schip en werf

48ste jaargang 3 juli 1981, nr. 14

TIJDSCHRIFT VOOR MARITIEME TECHNIEK

Schip en Werf – Officieel orgaan van de Nederlandse Vereniging van Technici op Scheepvaartgebied

Centrale Bond van Scheepsbouwmeesters in Nederland

Nederlands Scheepsbouwkundig Proefstation

Verschijnt vrijdags om de 14 dagen

Redactie
Ir. J. N. Joustra, P. A. Luikenaar en
Dr. ir. K. J. Saurwalt

Redactie-adres
Heemraadssingel 193, 3023 CB Rotterdam
telefoon 010-762333

Voor advertenties, abonnementen en losse nummers
Uitgevers Wyt & Zonen b.v.
Pieter de Hoochweg 111
3024 BG Rotterdam
Postbus 268
3000 AG Rotterdam
tel. 010-762566*, aangesloten op telecopier
telex 21403
postgiro 58458

Jaarabonnement	ƒ 59,–
buiten Nederland	ƒ 96,–
losse nummers	ƒ 4,20
van oude jaargangen	ƒ 5,25

(alle prijzen incl. BTW)

Vormgeving en druk
Drukkerij Wyt & Zonen b.v.

ISSN 0036 – 6099

Omslag

Scheepvaart hield zich goed staande

Uit het jaarverslag van de Koninklijke Nederlandse Redersvereniging (KNRV) blijkt dat onze scheepvaartbedrijvers zich ondanks de voortdurende recessie goed staande hebben kunnen houden. Tijdens de toelichting op het jaarverslag kwam zelfs naar voren, dat de reders dankbaar waren gestemd jegens de Nederlandse overheid, die, zoals voorzitter ir. M. L. C. van Heeswijk het uitdrukte, erin was geslaagd om de bedrijfstak weer goed in het aandachtsveld van de openbare opinie te brengen.

Nu verwachten de reders van de in 1981 aantredende regering dat deze, om uitvoering te geven aan de motie welke dit kabinet vier jaar geleden werd voorgelegd, drie punten in vervulling zal laten gaan:

1. Per 1 januari 1982 een premie voor de investeringspremies die voor langere termijn de concurrentiepositie van schepen onder de Nederlandse vlag veilig stelt, hetgeen voor de eerstkomende jaren een niveau betekent van tenminste twintig procent van het investeringsbedrag;
2. Alle voor de ontwikkeling van de zeescheepvaart noodzakelijke faciliteiten die de regering ter beschikking kan stellen voor de versterking van de Nederlandse economie, zowel op het gebied van investeringsbevordering, financiering en fiscaliteit, als van exportbevordering, speur- en ontwikkelingsprojecten, scheepvaartpolitieke bescherming (ook in het kader van ontwikkelingssamenwerking), onderwijs en arbeidsvoorziening; en
3. Een alerte bijstelling van wettelijke bepalingen en voorschriften betreffende de operationele veiligheid van de scheepvaart aan de ontwikkelingen in technologie en moderne bedrijfsvoering, zodat wettelijke bepalingen en voorschriften geen onnodige belemmeringen vormen voor een optimalisering van de bedrijfsvoering.

Het is een waslijst die in varianten al eerder is gepresenteerd en vermoedelijk zal de nieuwe regering, waarvan ten tijde van het schrijven van dit artikel nog geen spoor te vinden was, te zijner tijd er wel eens aandacht aan schenken. Daarbij kan zij het als een positieve waarde beschouwen, dat de Nederlandse koopvaardij de moeilijke tijden tot dusver heeft kunnen trotseren, of om het in de woorden van het verslag te zeggen, dat geconstateerd is, dat de werkelijkheid in 1980 ondanks de teruggang in het zeevervoer, meegevallen is.

Tot de uitschieters naar onderen behoorde de rampzalige concurrentietoeslag in de lijnvaart op de Noord-Atlantic, waar het al jaren flink spookt. De dollar is echter sterker geworden en de daaruit voortvloeiende vermindering van de valutatoeslagen heeft de Europese reders in de kaart gespeeld. Dat de slag echter nog geenszins is geëindigd zal elke waarnemer van het strijdtoneel zonder al te veel moeite kunnen vaststellen. Een aantal rederijen zijn op de USA/Canada-vaart met een gecompliceerde manipulatie begonnen, die o.m. heeft geresulteerd in het verdwijnen van de containerschepen van de Canadian Pacific uit de haven van Rotterdam en het opgeven van de US Gulf-dienst door de Engelse Bank Line (hoewel diens directeur een jaar geleden nog verkondigde dat de kansen van overleving er nog het meest mee waren gediend, wanneer men zich niet liet verleiden tot het noteren van zelfmoordvrachtprijzen).

Nog zo'n uitschieter naar beneden was het vervoer van ruwe olie en deze situatie is er dit jaar alleen maar slechter op geworden. De vrachten zijn omlaag gevlogen en alle hoop die in het begin van het vorige jaar nog werd gekoesterd omtrent een herstel van deze markt, is nu vervlogen. Onder de gegeven omstandigheden zijn de vooruitzichten voor de Very Large Crude Carriers

Inhoud van dit nummer:

(VLCC's) somberder dan ooit; de conclusie die al eerder is getrokken, maar thans door de nieuwste ontwikkelingen wordt bevestigd, is dat de VLCC-markt aan het verdwijnen is, om misschien nooit meer terug te keren. Men kan zich afvragen of het onder deze omstandigheden van een wijs beleid getuigt om de verdieping van de geul voor de tankschepen (van 68 tot 72 vt) door te zetten.
Voor de eerstkomende jaren – aldus het verslag van de redersvereniging – wordt algemeen een stagnatie van de economische ontwikkeling in de wereld verwacht en dus ook een stagnatie van de groei in het wereldzeevervoer. Wanneer men enerzijds het nog bescheiden huidige nieuwbouworderniveau in aanmerking neemt, anderzijds de economische veroudering van belangrijke gedeelten uit de wereldvloot, alsmede de toegenomen vervoersinefficiency (ten gevolge van langzamer varen, havencongesties en politiek-structurele veranderingen in het wereldproduktie- en afzetpatroon), dan is de hoop gerechtvaardigd dat er nog geen nieuwe overcapaciteit en scheepvaartcrisis voor de deur staan.
Rederijen uit de traditioneel maritieme landen, waaronder Nederand, zullen niettemin hun handen vol hebben om hun positie te handhaven.
Ondertussen krijgt de internationale scheepvaartpolitek een steeds meer gecompliceerd karakter. Kon men in het verleden volstaan met de constatering, dat de UNCTAD-Code voor de Lijnvaartconferences ergens een regulerende invloed op de wereldscheepvaart zou hebben, thans moet men leren onderscheid te maken tussen een verscheidenheid van vormen, waartoe behoren landen en/of rederijen die zich wel aan de Code wensen te houden, andere die dat niet willen, weer andere die weliswaar de regulering afwijzen maar er niets tegen willen ondernemen, landen welke los van de Code bilaterale verdragen

KNRV-voorzitter Van Heeswijk: Scheepvaart weer terug in het aandachtsveld van de regering.

met elkaar hebben gesloten, waarin andere verdeelsleutels voorkomen dan de Code aangeeft, landen die de Code niet ver genoeg vinden gaan, en naties, die zoals de EEG een eigen interpretatie aan de Codebepalingen geven.
In 1980 werd door de Europese Commissie voortgang geboekt met het overreden van een aantal andere OESO-leden om zich aan te sluiten bij de Europese interpretatie van de Code-conventie. Voorts constateerde de Europese Commissie dat een aantal EEG-landen, hangende het van kracht worden van de conventie, overging tot het afsluiten van bilaterale overeenkomsten, voornamelijk met ontwikkelingslanden, waarbij bepalingen over de ladingsverdeling werden opgenomen.
De KNRV zegt het initiatief te steunen van de Commissie om een EEG-richtlijn uit te geven over de uitgangspunten welke bij dergelijke bilaterale verdragen in acht moeten worden genomen.

Hierbij zal een onderscheid worden gemaakt tussen verdragen met landen die toetreden tot de UN-conventie – verdragen die slechts een tijdelijk karakter zullen mogen hebben – en landen die vermoedelijk buiten de Code zullen willen blijven, waarbij aan Europese zijde het principe van de non-discriminatie in acht genomen zal moeten worden. Wie durft er onder deze omstandigheden nog te spreken, dat de scheepvaart in wezen een zaak van grote eenvoud is?
Binnen de lijnvaartsector heeft zich op het nationale Nederlandse vlak een steeds verdergaande concentratie afgetekend. Na het samengaan rond de jaarwisseling 1980/81 van de KNSM Group met de Koninklijke Nedlloyd Groep, is er naast deze Groep nog slechts een viertal Nederlandse grote handelsvaart-ondernemingen die het lijnvaartbedrijf uitoefent.
Met betrekking tot de overige sectoren binnen de Nederlandse zeevaart zijn de perspectieven veel verscheidener, zo constateert de KNRV, en in sommige gevallen onduidelijker. Dat geldt vooral voor de perspectieven van de markt. In sommige gevallen, zoals het zeesleepvaart- en bergingsbedrijf, de bevoorradingsvaart en het zware lading transport, is bewezen dat vanuit Nederland door specialisatie een aanzienlijke positie op de markt kan worden opgebouwd. Dat houdt niet automatisch in dat dit ook mogelijk zou zijn voor andere gespecialiseerde sectoren, waar de Nederlandse positie bescheiden is, zoals in de tank- en bulkvaart, in de koel- en chemicaliënvaart.

De J.

DESIGN AGAINST FATIGUE AND FRACTURE FOR MARINE STRUCTURES*

by prof. ir. J. J. W. Nibbering**

Abstract

Design in connection to cracking and fracture aims at structural integrity at low costs. Integrity and safety are to a large extent determined by material quality and welding effects (defects, residual stresses, notch toughness of weld and H.A.Z., deformations) and the way these effects are measured and controlled. The estimation of the consequences of these effects and design geometry for fatigue and fracture in marine environment is an essential step in the design procedure. The reliability of the answer depends strongly on the amount of sophistication put into quality control tests and fatigue calculations. The paper will discuss a number of weak parts and inconsistencies inherent in current design procedures and why these yet seldom have given rise to great trouble.

1. Introduction

The word design has several meanings. It may be design procedure or design calculations or the actual structure.

In the present paper both procedure and actual structure will be discussed. In the first part of the paper the relative importance of shape and material properties of structures are considered from the viewpoint of cracking. It will be seen that material properties greatly determine safety with respect to brittle fracture while from the viewpoint of fatigue shape is most important. This is not unknown to many people, but it is not generally realised whether fatigue contributes little or much to the danger of brittle fracture. Apart from that wich nowdays' steels and welding methods brittle fractures in ships can be avoided with extremely high probability.

The second part of the paper discusses current design procedures in connection to fatigue. There is a need for more sophistication in calculations for crack growhth, but this need may disappear when more attention will be paid to shaping of details and welds.

2. Influence of shape and material on the fracture-strenth of structures

Our knowledge about the real brittle-fracture strength of ships is not large. This is mainly a consequence of the fact that the brittle-fracture-strength of ships is large. For, when this statement would be false, ship-fractures would occur more often and out knowledge would improve.

Another reason for the first statement is that realistic experiments with ship structural details in laboratories have become practically impossible in the course of years due to the increase in size of the ships. For instance testing a hatch corner of a large bulk-carrier would necessitate testing machines of capacities of some 10.000 tons.

* Paper presented at the International Symposium on Advances in Marine Technology, Trondheim Norway, 13-15 june 1979.

