give them an excuse to NCR the shipment and that is going to cause me all sorts of problems in terms of the money and the schedule.”

380. Mr Estabrook's reaction to the Roberts report was to set about investigating whether Mr Roberts could be right. At paragraph 54 of his witness statement he set out various steps which Fluor took in the light of it. These included checking ZPMC's records of the monopile that Mr Roberts had examined; checking the results of a Time of Flight Diffraction analysis on the same monopile which had been carried out by a testing company called Sonovation; the preparation of an internal report dated 28 April 2009 and providing a report to GGOWL on 5 May 2009. In addition, Fluor arranged for Sonovation to go to Vlissingen when Shipment No 1 arrived to carry out further testing on the monopile in which Mr Roberts had found cracking. This followed a recommendation by Mr Dove that this should be done (in a draft report dated 29 April).

381. The short report that was sent to GGOWL on 5 May 2009 contained the following conclusions:

“RWE have not provided the exact location of their reported defects in the circ welds of MP 082, so it is impossible to determine if TOFD was applied to these same welds locations. As Fluor QA at ZPMC was not informed of these findings until RWE had left China, there was no opportunity to verify the exact nature of these indications. However, the testing performed by ZPMC, Sonovation and SGS does not indicate any transverse cracking.”

382. On 14 May 2009 Mr Dekker wrote to Mr Jim Smith, of GGOWL, enclosing the internal memo on weld quality dated 29 April that Fluor had prepared, saying “*I am confident this memo addresses your concerns about weld quality shipment no. 1.*”. Mr Hovermale agreed that at this stage Fluor was still “pushing back” against UT testing at Vlissingen (Day 6/135).

383. On the same day there was contract Progress Meeting Number 13 attended by representatives from GGOWL and Fluor. At item 12/4.2 the following was noted:

“• F have no proposal to do more NDT's (sic) but will check for underfill. G may request more NDT's. There is a concern over IGI 04

... .

• TP's - Coating checks, adhesion checks, visual inspections. 14/05/09: G reviewing whether more NDTs are necessary. G requested a drawing of the welding geometry but F maintain that there isn't one. G to revert with the testing requirements formally early next week.”

384. At that point, therefore, Fluor's stated position was clear (as was accepted by the evidence of Mr Hovermale): it was not proposing to carry out any further testing of the MPs and TPs at Vlissingen in general, although it was arranging for Sonovation to

carry out a further test at Vlissingen on the monopile in which Mr Roberts had found cracking.

385. Meanwhile, the reaction within ZPMC was rather less robust. In an e-mail dated 11 May 2009 to Mr Chen Bin and Mr Cao, Mr Yan Hua wrote this:

“There are some transverse cracks on the repaired MP welds, and of course they have already been repaired. Regarding the reason for multiple times of repair, the base considers that it is because the welding procedure is not strictly followed. However, after the site has strengthened control, the problem is still not completely resolved.

Fluor has not squarely brought up the issue; maybe it’s because Fluor was rather weak in its NDT check.

And yet this is a very serious issue. If Fluor finds further problems that we left out during the check at the client’s wharf, things will get out of hand. We have to request the base to find out the root cause of the problem and solve it from its root once and for all.”

386. Although Mr Estabrook had found no evidence that Mr Roberts was correct (because the monopile in question was still on its way to Vlissingen), by the middle of May 2009 he had discovered that performing a scan on the top of the weld cap was a better means of testing for transverse cracks (paragraph 57 of his first witness statement).

387. On 19 May 2009 GGOWL wrote to Mr Hovermale requiring facilities to carry out additional NDT of the monopiles in Vlissingen. It said this:

“Further to other communication and meetings about the works to be carried out in Vlissingen, please take this note as confirmation that GGOWL want to verify weld acceptance and quality by additional NDT.

The requirement is to inspect to

ZPMC procedure simply QC-DNV-UT-02, Revision 1 dated 17th February 2009 using scan D as defined in the procedure. GGOWL will arrange independent NDT operators to carry out the work, they will be available from 25th to 30th May.

The area of weld to be inspected is the internal ground welds in the location of the mud line being the highest stressed areas, three monopiles are to be inspected. In most cases this will mean the three circumferential ground welds internal to the monopiles. The intention is to carry out ultrasonic NDT of the most available length of weld without additional access facilities being provided by Fluor, this in terms of weld length is expected to be about 6 meters and with the three ground welds being inspected be the equivalent of one full circumferential weld per monopile.

The three monopiles to be inspected should be nominated by Fluor together with time periods for inspection so as not to cause any disruption to the planned works in Vlissingen.”

388. Coincidentally, on the very same day, 19 May 2009, Mr Fuller sent an e-mail to Mr Dekker asking whether Fluor had been “*able to avert re-testing of the welds for Shipment 1*”, which suggests that Fluor had no intention at that stage of carrying out such retesting of that shipment.

389. The following day, 20 May 2009, Shipment No 1 arrived at Vlissingen. By then Shipment No 2 was in transit, having left Shanghai on 6 May 2009.

390. Towards the end of May 2009 numerous problems had arisen at Vlissingen such that the site manager was becoming overwhelmed, and so on 27 May Mr Hovermale asked Mr Ayres to go to Vlissingen as a matter of urgency and take over. There is no suggestion in the documents that any of these problems concerned weld testing or weld cracking.
391. However, at Changxing testing that had been carried out on the instructions of Mr Estabrook which involved carrying out D scans on both ground and unground welds revealed six areas of serious transverse cracking on one monopile. This was reported to ZPMC by Mr Estabrook in an e-mail dated 21 May 2009. He described the results as striking and very worrying. However, the reaction from ZPMC was to say that SGS should not have been testing along the cap of unground welds (e-mail dated 22 May 2009).
392. On 26 May 2009 Mr Estabrook sent an e-mail to ZPMC to notify it that Fluor SQS would be performing

“an additional 20% NDT inspection on the third shipment mono piles circumferential seams . . . This increased testing is due to the fact that your NDT QC has missed an abnormal amount of defects through their NDT process. Testing will be strictly in accordance with ZPMC approved NDT procedures. We will begin these activities immediately . . .”

Mr Estabrook explained that by “*strictly in accordance with ZPMC approved NDT procedures*” he meant using D scans on ground welds and E scans on unground welds (paragraph 74 of his first witness statement). So although Mr Estabrook had become seriously troubled about the discovery of further cracking, there was no proposal for any general enhanced testing (ie. testing that went beyond the agreed procedures) of Shipment No 3 at Changxing or in respect of Shipment No 1 at Vlissingen. Nevertheless, ZPMC replied promptly in the letter of the same date asserting that this additional testing was “*out of the contract scope*”.

393. At this stage, therefore, Fluor had engaged Sonovation to carry out further tests at Vlissingen on the pile in which Mr Roberts had found cracks but, the beyond that, I find that it was still not proposing to carry out any widespread testing at Vlissingen.
394. On 28 May 2009, two relevant events occurred. First, Fluor decided to perform a 100% re-test of all circumferential welds in Shipment No 3. This followed further testing on Shipment No 3 during which Fluor found an increasing number of transverse cracks in welds that had passed the ZPMC QC process. Having increased its QA testing to 20%, Fluor found even more transverse cracks. Fluor then decided to increase this to 100%.
395. The second event was that RTD Applus, the independent testing company engaged by GGOWL following its letter of 19 May, noted planar transverse defects in monopile IGH 06 during the inspection at Vlissingen. Mr Hovermale said that this was testing that Fluor had tried very hard to avoid. However, when Mr Dekker asked Mr Hovermale whether they had found transverse cracking at Vlissingen, Mr Hovermale passed the enquiry on to Mr Hardie. Mr Hardie’s immediate reply was “*No we have not*” and, two days later, in an e-mail to Mr Hovermale of 31 May 2009, he said:

“UT was carried out on 3 piles on ground welds. Some indications were found, these are planar defects. And are not considered to be cracks.

We are excavating one of the indications to determine if the indications are detrimental and will continue to scan additional ground welds if these are found to be injurious to the structural integrity.”

396. On 3 June 2009 Mr Short, of Fluor, sent an e-mail to Mr Gao, of ZPMC, copied to Messrs Hovermale, Ho, Den Dekker and Ayres, in which he wrote:

“Fluor and GGOWL have been undertaking further NDT on the first shipment of Mono-Piles in Vlissingen and I am sorry to say that in one of the first Mono-Piles that was checked we found a crack in the steel measuring 40 mm x 25 mm. This is extremely serious and at the moment we do not know if this is an isolated incident or not. Either way it is not good news for the Project. We will know more by the end of the day as to the seriousness of the problem but meanwhile you need to consider planning to get your NDT expert over to Vlissingen for him to see the extent of the problem and validate our findings as this could result in an extensive back charge.

As soon as I get more information I will send it over to you.”

397. The same day, Mr Reilly, of Airtricity, on behalf of GGOWL, sent the following message to Mr Hovermale:²⁵

“Please find attached initial document re further NCR on Monopiles for discussion tomorrow morning 0830 hrs, an update of NCR log is attached for completeness, you should also note that the power transformer failure is included.”

The issue of NCR 006 on 3 June and the parties’ reaction to it

398. Non conformance report GGL-NCR-006 (“NCR 006”) was dated 3 June 2009, and followed the inspection at Vlissingen by representatives of GGOWL that week to which I have already referred. As I have mentioned, it appears that it was sent to Fluor the following day. It described the relevant materials as “1st Shipment Mono Piles (14 in total)”. The details of the non conformance were described as follows:

“Ultrasonic examination of the five fatigue ground wells in the mud-line on MP IGH-06 revealed that four out of the five welds contained recordable transverse indications varying in amplitude. The indications are recorded as typically planar defects that are outside the code acceptance criteria. Additional testing on MP IGI-04 is continuing but similar indications have been identified and examination of MP ICJ-03 is continuing.

Based on this sample, the validity of the ultrasonic examination executed by ZPMC on all mono piles within the 1st shipment is in question and the examination results have to be re-validated and appropriate weld repairs made to ensure that all welds meet code requirements.”

399. In his evidence, at Day 6/171-172, Mr Hovermale said this:

²⁵ There is some doubt as to the accuracy of the time and date of this e-mail, since the reference 0830 "tomorrow morning" is probably to 4 June 2009. The NCR was dated 3 June 2009, so it is most unlikely that "tomorrow morning" could have been the same day.

“We were already fixing the ones that we knew about. But we had to do more. The effect of the NCR was now we had to do the whole shipment.

Q. So you had to then do the whole shipment?

A. Yes.

Q. Yes. I think you agree with me that once you receive the NCR that getting it cleared was the driver for you?

A. Yes.

Q. And at the point at which the NCR had been issued, your evidence to the Tribunal was that you believed the welds to be sound. Do you stand by that bit of evidence?

A. I do.”

400. This evidence is entirely consistent with an e-mail that Mr Hovermale sent at the time, on 4 June 2009, following receipt of the NCR, to Messrs Ayres and Fuller, in which he said: “*We have to formally clear these before we can take them offshore*”.
401. Although Mr Hovermale was at pains to reconstruct the precise timing of the various e-mails with a view to showing that Fluor had already embarked on repairing the defects before the NCR was actually issued, the evidence that I have just set out and in the skilful cross examination that led up to it shows very clearly, in my judgment, that the issue of the NCR effectively put a stop to any plans for the imminent loading out of Shipment No 1 and imposed the testing and repair regime that I consider that Fluor would not otherwise have countenanced. This was an attempt to rewrite history that I did not find convincing.

The events leading up to the issue of NCR 008

402. On 11 June 2009 Fluor wrote to ZPMC instructing the following changes to the NDT procedure:

“• Scanning Pattern D shall be required for all repairs and whenever deemed possible to sufficiently couple the probe to the face of the weld to allow scanning.
• Scanning Pattern E shall be required for all welds regardless of whether or not the weld has been scanned using Pattern D.”

403. On 16 June 2009 ZPMC wrote to Fluor in the following terms:

“The first shipment of Mono Piles and Transition Pieces arrived in Vlissingen already and we understand from your email that Fluor had found some welding problems by undertaking NDT. Your email also suggested ZPMC staff shall be in Vlissingen to validate the findings which could result in extensive back charge. ZPMC offered our assistance within reach in Vlissingen. And ZPMC is of opinion that ZPMC has fully fulfilled the contractual obligation. The site work in Vlissingen is performed by Fluor voluntarily and it’s out of the contract scope. The reasons are as follows.

The NDT inspections carried out during fabrication by ZPMC are all strictly compliance with the NDT procedure approved by both parties. Following are some extract from its requirement:

...

In view of above, ZPMC considers that the NDT testing in Vlissingen beyond the agreed NDT procedure scope. Therefore, testing and repair work in Vlissingen are out of the contractual specification between ZPMC and Fluor, and back charge to

ZPMC is not appropriate. Quite a few weld defects discovered are within the scope of allowable and it will not impact the operation ZPMC will try our best to support Fluor.”

404. What this letter shows very clearly is that from the outset ZPMC was in no doubt about its contractual rights. It understood clearly that it was not required to carry out without payment any work that was outside the scope of its contractual obligations. For its part, Fluor was justifiably concerned that the instructions in its letter of 11 June 2009 could be used as the basis of a claim by ZPMC for additional work.
405. At some stage in June Mr Hardie had a conversation with a Mr Pashley, of GGOWL, to discuss what Fluor had to do in order to have the NCR released. Apart from providing the relevant paperwork in relation to the welds, Mr Pashley made it clear that Fluor would have to scan all the welds using D scanning. Mr Hardie said that it was not practicable to scan unground welds with the probe on the weld cap on account of the irregularity of the surface, but he was told that it could be done using copious amounts of couplant.
406. On 25 June 2009 Fluor wrote to ZPMC giving formal notification of the discovery of “*many instances of welding problems*” at Vlissingen that had required repair. After setting out certain provisions of the PO, the letter went on to explain that:
- “Based on the above two paragraphs, Fluor maintain that it is their right to backcharge ZPMC for the costs involved in additional inspection of the Mono-Piles at Vlissingen and furthermore to claim for the additional costs for all repair and rework and any other expenses incurred including stand-by costs payable to our installation contractor due to the lack of acceptable piles that can be installed. Furthermore we wish to advise our intention to claim for liquidated damages for delay due to the late arrival of the 1st shipment . . .
- We are in the process of working out the costs, some of which are ongoing and will not be finalised for some time. As soon as the full extent of these are known we will let you know the overall cost of this claim giving you a detailed breakdown of the costs involved.
- Please be advised that the contents of this letter only refers to the Mono-Piles from the 1st shipment and we reserve our right to submit further claims in the event of any additional inspection, rework and/or delays for any other items being supplied. We invite ZPMC to offer proposals as to how we can work together to mitigate the cost and schedule impact resulting from this problem.”
407. On the same day there was a meeting at fairly high level between representatives of Fluor and ZPMC, including Mr Fuller Mr Cao and Mr Huang. Mr Fuller told Mr Cao and Mr Huang that Fluor had suffered losses of around £40 million as a result of the welding defects in Shipment No 1, and that he was expecting that a similar number of defects would be found in Shipment No 2 when it arrived.
408. On 29 June 2009, the day on which Shipment No 2 arrived in Vlissingen, there was a further high level meeting in Shanghai at which Fluor told ZPMC that it was facing costs of about \$47 million as a result of the welding problems, of which about \$16.6 million was made up of standby costs of the vessels that had been chartered to carry out the installation. The meeting was constructive and cooperative and ZPMC indicated that it was prepared to provide support for the testing and repair operation in Vlissingen.

409. By early July 2009 Mr Fuller had prepared a draft of a “White Paper” in which he reached the conclusion that the agreed procedure for NDT in Changxing could not be expected to find all defects with the result that indications below a certain level would be regarded as acceptable, even though they might in fact reflect the existence of a crack. If the agreed procedure complied with the DNV code, as Mr Fuller concluded that it did, this was an acceptable state of affairs and one which could not give rise to legitimate complaint by GGOWL.
410. According to a note made by Mr Ayres, on about 9 July 2009 Fluor began testing Shipment No 2. At this stage no NCR had been issued in respect of Shipment No 2.
411. It seems that one dissenting voice within Fluor at that time was that of Ms Cathy Shargay, Fluor’s in house welding expert. In an e-mail dated 13 July 2009 to Mr Hans Dekker, who had become Fluor’s Project Director for the Greater Gabbard project on 1 July 2009 in place of Mr Hovermale, she said, in relation to the draft “White Paper”:
- “I disagree with the logic of the last few paragraphs starting at “After further consideration . . .” If we know we have welds made with a process susceptible to transverse hydrogen cracking that exceeds acceptance criterias (sic), we are obligated to use the best methods to detect it. This is per Code, as stated in Section 3, paragraphs 405 and 406:
- . . .
- Hence, we can use the difference in scanning patterns to explain why the cracks were missed in China, but not claim that we should not be doing the D-scans.”
412. However, initially at least, her view did not prevail because, on 16 July 2009 Mr Dekker instructed Mr Ayres that, in relation to the monopiles for Shipment No 1, the ZPMC NDT testing procedure was to be used from then on and, in relation to Shipment No 2, there was to be no (or no further) NDT testing unless otherwise advised and that these monopiles were to be prepared immediately for loading out. This, therefore, revoked the instruction given in the letter of 11 June 2009.
413. On the same day there was a meeting between Fluor and GGOWL in Camberley. Mr Dekker said that Fluor’s strategy for this meeting was to try and force GGOWL “*off the side lines*” and make it state its position in relation to Shipment No 2. At paragraph 6.33 of his first witness statement, Mr Dekker said:
- “Accordingly, the dilemma we faced was that if we really did change back to the previously approved NDT procedure, the likelihood was that we would catch only some but not all of the transverse cracks; and if that scanning was not done properly, we would miss even more. At that stage, we still did not have an ECA to tell us what, if any, defects would be left unrepaired and we did not have an independent expert view confirming Doug Fuller’s analysis of the code. Against that background, I knew that however GGOWL responded to our bluff, Fluor had no choice but to continue to find all the defects and repair them.”
414. Mr Dekker’s bluff was to tell GGOWL that, whilst Fluor would continue to repair defects that had been identified in the retesting of Shipment No 1, the monopiles from Shipment No 2 would not be tested and would be loaded out as they were. However,

GGOWL reacted strongly to this proposal. Its position was recorded in an e-mail that Mr Dekker sent to Mr Steve Dobbs on 17 July 2009, in which he said:

“The client’s project director John Hill called me late afternoon today. He asked me if I was serious in continuing executing the works in Vlissingen as I told them in my presentation Thursday morning in Camberley. I reconfirmed to him the direction I am taking. Hill states Fluor should adapt the testing methodology themselves to include pattern-d on non-grounded welds. This because scanning pattern-e is not picking up to transverse defects which maybe can only be allowed for certain cracks (sic) sizes as stated by TWI. He stated we are responsible for installing products with minimum design life 25 year and can not step back from this.

He also stated that he was going to slow us down and stop us by executing NDT testing in shipment 2 monopiles that we have prioritised for loadout on the barge: “once we find a defect, which we will by carefully searching, you have to repair it”.

It was to be expected the client would respond to our presentation of last Thursday. I am sure we will see this response also reflected in their activities on the project level in Vlissingen and Camberley next week. I think this creates the clarity we need and makes the client aware of the impact and consequences of any position he chooses to take. We might want to conclude it is appropriate timing to elevate the argument of testing to Pat and Jim Smith next week if the project develops in a manner as suggested by Hill.”

415. Later the same day, Mr Dobbs replied:

“Thanks. Agree. Let us make sure our designer and technical experts are in agreement that piles passing the code testing are 25 year piles. Then Pat should work with Jim to explain we have a code compliant product with a valid warranty and see if we can get on with it. I don’t like the attitude of (sic) expressed in the call and Jim should be made aware that the “test until we find something” threat will be a no win for all of us.”

