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**Datasheet for the decision
of 7 February 2019**

Case Number: T 1562/13 - 3.2.05

Application Number: 07114962.9

Publication Number: 2028402

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E21B17/042

Language of the proceedings: EN

Title of invention:

Method for improving fatigue resistance of a threaded joint

Patent Proprietor:

Tenaris Connections B.V.

Opponent:

Vallourec Oil and Gas France

Relevant legal provisions:

EPC 1973 Art. 54(1), 56

EPC Art. 123(2)

Keyword:

Inventive step - main, first and second auxiliary request (no)
Amendments - third auxiliary request - added subject-matter
(yes)



Beschwerdekammern

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Case Number: T 1562/13 - 3.2.05

D E C I S I O N
of Technical Board of Appeal 3.2.05
of 7 February 2019

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Decision under appeal: **Interlocutory decision of the Opposition
Division of the European Patent Office posted on
7 May 2013 concerning maintenance of the
European Patent No. 2028402 in amended form.**

Composition of the Board:

Chairman M. Poock
Members: T. Vermeulen
T. Bokor

Summary of Facts and Submissions

- I. Both the patent proprietor and the opponent lodged an appeal against the interlocutory decision of the opposition division finding that the European patent No. 2 028 402 (hereinafter: "the patent") amended according to the first auxiliary request met the requirements of the EPC.
- II. In the opposition proceedings, the grounds for opposition according to Article 100(a) EPC 1973 (lack of novelty and lack of inventive step) and Article 100(b) EPC 1973 were raised. The opposition division held that the subject-matter of claim 1 according to the main request (patent as granted) was not novel.
- III. Oral proceedings were held before the board of appeal on 7 February 2019.
- IV. The appellant I (proprietor) requested that the decision under appeal be set aside and the opposition be rejected as main request, or alternatively that the patent be maintained in an amended form on the basis of one of the auxiliary requests 1 to 3 filed with letter dated 8 January 2018, or further alternatively on the basis of any of the auxiliary requests 4A/B to 7A/B filed with letter dated 10 January 2019. The auxiliary requests 4A/B to 7A/B were subsequently withdrawn during the oral proceedings.

The appellant II (opponent) requested that the decision under appeal be set aside, and that the patent be revoked.
- V. The following documents are referred to in the present decision:

- E1 US 2003/0102669 A1;
- E2 US 6 174 000 B1;
- E3 EP 0 713 952 A1;
- E4 EP 1 296 088 A1;
- E15 EP 1 726 861 A1;
- E24 "Fatigue Resistant Threaded and Coupled Connectors: The New Standard for Deep Water Riser Applications" by Sches et al, Proceedings of the 26th International Conference on Offshore Mechanics and Arctic Engineering, June 10-15 2007, San Diego, California, USA;
- E25 "Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads (U.S. Customary Units)", API Specification Standard 5B, 14th edition, August 1996, pages 9-11 and page 2 of addendum 1 with effective date September 2004;
- E28 "Stress Analysis of Premium Threaded Connection "FOX" by Finite Element Method" by Yamamoto et al, Kawasaki Steel Technical Report No. 22, May 1990.

VI. Claim 1 according to the main request (patent as granted) reads as follows (the feature numbering used hereinafter is introduced in square brackets):

"**[M1]** Method for make up of a threaded joint **[M2]** wherein there is provided a male threaded tube (2), defined as pin, and a female threaded tube (3), defined as box, the pin being provided with a first abutment shoulder, the box being provided with a second abutment shoulder, first and second abutment shoulders having complementary shape, the pin being adapted to be made up in the box, **[M3]** thread roots of either pin or box

and corresponding thread crests of the other one of pin and box have a radial interference, **[M4]** measured according to the nominal dimensions of the pin and box, comprised between 1% and 5% of the average thickness of the joint

the method comprising the steps of

[M5] a) inserting the threaded portion of pin into the threaded portion of box [*sic*]

[M6] b) applying a torque for making up the pin in the box until first and second abutment shoulders abut,

[M7] c) applying an extra torque **[M8]** until a magnitude between 50% and 90% of the steel's yield strength in the most stressed part of the joint is reached."

VII. Claim 1 according to auxiliary request 1 corresponds to claim 1 according to the main request except for an amended feature M4 (the added wording is highlighted in bold by the board):

"**[M4a]** measured according to the nominal dimensions of the pin and box, comprised between 1% and 5% of the average thickness of the joint, **the joint having a surface treatment comprising shot peening**, the method comprising the steps of".

VIII. In claim 1 according to auxiliary request 2 the feature M4 has been further amended to read (the added wording with respect to claim 1 according to the main request is highlighted in bold by the board):

"**[M4b]** measured according to the nominal dimensions of the pin and box, comprised between 1% and 5% of the average thickness of the joint, **the joint having a surface treatment comprising shot peening being applied to the beginning and end of the threaded zone of the pin**, the method comprising the steps of".