** Professor Naval Architecture State University Ghent/Delft University of Technology.

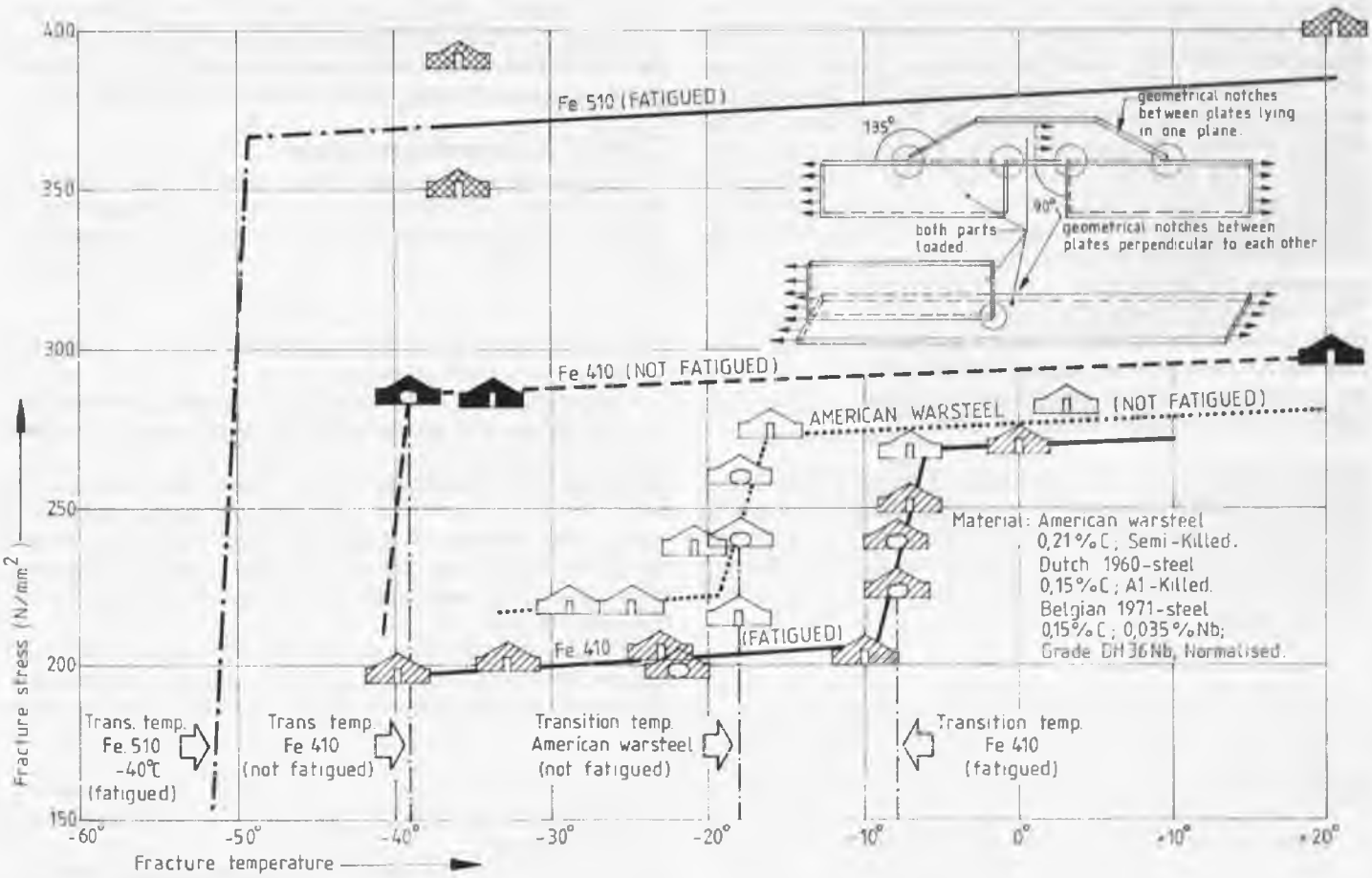


Fig. 1. Influence of material quality on the low-stress/high stress transition temperature of bottom longitudinals.

From the second statement of this paragraph it follows that there is also little impetus from practice to carry out such costly experiments. Another argument is that the knowledge and insight concerning the problem of brittle fracture (initiation) is probably good enough to make large scale experiments superfluous. Small scale testing can be relied upon with confidence.

It will be shown that in a general sense this picture is true. But caution is necessary, in case of thick plates which points to offshore structures.

As said before, results of full-scale brittle fracture experiments with ship structures are scarce, but they can nevertheless be found. Most of these have been reported in the proceedings of the committees on brittle fracture and fatigue of the International Ship Structures Congress /1/. In the present paper only one series of experiments will be mentioned. Apart from some subjectivism in the choice, the reasons are the following:

a. The experiments embraced:
   1. Steels of World War II used in Liberties and T2-tankers /2/.
   2. Common C-Mn-steels in the usual Al-killed condition of the years 1960 (mild steel Fe 410), /3/.
   3. Nb-containing fine grain steels (Fe 510) in use nowadays when grades D and E are required in large ships /4/.
b. Alle specimens were of equal design and dimensions.
c. The post-war specimens had been subjected to fatigue-loading prior to fracturing at low temperature.

Figure 1 shows the results.

Looking first to the American results with war-steel it is remarkable that the transition temperature of the specimens is as low as –20°C. This is some 20°C lower than the temperature at which brittle fractures have started in T2-tankers during and after the war. The use of Dutch 1960 C-Mn, Al-killed steel resulted in a substantial improvement of some 20°C in transition temperature. From this is might be concluded that in that time ships had become absolutely safe from brittle fracture. But this statement was not confirmed by the experience from practice /5/. Apparently the (full-scale) experiments were still not sufficiently realistic. Indeed, static loading of a virgin specimen is more favourable than the conditions which ship structures meet during their life. The cyclic loading due to wave-bending will cause fatigue-damage (cracking and deterioration of the material). It was thought that especially *small* cracks might impair the fracture strength, because the tips of these cracks will be situated in the weld zone. The results were really alarming: the transition temperature rose from –40°C to –8°C. This approaches the temperature region of interests to ships.
The investigation provided the proper explanation for the discrepancy between the American results and practical experience: they had not been cyclically loaded prior to fracture. For otherwise the transition temperature would have been about +10°C (–20°C (static) + 30°C (fatigue)) instead of –20°C.

We now come to the situation nowadays. Figure 1 shows that for Nb-normalised fine grain steels the transition temperature of specimens *with* fatigue cracks was at least 30°C lower than the one for the 1960 C-Mn-steels. In other words the results for the modern steels *with* fatigue cracks are as good as those for the 1960-steels *without* fatigue cracks.

A number of important observations can be made:

1. Safety with respect to brittle fracture is directly and mainly dependent on material (inclusive weld!) quality.
2. Design has an important *in*direct influence due to its effect on the development of fatigue cracks.
3. Brittle fractures in ships can only occur after extensive yielding. Due to that residual stresses cannot exert a direct influence. Some indirect effect is present in connection to fatigue.
4. Another consequence of *3* is that the yield point governs the brittle fracture strength of ship structures. In figure 1 the fracture strength is equal to yield strength for all experiments above the respective transition temperatures. Below these temperatures all fractures started after 1 % yielding of the bottomplates in the fracture section over the full width /3/.
   (This yielding was a consequence of axial loading plus overall bending). In fact the transitions in figure 1 are no real high stress – low stress' ones but 'general yield – extensive local yield' ones.
5. There was satisfactory correlation between the 21 Nm Charpy-transition, and the indicated transition temperature of the fatigue specimens. The Nilductility temperature was slightly too optimistic.

It is not suggested that the foregoing covers the whole brittle fracture problem for maritime structures!
For instance at crossing welds hot-straining embrittlement may occur (Greene-Wells effect /6/, which may trigger a brittle fracture. Nowadays the probability of occurrence will be very low, but still within practical possibilities. It is fortunate that with actual steel qualities there is a large chance that such a fracture will be arrested immediately after initiation.
A final problem is the welding of thick plates (>30 mm) with high heat-input (electroslag or electrogas). Shifts in transition temperature of some 100°C are possible in the heat-affected zone. Wide-plate testing of fatigued specimens with transverse welds has proved that brittle cracks may keep running within heat-affected zones of only 2 mm wide. The residual stresses cannot exert any influence on the fracture path due to their low gradient /7/. For offshore structures the fear of too high heat input has become so large that people have recoursed to extremely high numbers of weld passes. Even then satisfactory notch toughness could only be obtained by post-weld heating at 600°C, (stress-relieving).
The low qualities were probably caused by mutual hot-straining embrittlement of different layers. Often better results will be possible by a limited number of passes, say 12 to 16 in 50 mm plates. By the way, C.O.D. (Crack Opening Displacement) testing is indispensible for thick joints, despite some opposition from people who do not succeed in meeting the requirements involved (see also *4*).

3. Design in connection to fatigue

In 2 the importance of geometry in connection to fatigue, and of the latter in connection to brittle fracture, has been discussed. The present paragraph will deal with design procedure in connection to fatigue. That promises a lot more than will be treated actually. The reasons are that:

a. space is lacking for a thorough discussion;
b. in the literature a number of excellent relevant papers has appeared in recent years;
c. there are still white and black spots in proposed procedures and philosophies. It is on these that the author likes to focus attention.

Fatigue is a fast developing science. There will be not so many fields in technics in which as much money is spent, especially in experimental research. This is partly due to the fact that experiments take a lot of time. In this respect the situation has become even worse since corrosion fatigue necessitates long lasting low-frequency testing.
On the other hand crack-propagation studies combined with fracture mechanics can lead to an important reduction in number of specimens and testing time as compared to Wöhler-testing (figure 2).

It is only a pity that in *structural* specimens measurements of crack lengths are very difficult, especially when the specimens are tested in seawater.
This might be one of the reasons that existing design procedures are mostly using Palmgren-Miner's rule and Wöhler curves for

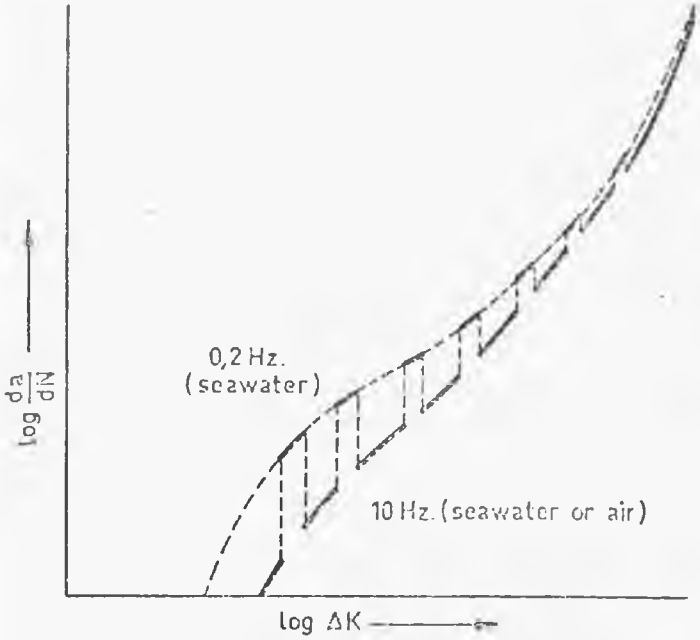


Fig. 2. Accelerated corrosion fatigue testing.