416. This message was clearly suggesting that Fluor should do nothing about loading out Shipment No 2 until it had received reassurance from both the designer and its technical experts that the monopiles in their unrepaired condition would meet the 25 year design life. Indeed, after Mr Jim Smith, of GGOWL, had spoken to Mr Dekker’s superior, Mr Flaherty, Fluor thought better of any precipitate action and so it was decided that the proposal to load out the shipment would not be pursued.

417. Of course, it was still the case that by this time no NCR had been issued in relation to Shipment No 2. What I find was preventing Fluor from loading out the Shipment No 2 piles without further ado was its concern that, in their present condition, they may not be good for the 25 year design life. Whilst it was putting up an ostensibly confident front, Fluor had no reason to think that the condition of the monopiles in Shipment No 2 was likely to be materially better than those in Shipment No 1 and the likely presence of defects created a reasonable source of doubt.

418. In his evidence prepared for the arbitration Mr Dekker gave a very clear account of his state of mind in mid-July 2009. In his first witness statement in the arbitration (at paragraph 49) Mr Dekker said this:

“By mid-July, I began to realise, after several weeks of investigating the welding and NDT issues, that Fluor and ZPMC had not done anything wrong in Shanghai. Fluor/ZPMC had developed a code-compliant UT procedure, and by all accounts, both Fluor and ZPMC had complied with those procedures. The only reason GGOWL (and now Fluor) was obtaining different results in Vlissingen was that they had changed the procedure in a way that was more likely to discover and reject indications found in the welds. I began to feel quite strongly that Fluor was only required to do what the DNV Code required and not what GGOWL was demanding . . . Unfortunately, I was not successful in convincing GGOWL (Jim Smith) on these points.”

419. When Mr Dekker was asked in cross-examination whether or not that paragraph was true, he said this (at Day 7/31):

“I started to become convinced that the reason we started to find the cracks in Vlissingen was because of the fact that we did not apply to ZPMC testing code. So, at that point in time, I thought if the testing code - the ZPMC testing code - is correct and we find cracks in Vlissingen with a different testing code, we apply the D-scan on top of unground welds, then there might be an argument that ZPMC is correct. So that is what I - that is my recollection of that - of that time.”

420. I regard this as a rather reluctant admission that what Mr Dekker had said in paragraph 49 of his witness statement for the arbitration was correct. Apart from anything else, Mr Dekker’s recollection of what he felt at the time about such an important problem is not one that is peculiarly dependent on contemporaneous documents, so even if he had been provided by Fluor’s US lawyers with a carefully filleted selection of documents - as he implied in the course of his evidence - I would not expect that to affect his evidence on a point so fundamental as this.

421. However, in other places Mr Dekker gave evidence that was directly contrary to what he had said in his witness statement for the arbitration. Whereas, for example, at paragraph 73 of his witness statement in the arbitration he had said:

“By issuing that NCR²⁶ GGOWL was preventing us from proceeding with the loadout of shipment 2, which it had been threatening to do and which I was in favour of doing since 16 July”

when Mr Dekker was asked if that statement was correct he said that it was not and that what had prevented Fluor from loading out Shipment 2 were the cracks in the piles, a point that he made on several occasions see (Day 7/35, 37-38 and 39).

422. By contrast, at paragraph 25 of his witness statement in reply in the arbitration, Mr Dekker put his original position even more strongly when he said this:

“At paragraphs 9.4 and 9.8 of his Witness Statement, John Hill makes an effort to repeat GGOWL’s position that it never “directed” or “instructed” Fluor to perform the Employer Required NDT and Remediation. This is a theme that I have noticed in many of the GGOWL witness statements, but I lived through those events of the summer of 2009, and I know that GGOWL was forcing their view on us, while trying to avoid giving a direct written order.

²⁶ That was a reference to NCR 008, which was issued on 27 July 2009.

- 25.1 NCRs 006, 008 and 009 condemn all the TPs and all the MPs in Shipments 1, 2 and 3, which brought the construction phase of in (sic) project to a complete halt. As described above at paragraph 16, John Hill's 24 July 2009 letter . . . made clear what was required to remove those NCRs."

Again, this is an example of evidence that bears the ring of firm recollection, not of a reconstruction of events based on carefully selected documents prepared by others. I therefore conclude that what Mr Dekker said in his witness statements in the arbitration reflected Fluor's view of the position following the issue of the three NCRs. I do not accept the evidence to the contrary that Mr Dekker gave at the trial.

423. Whatever may have been Mr Dekker's level of confidence in the quality of the monopiles, it is clear that Fluor's senior management was not prepared to take the step of installing them without an assurance that the presence of the cracks would not be detrimental to their service life. Thus at this point the delay in installing the MPs of Shipment No 2 was in my judgment the result of doubts about their condition, not the result of anything done by GGOWL - although, of course, GGOWL had made it clear that they shared the same doubts.
424. But the situation changed because, during an inspection carried out on 23-24 July 2009, a number of recordable transverse indications were found on three monopiles in Shipment No 2 which were described as planar defects outside the acceptance criteria. As a result, on 27 July 2009 GGOWL issued but did not provide to Fluor NCR 008 in relation to Shipment No 2. This was received by Fluor on 29 July 2009. The materials were described as "2nd Shipment Mono Piles (14 in total)", and it was in the following terms:

"Root Cause Analysis report from Fluor (presentations of 25th June & 16th July) identified Hydrogen cracking arising from failure to adequately control consumables in the SA W process in ZPMC. Fluor indicated changes in the process had been implemented following the 3rd shipment. Following ultrasonic examination of a sample of ground welds in a selection of three mono piles a number of recordable transverse indications varying in amplitude were detected as follows:

...

The indications are recorded as typically planar defects that are outside the acceptance criteria defined in table B5 of the code. As all welds in this shipment of mono piles utilized the same welding procedure the integrity of all items is in question until the requirements of clause B405 and B406 of the code have been complied with."

425. It seems to me that once this NCR had been issued Fluor became bound to comply with its requirements before the MPs in Shipment No 2 could be loaded out. In these circumstances the only rational conclusion is that the issue of NCR 008 prevented the subsequent loading out and installation of the MPs of Shipment No 2, at least until such time as Fluor had satisfied itself that those piles were fit to be installed and would fulfil their 25 year design life (which Mr Dekker said was the end of September 2009: see Day 7/47).
426. Accordingly, in relation to Shipment No 2, I conclude that the position is as follows:

- (1) The reason why the MPs were not loaded out and installed during July 2009 following delivery to Vlissingen on 29 June 2009 was Fluor's doubts about their quality and, in particular, whether the likely presence of cracking would affect their ability to fulfil the 25 year life.
- (2) After the issue to Fluor of NCR 008 on 29 July 2009, the MPs in Shipment No 2 had to be re-tested and repaired where necessary in accordance with the NCR so that the costs incurred as a result were the result of the issue of the NCR.

The events leading up to the issue of NCR 009

427. Shipment No 3 arrived in Vlissingen on 1 August 2009. Unloading started the following Tuesday, 4 August, and GGOWL tested a sample of MPs almost immediately.
428. On 6 August 2009 Mr Ayres reported by e-mail that GGOWL had already found one defect in Shipment No 3 and would "*either NCR this shipment or ask Fluor what they intend to do*". But the following day, before Fluor had an opportunity to consider the options, GGOWL issued NCR 009. The materials were described as "3rd Shipment Mono Piles", and it was in the following terms:

"Root Cause Analysis report from Fluor identified hydrogen induced cracking in submerged arc welds arising from failure to adequately control consumables during the welding process in ZPMC. Ultrasonic examination of a sample of welds was undertaken to determine if hydrogen induced cracking was present. Examination was completed in accordance with ZPMC US procedure ZPQC-DNV-U2-02 Rev1 Feb 17th 2009 with cap scan (D) used on ground welds profiles and side scan (E) on un ground weld profiles. A sample of circumferential and longitudinal weld in three mono piles was selected and a number of recordable transverse indications varying in amplitude were detected as follows:

...

The indications are recorded as typically planar defects that are outside the acceptance criteria defined in table B5 of the code. As all welds in this shipment of mono piles utilized the same welding procedure the integrity of all items in the batch is in question until the requirements of clause B405 and B406 in section 3 of the code have been complied with."

429. By this stage part of Shipment No 3 was still to be unloaded. Fluor's first reaction, as recorded in an e-mail from Mr Fuller dated 10 August 2009, was to consider loading the piles back onto the vessel on which they had been shipped and return them to Shanghai for repair. In fact, this was not done and the piles remained at Vlissingen.
430. In view of these events, the same reasoning applies and I consider that the costs of any subsequent testing and repair of Shipment No 3 MPs were incurred as a result of the issue of NCR 009.

The meetings in the latter part of 2009

The meetings of 31 August and 1 September 2009

431. On 31 August 2009 there was a high level meeting between Fluor and ZPMC. Amongst those present were Mr Guan, for ZPMC, and Mr Dobbs and Mr Fuller, for Fluor. In an e-mail sent later the same day, Mr Dobbs said that it had not gone well. He summarised the position - no doubt as ZPMC saw it - very pithily in the following terms:

“Basically we did not just order piles from them - we told them how to build the mouse trap. They followed our instructions, we signed off on the product that was shipped, so how can they have any responsibility. We watched them do exactly what we said to do. Later, people we presented as experts gave them repair procedures. These people were not experts and these repairs caused more cracks. We started repairing things in Europe without ever telling them about it and ended up spending a lot of money and getting nothing for it.”

432. On 1 September 2009 there was a further meeting between Fluor and ZPMC. It was attended by the following:

For Fluor:	For ZPMC
Messrs Fuller Ho	Messrs Guan Cao Liu Huang Gao Feng

On ZPMC’s side the meeting was led by Mr Guan. He opened by pointing out the unfairness of the contract, which he said was very “biased”. According to an e-mail sent by Mr Ho the day after the meeting, Mr Guan said that ZPMC would accept “some responsibility” for weld defects and, in particular, would assume responsibility for repairing them. ZPMC’s notes of the meeting record ZPMC as saying that it would “*take the responsibility entirely*” for repairing defects in the welding. ZPMC stated expressly that it would not be liable for indirect or consequential damages, including the cost of engaging other contractors to carry out repairs. Mr Cao’s notes and recollection were largely in line with ZPMC’s minutes (he was not asked about the meeting in evidence).

433. There is no reference in any of the notes of the meeting to Mr Fuller giving any indication of the position that Fluor would take in relation to claims. Nothing was agreed at this meeting. The way in which Mr Fuller put it in evidence was: “*this was them venting; and we didn’t agree with it*” (Day 8/21).

The meetings of 30 September and 1-2 October 2009

434. The next meeting on which reliance is placed by ZPMC was the first of a series of meetings which took place over three days at the end of September. It was another high level meeting and it took place on Wednesday, 30 September 2009. The following were present:

For Fluor:

Messrs Dobbs
 Fuller
 Ho

For ZPMC

Messrs Guan
 Cao
 Huang
 Gao Feng

435. Mr Ho and Mr Cao both made notes of the meeting on 30 September. The relevant parts of those notes are set out below:

Mr Ho's note	Mr Cao's note
Fluor (Dobbs): "NDT deviate. Do again. Cracks - Some of the procedures. Acceptance Criteria not perfect. Client use this reason not to install, cost." "Alternate proposal Install the product as is 1 to 3 What is Fluor will provide SSE notification no cost from either side Roundness, Lounge, Paint"	Fluor's suggestion: "Some cracks were found by using the same method for weld metal defects. Fluor, ZPMC, and the customer all checked but did not find. Now we should share the loss incurred by these quality problems."

436. Mr Fuller said that his understanding of the purpose of the meeting was for Fluor to tell ZPMC that they were going to discontinue operations for the repair of the monopiles in Vlissingen and that accordingly ZPMC would need to start withdrawing their workforce (Day 8/44). He said that the meeting turned out to be longer and tougher than they expected but that he did not remember them talking about sharing the losses (Day 8/46). In relation to the reference to "*SSE*²⁷ *notification no cost from either side*" in Mr Ho's note, Mr Fuller said that he thought that this was a reference to the extra contractual testing that they had been doing (Day 8/47). He said that the meeting fell apart over the issue of the bond, although he accepted that there is no reference to this in either of the notes. It was because the meeting had not ended satisfactorily that Fluor decided, in Mr Fuller's words, "*to re-engage and to keep the dialogue going*" (Day 8/47).
437. Mr Ho gave evidence immediately after Mr Fuller and he said that he had some recollection of the meeting and, if he was pointed in the right direction, "*probably I can tread on my memory*". In relation to his note of "*No cost from either side*", he said that he did not really know what that cost was (Day 8/185-187). Mr Ho did not recollect any discussion about the 25 year warranty, but he thought that there would not have been a further discussion on the following day unless Mr Guan had been fairly receptive during the first meeting.

²⁷ Scottish and Southern Energy.

438. In his witness statement Mr Cao said (at paragraph 5.6) that both sides had concerns about the extent of the costs incurred by the other: Fluor would have been concerned that ZPMC might make a claim for the additional testing and repair work carried out by ZPMC in both Vlissingen and Shanghai, and ZPMC was concerned about the enormous size of Fluor's costs and that these costs have been incurred because of the weld cracks in the MP's and TPs in Shipment Nos 1-3. He said that Fluor had said at the meeting on 30 September that the parties should "*share the loss caused by the weld cracks issue*", and that he understood this to mean that Fluor and ZPMC would each bear its own costs and would not claim against the other.
439. Although there was clearly a discussion at this meeting about sharing the losses resulting from the welding defects, I find that there was no concluded agreement to this effect: at this stage the talks were only exploratory.
440. On the following day, 1 October 2009, Fluor wrote to GGOWL a long letter dealing with the NDT requirements that were being implemented at Vlissingen. The letter included the following passages:

“Non-Destructive Testing Requirements / Non-Conformance Reports

the purpose of this letter is to outline the factors that have prevented anticipated progress on offshore installation and to identify certain actions to mitigate those factors, with an aim towards successful completion of the project in accordance with the contractual requirements.

Reference is made to monopile (MP) non-conformance reports designated GGL-NCR-006, GGL-NCR-008, and GGL-NCR-009 (the “MP NCRs”) . . . Suffice it to say that the Employer's testing parameters, methodology and techniques, including the requirement for the use of ultrasonic testing (UT) with a scanning sensitivity of + 14 dB over reference level (DAC), instead of + 6 dB and the use of scanning pattern “D” on unground welds to identify indications, which, after evaluation, the Employer has deemed to be Defects, as that term is defined in the Contract, so as to require the removal, re-welding, and re-testing of that area using again the same improper testing procedures (the “Employer Required NDT and Remediation”) is in violation of the Contract and not required by the welding codes incorporated therein.

. . .

Of course, the Employer Required NDT and Remediation in Shanghai and Vlissingen has forced Fluor to incur substantial indirect costs also, including extended overhead due to the resulting delays; lost productivity and inefficiencies resulting from disruption, interference and work-performed out-of-sequence; and idle time costs - particularly relating to offshore construction and installation vessels, which, as was made known to you, had been reserved for the MP, TP, Inter Array Cable and Wind Turbine Generator (WTG) installation in accordance with the Construction Programme.

Although Fluor is still quantifying all those damages, current indications are that they total no less than £76 million to date, with a projection of no less than £390 million if this process were to continue unabated. Neither figure includes ZPMC's very substantial costs, which are still being quantified . . .

While Fluor has been expending its resources in prodigious amounts to comply with the Employer Required NDT and Remediation, it has simultaneously continued its investigation of that wrongly imposed regime by consulting with and seeking the advice of outside consultants and experts noted for their expertise in the area of steel welding standards and procedures in general and NDT and UT of welds in particular and, most importantly, their effect on the integrity of structures

like the MPs and TPs in question. Their advice has reinforced and supported Fluor's position on this issue, as originally stated to you; *i.e.* the Employer Required NDT and Remediation is not required by the applicable codes . . .
Accordingly, this is to provide you notice, as may be required by any applicable provision of the Contract, that Fluor deems the MP NCR's invalid and of no force and effect, because they are the product of an NDT procedure neither required nor permitted by the Contract. The Employer Required NDT and Remediation presently being conducted on MPs and TPs by Fluor and ZMPC (sic) at the Vlissingen Staging Port will, therefore, cease, and Fluor will proceed immediately to install the MPs presently available, likely beginning with those in Shipment 3 and will also proceed immediately with fit-out of the TPs to prepare them for the earliest possible installation. Moreover, Fluor will henceforth strictly enforce its contractual right to restrict the Employer's testing on welds in the MPs and TPs to the ZMPC (sic) facility in Shanghai, and no such testing will be permitted at the Vlissingen Staging Port. After very careful consideration, Fluor is confident that, by proceeding in this manner, it is not only satisfying all applicable code requirements and mitigating the damages and delays that are being incurred, but it is also fully and completely discharging its contractual duty to execute the work in the "manner specified in the Contract" and "in a proper workmanlike and careful manner, in accordance with Good and Prudent Practice.

Testing in Shanghai

Because Fluor and the Employer have agreed upon and are proceeding with a testing protocol for the MPs and TPs before loading and shipping from Shanghai, which is based on the Employer Required NDT and Remediation and which involves the participation of ZPMC, Fluor and the Employer, Fluor will continue that protocol for Shipments 4 through 8 inclusive. All those efforts, however, have been - and will continue to be - without prejudice to and with a complete reservation of Fluor's rights to recover all resulting direct and indirect costs, which rights Fluor intends to pursue.

..."