IX. With respect to claim 1 according to the main request, feature M4 of claim 1 according to auxiliary request 3 was amended in the following manner (the added wording is highlighted in bold by the board):

"**[M4c]** measured according to the nominal dimensions of the pin and box, comprised between 1% and 5% of the average thickness of the joint, **the joint having a surface treatment comprising shot peening being only applied to the beginning and end of the threaded zone of the pin,** the method comprising the steps of"

X. Appellant I (patent proprietor) argued in writing and during the oral proceedings essentially as follows:

Novelty (Main Request)

There was no link in document E1 between the thread type of figure 1 and the threads used in the abutment-type joints shown in figures 2 and 3 that form the basis of the tests referred to in table 2. The API standard referred to in paragraph [0004] related to a joint without torque shoulder (see figure 6 of document E25), contrary to figures 2 and 3 of document E1, and did not prescribe that a radial interference is required. This was illustrated by figures 1 and 8 of document E2, which showed different types of trapezoidal thread geometries all complying with the API standard, but having flank-to-flank interference. Documents E3 and E4 referred to buttress threads which did not have a root-to-crest interference. Not only the thin line passing through the centre of the teeth in figure 3 of document E1, but also the mention of the "thread effective diameter" in paragraph [0055] and the equations cited in document E1 implied that the interference was calculated on the pitch line and was

therefore caused by a contact between the flanks of the respective protrusions on the pin and box threads. When the effective diameter of the pin thread increased, the trapezoidal shaped teeth on that thread were "pushed" radially into the corresponding grooves of the box thread, causing the flanks of the trapezoidal teeth to press harder against the corresponding flanks of the box grooves without there being any contact between crests and roots. This was similar to what happened with the threads disclosed in documents E2, E3 and E4, each of which contained a reference to the effective diameter of the thread when calculating interference between respective flanks. The reference to a trapezoidal thread in table 1 of document E1 was made without any further qualification. There were other types of trapezoidal threads with different dimensions. As a consequence, feature M3/M4 was not known from document E1.

The method step b) of feature M6 was only partially known from document E1. The tests of document E1 were not made by bringing together the shoulder portion 13 with the bearing surface 23. The possible contact mentioned in [0005] was only to avoid excessive tightening. In document E1 a torque was required only to overcome the thread interference.

Furthermore, the method step c) of claim features M7 and M8 was not known from document E1. Paragraph [0056] mentioned "a uniform tightening torque", therefore there was no extra torque. The measured stress value B in table 2 appeared to be reached by means of a uniform tightening without any abutment taking place. There was no reference in the document E1 to an abrupt increase of make-up torque suggesting an abutment. Comparing the experiments of table 2, the small incremental

difference in stress values between the different tests meant that this was only due to a difference in interference, i.e. a different inclination of the segment a-b of the curve shown in figure 3 of the patent. In order to design such threaded joints, the skilled person would carry out computer simulations in an iterative manner and test every part of the joint, so that the most stressed part for every design could be determined. This followed from document E28, which proved that at the filing date it was common general knowledge to use Finite Element Analysis tools to determine the location and magnitude of stresses in the threaded joint during make-up. For a joint of the type shown in figure 3 of document E1 the skilled person would have expected high stresses inside the pin nose 13, with values that were probably higher than the stress values given in table 2. Unless such information was explicitly explained in a document, which was not the case for document E1, one could not just assume that the most stressed region of the threaded joint would be the outer face of the coupling, where tests 7 and 8 showed high stress values.

Inventive Step (Main Request)

Document E15 would be a more suitable starting point than document E1, which failed to mention the problem of fatigue. A skilled person wanting to improve the resistance against stress corrosion of a joint did not automatically strive to improve its fatigue life.

Starting from document E1, however, there would have been no reason to arrive at claim feature M3/M4. In comparison to figure 1 and figure 6 of document E25, figures 2 and 3 of document E1 disclosed a different type of thread with a torque shoulder and with

interference between contacting tooth flanks, which caused completely different stress fields that altered the response of the threaded joint. This was clear from the equations and from the paragraphs [0041] and [0055].

Concerning claim feature M8, the test samples 7 and 8 of table 2 could not form the basis for the inventive step discussion because document E1 already indicated that they produced values outside the range of the invention. Moreover, the document failed to give further information about stresses in other zones of the joint, which could be higher than on the outer surface of the coupling. If the skilled person had used available tools to calculate the stress in any point of a joint when operative loads were applied, it would have become clear that other zones had higher stresses than the outer surface. As to any subsequent action following step c) in claim 1, paragraphs [0033], [0034] and [0039] of the patent stated that the extra torque was "final". There was no reason to think that the skilled person would exert a torque beyond the point "f" in the torque curve. The skilled person in this particular field of the invention belonged to the group of threaded joints design engineers and was not an operator who would have made up the pipes provided with the threaded joints.