fatigue calculations instead of crack-propagation calculations. Another reason is that the rule $\sum \frac{n_i}{N_i} = 1$ is certainly not illogical or unrealistic. It is easily understandable and simple to work with.
Very important is, that it forms a basis of reference for programmed and random loading: results can be expressed in terms of deviations of Miner's rule. It is often through that the rule is only applicable for the phase of life which is spent for crack-initiation. The argument is that during the crack propagation stage where $da/dn = c(\Delta K)^m$ does not remain constant, so that later load packets would give more crack growth than former ones (sequence effect). But already in 1974 Frost, Mars and Pook /8/ showed that for constant *m* crack growth is independent of sequence of cycles. Schütz /9/ has discussed extensively Miner's rule and some improvements against the background of test results (mainly for aircraft materials and structures).
The rule did not come out unfavourably. Yet it is the author's firm belief that with the aid of fracture mechanics for crack propagation a better balance may be obtained between the efforts spent for obtaining information about wave-induced loads and for calculating hot-spot stresses on one hand, and the capability of a structure from the viewpoints of fatigue and permissible crack-length on the other hand. A look into the proceedings of conferences dealing with fatigue, into the publications in journals devoted to fracture, fracture mechanics and fatigue will lead to the conclusion that both in theory and experiments much is going on which is of use for arriving at reliable crack propagation calculations for structures. The problem is that we need some standard procedure(s) acceptable to classification societies incorporating those items of crack propagation calculations which have met general or wide agreement. Such a procedure might be valid for 3 or 5 years, after which adjustments can be made.
As long as this is not obtained, the use of Miner's rule has to be preferred if only for reasons of safety. For, without standard procedures it cannot be avoided that self-made methods for crack propagation calculations involving corrections for crack closure, Elber effect, plastic zones, relief of welding stresses, residual stresses after overloads, strain hardening and softening in plastic zones etc., will lead to widely differing results. This will also be caused by the fact that the input of the loads into the calculations can be done in different ways, see /9/. For instance there are the cycle-to-cycle method and the equivalent constant RMS-stress method. The latter can be based on short or long periods related to changes of weather, loading conditions, routes or seasons. Each method has its specific problems. For instance in the RMS-approach the main problem is which factor times RMS gives the

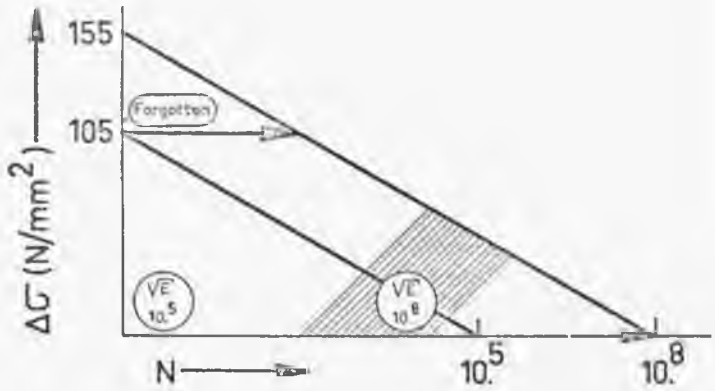


Fig. 3. Upper part of Figure is not included in √E-treatment.

proper equivalent stress for constant loading. This factor must be dependent of N because RMS is the same for short and long periods within stationary conditions. The point is illustrated in figure 3.
It means that the factor σ_{eq}/σ_{RMS} has to be a function of the number of cycles in each block of the whole load history. For Rayleigh distributions the equivalent stress should take the form of $\sigma_{eq} = c\sqrt{EL\ nN}$. c Will be in the order of magnitude of 0.3. (In /13/ the stress equivalence factor is given in terms of slope b of Wöhler curves for narrow band random loading. Applying Miner's rule they found $\sigma_{eq}/\sigma_{RMS} = \sqrt{2|\Gamma(1+b/2)|^{1/b}}$. It apparently applies to large N. Then the σ_{eq} is serverely understimated in the author's opinion.).
Both methods mentioned allow to take into account certain sequence effects. In the RMS-method this applies only to the (important) bad-good weather variations and changes of mean stress (loading conditions, direction of wind and tide streams for offshore structures). In the cycle-to-cycle method the calculations can be made as realistic as the input information (load data) allows. But it should be realised that in both methods crack growth data, obtained from *constant* load tests are used.
Other methods exist of which the quasi-stationary random method is the best for marine structures, but also an expensive one. They will not be discussed here. In /9/ and /12/ relevant information can be found. The purpose of the present paper is to show that because of a lot of parameters involved in crack-propagation calculations for maritime structures, and the existence of an overwhelming amount of specialised papers on the subject, a confused situation has emerged. In it it is very difficult to get a proper idea about whether or not certain calculation procedures lead to reliable and accurate answers (and their confidence limits!).
One up-to-date standard method could be used as a reference for judging other methods, improvements and deviations in case of special structures or conditions.

There have been made already important steps in the right direction. Standardisation of wave spectra started even tens of years ago. But the aim was not (so much) fatigue calculations. Haibach et al. /11/ proposed a standard random load sequence for fatigue in 1976. The author knows about an, as yet unpublished, paper by L. P. Pook on standard load histories for offshore structures. A very extensive discussion in the direction of procedure standardising from the fatigue (capability) point of view has been given by Francis, Lankford and Lyle in /12/. Yet it does not go so far as the author advocates, as is evident from page 16 where theories are excluded which 'require impractical (!) data input, such as knowledge of the plastic zone size at a crack tip'. Nevertheless the paper presents a wealth of data as well as methods in a form that allows the reader to put in his own ideas and judgments. Other interesting and/or useful papers have been published in proceedings of the BOSS /14/ and the Offshore Technology Conferences (O.T.C.).

In the abstract of the present paper it has been promised to show why despite rather poor fatigue calculation methods, practical

experience with offshore structures is not alarming.
This will be discussed in the next section.

4. 'On the safe side' design procedures in practice

Fatigue and fracture analysises for offshore structures largely tend to be on the safe side. For instance for S-N-curves (Wöhler) for welded connections, lower regions of scatterbands are used. Welding stresses are always taken tensile and equal to yield point. Crack closure is neglected. The beneficial influence of tensile overloads, both in connection to welding residual stresses as from the pure fatigue point of view, is not taken into account. Also it is seldom realised that in brittle fracture control the existing (Charpy) specifications have emerged from practical experience and consequently are not 'averages' but 'safe' values. On the other hand there are also approaches which are too optimistic. Post-weld heat treatments are not always as beneficial as is hoped. It may give rise to cracking, destroy compressive residual stresses at critical points or – in case of heating parts of existing structures – bring forward new stresses and deformations. Furthermore it can (and will) be shown that the generally held idea that high stress fatigue strength is not impaired by corrosive environment, is not justified. The influence of neglection of changes of mean stress has been discussed earlier /10/ and has also been found for aircraft-materials /9/.

In the following a case will be discussed, in which every possible aspect of fracture analysis was on the safe side. The whole story is no fantasy, but reflects an actual stage in the design of an existing offshore structure!

The problem started when it was observed that in a multi-run X-weld in a thick plate (figure 4) the specified C.O.D.-values could not be met in the as-welded condition.

The critical crack lengths calculated from the measured C.O.D.-values were in the order of magnitude of only a few mm's. The crack lengths calculated on the basis of expected loads in 20 years, hot-spot stresses, N.D.T.-detect lengths, Miner's rule and B.S. 153 S-N-curves, were about ten times as large as the critical ones. The situation seemed to be hopeless. The decision was taken to replace several meters of welds, and heat-treat others on the spot.

In the author's opinion, the outcome would have been different, when not every part of the analysis had been unduly conservative. The main point was a complete neglection (or misunderstanding) of the role of the residual welding stresses.

When a multi-run X-weld is made by alternatively laying beads on both sides of the plate, the residual stresses are tensile at the surfaces and compressive at the root of the X. Important defects are mostly only present in the root (slag inclusions, lack of penetration, root cracks). Consequently crack growth, if any, will start at the root.

Now, the fatigue calculations were made according to a standard procedure. In it it was stated (as usual!) that *tensile* residual welding stresses are present around defects and should be taken into account. Yet in the case considered the welding stresses were compressive! (Most unrealistic was that even for structural parts which were loaded in compression, fatigue calculations had to be made because of the presumed presence of tensile welding stresses in the X-roots!). A calculation procedure in which the compressive residual stresses were simply excluded resulted in zero crack growth!

But this is not yet the whole story. The C.O.D.-testing for estimating critical crack lengths had been carried out in a way which also suppresses the beneficial effect of compressive welding stresses in the centre where toughness is worst. It is well-known that in order to be able to supply a C.O.D.-specimen with a straight fatigue-crack, precompression in the thinkness direction of the notched zone is applied. This has two effects: elimination of the

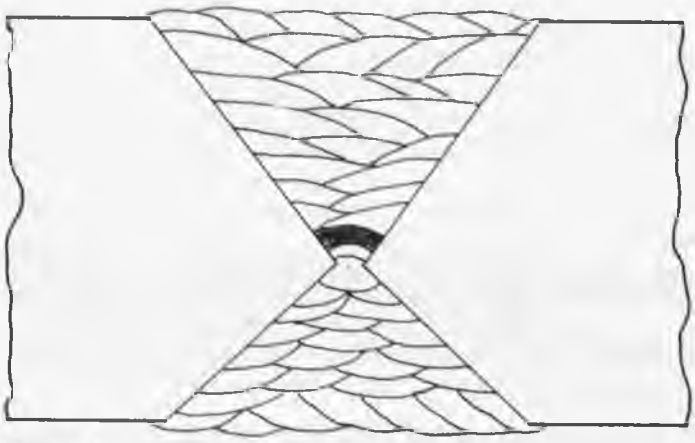
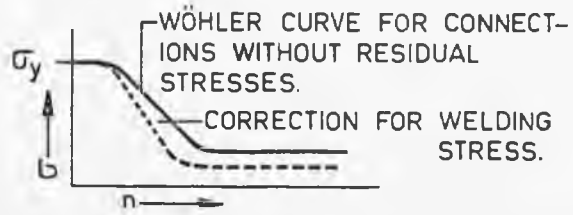


Figure 4.

INFLUENCE RESIDUAL STRESSES.

a. CONSTANT AMPLITUDE:

LARGE INFLUENCE AT SMALL LOADS
SMALL INFLUENCE AT LARGE LOADS



DISADVANTAGE: HIGH STRENGTH STEELS PENALISED.

b. VARYING AMPLITUDE

SEE INFLUENCE PEAK STRESSES

INFLUENCE OF EXTREME LOADS

1. TENSION PEAK

ADVANTAGE
- a. STRESS-FREE AT POINTS OF STRESS CONCENTRATION.
- b. HIGH COMPRESSIVE STRESSES IN UNLOADED CONDITION AT CRACK TIPS.
- c. BLUNT CRACK.

DISADVANTAGE
- a. LESS CRACK CLOSURE.
- b. STRAIN HARDENING.

2. COMPRESSION PEAK

CRACK CLOSURE IMPROVED – CONSEQUENTLY:
NO HIGH RESIDUAL TENSILE STRESSES AT NOTCH TIP.

Figure 5.

welding stresses, and strain hardening of the material /15/. the latter will be aggravated by the cyclic loading of the specimen (but that corresponds rather with what may happen in a structure).
But the first two factors may reduce substantially the C.O.D. of the weld metal. Consequently the *calculated* critical crack lengths will certainly be smaller than what is justified.
The reader will observe that both from the demand- as from the capacibility point of view the approaches were (very) pessimistic. This often happens, although not always as drastic. But it will be the cause that despite many mistakes in the design procedures practical experience with offshore structures is not too bad. In the next section some of the arguments given here will be explained further.

5. Optimistic and pessimistic arguments with respect to design procedures

a. Residual welding stresses.

Welding stresses have a clear influence on the fatigue-strength for *constant amplitude/constant mean stress* loading.
The smaller the cyclic stresses the larger the influence. Therefore Wöhler-curves obtained from small, or unwelded specimens are corrected as in firgure. 5.

There is nothing wrong in this as long as these curves are not used for *variable* amplitude loading. For, in actual structures welding stresses disappear quickly when incidental high loads occur. The first storm will do the job. It is often thought that this is only true in case the nominal stresses approach yield point. But figure 6 demonstrates that for a mild discontinuity being a circular hole, a nominal stress of only one third of yield point eliminates the welding stresses completely. In ships and offshore structures much higher stress (strain) concentrations are present. Precisely at these points where the danger of cracking is greatest, the residual stresses are soon relieved.