(My emphasis)

441. Accordingly, Fluor's stated position at the time of the meeting on 1 October 2009 was that whilst it had been "*expending its resources in prodigious amounts to comply with the Employer Required NDT and Remediation*", it had now concluded that this was unnecessary as well as being not in accordance with the contract.
442. Reverting to the meetings, Mr Fuller said in evidence that Fluor had decided that it might be more productive if the level of representation at the meeting the following day was, as Mr Fuller put it, "*taken down a notch*" (Day 8/51). As a result, the meeting on Thursday, 1 October 2009, was attended by Messrs Fuller and Ho only for Fluor, and Messrs Cao, Huang and Gao Feng for ZPMC.
443. The relevant parts of the contemporaneous notes of the meeting on 1 October are set out below:

Mr Fuller's speaking note	
"Make sure there are no issues between Fluor and ZPMC. ZPMC will not submit a request for payment for any additional work for this or for any other issues in the past or future. In turn, Fluor will not look to ZPMC for liquidated damages or any of the other costs we have incurred because of this issue."	
Mr Ho's note	Mr Cao's note (as translated by Pinsent Masons)

	for internal use)
<p>“Concepts</p> <p>A) Ship 1, 2 and 3 with issues GGOWL okay with 4, 5 therefore 6, 7, 8 will be the same as 4 & 5; same procedure testing weld defects → hydrogen cracking preheat consumables mgmt.</p> <p>B) VL work will stop ... C) Warranty for 25 years ... D) Payment will follow upon warranty 25 yrs E) Proceed per concepts</p> <ul style="list-style-type: none"> • No issues between Fluor and ZPMC • No claims from Fluor } past + future • No claims from ZPMC } past + future <p>→ 4 main points Repair cost Standby cost Re-mobilised cost LD for damages power on</p> <p>F) Support Fluor with GGOWL. G) ... H) GGA - unknown</p> <ul style="list-style-type: none"> • File for injunction → repairs defects by ZPMC • Terminate the contract ZPMC - will support W/Manpower VISA 	<p>“I. the pile roundness issue</p> <p>(1) lengthening stiffener ring. ZPMC’s on-site team can carry out part of the repair work of stiffener ring. Today we only discuss the principles and specific instructions shall be issued by the operation department. [In another translation of the note, by Merrill Brink, this sentence reads:</p> <p>“What is talked about today is only an outline and the details will be given by the legal department.”]</p> <p>1. There is a dispute on shipment 3. Shipments 4 and 5 are satisfactory. Hope this inspection method will continue to be applied to shipments 6, 7 and 8. ✓</p> <p>1.2 The cracks are caused by the storage, use and preheating of welding materials. Hope it will be improved. If there is any more crack and the User knows, we will be in trouble. ✓</p> <p>2. People in Netherlands can be sent back -- repair work. The remaining work at the site {painting could include {stiffener ring {flange etc Make a decision of the on-site work after completion of inspection.²⁸</p> <p>3. ZPMC shall warrant the unrepaired piles in the first, second, and third shipments for 25 years --- *</p> <p>4. ZPMC does not accept any LDs for delay/delay penalties. Fluor will pay all of the contract price to ZPMC on the condition that it gets the [25 year] warranty [in the form of a bank guarantee] and will not claim its costs [against ZPMC]. [<i>This point raised by Mr Cao</i>]</p> <p>5. Fluor and ZPMC shall be respectively responsible for their own costs. ✓ [The Merrill Brink translation reads: "Both parties bear their own expenses, respectively."]</p> <p>6. Hope ZPMC will support Fluor when Fluor makes claims against the User. ✓</p>

444. Mr Fuller explained in cross-examination that what he meant by “*any of the other costs we have incurred because of this issue*” in his speaking note were the costs of

²⁸ In the note there is a double ended arrow linking this sentence with "flange etc" in the line above.

the extra contractual testing, by which he meant the testing and repair programme that was going on in Vlissingen and, Mr Fuller thought, in Shanghai also (Day 8/54). The account of this meeting in Mr Cao's witness statement appears to be based on the Pinsent Masons translation rather than the Merrill Brink translation. He explained that he placed a tick at the end of points 1, 1.2, 2, 5 and 6, because these were points to which ZPMC had indicated at the meeting it would agree. He said that the tick against point 1.2 indicated that ZPMC had agreed to improve the storage, use and preheating of weld materials.

445. In cross-examination, Mr Ho was asked to tell the court what he remembered of the context of the discussion which took place on the following day, 2 October 2009. At Day 9/8, he said this:

“So on the first day, which is the 1 October, we discussed the concept. At the end of the meeting ZPMC walk away, did not really provide too much comment, and I assumed they actually updated or provided a status update on our meeting to Mr Guan. And subsequently they came back the following day and they were basically giving us their response to the eight points that we have.”

That answer was not challenged. Indeed, Mr White acknowledged it by saying “Yes”. That answer may explain why Mr Cao was not asked any questions about the meetings of 1 and 2 October 2009.

446. Mr Fuller described the approach to the meeting of 1 October 2009 in the following terms, at Day 8/56:

“No, what I remember is going through and laying out the eight points. And I think I actually started with nine and said: listen, before we get started, we are going to talk about a lot of things. Let's make sure that whatever we agree here, it's going to be in writing, it's going to be signed by both sides because we are going to be talking about a lot of stuff. So I remember kicking off the meeting that way. I remember laying out the points.”

This chimes quite closely with the wording in the Merrill Brink translation of Mr Cao's notes of the meeting (“*What is talked about today is only an outline and the details will be given by the legal department*”). I find as a fact that Mr Fuller did say something to the effect that any agreement reached at the meeting would have to be put into writing and signed by both parties. I find also that at this meeting Fluor was setting out the framework of a possible settlement.

447. However, there was a conceptual difficulty with the proposal recorded by Mr Ho, in so far as it concerned “*no claims . . . past + future*”. If Fluor was really saying that it would make no claim against ZPMC for any welding defects that might become apparent in the future, that would empty the warranty of most of its content: since welding defects would be one of the most likely causes of any pile failure within 25 years, Fluor could well be prevented from making a claim under the warranty if future claims in respect of welding defects had been waived in their entirety.
448. So if the parties had paused to think about it, it should have been clear to them that the statement “*no claims . . . past + future*” would need some qualification. For that reason, it seems to me that Mr Fuller's explanation of what he meant by “*this issue*”

makes sense. I find also that this fits with the reference in the Merrill Brink translation to “*both parties bear their own expenses, respectively*”, in the sense that the expenses being referred to were those caused by the “extra contractual testing”.

449. The final meeting, on the following day, Friday, 2 October 2009, was again attended by Messrs Fuller and Ho for Fluor, but this time by Messrs Huang and Gao Feng only for ZPMC.
450. The relevant parts of the contemporaneous notes are set out below:

Extracts from Mr Fuller’s notes of the meeting	
<p>“1. Testing - will continue testing same as [same] on Shipment 4 & 5. Will focus on preheat and handling of flux.</p> <p>2. . . .</p> <p>3. Warranty</p> <ul style="list-style-type: none"> • 25 years no problem • ZPMC wants to provide letter guarantee • Explained need bond and not flexible <p>4. . . .</p> <p>5. ZPMC will not ask for extras / Fluor will not hold ZPMC responsible for LDs / standby / extra because this issue.”</p>	
Mr Ho’s note	
<p>“A) Agreed with same testing for ship 6, 7, 8 similar to 4 & 5</p> <ul style="list-style-type: none"> • Preheat } agreed with and by • Consumable management } ZPMC production <p>B) VL works will stop</p> <ul style="list-style-type: none"> • Stiffener - ZPMC supply manpower, equipment Fluor will provide material and jacking frame. Canopy? • Flange – roundness Work with Fluor and ZPMC It is their problems. • Painting - Touch up but not major - ZPMC disagree it is their responsibility <p>C) Warranty</p> <ul style="list-style-type: none"> • Bond issue ? amount/Parent CCCC • 25 yrs - ? <p>X Probably 3rd parties bond & guarantee</p> <p>D) Payment okay for 100%</p> <p>E) Waive future claims from both parties</p> <p>F) ZPMC will support Fluor</p> <p>G) . . .</p>	

H) Remob ZPMC workers & equipment to VL”	
Telephone call at later that evening: Mr Guan says that “ZPMC will not provide a bond to Fluor.”	

451. Mr Fuller agreed that there was agreement in principle between Fluor and ZPMC on the items discussed, but he said that it was fully accepted that they “*would have to be more fully embellished than what we were talking about*” (Day 8/64). By this I understood Mr Fuller to mean that the terms of the agreement would have to be set out in writing before they could be finally agreed.

452. In relation to this meeting, Mr Fuller’s cross examination concluded as follows:

“Q. . . . You didn’t want ZPMC to get the impression that Fluor had agreed to waive its claims against ZPMC
A. I don’t think that we did, impression or otherwise.
Q. You did what?
A. Waive our claims against ZPMC.
Q. That’s what you had said at the meeting, didn’t you, no claims?
A. For extra contractual testing.
Q. What does that mean?
A. It was the extra contractual testing.
Q. What does that mean?
A. It means what it says in that letter.
Q. No, but what do you mean by that? Because you’ve used that term I think on five occasions today. When you say there will be no claims against ZPMC for extra contractual testing, what’s that?
A. That was testing - D scan on top of the unground welds at a higher sensitivity and everything else that was associated with that.
Q. But you would only have ever had a claim against ZPMC for that testing if they were in breach of contract; correct?
A. I’m not sure about that. We expected ZPMC to go through there and provide us a welded product that didn’t have defects in it, regardless of how it was tested.
Q. Yes. And your concern was that defects were being found in the welds; correct?
A. Say that again.
Q. Your concern was that defects were being found in the welds?
A. Of course.
Q. And that was causing you to incur massive delay and additional cost?
A. Yes. There were a lot of costs associated with the fact that there were defects in those welds, yes. And we had told ZPMC on several occasions that: we would not be here trying to mitigate this problem if there were no cracks in those welds.”

453. In my view the discussions between the parties at this point were focused principally on the very substantial costs that each of them had incurred as a result of the NDT regime imposed by GGOWL and GGOWL’s insistence that all cracks found on examination were repaired. However, both Fluor and ZPMC must have had cause to consider why the cracks were there in the first place and whether or not their existence was the result of a breach of contract by ZPMC (and, in consequence, a breach by Fluor of its contract with GGOWL). The fact that in earlier discussions

ZPMC had indicated its willingness to take some responsibility for the situation suggests that it was concerned that its workmanship, particularly in relation to Shipment Nos 1 to 3, might not have been up to standard. The early reference in Mr Fuller's note to focusing on "*preheat and handling of flux*" is, I find, a recognition of the fact that there were still concerns about the quality of the workmanship in Changxing. As Mr Fuller pointed out, the problem had only arisen because there were cracks in the welds in the first place.

454. If an officious bystander had intervened at this point and asked each party whether it thought that Fluor was agreeing to waive a claim for any costs attributable to welding defects that had been incurred prior to the imposition of the extra contractual testing insisted upon by GGOWL (by NCR 006), I do not consider that he or she would have received a ready answer. I consider that the parties were concerned to reach agreement in principle, and that the finer points - such as the precise extent of any waiver - were to be left to the drafting. However, on any view it appears to have been the common intention that Fluor would not seek to hold ZPMC responsible for the costs occasioned by the "*extra contractual testing*" imposed by GGOWL, but would instead join forces with ZPMC in order to recover those costs from GGOWL.
455. By way of example, Fluor's letter of 16 November 2009, the relevant parts of which are set out in full below, specifically referred to "*deficiencies that were discovered in ZPMC's welding procedures*" and mentioned the requirement for ZPMC to follow acceptable and appropriate welding procedures regardless of what requirements might be imposed by GGOWL. Fluor was not alone in this view, in an internal ZPMC document prepared on 7 December 2009, which appears to have been a draft of a report on "*Onsite Rework in the Netherlands*" prepared for Mr Chen, the author referred to the fact that many welders with insufficient skills were hastily brought into the project with a consequent high ratio of rework "*putting a lot of risk in the future*".
456. So far as the position in relation to the warranty was concerned, the note of the telephone call conveying Mr Guan's decision not to provide a bond makes it clear that the question of the warranty remained open. At this stage, therefore, there was no concluded agreement, albeit that many of the ingredients of a potential agreement were largely in place.

Events from early October 2009

457. On 14 October 2009, Mr Dobbs sent an e-mail to Mr Fuller in which he told him to be careful not to be manoeuvred into "*re-engaging*" with the discussions that were abandoned after 1 October. By this time there had been no change of position by ZPMC in relation to the provision of a bond. The e-mail went on to say this:

"The message that you should send back to Guan indirectly is that I was disappointed in not being able to settle the issues on GG after making the effort to travel all the way to China and meet with him face to face.

We continue to appreciate all of the support they are providing and appreciated Shipment 5 arriving on the agreed date. However, ZPMC must understand that since we did not settle the issues between us during my last visit, all of the issues remain to be settled. At some point, we will need to meet again to settle those issues and this will need to be done before we do any more work together . . .

The key point I need them to understand is that at this point, we have not agreed on anything. You do not need to be blunt or direct, but specifically we have not agreed to waive claims against each other.”

458. On 24 October 2009, Mr Fuller replied to Mr Dobbs in the following terms, having attended a meeting with ZPMC on 22 October 2009:

“Steve:

I arrived over the weekend and kept a low profile for the week. On Wednesday I received a request to meet with Mr Cao in Pudong on Thursday.

Mr Cao, Gao Feng (Ryan), and Fred (VP of Quality Assurance) represented ZPMC at the meeting. They had 4 items on their agenda:

1) They would like a formal letter from us confirming the direction to demobilise their workforce from performing weld repairs in Vlissingen.

...

With regard to item 1, I told them that we would discuss this request internally and respond before the end of next week. I cautioned that the letter would likely reflect the fact that we have not reached agreement and that all items we had discussed, including the agreement not to pursue claims against each other were still on the table and needed to be resolved at the next time Mr Dobbs was in Shanghai or Mr Guan was in the US. (I asked Hans Ho to make sure this statement was clearly recorded in the Meeting Minutes when they are produced.)

...

In all, the meeting was constructive and Mr Cao clearly wants to continue their assistance in Vlissingen and Shanghai. He confirmed they were in agreement with the items we discussed in the meetings in late September with the exception of the form of guarantee and that issue was with Mr Guan.”

459. Mr Ho complied with this request in an e-mail to Mr Gao Feng dated 28 October 2009 in which he said:

“Ryan,

Please incorporate the following comments to your meeting minutes that was discussed on that day.

“The lack of agreement on the items (8 concept points) from our October 1 meeting including agreement not to claim against each other and the need to come to closure on these items the next time Mr Dobbs is in Shanghai or Mr Guan is in the US. Therefore all items remains (sic) open as there are integral part of the entire agreements.”

Please call me if you have any questions.”

Mr Gao Feng sent an e-mail to Mr Cao the following day saying that Fluor had asked for the text set out above to be added to the meeting minutes and sought his agreement for this to be done.

460. Later that day, 29 October 2009, Mr Cao replied as follows, with a copy to Mr Huang (Fred):

“gaofeng,

Personally I think it is all right to add this issue (because it is the only issue which has not been agreed at the time). But you should send the finalised meeting minutes to Mr Guan for his information and thus he knows that Fluor would talk

about this issue again with him in the future. There will be a big trouble if we agree that Mr Guan has not been notified. Please consider.”

461. In my view, it is quite clear from this exchange that ZPMC also understood that no agreement had been reached on the matters that had been discussed at the September/October meetings. However, neither side had given the other any indication that it would not be prepared to renew the discussions from the position where they had left off. It must have been clear to ZPMC that no agreement was possible that did not include some form of long term warranty about the suitability of the piles.
462. In the meantime, Fluor was putting together a case against GGOWL which would attribute all the costs of the repairs and delay to the issue of the NCRs. On 16 November 2009 Fluor wrote to Mr Gao Feng in the following terms:

“Dear Ryan,

Subject: NDT and Repair of Mono-Pile and Transition Piece Welds

This letter is in response to your letters dated . . . concerning the above referenced subject.

Because we have had ongoing discussions with ZPMC regarding the issues raised in those letters, we do not think it would be productive to rebut each point with additional correspondence. Suffice it to say that Fluor continues to disagree with some of the statements made in those letters regarding the MP and TP welding and sets forth below a statement of the path forward that ZPMC should be following in the circumstances that have defined that course of action.

As a result of the Non Conforming Reports (“NCRs”) issued by the Greater Gabbard Offshore Winds Ltd (“GGOWL” or the “Employer”) with respect to certain welds in the mono piles on Shipment Nos. 1, 2, and 3, there has been much confusion regarding the appropriate Non-Destructive Testing (“NDT”) and the subsequent repair of any defects found in the welds, and, unfortunately, that has in turn caused much disruption and delay to this Project. This letter is an attempt to address that issue so that you will have a better appreciation of Fluor’s actions in this regard and to finally put to rest questions concerning this problem.

As you know, any deficiencies that were discovered in ZPMC’s welding procedures with respect to the MPs and TPs have been and continue to be addressed by your QC personnel and our QA staff. We have always expected ZPMC to follow acceptable and appropriate welding procedures regardless of what requirements GGOWL imposes or attempts to impose on the welding process, and that expectation remains in full force and effect.

The NCR with respect to Shipment No. 1 was not issued by GGOWL until that shipment reached Vlissingen and was inspected and tested by GGOWL there, even though GGOWL had done NDT on the MP welds while they were still at ZPMC’s facility in Shanghai. In an attempt to satisfy the Employer’s demands, Fluor agreed, under protest and with a complete reservation of its rights, to adopt an NDT procedure being required by the Employer, even though that procedure required ultrasound testing with a different scan pattern and at a higher sensitivity than that required by Fluor’s Contract with the Employer, the applicable welding codes incorporated therein, and Fluor’s Inspection and Test Plan (“IT&P”). That Employer Required NDT and Remediation required an extraordinary undertaking at the Vlissingen Staging Port, including the establishment and maintenance of a vast infrastructure to support the testing and repair work, as well as, of course, the transfer of some one hundred fifty ZPMC tradesmen to the Vlissingen Staging Port to perform that work.

...
Fluor has continued to meet with the Employer in an attempt to: (a) better understand the Employer's justification for issuing the NCRs and subsequently imposing the Employer Required NDT and Remediation; and (b) share with the Employer the investigation and analysis that Fluor and its consultants have done with respect to that issue, so as to give it the assurances that the structural integrity of the MPs and TPs and the twenty-five year design life and not in any way or to any extent been diminished. We know you share our conclusions in this regard and look forward to having your assistance in that effort with the Employer. I believe that, going forward, the best approach is for ZPMC and Fluor to work together in an effort to ensure that all the welding of the MPs and TPs, which remains to be completed, is performed in the appropriate standards of quality so as to eliminate any issue in that regard. We look forward to having your cooperation."

463. It is to be noted that in this letter Fluor appears to be saying two things. First, that "deficiencies" had been discovered in ZPMC's welding procedures and that these continued to be addressed by ZPMC's QC staff and Fluor's QA staff. Second, that it was the NCRs issued by GGOWL that had caused much "*delay and disruption*" to the project and the NDT procedure required by GGOWL that was responsible for the "*extraordinary undertaking at Vlissingen*"; it was not an independent need to repair cracks in the welds. Mr Dekker agreed in evidence that the position set out in the third paragraph of this letter was contrary to Fluor's present case in this litigation (Day 7/91).

A meeting in Shanghai in November or December 2009

464. It is ZPMC's case that in late November or early December 2009 there was a meeting between Mr Guan and Mr Dobbs in Shanghai, but there is no record of it. The only evidence that it took place comes from Mr Liu, who said that he was present. He said in his witness statement that it took place on a cold winter morning at the hotel where Mr Dobbs was staying in Puxi, Shanghai. He was there to translate. In evidence, he said that he thought the meeting was arranged at very short notice at a time when Mr Dobbs was passing through Shanghai.
465. In his witness statement he said that Mr Dobbs made it clear to Mr Guan at the meeting that for there to be no issues and claims between the parties the issue of the 25 year warranty would have to be resolved. Whilst Mr Guan was quite prepared to give a 25 year warranty for both the MPs and the TPs, he could not agree to Mr Dobbs's demand that it should be supported by a bank guarantee. Mr Liu said that Mr Dobbs made it plain that if ZPMC were to provide a 25 year warranty supported by a bank guarantee, there would no longer be any issues and claims between them and ZPMC would help Fluor in preparing information and documents to support the claim against GGOWL. He thought that Mr Dobbs was genuinely keen to reach a settlement with Mr Guan in order to avoid a dispute between Fluor and ZPMC - not only because he clearly valued the business relationship between the two companies, but also because of his personal relationship with Mr Guan.
466. He said that the meeting ended with Mr Dobbs saying that he would ask Fluor's lawyers to write up an agreement for the settlement of the issues regarding the weld

cracks problem between Fluor and ZPMC. The meeting took place very shortly before Mr Guan retired.