Auxiliary Requests

Claim 1 according to auxiliary request 1 was based on a combination of granted claims 1 and 2 and included the step of shot peening, which had a surprising effect on the increase of fatigue life of the threaded joint. In claim 1 of auxiliary request 2, based on a combination of granted claims 1, 2 and 3, the shot peening was

applied to the beginning and the end of the threaded zone, which linked the treatment to those threaded parts that experienced the highest load. The basis for these amendments in the original application were found in claims 3 and 4. Contrary thereto, the sample of figure 1 of document E15 underwent a shot peening treatment on its entire surface including the middle portion.

To overcome a potential objection that the middle part of the thread were not deemed to be excluded by the wording "*to the beginning and end*", claim 1 according to auxiliary request 3 additionally included the word "*only*", for which the basis could be found in paragraphs [0048] and [0049] of the original application.

- XI. The arguments presented by appellant II (opponent) in writing and during the oral proceedings can be summarised as follows:

Novelty (Main Request)

The subject-matter of claim 1 according to the main request was not novel over document E1. Paragraph [0004] of document E1 described a conventional API thread of the STD5B type in conjunction with figure 1, which inherently had interference between the crests and roots, as could be deduced from figure 6 of E25. Figure 2 combined that thread with an axial abutment. According to paragraphs [0031] and [0055], the thread joint seen in figure 3 and used in the tests described in document E1 had to be the same as that of figure 2. This was confirmed by Table I, according to which a "trapezoidal thread" with a "1/16" taper was used in the tests. The different test samples merely differed

from each other by the effective diameter of the thread without changing the cross-sectional geometry of the teeth. Increasing the interference of a joint by altering the effective diameter of a thread having trapezoidal teeth implied that radial interference between the crests and corresponding roots was involved (feature M3/M4). The thread type shown in figure 8 of E2 was of the triangular type, which belonged to a different standard than the one referred to in paragraph [0004] of document E1.

As to features M6 and M7, figure 3 clearly showed an abutment between 13 and 23. A contact was necessary in order for the joint to be used. Once this contact was made, the joint was tightened ([0011], [0032], [0056]) to ensure the seal. In addition, it was not sufficient to stop making-up at the moment when the shoulders contacted. Furthermore, the description in the contested patent of the torque curve and the meaning of the inflection point "b" proved that this was known (paragraph [0031]: "state of the art joint", "customary practice").

Regarding feature M8, the torque values at make-up of test samples 7 and 8 were clearly higher than 50% and lower than 90% of the yield strength given in table 1. As document E1 aimed to minimise the maximum constraints in the joint but failed to mention the stress situation in the shoulder or at the teeth, the most stressed part was not defined and could be any portion of the joint, including the outer surface thereof.

Inventive step (Main Request)

The most promising starting point was document E1. Regarding the alleged difference of the absence of radial interference, for which no technical effect was given in the contested patent, it would have been obvious for the person skilled in the art to look for alternatives and try out threads with different interference types. As the document already mentioned a buttress-type thread in connection with figure 1, it would have been logical to select such a thread, in particular since the figures did not suggest any difference in thread type. In addition, the skilled person took from documents E24 and E28, both submitted by appellant I, that radial interference between crests and roots was a well-known measure in connection with fatigue oriented design (cf. last paragraph on page 3 in document E24 and point 3.2.2 in E28). E3 also disclosed a thread of the type API STD5B together with an abutment shoulder (cf. page 2, line 39). In respect of the most stressed part, it could be assumed from document E1 that this would have been the outside surface. Alternatively, the skilled person would have looked for and constrained those parts that experienced more stress. Step c) of claim 1 did not actually impede a further make-up torque to be exerted, in which case it was inevitable that at some stage the stress in the most stressed part inside the joint would have taken a value within the claimed range. The test results of samples 7 and 8 in table 2 of document E1 could not be disregarded because they experienced stress corrosion under conditions of use, not during make-up. For those reasons, no inventive step was involved.

Auxiliary Requests

Both the patent and the description of document E15 referred to *fatigue* in the context of shot peening

treatment. Taking account of this prior art teaching, claims 1 of auxiliary request 1 could not define an inventive subject-matter. The wording "*to the beginning and end*" in claim 1 of auxiliary request 2 did not exclude any intermediate portion, so that this feature could not add anything inventive.

Both auxiliary requests 2 and 3 comprised added subject-matter in violation of Article 123(2) EPC. The amendment of the second auxiliary request was not only a combination of granted claims but also involved a reformulation. In paragraph [0049] of the patent, the amendment "*to the beginning and end*" was preceded by "*more specifically*", which had a different meaning than "*only*". In addition, this paragraph referred to the previous paragraph where a further phosphatising step was disclosed.