Another point is that on case cracks nevertheless develop, the cracking itself will also relieve welding stresses. It may be concluded that for the greater part of the life of a structure, residual stresses cannot exert a bad influence. This means that Wöhler-curves may be used without correction for the presence of welding stresses. Even curves for stress-relieved specimens might be used, provided the stress-relieving has not an effect on the material properties. (Such an effect – if favourable – would be the only justification for post-weld heat-treatments).
But whether or not the Wöhler-curves are corrected is far less important than the fact that in the absence of residual stresses the phenomena of crack closure and the Elber-effect can occur. This may cause increases in fatigue-life in the order of magnitude of a factor 5 /15/. for, when a crack of a few mm's has formed, the compressive part of a load cycle has become insignificant (see figure 7 a end b) from /16/.

in figure 8 the Elber-effect is explained /17/. in the Delft Ship Structures Laboratory it was confirmed that the effect was also very prominent for *highcycle repeated* bending loading in air and seawather (thickness 28 mm, see figure 9a). It constituted a reason for studying the effect also in repeated *axial* loading on a centrally notched 500 mm wide plate of 19 mm thickness.
The plate was instrumented with strain gauges and C.O.D.-meters as indicated in figure 9b. It can be seen that for some 90% of the time tested the effective load was only about 75% of the real load. From figures 9a and b it follows that this reduction in fatigue load occurs as well in high-stress as in low-stress fatigue.

b. Ultra low cycle-corrosion fatigue

This section will start with a quotation from a paper of Det norske Veritas /18/ on corrosion fatigue: 'In the low cycle fatigue range, normally defined to be less than 10^5 cycles, the deterioration promoted by seawater is less'.

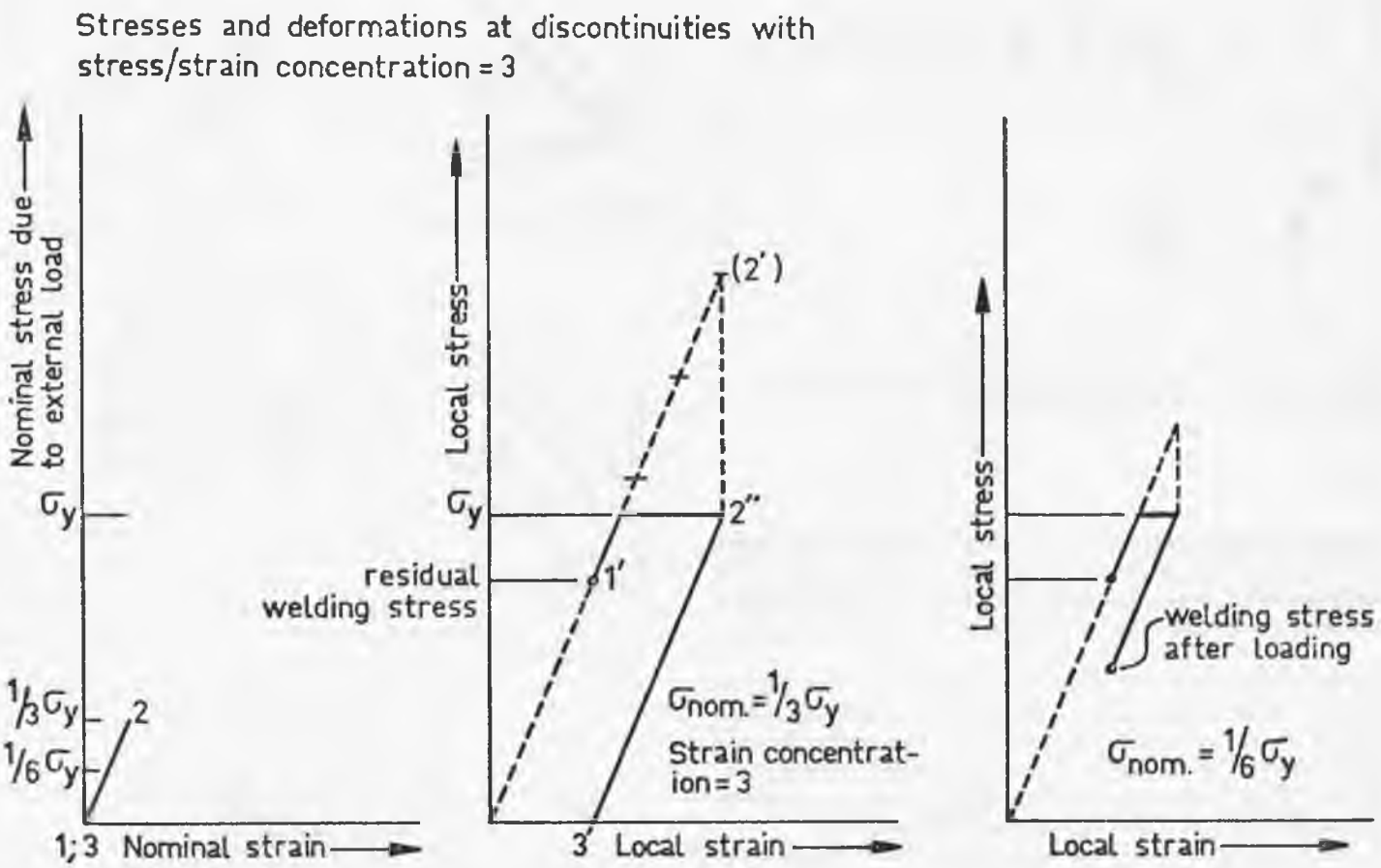


Fig. 6. The disappearance of welding stresses by high loads.

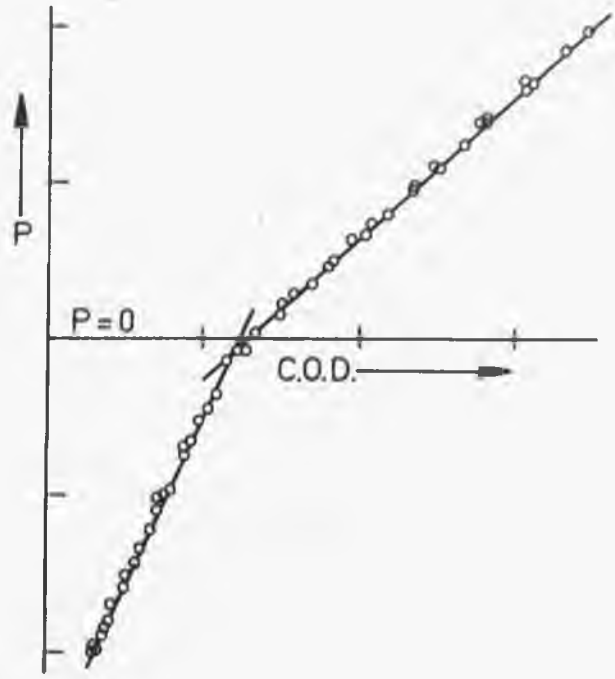


Fig. 7a. P-C.O.D. diagram after 37100 cycles for cracklength 10 mm.

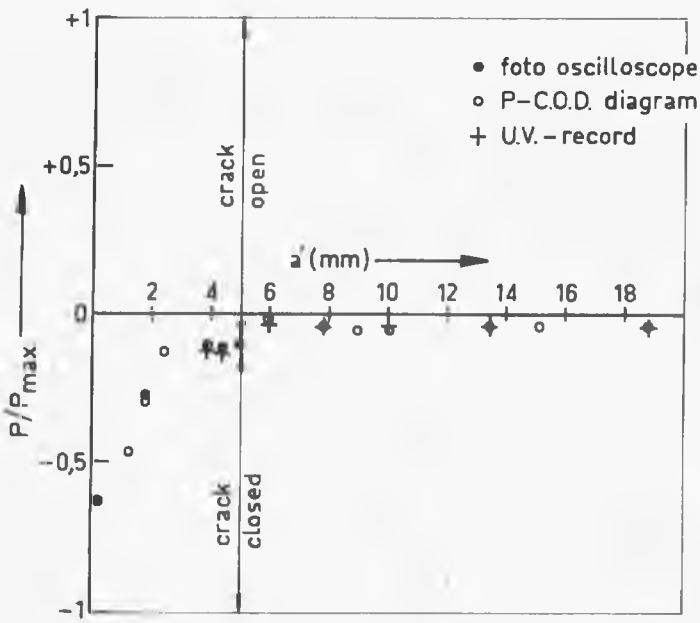


Fig. 7b. Alternating bending part of compressive load during which crack remains open /16/.

This is a generally held opinion. The arguments are in the sense that the crack growth is faster than the penetration rate of the corrosive environment. The cyclic frequency of the high loads is aparently taken equal to that of the lower loads (~0.1 Hz for ships).

Figure 10 taken from (19) and figure 11 from (20) allow another look into the situation. Figure 10 shows that one 'built up' stress-change of 270 N/mm² has occurred in a containership during a severe storm. The average level of wave-induced bending stresses was much lower. In Aertssen's paper it can be found that severe slamming occurred two to three times per hour.
So the frequency of these was not in the order of magnitude of 0.1 Hz but 0.001 Hz.

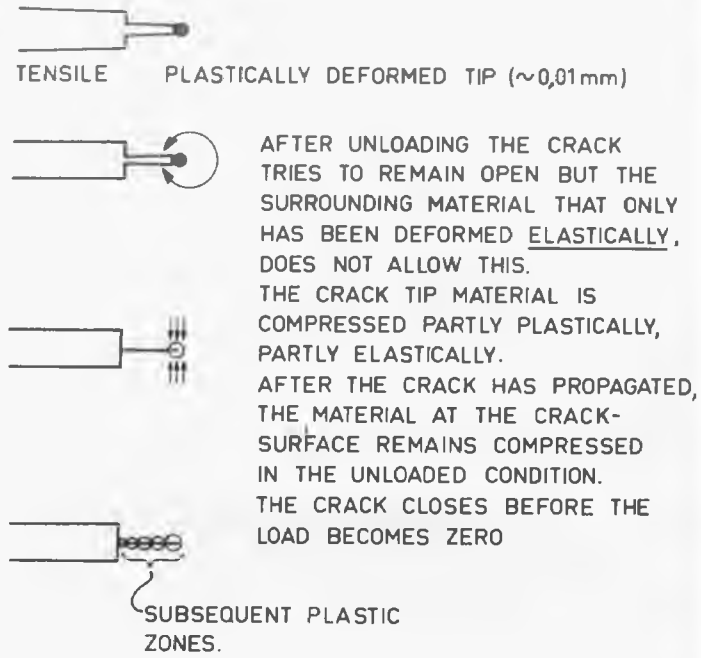
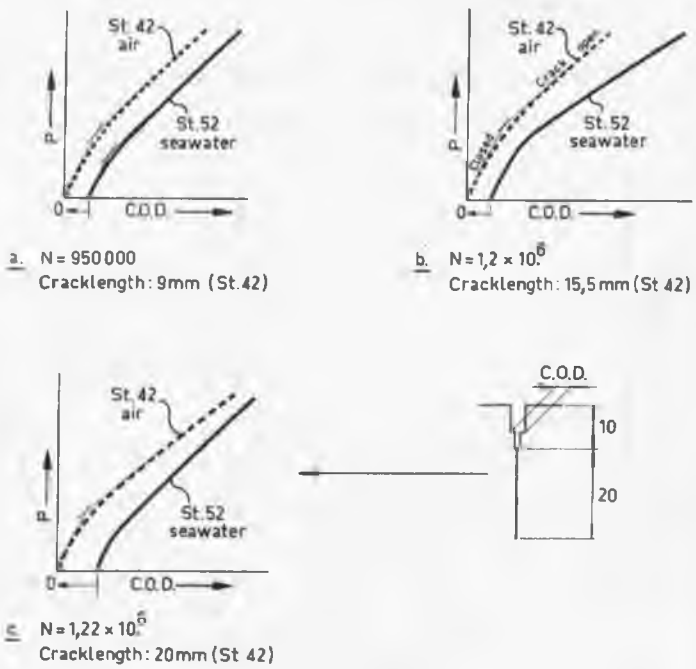


fig. 8. Crack closure and the Elber-effect.



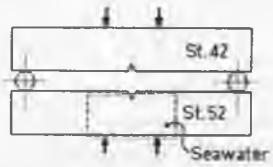


Fig. 9a. Crack closure during repeated loading.