467. Fluor does not accept that this meeting took place, but it did not call Mr Dobbs as a witness in order to refute Mr Liu's account.
468. Since there was no contrary evidence from Mr Dobbs, I see no reason not to accept Mr Liu's account of the meeting, at least in general terms. However, in the absence of any contemporaneous note I am somewhat sceptical about the reliability of Mr Liu's recollection of precisely what was said by either Mr Dobbs or Mr Guan. I think that it is more likely that, having read what had been said at the earlier meetings, he is remembering that which he would have expected to have been said, rather than what was actually said: however, his account of what happened is plausible and is entirely consistent with what had been said at previous meetings. To the extent that his recollection is reliable, I regard it as important that Mr Liu remembers Mr Dobbs as having said that the proposed terms would have to be reduced to writing. By that he must have meant that this would have to be done before any agreement could be finalised. That is, of course, what happened.
469. If one pauses at this point, it is abundantly clear that no agreement was reached at this meeting. Whilst ZPMC had indicated that it was willing to give a 25 year warranty, Fluor was still demanding that it be supported by a bank guarantee - something that Mr Guan was not prepared to offer - and no agreement had been reached as to any alternative form of security for it. According to Mr Liu's account Mr Guan said that he would see whether ZPMC's parent company would provide a guarantee in lieu of a bank guarantee. From the account in Mr Liu's witness statement, there is no suggestion that Mr Dobbs had indicated that a parent company guarantee, if available, would satisfy Fluor: on the contrary what Mr Dobbs was seeking was a bank guarantee.
470. There was then an important event. On 7 December 2009, and with little advance warning, Mr Guan retired as the president of ZPMC. He was replaced by Mr Kang Xuezheng. Appreciating the importance of the relationship between ZPMC and Fluor, Mr Kang took the opportunity to visit Mr Dobbs at Fluor's headquarters in Dallas the following month. This visit took place on 20 January 2010. At this time, the other major project that ZPMC shared with Fluor was the steelwork for the San Francisco Oakland Bay Bridge ("SFOBB"). In his witness statement Mr Kang said that the discussions in Dallas were mainly about exploring business opportunities, rather than the two current projects. He said that whilst there were some discussions about progress on the SFOBB project, the Greater Gabbard project was mentioned only in passing. Perhaps rather surprisingly, Mr Kang said that at that time he was unaware of the problem with cracking in the welds of the monopiles. He was not briefed about this until after his return. He was then given to understand that there was a proposal that each party should give up its claims against other, that Fluor would pursue GGOWL on behalf of both itself and ZPMC and that ZPMC was to provide a 25 year warranty for the monopiles and the transition pieces. Mr Kang understood that the only outstanding issue was the provision of a bank guarantee to support the warranty.

The events in early 2010

471. In the meantime, Mr Dobbs had told Mr Liu that he wished to have a meeting with the chairman of ZPMC, Mr Jichang Zhou, and Mr Kang in China. This meeting took the form of a dinner and drinks on 2 February 2010 in Beijing. At that time Mr Kang was more concerned with problems on the SFOBB project and he had decided not to reopen any of the discussions on the Greater Gabbard project. Mr Dobbs was taken to the meeting by Mr Liu and on the way Mr Dobbs asked Mr Liu if he thought that Mr Kang would stand by the agreement that had been reached in outline with Mr Guan. Mr Liu said that he had already obtained Mr Kang's assurance that he would stand by any undertakings given by Mr Guan, but in order to reassure Mr Dobbs he telephoned Mr Kang who confirmed the position.
472. Mr Dobbs sent an e-mail to Mr Fuller the following morning, in which he said:
- “Doug –
It was a very late and hard drinking night with Zhou and Kang last night.
On bridge, . . .
For GG they do not understand the claims assignment, but seemed willing to sign up. I will work with legal on some wording.”
473. This was the first occasion on which there was mention of an assignment. Hitherto, the notes of the meetings had recorded that ZPMC would “support” Fluor in the claim against GGOWL, but the way in which it would do so was not spelt out. The proposal for an assignment of ZPMC's claims to Fluor was, I assume, one that came from Fluor's lawyers.
474. So by this stage, that is mid-February 2010, there was still no concluded agreement. By then the matters known to or understood by both parties were, I find, as follows:
- (1) Substantial problems had arisen in relation to the fabrication of the MPs and TPs at Changxing. The major problem was the presence of cracks in many of the welds, which GGOWL was insisting had to be rectified. To this end GGOWL had served NCRs in respect of the first three shipments and had demanded that Fluor carry out further NDT and repairs.
 - (2) Both Fluor and ZPMC had taken the position that the additional NDT demanded by GGOWL was more stringent than their respective contracts required and was therefore, together with the demand to carry out repairs, unjustified. However, ZPMC was prepared to accept some responsibility for the state of the piles in Shipment Nos 1-3 and, as a result, had sent a large number of welders over to Vlissingen to carry out repairs.
 - (3) The investigation and repair of this cracking had resulted in enormous losses, actual and potential, particularly to Fluor, both by way of direct repair costs and delay.
 - (4) There were other fabrication problems with the piles and transition pieces, although they were very much less important. These included matters such as out of roundness of the piles, a need for further stiffening and poor

quality of the paintwork to the transition pieces. All these required remedial work.

- (5) By the end of September 2009 Fluor had concluded, having taken expert advice, that the MPs and TPs were fit to be installed as fabricated and that the additional NDT and repairs insisted on by GGOWL, some of which had already been carried out, were unnecessary. At the same time ZPMC was also asserting that its piles were fit for installation and was prepared to give a warranty that they would last for at least 25 years (but not one that was supported by a bank guarantee).
- (6) It was important to Fluor that not only was its position as to the fitness for purpose of the piles justified by independent expert advice, but also that ZPMC could be seen to have confidence in its piles by offering a 25 year warranty.
- (7) The parties had held several discussions with a view to settling their respective claims against each other and had reached agreement in outline as to the basis of a potential settlement agreement. In broad terms: (a) each had said that it was prepared to waive its claims against the other in respect of the losses sustained at Vlissingen as a result of the cracking in the welds and the extra contractual testing imposed by GGOWL, (b) ZPMC would assign its claims in respect of the cracking to Fluor and give Fluor every assistance in pursuing those claims against GGOWL, (c) Fluor would share with ZPMC a proportion of any recovery from GGOWL (after deducting its own costs), and (d) ZPMC would provide a warranty that the unrepaired piles in Shipment Nos 1-3 would last 25 years.
- (8) The parties were not agreed about whether or not the warranty was to be secured by a bank guarantee, or some other form of security.
- (9) A written agreement setting out the precise details of (7) and (8) above would be prepared by Fluor (or its lawyers) for consideration and approval by ZPMC.

475. In addition, I find that at all material times both Fluor and ZPMC appreciated the following:

- (1) That under a construction contract any claim for payment in respect of additional work needs to be founded upon an instruction, either express or implied, or a breach of contract, and thus
- (2) if the NDT adopted at both Vlissingen and Changxing from May 2009 onwards on Fluor's/GGOWL's instructions went beyond of the requirement of ZPMC's contract, ZPMC would have a potential claim against Fluor for the cost of carrying it out. In turn, Fluor would have a similar claim against GGOWL. This is confirmed by the evidence of Mr Dekker when he said

that he wanted to have an NCR because he could then use it as a direction from GGOWL to carry out repairs (Day 7/6).²⁹

- (3) However, if the issue of the NCRs and the losses occasioned by Fluor in consequence were a direct result of defects in the welds caused by breaches of contract by ZPMC, Fluor would have a potential claim against ZPMC in respect of the losses suffered as a result of the issue of the NCRs.
- (4) Thus if GGOWL was correct in its assertions and the welding did not comply with the requirements as to quality in Fluor's contract, and similarly the requirements as to quality in ZPMC's contract, then Fluor would have a claim against ZPMC as a result of the presence of the cracking and the cost of repairing it, together with any consequential losses that were not excluded by the terms of the contract.

The meeting of 20 April 2010 and the waiver and warranty letters

476. A meeting to finalise the agreement between the parties was arranged for 20 April 2010. It was attended by Messrs Fuller, Ho and Hsieh, on behalf of Fluor, and Messrs Cao, Gao Feng ("Ryan") and Yan Hua for ZPMC. Mr Fuller took two letters to the meeting. One was described by ZPMC as the "waiver letter" and the other as the "warranty letter". For simplicity, I will adopt this terminology irrespective of how apt it may be to describe the contents of each of the letters.
477. I need to set out the text of each letter in full. First, the waiver letter (in the form dated 19 April 2010 and reflecting the NCR numbers shown in the Chinese translation which was also given to ZPMC at the meeting on 20 April 2010³⁰):

"Dear Mr. Kang:

I am very pleased that we have reached an understanding on the joint pursuit of the **substantial additional costs both Fluor and ZPMC have incurred as a result of the MP and TP weld testing and repair protocol required by Greater Gabbard Offshore Winds Ltd. ("GGOWL")**. My understanding of the terms of our agreement are as follows:

1. ZPMC will and hereby does assign to Fluor any and all rights, title and interest it has to pursue compensation for the costs it has incurred that in any way or to any extent arise out of, result from, or relate to **the enhanced testing and remediation of MP and TP welds it has been required to perform as a result of the acts and omissions of GGOWL, including, but not limited to, GGOWL's issuance of NCRs 006, 008, and 009 relating to MP welds** (the "ZPMC Claims").

²⁹ At paragraph 5.4(b) of his first witness statement, Mr Dekker said "*the NCR is the closest thing we could find to an instruction to do what we began to describe as "Employer Required NDT and Remediation"*".

³⁰ Some confusion has been created by the fact that there is more than one version of this letter. An original draft in English dated 19 April 2010 gave the NCR numbers (in numbered paragraph 3) as 006, 007 and 008, and not, as they should have been, 006, 008 and 009. Curiously, the Chinese translation dated 19 April 2010, that was given to ZPMC at the meeting on 20 April 2010, has the correct numbers throughout. However, nothing turns on this. The passages that are struck out were in the version handed over at the meeting on 20 April 2010 but were deleted in the revised version of the letter that was signed on 30 January 2012. The passages in square brackets were added at the same time.

2. Further, and as part of the assignment described above, ZPMC will refrain from prosecution against Fluor and ~~hereby does~~ [will] relinquish any claim it has or may have against Fluor **for additional compensation or any other damages arising out of or related to the enhanced testing and remediation of MP and TP welds, as described above** [upon resolution of the matter with GGOWL].
3. In consideration of said assignment and [prospective] release by ZPMC, **Fluor will and hereby does waive, release and relinquish any claim it has or may have against ZPMC for the additional costs and delays it suffered as a result of NCRs 006, 008 and 009 issued by GGOWL** [upon resolution of the matter with GGOWL].
4. In further consideration of said assignment and release by ZPMC, Fluor agrees that, as [agent] ~~owner~~ of the ZPMC claims, it will include them with its own claims against GGOWL arising out of or relating to NCRs 006, 008 and 009 and the resulting enhanced testing and remediation protocol required by GGOWL (collectively, the "Weld Dispute Claims"), and pursue the Weld Dispute Claims against GGOWL in arbitration in London, as required by Fluor's contract with GGOWL (the "Arbitration") as described below.
5. In the Arbitration:
 - a. Fluor will advance all the costs necessary to pursue the Weld Dispute Claims, including arbitrators' fees, legal fees, expert witness fees, and [the] like.
 - b. ZPMC will cooperate fully with Fluor in the presentation and prosecution of the Weld Dispute Claims, including providing all the information and documentation necessary to quantify and prove ZPMC's claims and making available the necessary witnesses to testify in support of the Weld Dispute Claims.
 - c. Fluor will pay to ZPMC fifty percent (50%) of any award it receives on the Weld Dispute Claims in the Arbitration, after receipt of payment and after deduction of [Fluor's damages arising out of the Weld Dispute Claims and reimbursement to Fluor of] all costs incurred by Fluor in the Arbitration, including the costs of satisfaction of any award. [If the costs exceed the award, such difference shall be borne by Fluor.]
6. Any dispute that may arise under this agreement shall be resolved in the manner provided in our Purchase Order No. 66577000-2-0001.

If this letter accurately sets forth the terms of our understanding, please indicate your agreement, on behalf of ZPMC, by signing the enclosed copy of this letter and returning it to me."

478. The warranty letter (in its original form, also dated 19 April 2010) was not accompanied by a translation in Chinese and so at the meeting ZPMC had the English version only. That provided as follows:

"Dear Mr. Kang:

This letter confirms our agreement on the close out of the Purchase Order and final payment to ZPMC.

As you know, Greater Gabbard Offshore Winds Ltd., the owner of the Project (the "Owner") has claimed the welding of the monopiles (MPs) and transition pieces (TPs) by ZPMC was defective, in that the welds contained transverse cracks that

threaten the structural integrity and design life of the foundations supporting the wind turbine generators. Fluor and ZPMC have disputed that claim, but the rights and liabilities of the parties have yet to be adjudicated in arbitration or otherwise.

Under such circumstances, Fluor's policy would be to withhold final payment on the Purchase Order until and unless it was finally determined that Fluor had neither liability to the Owner for the claimed defective welds, nor liability to the Owner for any alleged service life less than 25 years.

Because ZPMC has advised Fluor that withholding of final payment would create a hardship for ZPMC, Fluor has agreed to pay the final sum due ZPMC on the Purchase Order within 35 days of presentation of all detailed invoices (including the final invoice) in good form as required by the Purchase Order. In consideration therefore, ZPMC agrees that it will - and hereby does - provide to Fluor³¹ a warranty of the materials and workmanship it provided in the fabrication of the MPs and TPs under the Purchase Order for twenty-five (25) years from the date of acceptance of the Project by the Owner. Such warranty shall be in writing in a form to be provided by Fluor; shall be, by its express terms, assignable to the Owner (or its successor in interest) by Fluor in its sole discretion; and shall cover all direct³² damages resulting from any structural failure of the MPs or TPs, including, without limitation, their repair or replacement as necessary.

Please indicate your agreement with the terms and conditions of this letter by signing the enclosed copy on behalf of ZPMC and returning it to me. Any dispute that may arise under this agreement shall be resolved in the manner provided in our Purchase Order No. 66577000-2-0001.

Thank you for your cooperation in resolving this issue."

479. Before the meeting Mr Fuller prepared some speaking notes, which set out what he intended to say by way of explanation of the terms of the agreement set out in the two letters. He said in evidence that he thought that he had prepared these notes in Australia, where he had been immediately before the meeting. These notes included the following comments:

"3. The centre piece of these discussions had 3 elements:

- We agreed not to pursue claims against each other
- Fluor would take a claim for against the Owners and ZPMC would support that claim
- ZPMC would provide a 25 year guarantee for the installed product

4. As I recall, we agreed on all issues, but the form of the 25 year guarantee. We could not agree on the form of guarantee.

...

6. We have brought 2 letters today to discuss. You will find many similarities between these letters and our previous discussions.

7. It is important we complete the agreement on both letters before end of Thursday.

³¹ In the final version of the letter the following words were added after "Fluor": "*in respect of all those MPs and TPs in Shipments 1, 2 and 3 that were not repaired in Vlissingen*".

³² In the final version of the letter the words "*and indirect*" were inserted between "direct" and "damages".

8. The first letter deals with how we proceed with the significant issue of the weld quality. This letter has 6 points which we have translated to Chinese so we can discuss.

1. Same as we had discussed before. ZPMC will assign ownership to Fluor for all its claims and Fluor will pursue this issue with the Owner.
2. ZPMC agrees not to submit any claim against Fluor.
3. Fluor agrees not to submit any claim against ZPMC.

...”

480. In cross-examination Mr Fuller was, not surprisingly, pressed as to what he meant by the reference to “any claim” in the last two extracts from his speaking note quoted above. In his witness statement, at page 463, he said this:

“In each case, my notes were shorthand for the claim that we and ZPMC believed we had for extra contractual work directed by GGOWL. At the meeting, that was the only claim we were discussing: we were not suddenly switching from discussing assigning claims for extra contractual work directed by GGOWL to abandoning that concept and simply waiving any and all claims . . .”

481. When that passage was put to him by Mr White, and he was asked what claims, leaving aside claims in relation to out of roundness and painting, Fluor thought it was waiving, he said:

“I do not know that I gave it thought, to be honest with you. I mean, the letters, I intended them to be itself-explanatory. Yet, if they had questions, if ZPMC had questions, I was going to take those back to our attorneys, have them answer it, and go forward.”

Then there was the following exchange, at Day 8/108:

“Q. And if your objective had been to preserve the right to bring ZPMC - bring proceedings against ZPMC for the cost and delay that you now claim against them, if you lost against Gabbard, you would have said so?”

A. No. The letters were prepared by our attorneys. I was not going to go through there and start putting words in the mouth of our attorneys. Like I said, I expected ZPMC to go through there and read those very carefully and ask any questions they have. But I was not going to go through there and interpret them for them. I wasn't going to do that.”

482. Although Mr Fuller did not strike me as a particularly impressive witness when he first began to give evidence, he was closely cross examined at considerable length and by the end of it I had come to the clear view that he was a man of integrity who had high respect for his opposite numbers in ZPMC. I am quite satisfied that he would have done nothing intentionally to mislead them. However, by the time of the meeting on 20 April 2010 Mr Fuller had been away from the project for some time and he was having to put himself back into the position in which he had been a few months earlier. In general, I accept his evidence except where I specifically indicate otherwise.
483. I doubt very much whether it had occurred to him that there might be potential claims against ZPMC that would not fall within the waiver that Fluor was proposing to give.

What I am sure would have been at the forefront of his mind was that Fluor's claim against GGOWL was for the costs that flowed from the additional NDT and repair work that had been carried out at Vlissingen (and at Shanghai) at GGOWL's insistence and which both Fluor and ZPMC were saying was outside the scope of their contractual obligations. After all, he had been the author of the draft "White Paper" which reached that conclusion.

484. Mr Cao's note of the meeting, in translation, is as follows:

"Some issues concerning the project:

1. Waive claim against each other, but ZPMC must support Fluor in its claim against the Owner. However, because of the defects, ZPMC shall give a 25-year warranty.

2. Achieve a good settlement with ZPMC on the commercial contract. There are two letters which can be used to close the relevant issues. Hope that the letters can be signed by Thursday this week.

(1) Both parties waive claim against each other;

(2) ZPMC to support Fluor in its claim against the Owner;

(3) ZPMC to provide a 25-year warranty.

Commission Fluor to make claims against the Owner? No guarantee to win.

Relevant documents support (relevant to ZPMC)

If Fluor wins the case, Fluor will share the proceeds on a 50/50 basis with ZPMC after deducting relevant costs.

The above-mentioned discussion is similar to the principles previously discussed.
2. Final settlement of the commercial contract with ZPMC.

...

The warranty can only be provided in the name of ZPMC itself. It is impossible to provide a bank guarantee."

485. It looks from these notes that the first part (before the underlined sentence) was recording Mr Fuller's opening remarks, because the paragraphs numbered (1), (2), and (3) follow exactly the same order as in the third item of Mr Fuller's note. The reference to "Relevant documents support" is, I am sure, a reference to the waiver and warranty letters, which were dealt with at Mr Fuller's items 6 to 8.

486. Mr Cao's notes of what Mr Fuller said about the two letters appears to record that their contents were similar to what had been discussed before - but they go into no detail. Mr Fuller's speaking note records that each of ZPMC and Fluor were agreeing "*not to submit any claim against*" the other. However, taken literally this is obviously not correct because it has never been either party's case that Fluor and ZPMC intended to settle all claims against each other whether or not connected with the welding defects that were discovered at Vlissingen and Shanghai in the summer of 2009. For the reasons that I have already given, apart from anything else, there would be little point obtaining a warranty from ZPMC if Fluor was agreeing not to make a claim under it. This suggests that these notes were a prompt of the points that he had to cover, rather than an attempt to explain the individual paragraphs in the letter.