Reasons for the Decision

1. The appeal is admissible.

Main Request

2. *Novelty*
 - 2.1 Figure 3 of document E1 shows a threaded joint consisting of a male threaded pin 11 and a female threaded box 20. A first abutment shoulder 13 formed at an axial end of the pin and a second abutment shoulder 23 on the inner surface of the box have a complementary shape. The threaded joint is made up by inserting the threaded portion 12 of the pin into the threaded portion 22 of the box. Hence, claim features M1, M2 and

M5 are known from document E1. This is not disputed by the parties.

- 2.2 During make-up of the threaded joint, a torque is applied until first and second shoulders 13, 23 abut. This follows from paragraphs [0015] and [0031], according to which the bearing surface 23 contacts the shoulder portion 13.

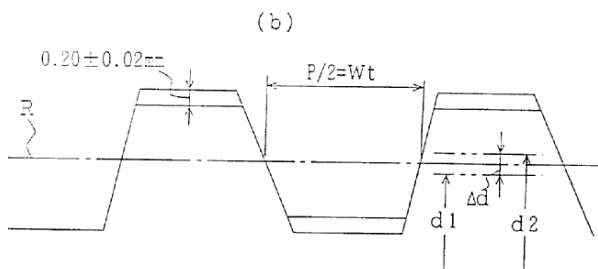
The argument raised by appellant I that an abutment at the shoulder portion 13 is not unambiguously disclosed in document E1 cannot be followed by the board. The contact mentioned in paragraphs [0015] and [0031] as well as the depiction of the unthreaded shoulder portion 13 as a "*torque shoulder*" in paragraphs [0026], [0029] and [0031] can only mean that the pin and box come into abutment during make-up. Moreover, it is well-known that the primary role of torque shoulders in threaded joints is to preload the joint so that it remains rigid under various load conditions. This only makes technical sense when an additional torque is applied after the shouldering position is reached, corresponding to segment "b-c" of the torque curve 10 shown in figure 3 of the contested patent. The mere fact that document E1 remains silent about an abrupt increase in torque does not imply that make-up terminates at the inflection point "b" of the torque curve. Also, a comparison of the stress values B in Table 2 of document E1 cannot lead to this conclusion, since the "uniform tightening torque" mentioned in paragraph [0056] must include an additional shoulder torque for *each* of the eight test samples, irrespective of the slope of the interference segment "a-b" in the corresponding torque curves. The function of the bearing surface 23 can therefore not be reduced to a

safety stop preventing unwanted axial movements of the pin.

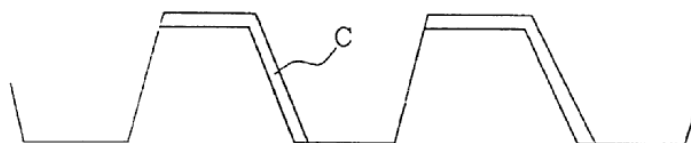
As a consequence, the board holds that document E1 discloses features M6 and M7.

2.3 The threaded portions 12 and 22 of the joint shown in figure 3 of document E1 have an amount of interference T (cf. paragraphs [0015] and [0035]). In order to determine the effect of the interference on the stress corrosion in the joint, paragraphs [0054] until [0061] of document E1 describe a series of tests that were carried out with interferences varying between 0.219 mm (test sample 1) and 0.519 mm (test sample 8). With an outer diameter D_3 of 194.33 mm and an inner diameter D_1 of 154.78 mm (cf. table I and figure 3), the average thickness of the joint must be $(D_3 - D_1)/2 = 19.78\text{mm}$, which means that the respective interferences of the eight test samples amount to 1.1%, 1.5%, 1.6%, 2.1% and 2.6% with respect to the average thickness of the joint. Each of these values lies well inside the claimed range.

Nonetheless, document E1 fails to disclose which type of interference is present in the threaded portion of the respective test samples. Table 1 indicates that the threaded joint used in the tests has a trapezoidal thread shape. The trapezoidal threads on the pin either interfere with the trapezoidal threads on the box through contacting flank surfaces (flank-to-flank interference, whereby a clearance is left between the facing tooth crests and roots), as in figure 1 of document E2 reproduced below,



or they interfere through mutual contact between the roots of one thread and the crests of the other thread (root-to-crest interference), as in figure 10 of document E2 reproduced below.



In both interference types, the degree of interference is typically controlled by pre-setting the effective diameter of the thread on the pin with respect to the effective diameter of the thread on the box. Therefore, contrary to the assertion of appellant II, the wording of paragraph [0055] ("*varying the thread effective diameter*") does not permit to conclude which type of interference is used.