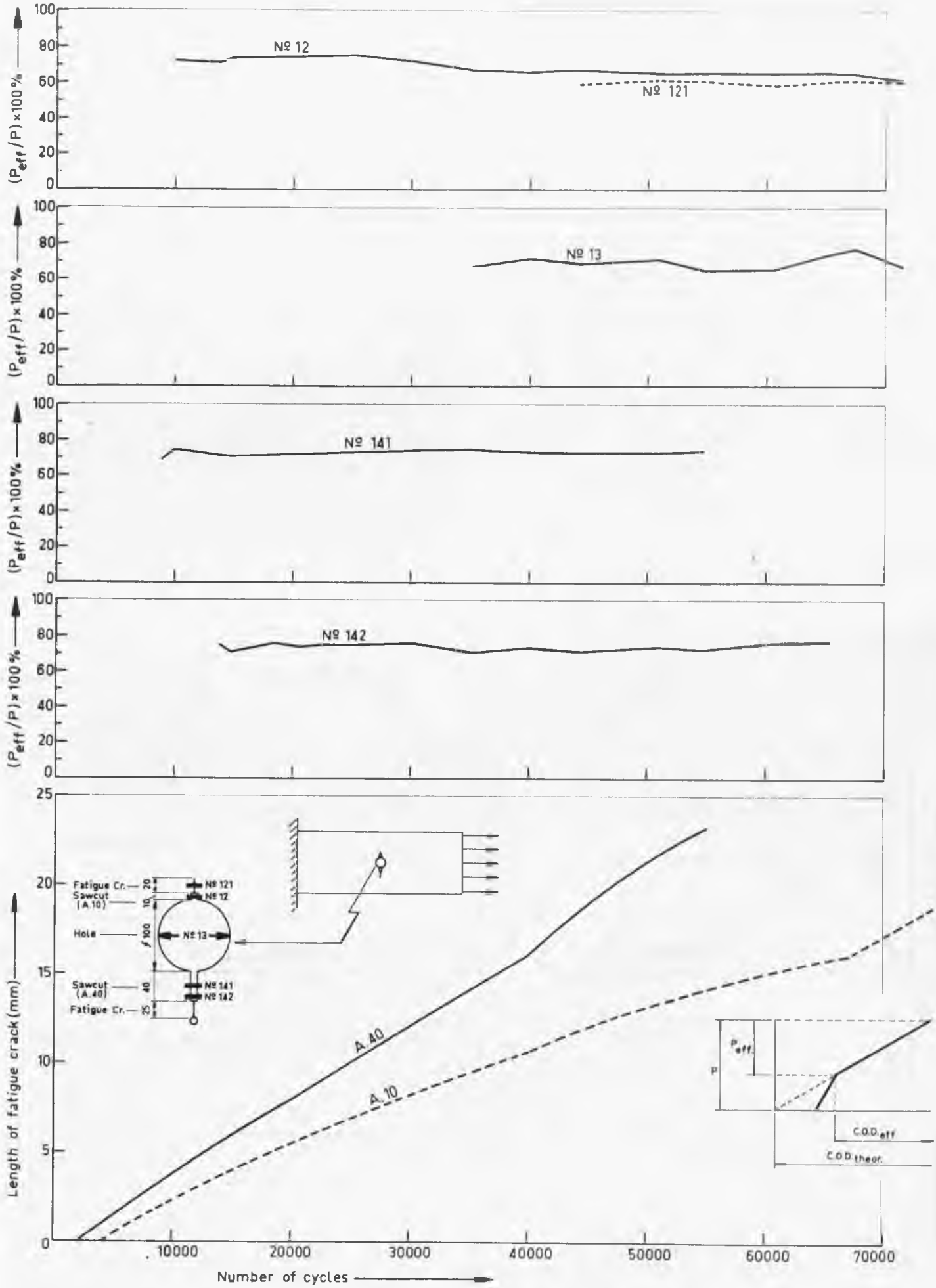


Fig. 9b. Crack closure in repeated axial loading.

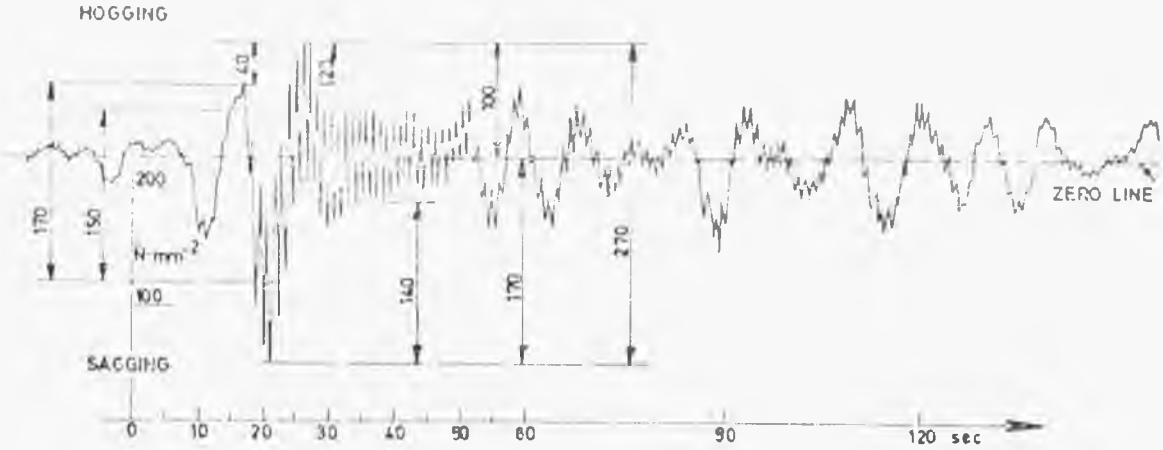


Fig. 10. Whipping stresses in upperdeck of containership IV, Beaufort 10.

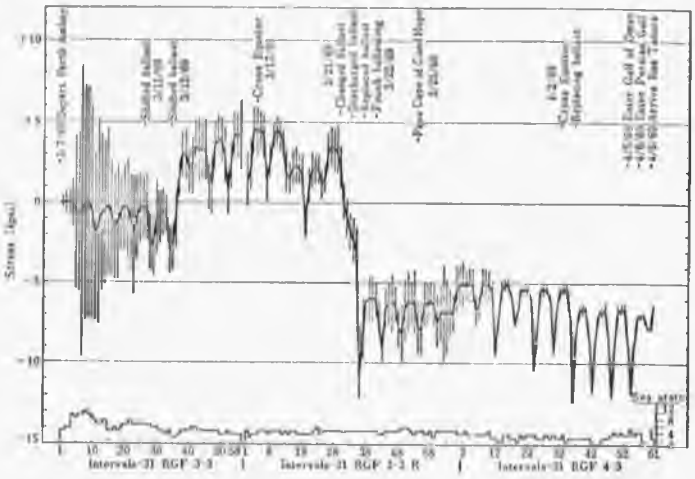


Fig. 11. Typical Voyage Variation of Midship Vertical Bending Stress, ss R. G. FOLLIS.

Figure 11 shows other very low frequent variations of stress. In order to get an idea about the corrosion fatigue damage caused by ultra-low frequent extreme stress cycles, the author carried out the experiments shown in figure 12. Two specimens were tested simultaneously, one in air, one in seawater. The loading program was as indicated below right in the figure. For the first two specimens the experiment started from a sawcut. For the other specimens the sawcut was firstly extended 1 mm by fatigue loading at 4 Hz before the low-frequent loading started. The first experiment started with 0.0003 Hz. After about 1500 cycles the crack in the seawater specimen was nearly 10 mm in length. In the air-specimen it was only 0.5 mm. After that stage the frequency was increased to 0.00084 Hz. At first some retardation occurred but soon the crack-growth in seawater continued at high rate, although not so high as before.

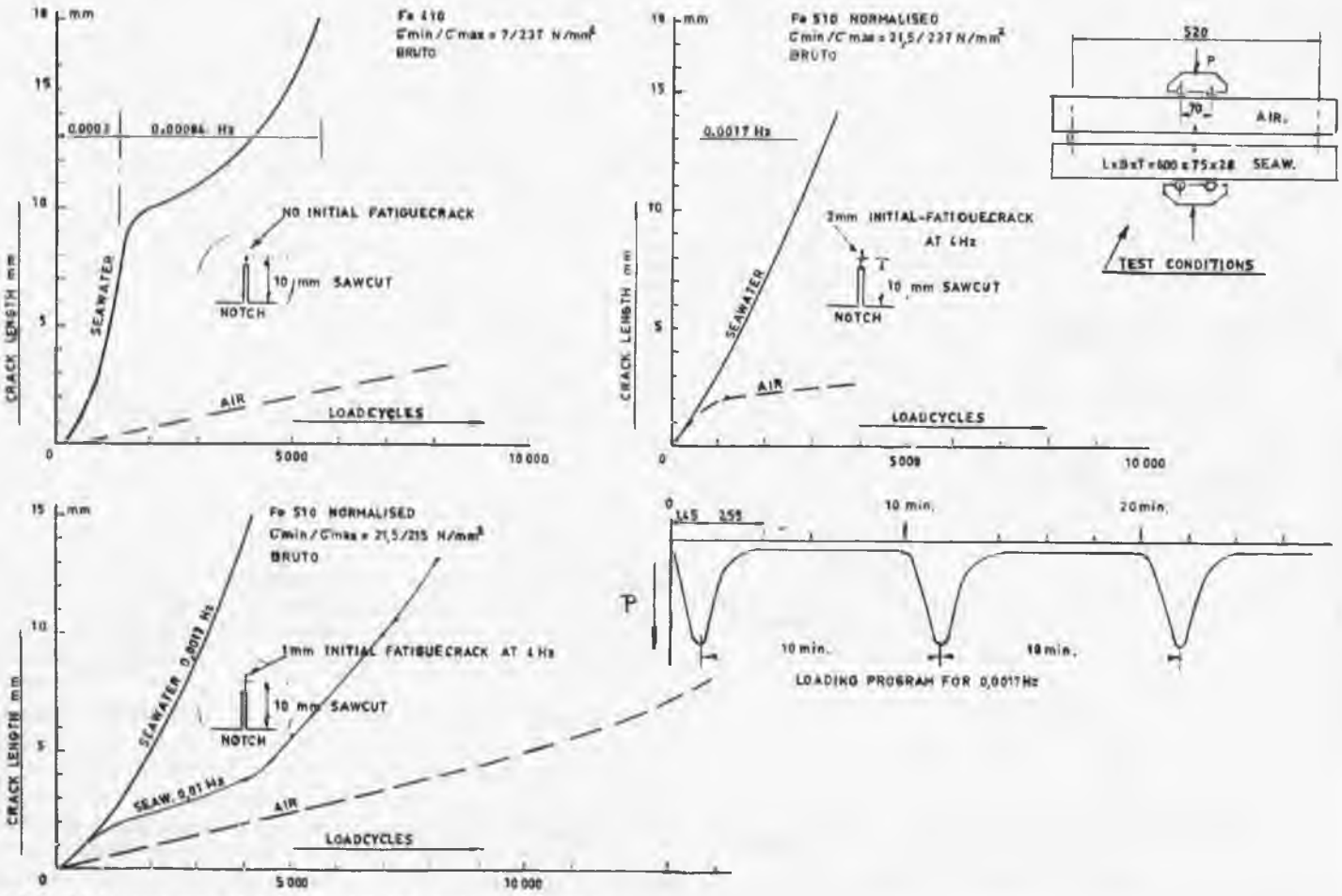


Fig. 12. Corrosion fatigue at ultra-low cyclic frequency.

This result applies to mild steel (Fe 410). Three more tests have been carried out with Nb-containing, normalised Fe 510 at two stress-values and two frequencies. There was a distinct difference between the behaviour at 0.0017 Hz and 0.01 Hz.

In the first case the crack growth was about 5 to 10 times faster in seawater as compared to air; at 0.01 Hz is was only 2 to 3 times. In figure 13 a da/dn-ΔK plot is shown. It is remarkable that the difference between seawater and air becomes manifest in the vertical position of the curves (c-value) and not in the inclination (m-value).

In conclusion it may be said that extremes occurring at large intervals contribute effectively to crack growth in seawater. A few thousand changes of hot-spot stress between 0 and σ_y at places where weld defects are present may lead to some 10 mm crack extension.