487. When considering the effect of whatever was said by Mr Fuller at the meeting on 20 April 2010, I think that it is necessary to bear in mind, as I was reminded by Fluor, that Mr Cao had a limited grasp of English (Mr Cao said in his witness statement that Mr Gao translated for him at the meeting). As subsequent events demonstrated, Mr Gao had a different understanding from others within ZPMC as to the extent of the waiver of claims by Fluor. He had attended the meetings on 30 September, 1 and 2 October 2009 and said in his first witness statement (at paragraph 2.9) that it was very clear to both parties that “*we were talking about claims relating to the weld cracks problem in shipments 1 to 3*”.
488. However, during the meetings to discuss the final account Mr Gao was presented with various heads of claim, such as a deduction to reflect the reduction in the weight of the steel, secondary steel repairs and the roundness issue. In a letter to Mr Kang, dated 21 February 2011, Mr Gao said that ZPMC could not accept the deductions proposed by Fluor (apart from that in relation to the weight of the steel) because the agreement reached between ZPMC and Fluor at an earlier stage was that both Fluor and ZPMC would “*bear their own part of the cost, respectively*”, whereas Fluor was saying that this cost was merely limited to the cost relating to the welding repair.
489. Mr Cao’s evidence was that his understanding was that Fluor and ZPMC had agreed that they would not claim against each other for the costs and losses that they had respectively incurred in relation to the weld cracks problem. He said that at the meeting on 20 April 2010 this was confirmed by Mr Fuller because he had said that the letter was prepared in accordance with the principles discussed previously, by which Mr Cao understood him to mean meetings that took place in September/October 2009 (paragraph 8.7.1).
490. In these circumstances I find it difficult to draw any clear conclusions as to what Mr Cao understood Mr Fuller to have said at the meeting on 20 April 2010, given that not only was it having to be translated but also that the translator appears to have had a different understanding about the scope of the waiver to that discussed at previous meetings. Matters cannot have been assisted by the fact that only the waiver letter was available in translation. A copy of the warranty letter translated into Chinese was provided to ZPMC following the meeting.
491. Further, as the course of evidence in this case demonstrated more than once, there are always difficulties when things said or documents prepared in English are heard or read by the recipient in translation. The understanding of the recipient is dependent on what is heard or written in his or her native tongue and the meaning that it conveys.³³ That is something that the Court can seldom discover. In the circumstances it seems to me that the most important feature of the meeting is not so much what was said (or was thought to have been said) but that ZPMC was provided with copies of the letters and was given time to consider them at its leisure.

³³ One memorable example of this occurred when one of ZPMC's witnesses, Mr Guan, gave an answer that clearly surprised and alarmed the bilingual members of ZPMC's team who were in court. It turned out that the source of the problem was that in the course of the interpretation the same Chinese word was used for the English word "projects" and the English word "items". In the course of the questioning, when translating the answer, the translator used the English word "projects" in a context when it was said that the witness must clearly have meant "items" (Day 10/63-64, 69).

492. Indeed, following the meeting over a month elapsed before the two letters, with some modifications, were signed by ZPMC in June 2010. I infer that ZPMC must have given them considerable and careful attention in the meantime. So far as the waiver letter is concerned, the only amendment, in addition to the correction of the erroneous NCR numbers, was the addition of the following words to paragraph 5c: “If the costs exceed the award, such difference shall be borne by Fluor”. In my view, this amendment does not have any impact on what would have been understood at the discussions on 20 April 2010.
493. In relation to the warranty letter, there were two significant alterations. The first was that the warranty was limited to all those MPs and TPs in Shipment Nos 1-3 that had not been repaired in Vlissingen. The second was that the words “and indirect” were deleted so that the warranty was limited to direct damages only resulting from any structural failure of the MPs or TPs. However, again I do not think that these affect the discussions that took place on 20 April 2010.
494. In January 2012 some amendments were made to the waiver letter, principally concerning the form of the assignment. The revised version of the letter was presented to Mr Kang with the explanation that Fluor had said that the English version of the letter was slightly inconsistent with the Chinese translation provided at the time. Accordingly, Fluor said that it had retranslated the letter so that it accorded with the Chinese version. Neither party relied on these amendments in themselves, but I have included them in the version of the letter set out above. The point of significance, relied on by Fluor, is that ZPMC was still prepared to sign the letter, which it did on 30 January 2012 in spite of having received Fluor’s letter of 14 October 2011 (see paragraph 509 and 510 below).

The waiver letter - some observations

495. Before I consider the submissions of the parties, the following points about the waiver letter are to be noted:
- (1) the subject of the “understanding” was the “*joint pursuit of the substantial additional costs that both Fluor and ZPMC have incurred as a result of the MP and TP weld testing and repair protocol required by [GGOWL]*”.
 - (2) ZPMC was agreeing to assign its claim for the costs resulting from the enhanced testing and remediation that it had to perform as a result of the acts and omissions of GGOWL, including but not limited to the issue of NCRs 006, 008 and 009. Thus, by this assignment, ZPMC was irrevocably forgoing any right to claim these costs from Fluor in the future. The costs in question were those consequent upon acts or omissions of GGOWL. Clearly ZPMC could have no claim against Fluor in respect of defects in its welding that were the result of its own breaches of the terms of the Purchase Order.
 - (3) Fluor was relinquishing any claim it may have against ZPMC for “*the additional costs and delays it suffered as a result of NCRs 006, 008 and 009 issued by GGOWL*”.

- (4) Thus there was a potentially important distinction between the waiver letter and the discussions that had preceded it. The waiver letter was concerned with claims for a certain category of costs. By contrast, the previous discussions - at least according to ZPMC's account - concerned the mutual waiver of claims arising from a particular cause of action, namely defective welding. However, as already discussed, an unqualified waiver of claims in relation to welding defects could well deprive the warranty of any content, since the most likely cause of any failure of the unrepaired MPs and TPs would be defects in the welding.
 - (5) So, whatever ZPMC may have thought, a blanket waiver of all claims past or future in relation to welding defects was inconsistent with the undertaking to give a warranty in relation to the life of the piles. Viewed objectively, that cannot have been the honest intention of either party. Accordingly, if there was to be a waiver of claims in respect of welding defects it had to be limited in some way so that it would not undermine the warranty. I anticipate that this point might have been appreciated by Fluor's lawyers who therefore made the waiver referable to categories of costs rather than to a cause of action, but whether or not that was in fact the case does not matter.
 - (6) Thus the assignment to Fluor of ZPMC's claims could only have practical effect if the additional testing and repairs required by GGOWL, and hence by Fluor of ZPMC, amounted to a variation of the contract between ZPMC and Fluor or a breach of it. Absent such a variation or breach, ZPMC would have no entitlement to payment.³⁴
 - (7) By contrast, the waiver of the claim by Fluor could only have practical effect if the testing and repairs required by GGOWL, and the additional costs incurred by Fluor as a result, were not a variation or breach of contract by GGOWL but were instead the consequence of a breach of contract by ZPMC: in the absence of a breach of contract by ZPMC, Fluor would have no claim to waive or relinquish.
496. It is therefore not quite correct for Fluor to submit, as it did, that the waiver letter (or, as Fluor called it, "the joint claims letter") involved claims being passed up the line and the warranty letter was concerned with claims being passed down the line. The waiver by Fluor in the waiver letter was of a claim down the line.
497. On any analysis of the language used in the letter, taken in isolation, Fluor was not waiving any claim that it might have against ZPMC for breach of contract. What was being waived was the claim for the additional costs and delays suffered by Fluor as a result of the issue of the NCRs, albeit that the only basis for such a claim would be a breach of contract by ZPMC. The important point was that the extent of the waiver was by reference to a type of cost, not to a type of cause of action.
498. However, it is correct, as Fluor contends, that numbered paragraph 3 of the waiver letter refers to costs and delays suffered "*as a result of*" the issue of NCRs 006, 008

³⁴ A point accepted by ZPMC at paragraph 336.1 of its closing submissions.

and 009. This suggests that if those costs and delays would have been incurred in any event irrespective of the actions taken by GGOWL, the waiver and release would not bite. This is obviously an available meaning of the words, but the question is whether - viewed objectively and applying the well recognised principles - it is one that the parties can be taken to have intended.

499. The premise underlying the agreement set out in the letters was that GGOWL had imposed an NDT regime, and consequent need for weld repair, that went beyond ZPMC's and Fluor's contractual obligations.³⁵ If that could have been the subject of any doubt, it is made clear in the warranty letter. That (assumed) state of affairs gave Fluor a claim against GGOWL and ZPMC a claim against Fluor. That is clear from the words of the opening paragraph of the waiver letter. The intention was that both claims should be pursued against GGOWL.
500. Thus the claim by Fluor against GGOWL was a claim for the cost of complying with an instruction to carry out additional or varied work (or by way of mitigating its loss caused by GGOWL's breach of contract): that instruction was given by the issue of the NCRs (or, alternatively, the issue of the NCRs constituted a breach of contract). That was the basis that underlay the agreement set out in the waiver letter. Costs incurred by Fluor prior to the issue of the relevant NCR could not be the subject of the claim against GGOWL since the only costs being waived were those incurred *as a result of* the NCRs.
501. In my judgment, the waiver letter must be read in the light of the parties' mutual understanding of the position, namely that the claims that were to be pursued against GGOWL were for the additional costs incurred in respect of the extra contractual work instructed by GGOWL. Those are the costs that form the subject matter of the assignment by ZPMC to Fluor and which were the subject of Fluor's release and waiver at numbered paragraph 3 of the waiver letter.
502. The corollary of this is that costs which did not arise out of or were not incurred in respect of enhanced testing and consequent remediation of the MPs and TPs required by GGOWL are not costs the claim for which was being assigned by ZPMC to Fluor. Similarly, such costs would not be included in the waiver given by Fluor.³⁶

Fluor's submissions on the construction of the waiver letter

503. Fluor characterises ZPMC's case as being that there was a common understanding that the words used in the waiver letter should not mean what they say, but instead mean "*the costs Fluor has incurred as a result of weld defects*".
504. Fluor has pointed out, correctly, that Mr Gao's understanding of the agreement that had been reached between the parties before the waiver letter was signed was different from the understanding shared by Mr Cao and Mr Huang. As I have mentioned, the former thought that all claims were being waived, whereas the latter thought that it was claims in respect of weld defects.

³⁵ In Fluor's opening submissions, at paragraph 191(d), it was accepted that any claim against GGOWL had to be for costs that arose out of something done by GGOWL, or which was "*arguably GGOWL's responsibility*".

³⁶ This disposes of the point made at paragraph 193(d) of Fluor's opening submissions.

505. Further, Fluor submits that the board of ZPMC, who took the final decision, knew nothing of the previous discussions between the parties, having been provided only with copies of the two letters and a proposal dated 20 June 2010. I do not recall being told who had prepared the proposal.
506. The text of the proposal provided to the board was as follows:

"Proposal in relation to providing 25 years warranty and other matters for FLUOR UK Great Gabbard offshore wind power project

All board members:

The UK Great Gabbard offshore wind power project was generally contracted by the US FLUOR company (hereinafter: FLUOR), among all our company subcontracted the detailed design, material procurement, fabrication and transportation (total 8 shipments to Holland) of 140 MPs and TPs, the contract price is approximately 234 million Euros. The MPs and TPs of shipment 1 arrived Holland in May 09, afterwards FLUOR used the extra contractual inspection method under the request of the owner to inspect the welds of the MPs, and the result was the discovery of transverse cracks. From July 09, our company has sent more than 100 management technical personnel and workers rushing to the Holland site to perform the welds repair work.

Currently the owner of the Great Gabbard offshore wind power project filed claims for the weld defects of the MPs and TPs provided by ZPMC. These welds contain the transverse cracks which will threaten the structure integrity and the design usage life of wind turbine electricity generator foundation. FLUOR and ZPMC raised questions to this claim, however, the rights and liabilities of each party will need to be decided through arbitration or other methods, FLUOR's strategy will withhold the balance of the Purchase Order, until final conformation [that] FLUOR would not need to take responsibility for the weld defects that the owner claimed, nor take responsibility for the usage life less than 25 years as alleged by the owner.

In the beginning of October 2009, FLUOR met and discussed with Mr Guan, requesting our company to provide a 25 years warranty to the MPs and TPs, this warranty includes all direct and indirect losses, and provides corresponding amount of bank guarantee as a guarantee. Mr Guan mentioned that can only provide the written guarantee of the company, at most provide an additional parent company Zhong Jiao Shares guarantee.

In April 2010, Fluor sent two letters, requesting our company to entrust FLUOR to claim against the owner, and provide a 25 years warranty (including all direct and indirect losses), and requesting ZPMC's parent company Zhong Jiao shares to provide a guarantee.

In June 2010, FLUOR sent two letters again, did not insist on indirect losses and the guarantee of Zhong Jiao shares company.

Letter one (please see attachment 1) requests our company to confirm entrusting FLUOR to claim against the owner, FLUOR will pay ZPMC 50% of any compensation received in its welding dispute claim in the arbitration, payable after receiving the payment and deducting FLUOR's losses incurred from the welding dispute claim and reimbursement of all costs incurred by FLUOR in the arbitration.

Letter two (please [see] attachment 2) requests our company to provide a 25 years warranty for the materials and fabrication quality in the MP and TP fabrication

process under the contract of all MPs and TPs that were not repaired in Vlissingen Holland and were shipped in the first 3 shipments. The commencement date of the warranty will be calculated from the owner's acceptance of this project. This warranty can be solely decided by FLUOR to assign to the owner or the owner's successor, and shall include all direct losses arisen from any structural defects of the MPs and TPs, including without limitation to repair or necessary replacement etc. Under the circumstances that the above is confirmed by ZPMC, FLUOR agrees to pay the balance within 35 days after ZPMC provides the invoice of all final settlement amounts under the contract.

Because of the dispute of the crack issue, the project progress was delayed, FLUOR alleged that the losses for waiting for work of the assembly crane ships and the other costs to rush work in the severe weather in winter in order to keep up the progress and avoid the strict penalty of the owner have exceeded our company's contract price, FLUOR states that if our company does not provide this kind of guarantee, will claim against our company for the losses they suffered from this.

After repeated thinking over and cautious studies, the company management level suggest to agree to FLUOR's requests, ie. Agreeing to confirm and sign the attached letter one and letter two sent by FLUOR on 4th June 2010.

The board authorises the management level to adjust and handle the specific matters in relation to this project based on the actual circumstances under the principle of striving for the maximum interests of the company.

Hereby submit to the board meeting for review.

Shanghai Zhenhua Heavy Industries Co Limited

28th June 2010"

(My emphasis)

507. It seems to me that the relevant passage in this report is the one that I have underlined, which refers to Fluor's intention to claim against ZPMC for the losses "*they suffered from this*" if ZPMC does not provide the requested guarantee. The difficulty is understanding what is meant by "*this*". It appears to refer back to the reference to the losses in relation to delay referred to earlier in the same paragraph. This does not really assist ZPMC: on the contrary, it appears to suggest that the losses that Fluor was agreeing not to pursue were losses in respect of delay caused by the dispute relating to the crack issue. However, the members of the board were provided with the two letters and had the opportunity to read them for themselves.
508. Further, I accept the submission by ZPMC, based on the evidence of Mr Liu (at Day 9/103), that the authority of the board was required to enable ZPMC to give the 25 year warranty, which Mr Liu described as "*abnormal*" - which I take to mean an act that lay outside the day to day powers of the directors individually. By contrast, Mr Liu said that an agreement to waive claims was not something that required approval from the board. I therefore reject Fluor's submission that ZPMC's estoppel claim must fail because the board was not aware of any common assumptions that might have been relevant to a consideration of the waiver letter.
509. On 14 October 2011 Fluor sent ZPMC a copy of a Notice of Defects issued by GGOWL and, in its covering letter, said, amongst other things:

“In the Notice of Defects letter, GGOWL claims that, based on the results of ultrasonic inspection and testing of welds in certain identified TPs, “the welding in the MPs and TPs in shipments 1 to 3 is defective and/or otherwise not in accordance with the Contract”.

...

The intent of this letter is to advise ZPMC that Fluor has received the subject notice from GGOWL, and that Fluor is in the process of investigating GGOWL’s allegations. It is our expectation that the testing will [show] that the quality of the product meets the contractual requirements, however should Fluor’s investigations validate GGOWL’s allegations, then Fluor will look to ZPMC to indemnify and hold harmless Fluor from any and all such liability and damages in accordance with the terms of: (1) the Purchase Order: and (2) the Letter Agreement.”

510. Fluor pointed out in its closing submissions that the waiver letter, in its revised form, was signed in the following January, at a time when ZPMC could have been expected to have this letter well in mind. Fluor’s letter of 14 October 2011 was transmitted to Mr Kang by e-mail by Mr Gao a few days later, although when giving evidence Mr Kang said that he had never seen it before (Day 15/140). Fluor submits that it is very surprising that ZPMC signed the waiver letter in its revised form - which, to all intents and purposes, was in the same form as the previous version - if it had the understanding of the effect of the waiver letter for which it now contends.
511. I do not regard this as a good point. The fact is that ZPMC had already signed the waiver letter, and so it was already bound by its terms. The revised version that was presented in January 2012 did not materially affect ZPMC’s existing rights: it seems that the alterations were being suggested in order to forestall any “no loss” argument that might be advanced by GGOWL in the arbitration on the basis of the letter in its original form.
512. However, Fluor’s real case is one of causation based on what it says is a correct reading of the waiver letter. Very simply, it submits that what it agreed to waive were the costs and delays it suffered *as a result of* the NCRs. Fluor’s case now, which is directly contrary to the case put forward in the arbitration, is that the actions that it took in relation to the discovery of the cracking at Vlissingen had nothing to do with the issue of the NCRs by GGOWL, but were caused by its own belief that cracking in welds such as these was unacceptable and that accordingly all the cracks should be discovered and repaired.
513. Fluor submits that this is demonstrated by what happened in relation to Shipment No 2: that shipment was tested by Fluor in Vlissingen using D scans from the moment that it arrived on 29 June 2009 and well before GGOWL got round to issuing NCR 008 at the end of July. In fact, that submission is not quite correct because, as I have already mentioned, a note by Mr Ayres suggests that the testing did not begin until 9 July 2009.
514. This raises three issues. The first concerns the true construction of the waiver letter and whether or not it is to be read in the manner contended for by Fluor. The second, which only arises if Fluor is right on its construction of the letter, is whether or not some or all of the losses in respect of which it claims were the result of the NCRs or the result of its own independent decision to carry out the testing and repairs that were in fact done. The third issue is whether Fluor is estopped from relying on its

construction of the letter. I shall deal with the first issue in this part of the judgment and the other two issues separately.

ZPMC's submissions on the construction of the waiver letter

515. ZPMC's fundamental submission is that if Fluor were to be permitted to contend now that none (or very few) of the costs incurred in relation to the additional NDT and remediation measures at Vlissingen resulted from anything done by GGOWL, that would fly in the face of the premise underlying the waiver letter. In fact, ZPMC goes further and says that if Fluor's position in these proceedings "*really does represent the true position, and its construction of the Waiver Letter is accepted, then ZPMC has been thoroughly and completely misled*" (paragraph 336.3 of its closing submissions). In my view, there is some force in that point.

516. ZPMC relied on Mr Cao's evidence of what was said at the meeting on 20 April 2010. In cross-examination (at Day 10/23-24) he said this:

"Q. I'm looking at 20902, but of course you can look at the Chinese. Under paragraph 2 there is a sub-paragraph (i) that says:

"Both parties waive claim against each other".

A. (Interpreted). Yes.

Q. To the best of your recollection, is that what Mr Fuller said?

A. (Interpreted). I remember that there were two aspects to both parties waive claim against each other, ie Fluor would not claim against us. And, secondly, we do not claim against them. And that's how both parties waive claim against each other. That's what he means.

Further to that, he actually went into great details about waiving claim against each other. and I remember, very specifically, that he said Fluor would not claim against us in relation to any issues to do with welding.

Q. That's not what the –

A. (Interpreted). In addition to that, ZPMC also waive all claims against Fluor in relation to any additional cost incurred as a result of the crack issues.