The details of the prior art joint according to figure 1 of document E1, and in particular the mention of "*a buttress type having a trapezoidal thread prescribed by STD5B of the API (American Petroleum Institute) standards*" in paragraph [0004], are not automatically transferable to the threaded joints of figures 2 and 3. Unlike figures 2 and 3, figure 1 shows a threaded joint of the type *without* an abutment shoulder, which is therefore substantially different in construction when compared with the joint of figure 3 on which the tests of table 2 were carried out. Therefore, the information

in paragraph [0004] does not necessarily mean that the threaded joints of figures 2 and 3 also have a buttress thread. Moreover, the board is not convinced that the particulars "thread taper - 1/16" and "thread shape - trapezoidal thread" in table 1 of document E1 establish a compelling link between the embodiment of figure 3 and the prior art thread type of figure 1. The taper of a threaded joint is the decrease in effective diameter of the threaded surface along the axial direction of the joint. A thread with trapezoidal cross-section and a taper of 1/16 is common for oil well pipe joints (see for example figures 6, 7 and 9 of document E2; page 7, line 41 of document E3) and is completely independent of the type of interference used. Hence, there is no explicit or implicit disclosure of the type of interference used in the threaded joint of figure 3.

In conclusion, feature M3 in combination with feature M4 (hereinafter: M3/M4) is not disclosed by the embodiment shown in figure 3 of document E1.

2.4 On page 7 of the decision under appeal the opposition division concluded the following in respect of feature M8:

"Without any definition in the contested patent itself it is thus totally unclear what limitations this feature [the board notes: feature M8] infers to the threaded joint of claim 1 of the contested patent. If such limitations are rather unclear by the contested patent itself, the opponent's view has to be followed that the region of most stress is in E1 on the outer surface of the coupling until otherwise proved by the patent proprietor, which is not the case here."

It seems that the opposition division *de facto* ignored the expression "in the most stressed part" in feature M8. Still, the wording of claim 1 of the main request is unequivocal: it excludes that other parts of the threaded joint develop higher stresses than that part which is taken to be the most stressed part.

In the example described in paragraphs [0054] to [0061] of document E1 the threaded joint of figure 3 was tested with eight different "amounts of thread interference T" caused by varying the thread effective diameter of the male thread of the pin portion at the basic diameter position. After making up the threaded joints with a uniform tightening torque the stress acting on the coupling outer surface was calculated and measured for each joint, both at the time of make-up (values A resp. B in table 2) and under conditions of use (values E resp. F in table 2), see paragraph [0056].

The board agrees with the conclusion of the opposition division on page 7 of the decision under appeal that, in order to make technical sense, the heading of table 2 should read "Stress on outer surface of coupling (kgf/mm²)" (emphasis added by the board), instead of the obviously erroneous dimension of (kgf/cm²). This follows both from the values of σ_y , E and P_i given in table 1 and from the statement in paragraph [0061], which implies that the thread interference T of the test samples 7 and 8 yields a stress on the outer surface of the coupling under conditions of use that exceeds the yield strength σ_y of the base metal.

With the value of the yield strength $\sigma_y = 76.98 \text{ kgf/mm}^2$ (or 755 MPa) taken from table 1 and the measured stress values B at make-up given in table 2, the ratio between

the stress acting on the coupling outer surface and the yield strength amounts to $17.7/76.98 = 23\%$ for test sample 1. For the test samples 2-6 this ratio is 17%, 37%, 37%, 43%, 43%, respectively, i.e. below the lower limit of the claimed range in feature M8. For test samples 7 and 8, on the other hand, the stress on the outer surface amounts to 56% resp. 54% of the yield strength. This means that the threaded joints with an interference of 0.509 mm or 0.519 mm are made-up by applying an extra torque until a magnitude between 50% and 90% of the steel's yield strength is reached on the outer surface of the coupling.

Whether the outer surface of the coupling is the most stressed part during make-up cannot be answered on the basis of the example of document E1 alone. This may be the case under particular conditions of use, but seems very unlikely during assembly of the oil tube strings, where peak stress values are typically reached near the thread roots and in the region of the abutment shoulder. Even if it is plausible to assume that at least the test samples 7 and 8 yield peak stress values in the joint that exceed the corresponding stress values given in table 2 so that a magnitude of more than 50% of the yield strength is also reached in the most stressed part of the joint, the board is left in the dark as to whether or not these peak stress values exceed the upper limit of 90% of the yield strength.

As a consequence, feature M8 is not unambiguously disclosed in document E1.

- 2.5 With the claim features M3/M4 and M8 not being disclosed in document E1, the subject-matter of claim 1 is novel (Article 54(1) and (2) EPC 1973).