Conclusions

1. Classification societies and (other) fatigue-experts should develop a standard method for calculating crack growth. It should take into account actual knowledge and theories about plastic zone sizes, strain hardening, crack closure etc.
2. The standard procedure should (also) act as a reference for checking new theories and should be corrected every 3 or 5 years.
3. Residual stresses in maritime structures are hardly harmfull from the point of view of fatigue.
4. In corrosion fatigue low frequent changes of high stress are more dangerous than generally thought.

References

1. Committee reports on fatigue and fracture of the International Ship Structures Congresses 1967-1970-1973-1976.
2. *Irwin, L. K. and Campbell, W.R.:* 'Tensile tests of large specimens representing the intersection of a bottom-longitudinal with a transverse bulkhead'.
   Report of Ship Structure Committee, SSC 68, January 1954.
3. *Nibbering, J. J. W.:* 'An experimental investigation in the field of low-cycle fatigue and brittle fracture of ship structural components'.
   Transactions of the Royal Institution of Naval Architects, 1967.
4. *Nibbering, J. J. W. and Scholte, H. G.:* 'The fatigue problem in shipbuilding in the light of new investigations'.
   Transactions of the Royal Institution of Naval Architects, vol. 118, 1976.
5. *Vedeler, G.:* 'To what extent do brittle fracture and fatigue interest shipbuilders today?'.
   Sveiseteknikk 1962, No. 3.

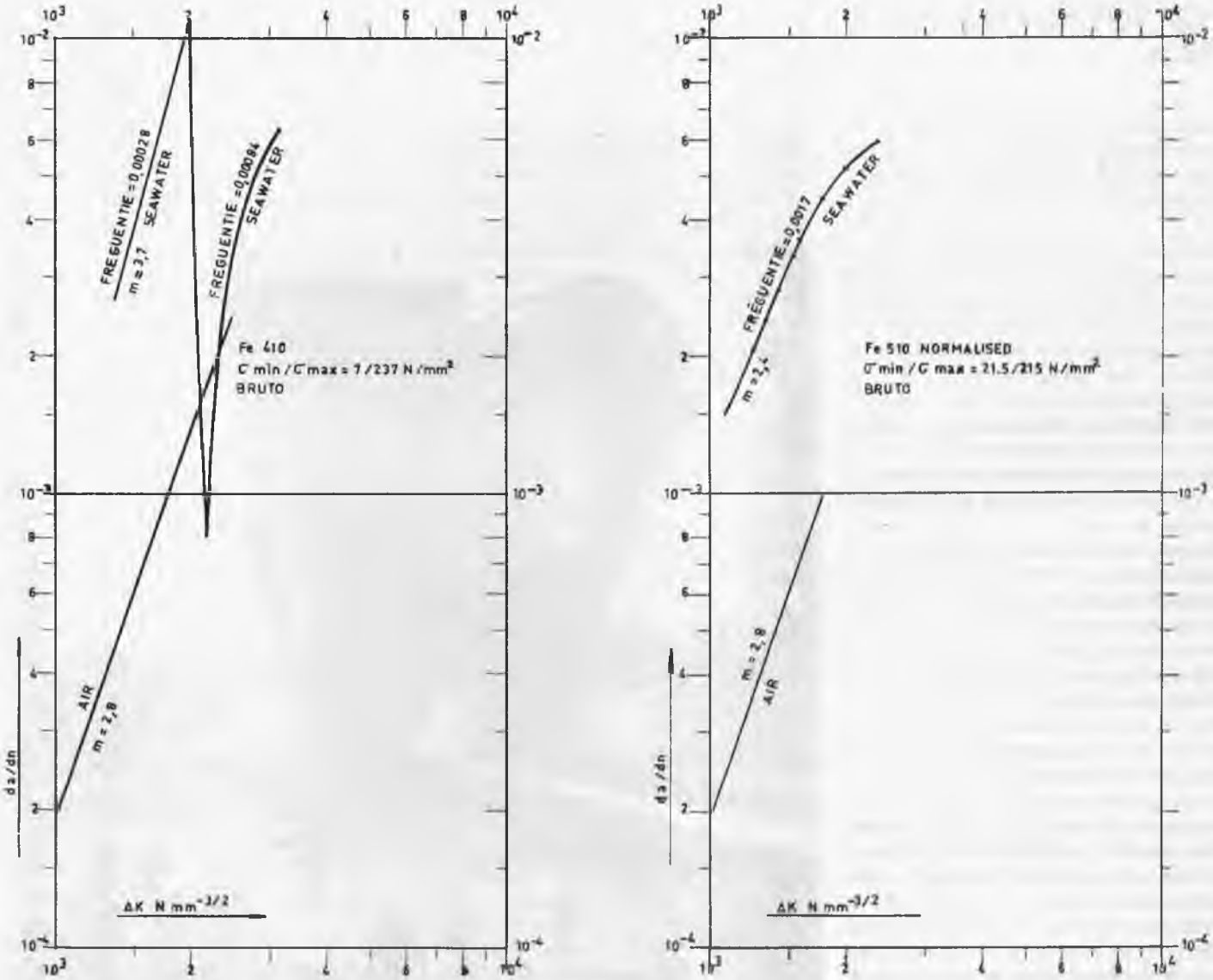


Fig. 13. da/dn-ΔK curves (air and seawater) for ultra-low cyclic frequency.

6. *Wells, A. A.:* 'The brittle fracture strength of welded steel plates'.
Transactions of the Royal Institution of Naval Architects, vol. 98, 1956.
7. *Nibbering, J. J. W.:* 'Fracture mechanics and fracture control for ships'.
Report No. 178 S, NSS-TNO Delft, May 1973.
8. *Frost, N. E., Marsh, K. J. and Pook, L. P :* 'Metal fatigue'.
Oxford Engineering Science Series, Clarendon Press 1974.
9. *Schütz, W.:* 'The prediction of fatigue life in the crack initiation and propagation stages – A state of the art survey'.
Engineering Fracture Mechanics, Vol. 11, pp. 405-421, 1979.
10. *Nibbering, J. J. W. and Faulkner, D.:* 'Some considerations for fracture-safe design of maritime structures'.
Paper 1, Proceedings International Symposium 'Integrity of Offshore Structures', organised by the Institution of Engineers and Shipbuilders in Scotland, Glascow, April 6-7, 1978, pp. 1/1-1/18.
11. *Haibach, E., Fischer, R., Schütz, W. and Hück, M.:* 'A standard random load sequence of Gaussian type recommended for general application in fatigue: its mathematical background and digital generation'.
Proceedings Conference on Fatigue Testing and Design, London, 1976, Vol. 2, pp. 29.1-29.21. Buntingford, Herts: Society of Environmental Engineers Fatigue Group, 1976.
12. *Francis, P. H., Lankford, J. Jr. and Lyle, F. F. Jr.:* 'A study of subcritical crack growth in ship steels'.
Report of Ship Structure Committee, Washington, SSC-251, 1975.
13. *Crandall, S. H. and Marks, W. D.:* 'Random vibration in mechanical systems'.
Acad. Press, New York.
14. Proceedings of the 1st International Conference on Behaviour of Offshore Structures (BOSS '76), Trondheim, August 1976. (2 Volumes).
15. *Nibbering, J. J. W.:* 'Experiments for the estimation of fracture toughness and fatigue-strength'.
Proceedings BOSS '76, Vol. 1, pp. 679-703, Trondheim, 1976.
16. *Truyens, P.:* 'Scheurgroei ten gevolge van veranderlijke belastingen in schepen' (in Dutch).
Dcotor's thesis, State University of Ghent, Nov. 1976.
17. *Elber, W.:* 'Fatigue crack closure under cyclic tension'.
Engineering Fracture Mechanics, Vol. 2, pp. 37-45, 1970.
18. *Walter, J. C., Olbjørn, E., Alfstad, O. and Eide, G.:* 'Safety against corrosion fatigue offshore'.
Noroil, Vol. 4. No. 3, March 1976.
19. *Aertssen, G.:* 'An estimate of whipping vibration stress based on slamming data of 4 ships'.
International Shipbuilding Progress, Vol. 26, Feb. 1979.
20. *Little, R. S. and Lewis, E. V.:* 'A statistical study of wave-induced bending moments of large tankers and bulk-carriers'.
Transactions Society of Naval Architects and Marine Engineers, 1971.

ARK ROYAL FOR THE 1980s

HMS Ark Royal, the Royal Navy's latest anti-submarine aircraft carrier, is pictured after her launch form the Swan Hunter yard on the River Tyne in north east England recently.
The last Invincible class through-deck cruiser to be built, HMS Ark Royal has an expected completion date of 1985. The ship will be used as an offshore base for vertical take-off Sea Harrier fighter aircraft and Sea King anti-submarine helicopters. It will also be a communications centre from which to control surface escorts and co-ordinate operations with Royal Air Force (RAF) Nimrod maritime patrol aircraft.
The ship, which was launched by Her Majesty Queen Elizabeth The Queen Mother on 2 June 1981, is the fifth to bear the name Ark Royal and – at over £ 200 million – is the most expensive warship ever built for the Royal Navy. It has an overall length of approximately 206 metres, beam of 32 m and will accommodate over 1000 officers and men.

NEDERLANDSE VERENIGING VAN TECHNICI OP SCHEEPVAARTGEBIED
(Netherlands Society of Marine Technologists)

Personalia

G. VAN SLUIJS
Tijdens de jaarvergadering van de CEBOSINE op 3 juni j.l. werd de heer G. van Sluijs benoemd tot Ridder in de Orde van Oranje Nassau.
Bij zijn afscheid als hoofd van de afdeling Bedrijfsnormalisatie Nederlandse Scheepsbouwindustrie op 20 maart j.l. ontving de heer Van Sluijs de legpenning van het Nederlands Normalisatie Instituut als waardering voor zijn verdiensten in het nationale- en internationale normalisatiewerk.

Nieuwe opdrachten

RSV
Op 5 juni 1981 is bij Verolme Brazilië (VERB), één van de zeven RSV-groepen, door de Minister van Transport van Brazilië een dok geopend voor de bouw van boorplatforms. Het dok meet 70 × 80 meter en kon worden gebouwd nadat de ter plaatse aanwezige rots werd opgeblazen.
Ir. A. Stikker, president van de raad van bestuur van RSV, was bij de opening van het dok aanwezig.

Tevens is bekend gemaakt dat Verolme Brazilië met de Braziliaanse onderneming Docenave een letter of intent heeft getekend voor de bouw van 3 bulkcarriers van 130.000 ton, terwijl daarin tevens door deze onderneming een optie is genomen voor de bouw van nog 2 bulkcarriers van deze grootte en 3 van 190.000 ton.
Deze ondertekening geschiedde overigens onder voorbehoud van goedkeuring van de betrokken Braziliaanse instanties. Indien de totale opdracht wordt uitgevoerd, heeft deze een waarde van circa 500 miljoen dollar.
De bulkcarriers zijn geschikt voor het transport van erts en kolen.
Op dezelfde dag van de opening van het dok werd een bulkcarrier van 70.000 ton te water gelaten, eveneens bestemd voor Docenave. Dit schip is het vierde uit een serie van 10, welke de werf in opdracht heeft voor zowel nationale rederijen als voor de export.

Tewaterlatingen

Janny
Op 5 juni 1981 is met succes het Rijnmotorvrachtschip *Janny*, bij Bodewes Scheepswerven te Martenshoek tewatergelaten.
De doop geschiedde door mevrouw Bruinsma, echtgenote van de heer G. Bruinsma, voor wiens rekening het schip gebouwd wordt.

Het schip, met de afmetingen L × B × H: 81.94 × 8.16 × 2.95 mtr. is uitgerust met een 707 pk DEUTZ dieselmotor en voldoet aan de A.D.N.R. voorschriften en éénmansradarvaart. Twee Pols aggregaten met B.K.B. generatoren van resp. 25 en 35 KVA verzorgen het boordnet, terwijl een DIMO JET boegbesturing voor een hoge manoevreerbaarheid zorgt.
De motoren worden gekoeld door WEKA bunkoelers. Het contract en het ontwerp werden verzorgd door Intershipping Holland b.v. te Driebruggen.