Q. Well, that's not what your note says, is it? It certainly doesn't contain that detail.

A. (Interpreted). I remember it very clear –

THE INTERPRETER: Sorry. I will start again.

A. (Interpreted). It doesn't mean that I didn't hear that he said these things. And he actually said it in -- with a lot of details. And I can recall the meeting quite distinctly in my mind. Before the meeting in September/October there was lots of discussions.

So, therefore, you can see in my note it actually said that:

"The above-mentioned discussion is similar to the principles previously discussed"."

517. ZPMC submitted that Mr Cao was a careful and palpably honest witness and that his evidence of this meeting should be accepted. Since Mr Cao gave evidence through an interpreter my ability to form an impression of him as a witness was inevitably limited. He had a significant role in that he was ZPMC's vice president in charge of production planning and manufacturing from 2006 to 2013.

518. As a matter of general impression, I thought that Mr Cao was a little inclined to distance himself from the events of late 2008 and early 2009. Of course, it may be that he was as remote from these events as he indicated in evidence - but either way I

did not regard his evidence about the events up to mid 2009 as of much assistance. In relation to the meeting of 20 April 2010, I have serious reservations as to how much he could really recollect independently of his note. This is not in any sense a criticism of him: I have a similar reservation about the evidence of every witness who was being asked to give an account of a meeting which took place some six or seven years ago.

519. ZPMC submitted that it was the cost incurred as a result of following the “*MP and TP weld testing and repair protocol*” imposed by GGOWL that was being addressed by the waiver letter. It submits that whether or not Fluor would have followed that course in any event is irrelevant: the course was followed and additional costs were incurred. However, ZPMC then goes on to say that the “*substantial additional costs*” referred to in the waiver letter must be taken to have included all the costs relating to the transverse cracking issue that were incurred at Vlissingen.
520. ZPMC submits that there was only one “pot” of costs at Vlissingen that, in previous discussions, had never been subdivided. This is true, but as ZPMC also submits, the waiver is directed towards a particular package of costs and liabilities, namely “*the additional costs and delays [Fluor] suffered as a result of NCR 006, 008 and 009*”. ZPMC is therefore accepting that there has to be a causal link between the costs being waived and the issue of the NCRs. However, ZPMC goes on to submit that the meaning of those words must be determined having regard to the background to the formation of the agreement.
521. ZPMC makes the point that at no stage prior to this litigation did Fluor suggest that the costs representing the “*extra contractual testing*” would have been incurred in any event, irrespective of the view taken by GGOWL, because such a testing regime was necessary in order to ensure that all cracks in the welds were repaired. The common assumption, submits ZPMC, was that Fluor and ZPMC had no option but to implement the enhanced testing regime once the NCRs had been issued. The only question was who was liable to pay for them. If the NCRs were properly issued, then the risk lay with ZPMC and Fluor. If the NCRs were not justified, as both Fluor and ZPMC said at the time, then GGOWL would be liable to pay for the enhanced testing and consequent repairs.
522. In their letter sent as ZPMC’s response to Fluor’s letter setting out its claim as part of the pre-action protocol procedure, ZPMC’s solicitors, Pinsent Masons, summarised the waiver that had been given by each party in the following terms:

“Fluor and ZPMC agreed that they would each waive their claims against the other in respect of all of the costs that had arisen as a result of the testing regime imposed on Fluor by GGOWL and thus by Fluor on ZPMC and in respect of the additional work that was carried out as a result of the testing. As part of the waiver agreement, ZPMC agreed to provide assistance to Fluor in its arbitration against GGOWL. ZPMC also agreed to provide an additional warranty for the goods that had not been the subject of GGOWL unnecessary enhanced testing regime as part of that agreement.

The final account was agreed on the express understanding that the claims for **additional work required as a result of the D scanning and other GGOWL testing requirements** had been settled by the waiver agreement. ZPMC provided continued assistance to Fluor in the arbitration on the basis and because of

continued and repeated assurances by Fluor that the claims being advanced against GGOWL had been settled as between ZPMC and Fluor.”

(My emphasis)

The law

Fitness for purpose

523. Fluor’s case is that the MPs and TPs were not of good quality or “fit and sufficient for the purposes for which they are intended as evidenced by this Purchase Order”. The PO was for the supply of “materials, labour and services described under the heading ‘Description of Purchase’”.

524. The Description of Purchase was as follows:

“Mono Pile Foundations & Transition Pieces Total Purchase Order Value, Export Packed, Delivered CFR (INCOTERMS 2000) Vlissingen, The Netherlands – €234,097,500.”

There were some changes to the price, but otherwise this description remained unchanged.

525. Section 8 of the PO provided that:

“Material will be delivered CFR Vlissingen 9 months from receipt by Seller of design documentation . . .”

526. It was clear from the terms of the PO that the MPs and TPs were being supplied to Fluor for onward supply to GGOWL and installation at its offshore wind farm off the Suffolk coast.

527. It is Fluor’s case that the MPs and TPs had to meet the contractual requirements at the time of delivery at Vlissingen. This is not disputed. It is also Fluor’s case that, on delivery, the MPs and TPs had to be:

(1) in a condition such that a reasonable buyer in the position of Fluor could load them out and install them in the seabed without further examination or remediation; and

(2) suitable for installation in the seabed and thereafter to perform in service satisfactorily for 25 years.

528. ZPMC’s case is that the test of fitness for purpose is objective. It submits that the purpose for which the MPs and TPs were intended was to act as foundations for offshore wind turbines with a service life of 25 years. Once this purpose is identified, the only question is whether the goods supplied were reasonably fit for it - namely, whether they were capable of supporting the wind turbines for 25 years. The point made by ZPMC is that whether or not the buyer thinks that the goods are fit for their purpose is irrelevant: either they are or they are not. At trial Fluor did not advance any positive case that the MPs and TPs were not capable of achieving a 25 year service life.

529. There is, surprisingly, so far as I can tell, no authority on this point. When I asked counsel if they knew of any, ZPMC were able to refer me to two authorities only. These were *Frost v The Aylesbury Dairy Company* [1905] KB 608, and the well known decision of the House of Lords in *Henry Kendall & Sons v William Lillico & Sons* [1969] 2 AC 31, at pages 75, 96, 108, 118 and 126. However, these two cases were of fairly limited assistance in resolving the issue here. In *Henry Kendall* two members of the House of Lords accepted the proposition that, when considering whether or not goods were of merchantable quality, some knowledge acquired later should be brought in otherwise it would never be possible to hold that goods were unmerchantable by reason of a latent defect (per Lord Reid, at page 75; Lord Guest, at pages 108-109). However, Lord Pearce took a rather more circumspect view (at page 119).
530. In these circumstances, one must begin at the beginning. In *Grant v Australian Knitting Mills Ltd* [1936] AC 85, the Privy Council approved the test of merchantability formulated by Dixon J in the High Court of Australia, a course followed by the House of Lords in *Henry Kendall*, in the following terms:
- “The condition that goods are of merchantable quality requires that they should be in such an actual state that a buyer fully acquainted with the facts and, therefore, knowing what hidden defects exist and not being limited to their apparent condition would buy them without abatement of the price obtainable for such goods if in reasonably sound order and condition and without special terms.”
531. Assuming that there is only one use for the type of goods in question (so that fitness for purpose and merchantability elide), what is the position if the buyer knows of their true condition but is unable to discover, without lengthy investigation, whether or not that condition affects that use? The answer, it seems to me, would be that he would impose a condition that the necessary investigation is carried out before agreeing to buy the goods. That, therefore, would amount to the imposition of a special term, namely the satisfactory outcome of the investigation.
532. In this case the experts agreed in their joint statement that the indications identified at Vlissingen reasonably justified a further investigation. In evidence, Dr Morgan agreed that there were features in the welds that would have been revealed on testing by D scan and, that being the case, it was right to go ahead and test the monopiles at Vlissingen (Day 16/89). I have already mentioned that Mr Teale agreed in cross examination that Fluor could not just go ahead and install the piles without carrying out a detailed ultrasonic investigation and then repairing what had to be repaired (Day 17/163-165). Dr Gordon said much the same (Day 18/204). So the evidence given by ZPMC’s experts was consistent with the agreement recorded in the joint statement.
533. In my view, this evidence clearly establishes that, as a result of the cracking that had been found in the piles at Vlissingen, the only reasonable option available to Fluor was to carry out an investigation into the true condition of the piles and to establish the extent (if any) to which this might affect their performance in service.
534. There is no doubt in my mind that, so far as Fluor was concerned, the MPs and TPs had to be in a condition on delivery at Vlissingen such that any reasonable purchaser in Fluor’s position could, without further inquiry or investigation, load them out onto

the installation vessels and install them in the seabed. They were not delivered in such a condition and so in my judgment they were not fit for their purpose.

The approach to construction

535. It is now trite law that agreements must be construed objectively: the classic statement of the law is still that by Lord Hoffmann in *Investors Compensation Scheme Ltd v West Bromwich Building Society* [1998] 1 WLR 896, at 912, which is that a document must be given

“the meaning which the document would convey to a reasonable person having all the background knowledge which would reasonably have been available to the parties in the situation in which they were at the time of the contract.”

536. I was referred also to the recent statement by Lewison LJ in *Honda Motor Europe Ltd v Tony Powell* [2014] EWCA Civ 437, at paragraph 24:

“The task is to determine what the words of the instrument, read against the relevant background, would have meant to a reasonable reader. It is an iterative process in which possible meanings are checked against their likely consequences and the background facts. If the language is reasonably susceptible of two or more meanings, the court should choose that which best serves the object or purpose of the transaction, objectively ascertained. Any interpretation must, so far as possible, be one that is not impractical or over-restrictive or technical in practice. But three further points are of importance in this case. First, the question is not what the parties meant to say; but what is the meaning of what they did say. Second, the language that they used is likely to be the most important factor, unless the court can conclude that something has gone wrong with the language. Third, where the parties have themselves defined their own terms, the court must give effect to those definitions.”

537. However, what the parties said in their pre contractual negotiations are matters to which the court can pay only very limited regard and in certain limited circumstances. This is often referred to as “the exclusionary rule”. Again, one of the classic statements of the rule comes from Lord Hoffmann in *Chartbrook Ltd v Persimmon Homes Ltd* [2009] UKHL 38, at paragraph 28 and onwards:

“28. The rule that pre-contractual negotiations are inadmissible was clearly reaffirmed by this House in *Prenn v Simmonds* [1971] 1 WLR 1381, where Lord Wilberforce said (at p 1384) that earlier authorities “contain little to encourage, and much to discourage, evidence of negotiation or of the parties’ subjective intentions.” It is clear that the rule of inadmissibility has been established for a very long time. In *Inglis v John Buttery & Co* (1878) 3 App Cas 552, 577 Lord Blackburn said that Lord Justice Clerk Moncreiff (at (1877) 4 R 58, 64) had laid down a principle which was nearly accurate but not quite when he said that in all mercantile contracts “whether they be clear and distinct or the reverse, the Court is entitled to be placed in the position in which the parties stood before they signed”. The only qualification Lord Blackburn made was to reject Lord Moncreiff’s view that the Court was entitled to look at the pre-contractual negotiations because unless one did so, one could not be fully in the position in which the parties had been.

29. Instead, Lord Blackburn preferred (at p. 577) the opinion of Lord Gifford ((1877) 4 R 58, 69-70):

“Now, I think it is quite fixed - and no more wholesome or salutary rule relative to written contracts can be devised - that where parties agree to embody, and do actually embody, their contract in a formal written deed, then in determining what the contract really was and really meant, a Court must look to the formal deed and to that deed alone. This is only carrying out the will of the parties. The only meaning of adjusting a formal contract is, that the formal contract shall supersede all loose and preliminary negotiations - that there shall be no room for misunderstandings which may often arise, and which do constantly arise, in the course of long, and it may be desultory conversations, or in the course of correspondence or negotiations during which the parties are often widely at issue as to what they will insist on and what they will concede. The very purpose of a formal contract is to put an end to the disputes which would inevitably arise if the matter were left upon verbal negotiations or upon mixed communings partly consisting of letters and partly of conversations. The written contract is that which is to be appealed to by both parties, however different it may be from their previous demands or stipulations, whether contained in letters or in verbal conversation. There can be no doubt that this is the general rule, and I think the general rule, strictly and with peculiar appropriateness applies to the present case.”

...

38. Like Lord Bingham, I rather doubt whether the ICS case produced a dramatic increase in the amount of material produced by way of background for the purposes of contractual interpretation. But pre-contractual negotiations seem to me capable of raising practical questions different from those created by other forms of background. Whereas the surrounding circumstances are, by definition, objective facts, which will usually be uncontroversial, statements in the course of pre-contractual negotiations will be drenched in subjectivity and may, if oral, be very much in dispute. It is often not easy to distinguish between those statements which (if they were made at all) merely reflect the aspirations of one or other of the parties and those which embody at least a provisional consensus which may throw light on the meaning of the contract which was eventually concluded. But the imprecision of the line between negotiation and provisional agreement is the very reason why in every case of dispute over interpretation, one or other of the parties is likely to require a court or arbitrator to take the course of negotiations into account. Your Lordships’ experience in the analogous case of resort to statements in Hansard under the rule in *Pepper v Hart* [1993] AC 593 suggests that such evidence will be produced in any case in which there is the remotest chance that it may be accepted and that even these cases will be only the tip of a mountain of discarded but expensive investigation. *Pepper v Hart* has also encouraged ministers and others to make statements in the hope of influencing the construction which the courts will give to a statute and it is possible that negotiating parties will be encouraged to improve the bundle of correspondence with similar statements.

...

40. In his judgment in the present case, Briggs J thought that the most powerful argument against admitting evidence of pre-contractual negotiations was that it would be unfair to a third party who took an assignment of the contract or advanced money on its security. Such a person would not have been privy to the negotiations and may have taken the terms of the contract at face value. There is clearly strength in this argument, but it is fair to say that the same point can be made (and has been made, notably by Saville LJ in *National Bank of Sharjah v Dellborg* [1997] EWCA Civ 2070, which is unreported, but the relevant passage is cited in Lord Bingham’s paper in the *Edinburgh Law Review*) in respect of the admissibility of any form of

background. The law sometimes deals with the problem by restricting the admissible background to that which would be available not merely to the contracting parties but also to others to whom the document is treated as having been addressed. Thus in *Bratton Seymour Service Co Ltd v Oxborough* [1992] BCLC 693 the Court of Appeal decided that in construing the articles of association of the management company of a building divided into flats, background facts which would have been known to all the signatories were inadmissible because the articles should be regarded as addressed to anyone who read the register of companies, including persons who would have known nothing of the facts in question. In *The "Starsin" (Homburg Houtimport BV v Agrosin Private Ltd* [2004] 1 AC 715) the House of Lords construed words which identified the carrier on the front of a bill of lading without reference to what it said on the back, on the ground that the bankers to whom the bill would be tendered could not be expected to read the small print. Ordinarily, however, a contract is treated as addressed to the parties alone and an assignee must either inquire as to any relevant background or take his chance on how that might affect the meaning a court will give to the document. The law has sometimes to compromise between protecting the interests of the contracting parties and those of third parties. But an extension of the admissible background will, at any rate in theory, increase the risk that a third party will find that the contract does not mean what he thought. How often this is likely to be a practical problem is hard to say. In the present case, the construction of the agreement does not involve reliance upon any background which would not have been equally available to any prospective assignee or lender.

41. The conclusion I would reach is that there is no clearly established case for departing from the exclusionary rule. The rule may well mean, as Lord Nicholls has argued, that parties are sometimes held bound by a contract in terms which, upon a full investigation of the course of negotiations, a reasonable observer would not have taken them to have intended. But a system which sometimes allows this to happen may be justified in the more general interest of economy and predictability in obtaining advice and adjudicating disputes. It is, after all, usually possible to avoid surprises by carefully reading the documents before signing them and there are the safety nets of rectification and estoppel by convention. Your Lordships do not have the material on which to form a view. It is possible that empirical study (for example, by the Law Commission) may show that the alleged disadvantages of admissibility are not in practice very significant or that they are outweighed by the advantages of doing more precise justice in exceptional cases or falling into line with international conventions. But the determination of where the balance of advantage lies is not in my opinion suitable for judicial decision. Your Lordships are being asked to depart from a rule which has been in existence for many years and several times affirmed by the House. There is power to do so under the Practice Statement (Judicial Precedent) [1966] 1 WLR 1234. But that power was intended, as Lord Reid said in *R v National Insurance Comrs, Ex p Hudson* [1972] AC 944, 966, to be applied only in a small number of cases in which previous decisions of the House were "thought to be impeding the proper development of the law or to have led to results which were unjust or contrary to public policy". I do not think that anyone can be confident that this is true of the exclusionary rule.

42. The rule excludes evidence of what was said or done during the course of negotiating the agreement for the purpose of drawing inferences about what the contract meant. It does not exclude the use of such evidence for other purposes: for example, to establish that a fact which may be relevant as background was known to the parties, or to support a claim for rectification or estoppel. These are not exceptions to the rule. They operate outside it."

538. A little later, the approach to the exclusionary rule was restated by the Supreme Court in *Oceanbulk Shipping & Trading SA v TMT Asia Limited* [2010] UKSC 44, where Lord Clarke said, at paragraphs 37-39:

“37. As Lord Hoffmann himself put it in para 14 of his speech in *Chartbrook Ltd v Persimmon Homes Ltd* [2009] UKHL 38, [2009] AC 1101, in every case in which the interpretation of the language used in the contract is in issue, the question is what a reasonable person having all the background knowledge which would have been available to the parties would have understood them to be using the language in the contract to mean. In *Chartbrook* the House of Lords considered and rejected the submission that what at para 42 Lord Hoffmann called the exclusionary rule, which excludes evidence of what was said or done in the course of negotiating an agreement for the purpose of drawing inferences about what the contract means, should now be abolished. It accordingly remains part of English law. The exclusionary rule does not exclude such evidence for all purposes. Lord Hoffmann put it thus in para 42:

"It does not exclude the use of such evidence for other purposes: for example, to establish that a fact which may be relevant was known to the parties, or to support a claim for rectification or estoppel. These are not exceptions to the rule. They operate outside it."

38. It is not in dispute that, where negotiations which culminate in an agreement are not without prejudice, the exclusionary rule applies to the correct approach to the construction of the agreement. Nor is it in dispute that in those circumstances evidence of the factual matrix is admissible as an aid to interpretation even where the evidence formed part of the negotiations. The distinction between objective facts and other statements made in the course of negotiations was clearly stated by Lord Hoffmann in para 38 of *Chartbrook*:

"Whereas the surrounding circumstances are, by definition, objective facts, which will usually be uncontroversial, statements in the course of pre-contractual negotiations will be drenched in subjectivity and may, if oral, be very much in dispute."

39. Trial judges frequently have to distinguish between material which forms part of the pre-contractual negotiations which is part of the factual matrix and therefore admissible as an aid to interpretation and material which forms part of the pre-contractual negotiations but which is not part of the factual matrix and is not therefore admissible. This is often a straightforward task but sometimes it is not. In my opinion this problem is not relevant to the question whether, where the pre-contractual negotiations that form part of the factual matrix are without prejudice, evidence of those negotiations is admissible as an aid to construction of the settlement agreement. The two questions are, as I see it, entirely distinct.”

539. In the recent decision of *Arnold v Britton* [2015] UKSC 36 the Supreme Court took a rather harder approach to the construction of contracts. Lord Neuberger, with whom Lords Sumption and Hughes agreed, said, at paragraphs 14-23:

“14. Over the past 45 years, the House of Lords and Supreme Court have discussed the correct approach to be adopted to the interpretation, or construction, of contracts in a number of cases starting with *Prenn v Simmonds* [1971] 1 WLR 1381 and culminating in *Rainy Sky SA v Kookmin Bank* [2011] UKSC 50; [2011] 1 WLR 2900.