3. *Inventive Step*

3.1 Document E1 as Starting Point

As established above, document E1 discloses a method for making up a threaded joint, which has the technical features M1, M2 and M5 to M7 in common with the claimed subject-matter. The prior art document is concerned with controlling the stress level with respect to the material's yield strength. Its aim of reducing stress corrosion is also mentioned in paragraph [0002] of the patent.

In contrast, document E15 essentially deals with surface treatment. The fatigue fracture strength of a threaded joint is improved by treating its surface through shot peening. The threaded joint mentioned in paragraph [0042] of document E15 has a buttress-type threaded shape with a metal seal and shoulder. However, nothing is said about making up the joint or about any stress levels reached at the joint during said process. In addition, there is no mention of any interference.

The board therefore concludes that document E1 and in particular the embodiment of figure 3 (described in paragraphs [0054] to [0061]) is a more suitable starting point than document E15 for assessing the inventive merit of the claimed subject-matter.

3.2 Technical Problem

Paragraph [0042] of the patent teaches that lower stress concentrations are produced by the feature M3/M4. The skilled person knows that the main component of the contact forces between threads with a root-to-crest interference is in the radial direction, normal to the

surface of the crests and roots, so that this type of interference causes high radial loads. According to paragraph [0013], both the reduced stress concentrations and the higher radial loads improve the fatigue resistance of the threaded joint.

The patent does not include any reference to a possible technical effect associated with feature M8. In fact, apart from a reference to claim 1 in paragraph [0012], there is no mention at all in the patent description of the "most stressed part of the joint". The example given in paragraph [0033], however, illustrates that the lower limit of 50% serves to differentiate the final torque of a customary make-up operation from the extra torque of claim 1. Therefore, the technical effect of the lower limit of the range claimed in feature M8 is the same as that of feature M7, i.e. to provide "*an additional axial energisation*" to the joint (cf. paragraph [0028]), which basically amounts to tightening the joint beyond what is presumed to be customary practice. Paragraphs [0013], [0029] and [0040] of the patent cite the high shoulder load as a factor that improves fatigue resistance. The meaning of the upper limit of the range can be deduced from the context of paragraph [0039], according to which "*As a general rule neither normal torque nor Δ torque exceeds the yielding strength of the material in the shoulder region*". Setting the upper limit at 90% instead of at 100% builds in a margin of safety that makes sure the joint is not overtightened so that local plastic deformation is avoided and the fatigue life is not affected.

The objective technical problem is thus to improve the fatigue resistance.

3.3 Skilled Person

The "method for make up of threaded joint" of claim 1 is clearly directed at an operator who is generally responsible for assembling a tube string for a hydrocarbon well. However, in view of the highly automated nature of this work, where the actual repetitive and high precision demanding aspects are typically carried out by a computer programmed power tong, the operator cannot be assumed to be acquainted with interference levels and stress constraints within the threaded joint. The expertise of those persons who design the threaded joint and who program the power tong in function of the details of the threaded joint is crucial. In real life, the operator will have recourse to this expertise as soon as a problem concerning the actual make-up occurs, be it related to the operation of the tong or to the handling of the threaded joint. Hence, in accordance with established case law (see "Case Law of the Boards of Appeal", 8th edition 2016, I.D.8.1.2) the board regards the "skilled person" in the present case to be a group of people including the operator and the engineer who designs the threaded joint, and possibly also the supplier of the power tong.

3.4 Obviousness

3.4.1 Starting from the example shown in figure 3 and described in paragraphs [0054] to [0061] of document E1, the skilled person will have to make some choices regarding the thread on the pin and box portions. The design engineer knows that only limited options are available to build in interference in case of a trapezoidal thread: either the protruding trapezoids engage the mating trapezoidal recesses, resulting in a

flank-to-flank interference, or the crests of the protruding trapezoids come into contact with the roots of the mating recesses, which produces a root-to-crest interference.

The board has no doubt that threads with either type of interference are well known to the skilled person mentioned above. In this respect, the patent confirms in paragraph [0031] that the thread type with root-to-crest interference *"is usual in many state of the art joints"*.

As established under 'Novelty' (cf. point 2.3 above), the only information contained in document E1 regarding the type of interference can be found in the description of the prior art in paragraph [0004]. A buttress type having a trapezoidal thread prescribed by STD5B of the API is shown in the API specification of document E25 (figure 6) and is also described in document E3 (page 2, lines 39-48 and figure 2). Such a thread type is characterised by an interference between the crest surfaces and the root surfaces. The board concurs with the appellant II that nothing in document E1 would impede the skilled person to realise the interference of the joint shown in figure 3 through a contact between roots and crests rather than between mating flanks of the trapezoidal threads. On the contrary, in absence of any further suggestions in document E1, the information found in paragraph [0004] of the document actually incites the skilled person to opt for a root-to-crest interference.