Technische informatie

Nieuwe effectieve gasturbine
Kongsberg Våpenfabrikk (KV) is bezig met het ontwikkelen van een heel nieuw en revolutionair type gasturbine. Deze gebruikt zo weinig brandstof dat het een revolutie betekent in de huidige energiesituatie. Wanneer de turbine in produktie komt zal dit op zeer grote schaal geschieden en grote leveranties voor de Noorse machineindustrie betekenen.
Het hoofdontwerp van de turbine is nu klaar en men is bezig met de detaillering. Men rekent ermee dat over twee jaar het prototype gereed zal zijn, maar pas na een periode van 5 jaar zal deze innovatie zijn invloed doen gelden. De laatste 6 maanden heeft een groep van 8 Noren en 6 Amerikanen onder leiding van KV in Florida aan het project gewerkt.
Een Noors idee gecombineerd met Amerikaanse expertise op het gebied van metallurgie heeft deze nieuwe gasturbine bewerkstelligd.
In de eerste plaats zal de machine gebruikt kunnen worden voor kleine elektriciteitscentrales (ca. 1-3 megawatt), maar ook voor locomotieven, grote vrachtwagens en groot aannemersmaterieel. Het bezwaar van gasturbines is geweest dat zij meer energie gebruiken dan een dieselmotor. Dit is niet het geval met de nieuwe turbine. De vroegere modellen haalden 20% energie uit de brandstof, een goede dieselmotor echter krijgt 39-40% energie uit de brandstof.
De turbine die nu ontwikkeld wordt zal een rendement van 45% bereiken en met het benutten van de energie van de uitlaatgassen, zal de nieuwe turbine van Kongsberg 80% van de energie uit de brandstof kunnen halen. Bovendien zal de gasturbine bij opwekking van elektriciteit een lager warmteverbruik te zien geven dan welke andere machine dan ook.
Nadere inlichtingen: Kongsberg Våpenfabrikk, Gasturbindivisjonen, N – 3601 Kongsberg.

Steel valve-actuators for tough conditions
Pneumatically operated steel actuators for ball, butterfly and plug valves or for other applications demanding a compact 90° rotary torque motion in corrosive surroundings are available from the British firm Hytork Actuators Ltd.
Hyresist actuators have been specifically designed to meet the stringent requirements of the marine, offshore and chemical industries. Their design and the use of carefully selected materials and finishes ensure reliable operation and low wear in the corrosive atmospheres encountered in these applications.
Actuators are offered in three versions – double acting, spring return fail-safe and air fail-safe – each in several sizes to give a graduated range of torque outputs from 8 N m (to 3400 N m with a supply pressure of 550 kPa.
A high level of protection is afforded by pistons of molybdenum disulphide coated LM25TF aluminium (a specially treated alloy containing silicon and manganese), phosphated and two-coat epoxide painted steel bodies, nickel-plated steel pinions, and zinc-plated and epoxide-coated steel and caps. Seals are of nitrile rubber and bushes of phosphor bronze.
All actuators are of double rack and pinion design with large safety margins and are sealed against external contamination.
Among optional accessories are facilities for remote indication and control and for manual operation; also available are speed controllers, quick-exhaust and lock valves, silencers and filters.
For more information: Serck Audco NV, Postbus 112, 4600 AC Bergen op Zoom

A new Fuel Oil Sampler
Shipowners are experiencing increasing operational problems with the ships propulsion system and auxiliary machinery due to deteriorating residual heavy fuel oil quality. These problems will get worse with the increasing effort to get higher yields of distillates from the crude oil. Consequently, the oil industry and shipowner associations in cooperation with inspection and classification organisations are developing

standards for bunker oil as well as quality assurance services.
The Fuel Oil Sampler has been developed by Interpower A/S in close cooperation with these organisations. It enables a ship to take a representative sample of the bunker oil as it enters the ship.
The Interpower Oil Sampler is semicontinuous and can be bolted on to the bunker manifolds on board. It consists of a short pipe enclosed by a small cabinet. The pipe matches the bunker manifold flanges. A static mixer inside the pipe guarantees the complete mixing of blending components, water and particles. The Oil Sampler is stored indoor when at sea and installated prior to each bunkering operation. Installation has been made simple by the use of quick connectors.
An air driven positive displacement pump extracts the sample from the line, downstream from the static mixer. The sample is extracted in small volumes at fixed intervals and accumulated in a sample receiver. The interval varies with the duration of the bunkering and is set by dialling the anticipated duration of the bunkering operation. The cabinet is steam heated to provide reliable operation even under the coldest conditions. The sample is distributed into smaller sample bottles; one will be retained by the ship, one by the terminal and one will be sent away for analysis. Prior to removing the sampler it is cleaned internally by steam and air.
More information from: Interpower A/S
P.O Box 71 Bryn Oslo 6 Norway.

Central heating from the sea
Two new residential areas in the town of Haugesund on Norway s west coast may be the first in the world to be supplied with central heating from the sea. Plans are in hand to heat villa areas with energy supplied by a heat pump based on seawater, in combination with a district heating network. A plant of this type could cut 45% off the total energy consumption for the houses. The costs of installing the necessary equipment are estimated at about 185 USDollar more per house than the costs of conventional heating, when dealing with a district of about 200-300 residences.
A report on the project states that the necessary investments per annual generated kWh are on the par with those of planned hydro power projects. In other words, the seawater-based heat pump can constitute a genuine addition to future power supply, and one which will have a natural place in future development plans.
The pilot project has been carried out by the building firm G. Block Watny A/S, the Institute of Refrigeration Engineering at the Norwegian institute of Technology (NTH), and the consultant firm Imenco A/S of Haugesund. Financial support has been supplied by the Ministry of Petroleum and Energy.

Diversen

Vereniging van Hogere Zeevaartscholen
De 29-jarige vereniging van besturen van Hogere Zeevaartscholen in Nederland heeft haar statuten aangepast aan de omstandigheden en de naam van de vereniging veranderd.
De naam van de vereniging luidt voortaan: *'Vereniging van Instellingen voor Nautisch Onderwijs' (V.I.N O.)*
Hiermede is het mogelijk geworden dat elke instelling voor lager-, middelbaar- en/of hoger nautisch onderwijs, alsmede elke instelling die als zodanig wordt aangemerkt – in principe – als lid van de VINO kan toetreden.
Duidelijker dan met de VHZS het geval was kan de VINO ook de belangen behartigen van het onderwijs aan de mbo-afdeling die aan verschillende hogere zeevaartscholen is verbonden.
Tevens is nu de gelegenheid aanwezig dat het lager-, middelbaar- en hoger nautisch onderwijs zich binnen de VINO verenigt, zodat van een gecoördineerde aanpak van het nautisch onderwijs sprake kan zijn. Het bestuur meent dat hiermede het belang van het zeevaartkundig onderwijs in Nederland is gediend.

Spraakverwarring bij verzinken
Nog altijd worden bij het verzinken onnodige fouten en kosten gemaakt als gevolg van een foute terminologie in bestekken, voorschriften, correspondentie, publikaties, enz. Om dit zoveel mogelijk tegen te gaan heeft de Stichting Doelmatig Verzinken de brochure 'Spraakverwarring bij verzinken' laten herdrukken.
In de brochure vindt u de juiste benamingen voor de vier bestaande methodes om staal te verzinken. Ook wordt uitgelegd waarin de methodes verschillen, welke-vaak gebruikte-andere benamingen onjuist zijn en waarom. Verder geeft de Stichting Doelmatig Verzinken in deze brochure aan welke Nederlandse verzinknormen in bestekken, offertes en correspondentie moeten worden gebruikt om misverstanden te voorkomen.

Een nog te vaak gemaakte fout is het gebruik van de term 'verzinken' zonder enige verdere aanduiding. Hiermede wordt alleen gezegd: het aanbrengen van een laag zink. De applicatiemethoden en de dikte van de zinklagen worden dan in het midden gelaten, terwijl die bepalend zijn voor de weerstand tegen corrosie.
In de brochure wordt niet alleen gewezen op foutieve benamingen voor de verschillende verzinkmethodes. Er kan namelijk ook sprake zijn van misleidend woordgebruik. Een voorbeeld daarvan is de term 'koudverzinken'; in feite betekent dat geen verzinken, maar schilderen met een zinkstofverf.
De brochure 'Spraakverwarring bij verzinken' kan u helpen eventuele fouten en daardoor onkosten te voorkomen door gebruik van de juiste term op de juiste plaats. Geïnteresseerden kunnen de brochure gratis verkrijgen bij de Stichting Doelmatig Verzinken, Weissenbruchstraat 115, 2596 GD Den Haag, telefoon 070-245964.

Goed eerste kwartaal voor scheepsbouw
Lloyds Scheepsregister zegt dat de ordervoorraad van de scheepsbouw in de wereld in het eerste kwartaal van dit jaar verder is toegenomen. Eind maart waren bestellingen van schepen met een gezamenlijke inhoud van 35,2 miljoen bruto ton in portefeuille. Dat was tien miljoen ton meer dan het dieptepunt van eind maart 1979. De ordervoorraad was echter nog ver verwijderd van het hoogtepunt van 133,4 miljoen bruto ton in maart 1974. Ongeveer 84 procent van de bestellingen die eind maart van dit jaar in voorraad waren, moet voor het einde van het komende jaar worden uitgevoerd. In de eerste drie maanden van 1981 kwamen bestellingen van ongeveer vier miljoen ton binnen, bijna een half miljoen ton meer dan er aan schepen werd afgeleverd.

ED 5/6/81

7th International Symposium on Developments of Interest to Yacht Architecture
The 7th of these well-known biannual Symposia will be held Monday 31st August and Tuesday 1st September 1981 in the International Congress Centre RAI, Amsterdam.
This Symposium is organized under the auspices of HISWA, The Netherlands Association for Trade and Industry in the field of Shipbuilding and Aquatic sports.
Members of the Symposium-committee are Professor ir. J. Gerritsma of the Ship-Hydromechanics Laboratory of the Technological University Delft (chairman) and the naval-architects G. W. W. C. Baron van Höevell and W. De Vries Lentsch. G. Vis is secretary of the committee.
Papers and discussions will be in English. The pre-registration entrance fee is *f* 400,—. The entrance fee includes: papers, coffee, tea, lunches, cocktails and a ticket for the 4th HISWA TE WATER floating Boat Show (2-6 September).

Papers to be presented:
- H. M. Barkla; University of St. Andrews, School of Physical Sciences; 'THE MORPHOLOGY OF THE YACHT'
- L. Bennison, International Yacht Paints; 'THE DEVELOPING AND TESTING OF PAINTS FOR WORLD YACHT MARKETS'
- S. L. Boersma, Engineering consultant; 'MODERN CELESTIAL NAVIGATION'
- J. Gerritsma, R. Onnink, A. Versluis;

Technological University Delft, Ship-Hydromechanics Laboratory; 'GEOMETRY, RESISTANCE AND STABILITY OF THE DELFT SYSTEMATIC YACHT HULL SERIES'
- W. Huisman, W. Zantvoort; Overijsselse Jachtwerf W. Huisman – A. J. A. van den Andel; CONSTRUCTION OF ALUMINIUM YACHTS'
- J. R. C. Turner; Brookes and Gatehouse; 'THE DEVELOPMENTS OF INSTRUMENTS FOR USE ON SAILING YACHTS'
- C. A. Marchaj; University of Southampton; 'SOME ASPECTS OF YACHT SURVIVAL DYNAMICS IN HEAVY SEAS'
- Bo M. Hoeglund; Ab Volvo Penta; 'THE INSTALLATION OF MARINE PROPULSION ENGINES IN MODERN PLEASURE CRAFT'
- B. E. Perry; Ian Proctor Metal Masts; 'SPAR DESIGN, CONSTRUCTION AND STRENGTH CALCULATION'
- Gary W. Mull; Naval Architect; 'STRENGTH REQUIREMENTS FOR SAILING YACHTS'

All information: HISWA Gebouw Metropool, Weesperstraat 93, 1018 VN Amsterdam (tel. 020-221307)

IMAEM Congress 1981

The Second International Congress of the International Maritime Association of the East Mediterranean (I.M.A.E.M.) will be held in Trieste (Italy) from the 21st to the 26th September, 1981. Its aim is to provide an international forum for the presentation of the latest achievements in the different branches of Naval Architecture, Ship design and construction, Marine Engineering, Ocean Engineering, Education in Naval Architecture, Marine Engineering and connected fields, Sea Transportation, Safety at Sea and related subjects and Design of Sailing Yachts.