15. When interpreting a written contract, the court is concerned to identify the intention of the parties by reference to "what a reasonable person having all the background knowledge which would have been available to the parties would have understood them to be using the language in the contract to mean", to quote Lord Hoffmann in *Chartbrook Ltd v Persimmon Homes Ltd* [2009] UKHL 38, [2009] 1 AC 1101, para 14. And it does so by focussing on the meaning of the relevant words, in this case clause 3(2) of each of the 25 leases, in their documentary, factual and commercial context. That meaning has to be assessed in the light of (i) the natural and ordinary meaning of the clause, (ii) any other relevant provisions of the lease, (iii) the overall purpose of the clause and the lease, (iv) the facts and circumstances known or assumed by the parties at the time that the document was executed, and (v) commercial common sense, but (vi) disregarding subjective evidence of any party's intentions. In this connection, see *Prenn* at pp 1384-1386 and *Reardon Smith Line Ltd v Yngvar Hansen-Tangen (trading as HE Hansen-Tangen)* [1976] 1 WLR 989, 995-997 per Lord Wilberforce, *Bank of Credit and Commerce International SA (in liquidation) v Ali* [2002] 1 AC 251, para 8, per Lord Bingham, and the survey of more recent authorities in *Rainy Sky*, per Lord Clarke at paras 21-30.

16. For present purposes, I think it is important to emphasise seven factors.

17. First, the reliance placed in some cases on commercial common sense and surrounding circumstances (eg in *Chartbrook*, paras 16-26) should not be invoked to undervalue the importance of the language of the provision which is to be construed. The exercise of interpreting a provision involves identifying what the parties meant through the eyes of a reasonable reader, and, save perhaps in a very unusual case, that meaning is most obviously to be gleaned from the language of the provision. Unlike commercial common sense and the surrounding circumstances, the parties have control over the language they use in a contract. And, again save perhaps in a very unusual case, the parties must have been specifically focussing on the issue covered by the provision when agreeing the wording of that provision.

18. Secondly, when it comes to considering the centrally relevant words to be interpreted, I accept that the less clear they are, or, to put it another way, the worse their drafting, the more ready the court can properly be to depart from their natural meaning. That is simply the obverse of the sensible proposition that the clearer the natural meaning the more difficult it is to justify departing from it. However, that does not justify the court embarking on an exercise of searching for, let alone constructing, drafting infelicities in order to facilitate a departure from the natural meaning. If there is a specific error in the drafting, it may often have no relevance to the issue of interpretation which the court has to resolve.

19. The third point I should mention is that commercial common sense is not to be invoked retrospectively. The mere fact that a contractual arrangement, if interpreted according to its natural language, has worked out badly, or even disastrously, for one of the parties is not a reason for departing from the natural language. Commercial common sense is only relevant to the extent of how matters would or could have been perceived by the parties, or by reasonable people in the position of the parties, as at the date that the contract was made. Judicial observations such as those of Lord Reid in *Wickman Machine Tools Sales Ltd v L Schuler AG* [1974] AC 235, 251 and Lord Diplock in *Antaios Cia Naviera SA v Salen Rederierna AB (The Antaios)* [1985] AC 191, 201, quoted by

Lord Carnwath at para 110, have to be read and applied bearing that important point in mind.

20. Fourthly, while commercial common sense is a very important factor to take into account when interpreting a contract, a court should be very slow to reject the natural meaning of a provision as correct simply because it appears to be a very imprudent term for one of the parties to have agreed, even ignoring the benefit of wisdom of hindsight. The purpose of interpretation is to identify what the parties have agreed, not what the court thinks that they should have agreed. Experience shows that it is by no means unknown for people to enter into arrangements which are ill-advised, even ignoring the benefit of wisdom of hindsight, and it is not the function of a court when interpreting an agreement to relieve a party from the consequences of his imprudence or poor advice. Accordingly, when interpreting a contract a judge should avoid re-writing it in an attempt to assist an unwise party or to penalise an astute party.

21. The fifth point concerns the facts known to the parties. When interpreting a contractual provision, one can only take into account facts or circumstances which existed at the time that the contract was made, and which were known or reasonably available to both parties. Given that a contract is a bilateral, or synallagmatic, arrangement involving both parties, it cannot be right, when interpreting a contractual provision, to take into account a fact or circumstance known only to one of the parties.

22. Sixthly, in some cases, an event subsequently occurs which was plainly not intended or contemplated by the parties, judging from the language of their contract. In such a case, if it is clear what the parties would have intended, the court will give effect to that intention. An example of such a case is *Aberdeen City Council v Stewart Milne Group Ltd* [2011] UKSC 56, 2012 SCLR 114, where the court concluded that "any ... approach" other than that which was adopted "would defeat the parties' clear objectives", but the conclusion was based on what the parties "had in mind when they entered into" the contract (see paras 17 and 22).

23. Seventhly, reference was made in argument to service charge clauses being construed "restrictively". I am unconvinced by the notion that service charge clauses are to be subject to any special rule of interpretation. Even if (which it is unnecessary to decide) a landlord may have simpler remedies than a tenant to enforce service charge provisions, that is not relevant to the issue of how one interprets the contractual machinery for assessing the tenant's contribution. The origin of the adverb was in a judgment of Rix LJ in *McHale v Earl Cadogan* [2010] EWCA Civ 14, [2010] 1 EGLR 51, para 17. What he was saying, quite correctly, was that the court should not "bring within the general words of a service charge clause anything which does not clearly belong there". However, that does not help resolve the sort of issue of interpretation raised in this case."

540. Lord Hodge, who also agreed with Lord Neuberger, said this, at paragraphs 76-77:

"76. This conclusion is not a matter of reaching a clear view on the natural meaning of the words and then seeing if there are circumstances which displace that meaning. I accept Lord Clarke's formulation of the unitary process of construction, in *Rainy Sky SA v Kookmin Bank* [2011] 1 WLR 2900, para 21:

"[T]he exercise of construction is essentially one unitary exercise in which the court must consider the language used and ascertain what a reasonable person, that is a person who has all the background knowledge which would reasonably have been available to the parties in the situation in which they were at the time of the contract, would have understood the parties to have meant. In doing so the court must have regard to all the relevant surrounding circumstances. If there are two possible constructions, the court is entitled to prefer the construction which is consistent with business common sense and to reject the other."

77. This unitary exercise involves an iterative process by which each of the rival meanings is checked against the provisions of the contract and its commercial consequences are investigated (*Re Sigma Finance Corp* ([2009] UKSC 2) [2010] 1 All ER 571, para 12 per Lord Mance). But there must be a basis in the words used and the factual matrix for identifying a rival meaning. The role of the construct, the reasonable person, is to ascertain objectively, and with the benefit of the relevant background knowledge, the meaning of the words which the parties used. The construct is not there to re-write the parties' agreement because it was unwise to gamble on future economic circumstances in a long term contract or because subsequent events have shown that the natural meaning of the words has produced a bad bargain for one side. The question for the court is not whether a reasonable and properly informed tenant would enter into such an undertaking. That would involve the possibility of re-writing the parties' bargain in the name of commercial good sense. In my view, Mr Morshead's formulation (para 67 above), on which his case depends, asks the court to re-write the parties' leases on this illegitimate basis."

My conclusion on the meaning of the waiver letter

541. A proposition from which neither side dissents is that a claim by Fluor for the costs of "*additional work required as a result of the D scanning and other GGOWL testing requirements*" could only be made successfully if it could show that GGOWL had instructed Fluor - either expressly or by necessary implication - to carry out the work and the work was outside the scope of its contractual obligations. Or, alternatively, that the additional work was necessary as a result of a breach of contract by GGOWL.
542. In my view it follows from this that ordinarily Fluor would not be entitled to make a claim for work that it had carried out in anticipation of such an instruction or in order to avoid such an instruction being given. As I have already mentioned, this was the view of Mr Dekker when he was seeking to provoke GGOWL into issuing NCR 008 in respect of Shipment 2. That is because the NCR would be the instruction that would justify the claim.
543. So, as a matter of contractual allocation, there was not one indivisible "pot" of costs, as ZPMC put it, because Fluor and ZPMC would always have had to identify the costs that they claimed were caused by the relevant instructions. In my view, it is those costs that are the "*substantial additional costs*" referred to in the opening paragraph of the waiver letter. I therefore reject ZPMC's case that, on a true construction of the waiver letter, the waiver given by Fluor extended to all costs attributable to enhanced testing and consequent repairs as a result of allegedly defective welding even if they were not the result of the issue of the NCRs (or a breach of contract).

544. Although it is true that, at the various meetings, there were broad statements about neither side making claims against the other, it was always understood that there would be no binding agreement unless and until its terms had been reduced to writing and approved by both parties. Following the meeting of 2 October 2009 Fluor made it quite clear to ZPMC that no agreement was in place. It was not until early 2010 that the concept of an assignment of ZPMC's claims to Fluor was introduced into the dialogue.
545. However, it was in my view equally the case that both parties were acting on the assumption that the enhanced testing regime and consequent repairs to each shipment were made necessary by the issue of the relevant NCR. ZPMC made it clear from an early stage that it did not accept that the enhanced testing was required by the contract: for example, by its letter of 16 June 2009. At no stage thereafter could Fluor have thought otherwise.
546. As for Fluor, its stated position was the same: see its letter to GGOWL dated 1 October 2009 (extracts from which I have set out above). Mr Dekker said that he had arrived at that conclusion by mid-July 2009, evidence that I accept.
547. Accordingly, I find that it was the common understanding of the parties in June 2010 that the enhanced testing and remediation of each shipment required by the NCR for that shipment was to be regarded as the result of the relevant NCR. Whether or not Fluor privately took the view that it would have carried out the enhanced testing and remediation in any event is, for the purposes of the construction of the waiver letter, irrelevant.
548. It seems to me that this case demonstrates vividly the wisdom of Lord Hoffmann's observations in *Chartbrook*, particularly at paragraph 38. It is very difficult to distinguish between things said at meetings by way of aspiration and those said by way of provisional agreement. The important fact is that both parties always intended that any agreement should be set out in writing, and that is what happened. The writing in this case is the waiver letter and the warranty letter. That was the contractual bed that the parties made. In my judgment they must now lie on it - for better or worse, richer or poorer.

Summary: did the enhanced testing and remediation result from the NCRs?

NCR 006

549. I can now deal with this shortly. The evidence of Mr Hovermale to which I have already referred left me in no doubt that the enhanced testing using D scans on the welds at Vlissingen, together with the consequent repairs, was the result of the issue of NCR 006. It is hardly surprising that the NCR followed the discovery of some cracks, because had they not been discovered the NCR would not have been issued.
550. The evidence of Mr Hovermale made it clear that the issue of NCR 006 was "*the driver*" for the testing and remediation of Shipment No 1 MPs and therefore the cause of it. Accordingly, Fluor's claim in relation to the enhanced testing and remediation at Vlissingen for Shipment No 1 MPs which was required by NCR 006 has been waived by the agreement in the waiver letter.

NCR 008

551. The position here is different. Shipment No 2 arrived at Vlissingen on 29 June 2009. It must be the case that any enhanced testing and remediation that was implemented in relation to Shipment No 2 following its arrival must have been on Fluor's instructions because the NCR in relation to Shipment No 2, NCR 008, was not issued for another month.
552. Fluor implemented this regime because it felt, understandably and reasonably, that that such testing might well reveal a similar degree of cracking to that found in the Shipment No 1 and, if it did not, GGOWL would carry out similar testing itself and that the results will be similar to those found in Shipment No 1. So, whilst it may be that, in one sense, the enhanced testing of Shipment No 2 was prompted by the issue of NCR 006 - in that Fluor feared a repetition in the case of the second shipment also, the fact is that NCR 006 was expressly limited to the "1st shipment". Fluor could not have made a claim against GGOWL on the basis that NCR 006 constituted an instruction to carry out enhanced testing and remediation in relation to Shipment No 2 for the simple reason that it was not such an instruction.
553. The reality was that, in implementing a similar testing and remediation regime in relation to Shipment No 2, Fluor was mitigating its loss in the event that the need for this work was the result of ZPMC's breach of contract. It must have known that it was most unlikely that GGOWL would agree to the MPs and TPs in Shipment No 2 being installed without having been tested by inspectors appointed by GGOWL - as proved with the case when Mr Dekker tried to call GGOWL's bluff in mid July 2009.
554. I find therefore that the additional testing and remediation that was applied to Shipment No 2 between 29 June and 29 July 2009 was the result of ZPMC's breaches of contract in failing to achieve the standard of workmanship that the contract required. It was not the result of issue NCR 008 (or, indeed, NCR 006).
555. However, on 29 July 2009 GGOWL issued NCR 008. Thereafter there were two causes of the enhanced testing and remediation of Shipment No 2 MPs: Fluor's initial decision to carry it out and GGOWL's instruction to do so in the form of NCR 008. It was only the costs that followed the issue of the latter that could form the basis of a claim against GGOWL (as Mr Dekker understood only too well).
556. Accordingly, subject to any argument based on estoppel, Fluor is entitled to recover from ZPMC (and subject to any contractual limitation or exemption) the costs of or consequent on the testing and remediation of Shipment No 2 that it incurred prior to 29 July 2009. The costs incurred after 29 July and required by NCR 008 fall within the terms of the waiver letter and therefore Fluor cannot recover them from ZPMC.

NCR 009

557. Shipment No 3 arrived in Vlissingen on 1 August 2009. On 4 August 2009 GGOWL arranged for tests to be carried out on the MPs of Shipment No 3. These were carried out by Sonovation, another independent tester appointed by GGOWL, and the results were reported to Fluor the following day, 5 August 2009. Defects were found on ground welds using D scan - a procedure that fell within the testing procedures agreed between Fluor and ZPMC.

558. On 7 August 2009 GGOWL issued NCR 009. The reasons that I have already given in relation to the first two NCRs apply equally to this one. Mr Dekker made it clear in evidence that he wanted to provoke GGOWL into issuing an NCR for Shipment No 2 so that Fluor would have a contractual basis for a claim against GGOWL in relation to the costs of the enhanced testing and remediation. The same reasoning must apply to NCR 009: without it, Fluor would have no basis for making a claim against GGOWL in respect of the same costs for Shipment No 3.
559. Accordingly, I find that the costs of the enhanced testing and remediation in relation to Shipment No 3 MPs after the issue of NCR 009 on 7 August 2009 fall within the terms of the waiver letter and are therefore not costs that Fluor can recover from ZPMC. The costs that Fluor incurred in relation to additional testing and repair of Shipment No 3 prior to 7 August 2009 - whether in Shanghai or Vlissingen - can, subject to any estoppel, form the subject of a claim against ZPMC.

Estoppel

Estoppel by convention – the law

560. Both parties referred me to a helpful recent summary of the law relating to estoppel by convention by Akenhead J in *Mears Limited v Shoreline Housing Partnership Limited* [2015] EWCH 1396, where he said:

“49. From the cases, one can conclude that the relevant law on estoppel by convention is:

- (a) An estoppel by convention can arise when parties to a contract act on an assumed state of facts or law. A concluded agreement is not required but a concluded agreement can be a "convention".
- (b) The assumption must be shared by them or at least it must be an assumption made by one party and acquiesced in by the other. The assumption must be communicated between the parties in question.
- (c) At least the party claiming the benefit of the convention must have relied upon the common assumption, albeit it will almost invariably be the case that both parties will have relied upon it. There is nothing prescriptive in the use of "reliance" in this context: acting upon or being influenced by would do equally well.
- (d) A key element of an effective estoppel by convention will be unconscionability or unjustness on the part of the person said to be estopped to assert the true legal or factual position. I am not convinced that "detrimental reliance" represents an exhaustive or limiting requirement of estoppel by convention although it will almost invariably be the case that where there is detrimental reliance by the party claiming the benefit of the convention it will be unconscionable and unjust on the other party to seek to go behind the convention. In my view, it is enough that the party claiming benefit of the convention has been materially influenced by the convention; in that context, Goff J at first instance in the Texas Bank case described that this is what is needed and Lord Denning talks in these terms.
- (e) Whilst estoppel cannot be used as a sword as opposed to a shield, analysis is required to ascertain whether it is being used as a sword. In this context, the position of the party claiming the benefit of the estoppel as claimant or indeed as defendant is not determinative or does not even raise some sort of presumption one way or the other. While a party cannot in terms found a cause of action on an estoppel, it may, as a result of being able to rely on an estoppel, succeed on a cause

of action on which, without being able to rely on the estoppel, it would necessarily have failed.

(f) The estoppel by convention can come to an end and will not apply to future dealings once the common assumption is revealed to be erroneous.

I accept this as a correct statement of the law and I do not consider it necessary or helpful to cite any further authority in relation to the general principle.

561. It is, I think, well established that for an estoppel to arise the promise or assumption must be clear and unequivocal: see *Woodhouse AC Israel Cocoa v Nigerian Produce Marketing Co* [1972] AC 741, at 755-6, 761, 762 and 771. The passages that I have already cited from the speech of Lord Hoffmann in *Chartbrook* show that representations made during negotiations can be relied upon to found an estoppel. That is one of the two exceptions to the exclusionary rule.

Estoppel by convention – the facts

562. At the meeting held on 1 October 2009 Mr Fuller told ZPMC that “*Fluor will not look to ZPMC for liquidated damages or any of the other costs we have incurred because of this issue*”. The “*other costs*” referred to were, as he explained in cross-examination, the costs of the extra contractual testing - being the testing and repair programme that was going on in Vlissingen and, as he thought, in Shanghai also (Day 8/54). A little later in his evidence Mr Fuller amplified this explanation: he said that what he meant by “*extra contractual testing*” was the use of D scanning on top of unground welds at a higher sensitivity “*and everything else that was associated with that*” (Day 8/68).
563. On any view it is clear from this that the costs incurred by Fluor to which Mr Fuller was referring were the costs that resulted from the testing protocol - including the cost of the consequent repairs of cracks revealed by the testing - that was imposed on Fluor by GGOWL. There was never any suggestion by Fluor - at that meeting or subsequently - that its offer to waive these costs was dependent on its own belief as to the true reason for carrying out the extra contractual testing: or, to put it another way, that if Fluor would have implemented the extra contractual testing irrespective of anything said or done by GGOWL, then the waiver would not apply.
564. Thus in my judgment the costs that Fluor incurred in respect of the extra contractual testing required by an NCR for the relevant shipment were costs that it had promised to waive, and that both parties proceeded on the assumption that that was the basis on which they would go forward. That was not only what Fluor said to ZPMC but also what it, according to Mr Fuller’s evidence, believed to be the case.
565. It is, I accept, quite possible that ZPMC treated the promised waiver as extending to all the costs incurred by Fluor at Vlissingen, and at Changxing also, that were a consequence of the welding defects, regardless of whether or not they were the consequence of the issue of an NCR or some other conduct by GGOWL. However, that is a view, if held, that cannot survive the clear wording of the waiver letter. What Fluor agreed to waive in the letter was any claim it may have against ZPMC “*for the additional costs and delays it suffered as a result of the NCRs*”. In my view that

cannot be read as including costs that it suffered which were not required by or could not be linked directly to the issue of an NCR.