The board is not convinced by the argument of appellant I that the absence of a torque shoulder in the STD5B buttress type mentioned in paragraph [0004] implies that it cannot be used for the abutment-type joint of

figure 3. There is no doubt that the stress field in a joint is very different with or without an axial abutment, but that does not discourage the design engineer to use a thread with root-to-crest interference in combination with a torque shoulder. Examples thereof are given in document E24 (figure 2 and bottom right paragraph on page 3) and in document E28 (point 3.2.2 on page 43), both submitted by appellant I.

Contrary to the line of argumentation of appellant I, neither figure 3 of document E1 nor the equations used in the document or the wording "*thread effective diameter*" in paragraph [0055] point in the direction of a flank-to-flank interference. The board is persuaded that the thin line in figure 3 shows a pitch line, similar to line R depicted in figure 1 of document E2. As to the equations, appellant I has not provided any arguments corroborating which part of, for example, equation (1) in paragraph [0032] of document E1 would unequivocally derive from a flank-to-flank interference model. As established under 'Novelty' (cf. point 2.3 above), irrespective of the type of interference used, a variation of the effective diameter of the pin thread will have as a consequence that the trapezoidal threads either "approach" or "retreat" with respect to the box threads, hereby increasing or decreasing the contact forces between their mating surfaces. How the contact materialises only depends on the relative dimensions of the pin and box trapezoids.

- 3.4.2 The threaded joints of document E1 were made up with a uniform tightening torque (cf. paragraph [0056]), which equals the sum of the initial make-up torque of feature M6 and the extra torque of feature M7. With the aim to improve the fatigue resistance of the threaded joint,

the skilled person, initially primarily the design engineer, will attempt to avoid any onset of plastic deformation. As the fatigue constraint applies to the joint as a whole, the design engineer will not limit his analysis of the stress situation to the outer surface of the joint. Rather, he will undertake to map the stress field in the entire joint, or at least in those parts of the joint in which he knows the highest stresses occur.

Making use of well-known numerical techniques, such as finite element analysis (FEA), the design engineer will compute the stress distribution in each of the eight test samples of table 2, based on the geometry of figure 3 and on the data provided in table 1. In this context, the board notes that the footnote to table 2 refers to the test samples 7 and 8 *under conditions of use*, simulated by applying a specific internal pressure to the joints. The question of the suitability of these test samples as a starting point for the inventive step discussion of a claim defining a method for make up is therefore not considered relevant. As the design engineer knows that the highest stress concentrations for a threaded joint with a crest-to-crest interference and a torque shoulder tend to occur near the thread roots and at the torque shoulder, he will take particular care that the results in those parts of the joint are accurate, for example by locally refining the FEA mesh. As established under 'Novelty' (cf. point 2.4 above), the results presented in the column "Measured value B" of table 2 yield that the ratio of the calculated stress at the outer surface ranges from 17% to 56% of the yield strength at make-up. Since these values must be considerably smaller than the peak ratio reached during make-up near the thread roots or in the torque shoulder, it is evident that the peak ratio for

some if not for all the test samples will be higher than the claimed lower limit of 50%. As is already clear from paragraph [0012] of document E1, the design engineer has every interest to increase the thread interference in order to strongly tighten the joint. He will therefore establish at which maximum amount of interference the value of the stress in the most stressed part of the joint remains below the yield strength σ_y of the base metal and select this amount of interference for the design of his threaded joint. In point 2.3 above it was established that the amount of this preferred interference will lie inside the claimed range, as required by claim feature M4. By analysing not only the surface but also the interior of the joint, a situation is avoided in which the stress on the outer surface might remain well below the yield strength whereas a peak stress near one of the thread roots or inside the abutment shoulder would cause local plastic deformation and affect the fatigue resistance of the joint.

As inaccuracies in the numerical model, in the FEA mesh or in the boundary conditions typically misplace the exact onset of plastic deformation, the design engineer will build in a safety margin to make sure that the maximum stress does not come too close to the yield strength. In the absence of any surprising technical effect associated with a safety margin of 10%, the design engineer will readily and without any inventive capacity opt for a maximum value of 90% of the yield strength. Taking into account the safety margin put in place, the design engineer will therefore discard those test samples of table 2 where the peak stress of the threaded joint comes too close to or exceeds the yield strength.

3.4.3 Having established which design yields the best results, the design engineer will then test the design in full scale and, where necessary, repeat the numerical analysis in a series of iterative steps. With the validation of the optimised threaded joint, also the method of making up the joint will be fixed, so that the power tong can be programmed by the skilled person, for example its supplier, to carry out a precise number of turns at a certain make-up speed with a predetermined torque value per turn. At the end of the make-up process initiated and supervised by the operator, the power tong will apply a torque until a stress with a magnitude larger than 50% and smaller than 90% is reached in the most stressed part of the joint, corresponding to the values determined in the design process. In doing so, the subject-matter of claim 1 is arrived at in an obvious manner.