About eighty papers have already been announced. For further information to: I.M.A.E.M. Congress 1981, c/o Instituto di Architettura Navale Universita Degli Studi di Trieste, Via A. Valerio, 10, I – 34127, Trieste (Italy).

Floating airport study – first stage complete

The first stage of a major independent evaluation of the floating airport concept developed by Seaforth Maritime Ltd, of Aberdeen, for use by the offshore oil and gas industry has been completed by representatives of the Norwegian Ship Research Institute (NSFI).

Several leading offshore operators in the North Sea commissioned the study. Its findings are expected before the end of 1981.

The concept envisages a floating airport known as STOLPORT, based on a semi-submersible hull design, with a runway 600m long and 90m wide.

Working with Seaforth in the design studies are Harland and Wolff, who have the only UK dock facilities to build STOLPORT in one piece; de Havilland of Canada, whose STOL (Short Take Off and Landing) aircraft the Dash-7 could operate efficiently the proposed fixed wing flights to and from STOLPORT and the mainland; and Stad Seaforth, Seaforth's Norwegian associates.

Items covered in the first-stage discussions included all aspects of the semi-submersible design, airport and hotel facilities, runway and hangar operations, the Dash-7's attributes, and economics.

The team also studied the combined fixed wing/helicopter operational requirements involved and the contribution which the floating airport might make in enhanced safety and rescue capabilities in its operational area.

UK oil production in 1980

United Kingdom oil production in 1980 was 80.5 million tonnes, a further increase on previous years. The figure for 1979 was 77.9 million tonnes. Revenue from the sale of oil produced on the UK Continental Shelf (UKCS) last year was £ 8.9 billion. The sale of gas produced £ 0.6 billion.

Total capital investment in oil and gas production in 1980 is estimated at £ 2.4 billion, about six per cent of total UK investment. Cumulative investment to date in 1980 prices is estimated at £ 21 billion.

These facts are in the recently-published 1981 'Brown Book' the annual report to Parliament by the Energy Secretary on the development of the oil and gas resources of the UK.

The report says that, taking account of the cumulative production to the end of 1980 of 263 million tonnes, the remaining recoverable reserves of oil on the UKCS are estimated to be 1,900-4,075 million tonnes. After deducting cumulative production to the end of 1980, remaining gas reserves are put at 750 to 2,150 billion cu m.

There was continuing emphasis on development drilling in 1980, as in 1979. Total disposals of North Sea oil in 1980 amounted to 78.1 million tonnes, of which 39.3 million tonnes were delivered to UK refineries and 38.8 million tonnes exported. More than two-thirds (25.1 million tonnes) of the exports went to EC countries. The balance (13.8 million tonnes) went to other European countries and North America.

The workforce on offshore installations such as rigs and platforms is put at 22,000 in June 1980.

Production costs vary widely from one field to another, the report says. The average cost of fields which started production before the end of 1980 is put at 11 dollars per barrel at 1980 prices. For fields under development at that time, the average cost is forecast to be 14 dollars a barrel. These figures include exploration, development and operating costs, but not payment to the Government of royalties, taxes on oil production and abortive exploration costs not attributable to individual fields.

Total value of goods and services purchased for offshore operations on the UKCS in 1980 was £ 2.4 billion, the book says, of which £ 1.7 billion (71 per cent) was placed in the UK, compared with 78 per cent the previous year, mainly due to the placing of fewer production platform orders in 1979. (LPS)

OECD adopts 'polluter pays' principle for oil spill clean-up operations

The 'polluter pays' principle should apply to oil spills at sea and the polluters liable for them should bear the total costs of 'reasonable remedial action taken by public authorities after an incident'.

This is one of the main conclusions just adopted by the OECD Council in a Recommendation based on studies by the Organisation's Environment Committee on certain financial aspects of the prevention and control of oil spills.

In addition, the Recommendation calls on Member countries to enter into agreements concerning mutual assistance in action to control oil spills which would specify the financial terms of their respective action. Such arrangements would be particularly useful when high-cost air or sea operations are involved and when the scale of the oil spill is such that there would be little chance of the authorities which provide assistance being fully reimbursed by the polluter.

The polluter pays' principle was adopted by the OECD Member countries in a Recommendation of the OECD Council in 1972. The agreement now extends the principle to cover accidental oil pollution. It should facilitate the introduction of national legislation and regulations to ensure that the persons liable for oil spills pay the total costs of reasonable remedial action taken by public authorities. These arrangements would relieve coastal countries of some of the financial burden caused by oil spills. They would imply an insignificant increase in the cost of oil for importing countries.

The Recommendation is also designed to encourage countries to adopt financial arrangements concerning the assistance that one country may give to another to clean up an oil spill. These arrangements could stipulate that such assistance would be completely free of charge, reimbursed in part or charged in full.

In the absence of any financial arrangements, payment should be required for assistance only if it has been requested, since it is clear that a country offering assistance that has not been requested cannot normally demand payment for it. The way in which any payment should be calculated is spelled out and includes costs of food, accommodation and fuel as well as

the wages of the staff employed and the wear and tear of the equipment used. This clause would comply with the 'polluter pays' principle.

The financial problems of bilateral mutual assistance operations to control oil spills affecting one or more countries were examined by OECD Environment Committee's Group on Transfrontier Pollution in 1979 and 1980. The studies, carried out with the support of the countries of the Bonn Agreement of 1969 (Pollution of the North Sea by hydrocarbons) led to the adoption of the present Recommendation by the OECD Council in April 1981.

The Committee's report, 'Certain Financial Aspects of Prevention and Control of Oil Spills' and the Recommendation are available on request from the OECD Press Division, 2 rue André Pascal, 75775 Paris Cedex 16 (Tel: 524 80 89).

All-out effort to improve oil sector training

At the same time as schemes for training oil experts in Norway are considerably improved and intensified, some twenty oil companies and major industrial concerns operating in the North Sea will pay the expenses of sending Norwegian students to study for engineering degrees abroad, as training capacity in Norway is inadequate. This is the first time that industry has financed studies abroad.

The scheme is expected to come into operation by the autumn when 100-200 Norwegian students leave for Sweden. The extra costs of studying abroad will be paid from a fund established especially for this purpose, says Mr Egil Abrahamsen, head of the classification society Det norske Veritas.

The arrangement will probably last five-six years until study capacity in Norway is expanded. The whole programme will cost about 10 million US$. The same type of scheme may be established in other countries.

Every year the Norwegian Institute of Technology (NTH) in Trondheim has to turn down about 1 000 applications from would-be students. Added to this are those who do not apply because of the acknowledged difficulty of getting in.

In order to improve possibilities in this field NTH, SINTEF, – The Foundation of Scientific and Industrial Research –, and the Continental Shelf Institute (IKU) are to coordinate their resources in the petroleum related sector. Two large centres for research and training in petroleum technology will probably be established shortly.

They are expected to cost about an aggragate 35 million USD, and they will be built up in connection with the technical training facilities in Trondheim and Stavanger. A group of oil companies will finance the project.

The aim is to bring together all the expertise on the research and education side in order to achieve the most rational utilization of this knowledge. The institutions and oil companies have completed their part of the preparations and will put the plan into operation as soon as the authorities have given their approval. The salient condition for the approval of the Ministry of Church and Education is that the centre will benefit education.

An officially appointed committee has recently delivered its report on the specialized training of personnel for work on the fixed production installations on the Norwegian shelf. The report covers most of the special fields related to providing adequate and sound training for such personnel.

If the problem is not solved, the dearth of qualified drilling personnel may prove to be a bottleneck in Norwegian oil developments within the next few years. The problem already exists – a tendency to accept offers of jobs abroad is accompanied by wage demands reaching as much as 52 000 US $ per year.

On a world-wide basis 150 new drilling platforms are on order. Ten of these are Norwegian. Calculating with a net inflow of six rigs to Norwegian owners, this means an increased need for qualified drilling personnel of the magnitude of 500. In addition comes the production drilling on fields such as Statfjord C, Heimdal, Valhall and the 'gold block'. Competition for Norwegian labour from abroad is beginning to be sharp. Control stipulations in other parts of the world are not so stringent as in Norway and the economic prospects are good – net salaries reaching 52 000 to 87 000 $.

Vast potential gas reserves on Norwegian shelf

Provided that the government gains the Storting's permission to land the gas from Statfjord, Heimdal, and the 'gold block' (34/10), Norway will towards the late 80s, emerge as a nation which is rich not only in oil, but also in gas.

As previously reported in Norinform, the government has proposed that the rich gas containing liquids from the three areas should be piped ashore at Kårstø north of Stavanger. Up to now, the wet gas has been used as petrochemical feedstock in Norway. The dry gas will mainly be exported to the Continent via the pipeline from Ekofisk to Emden in West Germany.

A survey from the Ministry of Petroleum and Energy shows that the proven recoverable reserves of gas on the Norwegian shelf south of the 62nd parallel are estimated at almost 1 300 milliard m^3. The value of the gas is normally put at 1 NOK (18.5 cents) per m^3. In other words, this means that the oil finds registered so far are worth 228 milliard US$.

However, the total value of gas reserves on the Norwegian shelf may be in the region of 701 milliard US$. The Ministry of Petroleum and Energy has in fact calculated that the gas reserves in one area alone (sector 31 – west of Bergen) may be between 1 800 and 1 900 milliard m^3.

The Petroleum Directorate in Stavanger operates with figures for probable oil and gas reserves south of the 62nd parallel of approx. 4.7 milliard tons of oil equivalents. Gas probably constitutes about 54% of this. In other words, it is calculated that there are about 2 400 milliard m^3 of gas in the area south of the island of Stad (outside Bergen) alone. This constitutes about 15% of the Norwegian continental shelf.

If corresponding amounts of oil and gas are found on the shelf north of Stad – an area which is six times as big – then vast amounts of money are involved – even though estimates are fairly cautious.

Another interesting eventuality is possible gas finds and landing of the gas off north Norway, plus the establishment of a petrochemicals industry in this area. Market conditions for the petrochemicals are, however, very difficult at present and plans for further expansion within petrochemicals, particularly in north Norway, have been laid aside, at least for a few years.

Preparations for dealing with possible gas finds offshore north Norway are, however, in progress and prospecting is under way. The state oil company Statoil has initiated a comprehensive research project with the express aim of meeting this possibility. A sum of 27 million US$ has been earmarked for this purpose. Statoil is aware of the fact that there is no market at present for large amounts of gas from north Norway. Most experts agree, however, that such a market will emerge in the not far distant future.

Gas finds offshore North Norway

Traces of hydrocarbons have been found on the blocks now being drilled offshore North Norway. Both Norsk Hydro and the state oil concern Statoil have reported finds in these areas.

Norsk Hydro found gas on he second wildcat drilled on the Tromsøflaket. The discoveries were made at a depth of 2 000 m. The magnitude of the find cannot be established until the well is drilled to its planned depth of 5 000 m, in August. The find has been characterized as interesting as it was made in porous strata which means that it should be possible to exploit it.

Statoil found traces of hydrocarbons on a neighbouring block to Hydro's. There is not yet sufficient data to determine whether this indicates oil or gas, or how big the find will prove to be.

Spokesmen for the companies and the petroleum authorities are cautious in their predictions, but such early indications are encouraging when compared with the corresponding exploratory activity south of the 62nd parallel. In the latter area it took 33 trial drillings to find the first traces of hydrocarbons.