566. What in my view Fluor is estopped from contending is that its conduct in carrying out the extra contractual testing of a particular shipment that was required by an NCR for that shipment was not caused by the NCR but by its own independent decision to carry out that testing. As it happens, I have already found that, in relation to Shipment Nos 1 and 3 all, or almost all, of the extra contractual testing and remedial work to the MPs was, as a matter of fact, the result of the issue of the NCR and not of any independent decision by Fluor.
567. However, Shipment No 2 falls to be treated differently because that is a case where Fluor had embarked on the extra contractual testing of the shipment without there being an NCR for that shipment in place. In my view, the doctrine of estoppel cannot be invoked to prevent Fluor from asserting, correctly I find as a matter of fact, that the extra contractual testing for that shipment that was carried out until 29 July 2009 was not the result of the issue of an NCR. By contrast, Fluor is in my view estopped from contending that the extra contractual testing required by NCR 008 that it carried out on Shipment No 2 after 29 July 2009 was not caused by NCR 008.
568. In these circumstances I consider that ZPMC has made out its case for estoppel by convention to the extent that I have indicated.

Estoppel by representation– the law

569. Akenhead J also considered estoppel by representation in *Mears Limited v Shoreline Housing Partnership Limited* [2015] EWCH 1396, at paragraph 50, where he said:

“Estoppel by representation may in some cases overlap with estoppel by convention but it is, in legal terms, distinct. *Wilken and Ghaly* (The Law of Waiver, Variation, and Estoppel 3rd Ed) summarise the elements of this estoppel at Paragraph 9.01 by reference to two parties A and B as follows:

“First, A makes a false representation of fact to B . . . Second, in making the representation, A intended or knew that it was likely to be acted upon . . . , B, believing the representation, acts to its detriment in reliance on the representation. Fourth, A subsequently seeks to deny the truth of the representation. Fifth, no defence to the estoppel can be raised by A”.

They go on to say at Paragraph 9.04 that the “weight of authority favours the view that estoppel by representation is a rule of evidence rather than of substantive law”. The doctrine does not, in itself, amount to a cause of action. The authors consider that representations of present intention can give rise to estoppel by representation but that representations of future intention in simple terms will not at least usually give rise to such estoppel due to running foul of the contractual doctrine of consideration (see for instance Paragraph 9.26). They accept that representations of mixed fact and law may give rise to an estoppel by representation. The editors of *Spencer Bower on The Law Relating to Estoppel by Representation* (4th Ed) go somewhat further and suggest that an estoppel by representation of law may now be raised, quoting *Kleinwort Benson Ltd v Lincoln CC* [1999] 2 AC 349 and [1999] 2 Lloyd's Rep 159.”

Estoppel by representation– the facts

570. In this case I do not consider that the representation made by Fluor, namely that the costs that it was proposing to waive were those incurred as a result of the extra contractual testing imposed by GGOWL, was false - rather it was a representation that was inconsistent with the position that it now seeks to adopt. But I do not consider that that prevents ZPMC from asserting that there has been a valid estoppel by representation.
571. Since I have concluded that this is a case where ZPMC can rely on the doctrine of estoppel by convention, the question of estoppel by representation does not arise. Nevertheless, essentially for the same reasons, I consider that ZPMC can rely on this doctrine also in order to prevent Fluor from contending to the same extent that the extra contractual testing that was carried out at Vlissingen was done on its own initiative and not as a result of the issue of any of the NCRs.

Conclusions

572. The extensive cracking in weld repairs discovered at Vlissingen was the result of breaches by ZPMC of its obligations under the PO.
573. As a result of the presence of this cracking the MPs and TPs on delivery at Vlissingen were not fit for the purpose of being installed forthwith without either further examination, testing and repair or a satisfactory Engineering Critical Assessment indicating that repairs were not necessary and that the MPs and TPs would, from a structural point of view, perform satisfactorily in service for 25 years. That was a purpose for which they were required by Fluor.
574. The testing and repair of the welds in each of Shipment Nos 1-3 that was required by the issue of an NCR for that shipment was carried out as a result of that NCR.
575. The testing and repair of the MPs (and TPs, if any) in Shipment No 2 that was carried out by Fluor prior to 29 July 2009 was carried out at its own initiative and was not the result of the issue of an NCR. The same is the case in relation to Shipment Nos 1 and 3 if and to the extent that testing and/or repair was carried out before the issue of the NCR for that shipment.
576. In any event, Fluor has waived its claim against ZPMC in respect of the costs of the testing and repair of the MPs and TPs of each of Shipment Nos 1-3 at Vlissingen to the extent that such testing and repair was required by an NCR issued in respect of that shipment. Alternatively, Fluor is now estopped from contending the contrary.
577. Fluor has not waived its claim in respect of the testing and repair of the MPs and TPs in Shipment No 2 that were carried out prior to 29 July 2009 (and similarly in relation to any testing and/or repair carried out to MPs and TPs of the other two shipments that was carried out prior to the issue of the NCR for that shipment).
578. NCRs 006, 008 and 009, on their face, referred only to the welding of the MPs. Fluor's letter of 25 June 2009 indicating an intention to backcharge ZPMC for the reworking required at Vlissingen referred only to the MPs of Shipment No 1: there was no reference to work to any TPs, although Fluor reserved the right to make

further claims. I have heard no evidence as to the extent, if at all, to which any of the NCRs required, either expressly or by implication, testing or repair of TPs. The opening paragraph of the waiver letter referred to the “*weld testing and repair protocol required by [GGOWL]*” (see paragraph 477 above).³⁷

579. I must therefore leave open for further argument the issue of whether costs of testing or repairing any TPs was required - either expressly or by necessary implication - by any of the three NCRs and, if so, to what extent. This includes the question of whether or not it is open to Fluor to take this point.
580. For ease of reference, a summary of my findings of fact is set out in Appendix B to this judgment. In the event of any apparent conflict between the summary set out in Appendix B and the principal judgment, the latter is to prevail.

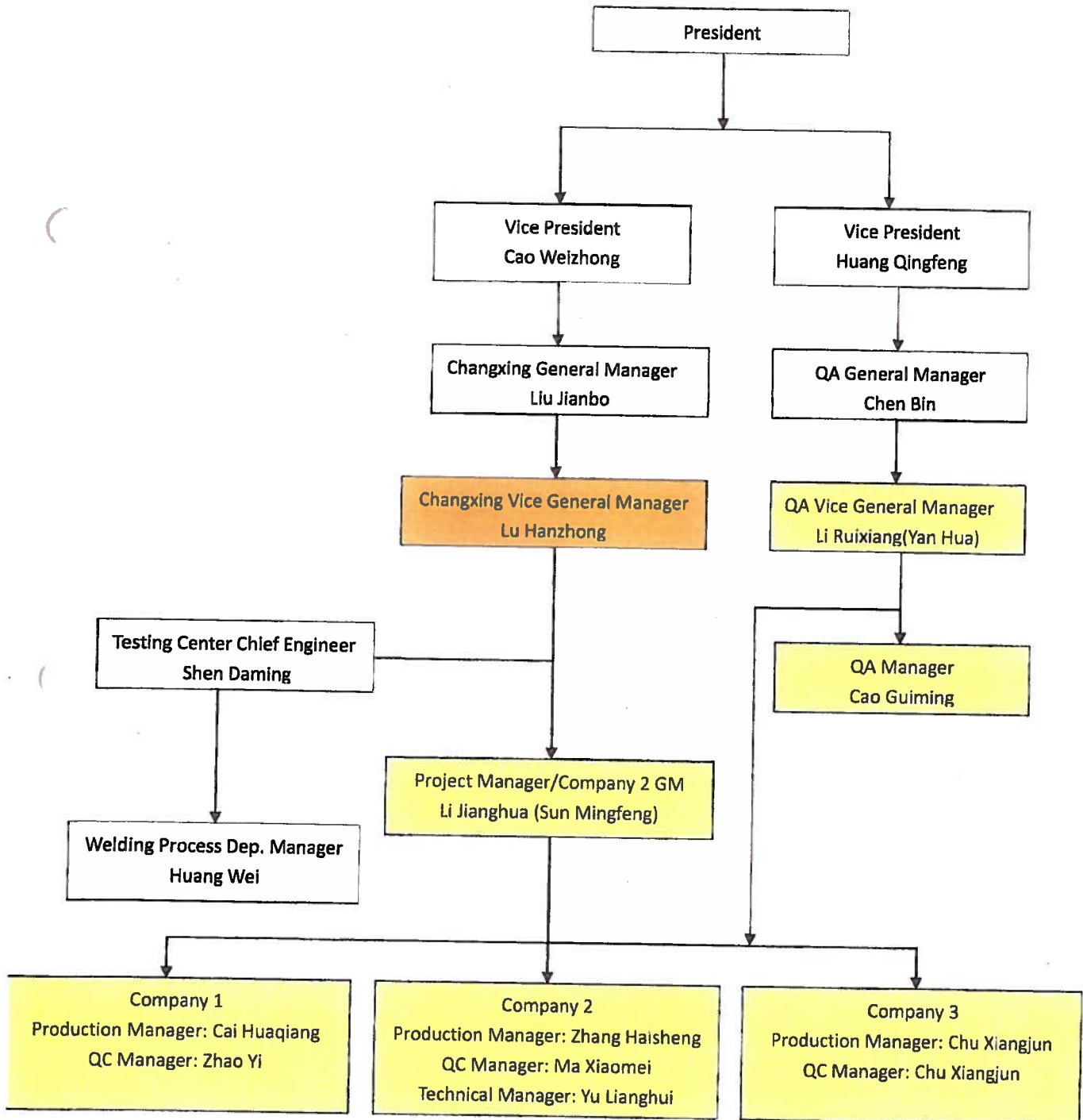
Disposal

581. There must be judgment for Fluor, with damages to be assessed in the light of the findings set out in this judgment and any further findings which it may be necessary to make in order to dispose finally of all questions of damages.

³⁷ In the context of the NCRs, during neither the openings nor the evidence was any distinction drawn by either party between the MPs and the TPs. It was not until a responsive submission by Fluor dated 27 June 2016 that it was asserted that “*the NCRs did not extend to the TPs*”. In response, ZPMC said in a submission dated 8 July 2016 that no distinction had been drawn by the parties between the costs referable to the MP defects as opposed to the TP defects, and that no one had ever suggested that any distinction should be drawn when construing the waiver and warranty letters. ZPMC submitted that it was too late to take the point now.

Attachment 2

Organization Chart for the Wind Farm Project



APPENDIX B TO JUDGMENT

FLUOR LTD v SHANGHAI ZHENUA HEAVY INDUSTRY CO LTD

	Finding or conclusion	Para in judgment
(1)	A steel fabricator would have to give careful consideration to the question whether or not the preheat temperature stated in Table 3.2 should be increased for a repair weld in steel of the same thickness.	102
(2)	The onus was on ZPMC to select a preheat temperature that was appropriate to the conditions in which a particular type of weld was to be carried out.	112
(3)	Where a particular type of repair will necessarily be carried out under conditions different from the production weld - for example, a different degree of restraint - good practice would require the preparation and approval of a designated WPS for that type of repair.	114
(4)	It was ZPMC's duty to prepare an appropriate WPS, which would be required to specify preheat and interpass temperatures that were appropriate for repair welds in thick plates.	121
(5)	For repair welds using Supercored 71H in plates that were 65 mm thick or greater, ZPMC should have prepared a WPS for repair welds that specified a preheat temperature of 150°C.	122 206
(6)	Mr Dove's annotations on the proposed critical weld repair procedure did not make any material difference to the procedure actually adopted by ZPMC when carrying out repair welds from then onwards. Mr Dove's rejection on 28 January 2009 of the proposed critical weld repair procedure did not excuse or relieve ZPMC from its obligation to devise an appropriate WPS for non-critical weld repairs.	140 257
(7)	There is no reason to question the criticisms that Mr Dove and Mr Hardie made at the time of their visits to Changxing in late 2008 and early 2009. At the start of this project ZPMC was on a very steep learning curve.	149

(8)	The indications which were identified at Vlissingen reasonably justified a further investigation.	153
(9)	As a matter of principle it was for ZPMC to adopt a method of preheating that would achieve the temperature requirements laid down by the code and, all other factors being satisfactory, would produce a sound weld.	177
(10)	Section 5.6 of AWS D1.1 is to be construed in the manner contended for by Dr Dolby.	184
(11)	Without close supervision, the use of handheld gas torches could produce regions under the area being repaired that would be significantly cooler than the temperature at the surface. By contrast, if preheat was applied to the surface opposite from that being welded there would be a much more uniform heat distribution through the plate thickness underneath the repair groove so that the heat sink effect would be negligible.	189
(12)	During the first six months or so of fabrication (October 2008 to March 2009, perhaps longer) there were many instances where the preheating of the base metal prior to welding was either insufficient or uneven.	190 204
(13)	On thick material the temperature had to be measured on the opposite side to that to which the heat was being applied.	205
(14)	ZPMC should have adopted a preheat temperature of 150°C.	206
(15)	The problems encountered by ZPMC in achieving successful repair welds was very largely the result of inadequate preheating and the specification of a preheat temperature, 110°C, which was too low.	210
(16)	The majority of the transverse cracks discovered at Vlissingen were cracks in repair welds carried out using FCAW.	220
(17)	Those cracks had to be repaired unless and until an Engineering Critical Assessment (“ECA”) had been carried out and had shown that the piles were fit for installation in their as delivered condition.	220 221
(18)	There is no evidence to support the suggestion that cracking occurred at Vlissingen when a preheat temperature of 150°C was used.	245

(19)	It is impossible to draw a conclusion as to whether cracking at Vlissingen was prevented by the use of a higher preheat temperature, 150°C, or the use of post heating, or a combination of both.	245
(20)	The August 2015 tests provide no satisfactory evidence that a preheat temperature of 150°C, properly applied, would not have been sufficient to prevent transverse cracking. On the contrary, they provide some basis for concluding that, if applied to the opposite side of the plate from that being welded, a preheat temperature of 150°C might have been sufficient.	255
(21)	Conclusions as to the causes of the transverse cracking.	256
(22)	The various different UT scanning patterns are not different <u>methods</u> of NDT: for the purpose of the standard, they are UT.	279
(23)	If an operator is certain that what he is seeing is, for example, a crack, then he can reject the flaw forthwith without needing to seek an independent examination by a second operator.	286
(24)	From a contractual point of view RFI 34 left ZPMC free to choose whether it carried out UT before or after grinding.	291
(25)	<p>It was not only open to ZPMC to increase the extent of the NDT by adding a requirement for D scans to be carried out in addition to E scans but also that, under paragraph 405, it was obliged to do so if that was necessary to ensure that “<i>all relevant defects are discovered in the areas of concern</i>”. However, there is an important qualification: in this event the D scanning to be carried out would have to be in accordance with a technique laid down in the agreed written procedures.</p> <p>. . . an increase in the extent of the NDT that did not require a change to the agreed process would not require the consent of the customer.</p> <p>ZPMC’s failure to carry out D scans on ground welds and its failure to notify senior management within ZPMC that cracks were being found by “<i>riding on the welds</i>” was a breach of paragraph 405 of the DNV standard and of ZPMC’s workmanship obligations under the PO.</p>	<p>300</p> <p>298</p> <p>300</p>
(26)	It is an incident of the duty to exercise reasonable skill and care in carrying out the prescribed processes that the contractor will bring to the attention of the employer any	306

	shortcomings in the methods of NDT or procedures chosen which have become apparent and to propose alternative procedures of which the contractor is or ought reasonably to be aware that will enable a type of defect that has become apparent to be detected.	
(27)	If, where frequent repairs were being carried out, ZPMC became aware of the occurrence of cracking that was not always being detected by E scanning, but which could be detected by D scanning, then it became obliged to submit a proposal to adopt a different method of NDT or, alternatively, different UT procedures so as to identify the cracks. Its failure to do so was a breach of its workmanship obligations under the PO.	307
(28)	Until he received the e-mail from Mr Edwards on 6 April 2009, Mr Estabrook was unaware of the fact that D scans might detect the existence of transverse cracks that were not seen with an E scan.	327
(29)	It has not been shown that knowledge of the fact that transverse cracks were being found by D scanning that were not being found by E scanning spread outside branch company 3 until early or mid May 2009, by which time it was known to Fluor also.	329
(30)	If ZPMC's shop managers became aware of the occurrence of cracking that was not always being detected by E scanning, but which could be detected by D scanning, they should have reported this up the line.	332
(31)	If the production or QC management in branch company 3 knew that the NDT testing procedure that they were having to adopt in order to detect cracking was not in accordance with the agreed procedures, and if they knew that the other two branch companies were not using such scanning method, they should have raised the matter with their superior management. If that had happened, it would have been the duty of the superior management to raise the matter with Fluor and submit an appropriate proposal for the modification of either the procedures or the methods of NDT.	332
(32)	ZPMC's failure to make a formal report of the fact that cracks could be found by D scanning which were not found by E scanning, or to do so in a manner that ensured that the point was understood, was a breach of contract because making such a report was a necessary step in the carrying out of the work in a workmanlike manner.	333

(33)	ZPMC's submission that Mr Yuan's e-mail of 20 January 2009 showed that Fluor, through its inspectors SGS, was aware of transverse cracking in the welds in early 2009 and of the fact that D scanning could detect such cracks in circumstances where E scanning did not, was not justified.	351
(34)	The obligation to report problems on site under section 8 of the Purchase Order arose only when there was an actual or potential problem in meeting a delivery date.	354
(35)	Fluor's reliance on clause 5.26.3 of AWS D1.1 and clause 5.4 of the Weld Repair Procedure was misconceived.	362
(36)	Prior to the anticipated shipment date of Shipment No 1, there was no clear understanding at middle to senior management level within ZPMC that there was a widespread problem with transverse cracking which was likely to cause delays to the schedule.	371
(37)	Fluor has not proved its case that ZPMC was in breach of any duty to notify Fluor of any problems under section 8 of the Purchase Order.	373
(38)	NCR 006 effectively put a stop to any plans for the imminent loading out of Shipment No 1 and imposed a testing and repair regime that Fluor would not otherwise have countenanced.	401
(39)	The reason why the MPs of Shipment No 2 were not loaded out and installed during July 2009 following delivery to Vlissingen on 29 June 2009 was Fluor's doubts about their quality and, in particular, whether the likely presence of cracking would affect their ability to fulfil the 25 year life.	426
(40)	After the issue of NCR 008 on 27 July 2009, the MPs in Shipment No 2 had to be re-tested and repaired where necessary in accordance with the NCR so that the costs incurred as a result were the result of the issue of the NCR.	426
(41)	The costs of subsequent testing and repairs of Shipment No 3 MPs after 7 August 2009 were incurred as a result of the issue of NCR 009.	430
(42)	At the meeting on Thursday, 1 October 2009, the reference to " <i>both parties bear their own expenses, respectively</i> " refers to the expenses that were caused by the "extra contractual testing".	448
(43)	There was a meeting between Mr Dobbs and Mr Guan in November/December 2009, but no agreement was reached	468-469

	at it.	
(44)	Summary of matters known to or understood by both parties as at mid February 2010.	474
(45)	At the meeting on 20 April 2010 Mr Fuller did nothing intentionally to mislead ZPMC.	482
(46)	The authority of the Board was required to enable ZPMC to give the 25 year warranty because it was “ <i>abnormal</i> ”, whereas authority to waive claims did not require the approval of the Board.	508
(47)	Fluor’s letter of 14 October 2011 did not affect the true construction of the waiver letter or defeat any plea of estoppel.	511
(48)	It was the common understanding of the parties in June 2010 that the enhanced testing and remediation of each shipment that was required by an NCR for that shipment was to be regarded as the result of the relevant NCR.	547
(49)	Fluor is estopped from contending that its conduct in carrying out the extra contractual testing of a particular shipment following the issue of an NCR for that shipment was not caused by the NCR but by its own independent decision to carry out that testing.	566