3.4.4 Therefore, claim 1 does not involve an inventive step (Article 56 EPC 1973).

Auxiliary Request 1

4. On page 9 of the impugned decision, the opposition remarked the following in respect of the inventive step of claim 1 according to auxiliary request 1:

"In view of the division shot peening is such a familiar surface treatment in the present technical field, see also several documents E15 par. 26, E16 col. 3 lines 38 - 44, E 17 par. 7 that there can be no reasonable doubt, that feature M9 [the board notes: the amendment to feature M4a] is rather obvious to apply to the process of claim 1."

The board concurs with the finding that shot peening is a well-known surface treatment in the technical field of threaded joints. In paragraphs [0005] and [0014] and [0026] of document E15 the advantageous effects of such a treatment on the fatigue resistance of threaded joints is mentioned. In addition, document E15 makes mention of an API buttress type thread (cf. paragraph [0016]), which is shown in figures 2 and 7, similar to those used in figure 1 of document E1.

In order to further improve the fatigue resistance of the threaded joint made-up according to the method of claim 1 according to the main request, the skilled person will therefore not hesitate to turn to document E15 and apply its teaching on the thread of document E1. Accordingly, by applying a shot peening surface treatment on the outer peripheral surface of the tapered male thread 12 of document E1 and making up the threaded joint according to claim 1 of the main request, the subject-matter of claim 1 of auxiliary request 1 will be arrived at without the involvement of an inventive step.

As a consequence, claim 1 according to auxiliary request 1 does not meet the requirements of Article 56 EPC 1973.

Auxiliary Request 2

5. *Allowability of the Amendments*

Literal basis for the amendment in feature M4b of claim 1 can be found in original claims 3 and 4 (granted claims 2 and 3). Other than some syntactic changes ("*having*", "*being*", "~~*said shot peening*~~") that are generally required when incorporating the additional

features of dependent claims in an independent claim, the board fails to see any reformulation which would have resulted in subject-matter not previously disclosed.

Therefore, the requirements of Article 123(2) EPC are met.

6. *Inventive Step*

The board is not persuaded by the argumentation of appellant I that the amendment "being applied to the beginning and end of the threaded zone" should be read in a restrictive manner to exclude an application of the surface treatment to any intermediate part of the threaded zone.

In view thereof, the objection of point 5 above also applies to claim 1 of auxiliary request 2. The pin of document E15 undergoes a shot peening treatment on the entire surface of its threaded zone including the beginning and the end.

As a consequence, claim 1 according to auxiliary request 2 does not meet the requirements of Article 56 EPC 1973.

Auxiliary Request 3

7. *Allowability of the amendments*

The shot peening surface treatment is described in paragraphs [0046] to [0052] of the published European application which led to the patent in suit. The first sentence of paragraph [0049] reads:

"In a preferred embodiment, such a surface hardening treatment is applied to the pin, which is in general more loaded than the box, and more specifically to the beginning and end of the threaded zone, which are subject to higher stress concentration."

Appellant I argues that the construction "applied ... **more specifically** to the beginning and end of the threaded zone" (emphasis by the board) is commensurate to the amendment in feature M4c that the shot peening is only applied to the beginning and end of the threaded zone of the pin.

When determining whether the amended subject-matter extends beyond the content of the application as filed, the board must assess which information was disclosed in the application, without going beyond the limits of what a skilled person would derive directly and unambiguously in an objective manner therefrom. Although the expression "more specifically" indicates a preferential application to the beginning and end of the threaded zone, it does not necessarily imply that an intermediate zone is excluded from the surface treatment. If this expression must be given some information content, it would rather be read as meaning "at least". Following the suggestion of the second sentence of paragraph [0048] that the treatment can be "applied with different magnitudes", the first sentence of paragraph [0049] could purport that the beginning and end of the threaded zone undergo a more intensive shot peening, resulting in a non-uniform build-up of residual stresses along the threaded zone. Hence, there remains a certain ambiguity as to whether the surface hardening treatment is applied to the intermediate zone of the pin thread.

Furthermore, through the use of the word "such" in the first sentence of paragraph [0049], a clear reference is made to the surface hardening treatment of the preceding paragraph, which mentions, amongst others, an additional phosphatising step. The content of this paragraph does not permit to conclude beyond any doubt whether the shot peening treatment can be carried out in this context without applying the additional phosphatising step.

Hence, the amendment "only" does not follow directly and unambiguously from the original application, so that the requirements of Article 123(2) EPC are not met.

8. As none of the requests of the patent proprietor is allowable, the patent must be revoked.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The patent is revoked.

The Registrar:

The Chairman:



K. Boelicke

M. Poock

Decision electronically authenticated