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FATIGUE AND CORROSION FATIGUE BEHAVIOUR OF OFFSHORE STEEL STRUCTURES

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1. Work in progress.

2. Research programme

2.2.1. Effect of plate thickness

The fatigue behaviour of welded steel joints has been found to depend significantly on plate steel thickness. It has been observed in flat plate tests as well as in tests on tubular connections up to a plate thickness of about 40 mm that the fatigue strength decreases with increasing plate steel thickness. It is not clear until now whether the observed phenomenon must be explained as a pure thickness effect or that other factors are involved such as:

- an decrease of the stress gradients with an increase of the size of the specimen
- the increase of residual stress level in welded steel joints with increasing plate steel thickness
- the higher probability of the occurrence of weld defects in welded steel joints with increasing plate steel thickness
- the non-linearity of plate thickness and weld toe dimensions.

Some preliminary results indicate that at thicknesses above 40 mm the fatigue strength does not decrease any longer.
The use of very thick steel plate thickness in offshore structures requires a more detailed examination of this thickness effect.
The main objective to study the thickness effect is to clearify the discrepancy found between the Dutch testresults of the last ECSC programme and the results of other investigations. All tests of these series will be done in air.

2.2.2. Effect of weld geometry and weld finishing (weld flank angle and weld toe curvature.

The fatigue behaviour of welded steel joints has not been found to alter significantly (between certain limits) with the weld flank angle. However the weld toe curvature influences the fatigue strength of welded joints significantly as can be seen from results of tests of different investigations.
This local weld toe curvature can be improved by weld finishing techniques like grinding, TIG- and Plasma dressing.
The interaction between finishing of the weld toe and weld flank angle will be studied with two plate thicknesses. These test series are considered to form an extension to earlier work. These series will be executed in artificial seawater (ASTM).

1. Root layers

   Manual metal arc welding: horizontal position

   Electrode : Covered basic electrodes
   AWS code E7016

   Electrode diameter : ϕ 3¼ - ϕ 4 mm

   Preheat- and interpass temperature : 125-150°C

2. Intermediate layer

   Submerged arc welding : horizontal

   Threat-thickness : ϕ 4 mm

   Powder : P 230R

   Preheat- and interpass temperature : 125-150°C

3. Surface layers

   Manual metal arc welding: vertical uphill position

   Electrode : Covered basic electrodes
   AWS code 7016

   Electrode diameter : ϕ 3¼ - ϕ 4 mm

   Preheat- and interpass temperature : 125-150°C

4, Welding parameters :

   welding current : ϕ 3½ mm electrodes 110-125A
   ϕ 4 mm electrodes 140-155A

   Voltage : 24-27 V

Fig. 3 gives the build-up sequence of the welds. The surface layers (MMA welds) were done in vertical uphill position and considered to result in a comparable weld geometry (flank angle and toe curvature) as the test-specimens used in the first phase ECSC programme.

2.3. Tubular joints

The influence of some important parameters studied on plate specimens will be checked on tubular joints. Because the last ECSC programme showed a very significant size effect, the influence of these parameters will be investigated on large size tubular joints (chord diameter ϕ 918).
Table 2 gives detailed information about the testing programme on tubular join

2.3.2.5. Loading conditions

The joint will be axially loaded on the brace. To avoid secondary effects all supports in the test rigs will be hinges. The loads are applied by servo-hydraulic actuators.

2.3.2.6. Test programme

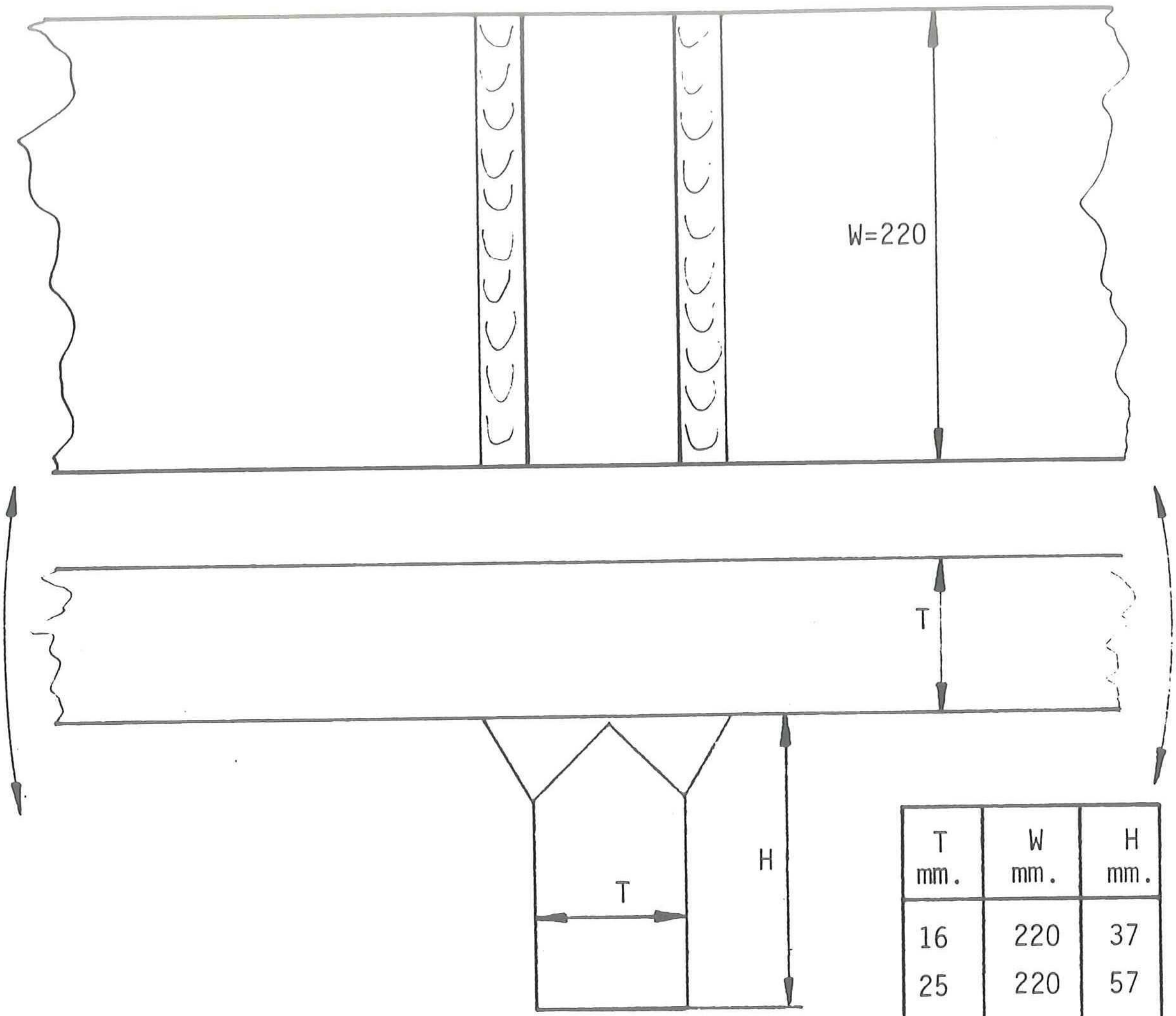
The investigation includes 10 tests. Table 2 gives a review of the tests on tubular joints. The loading frequency: in seawater 0.2 Hz and in air about 3 Hz. The stress ratio R = 0. The number of cycles will vary between 5.10^5 and 5.10^6.

2.3.2..7 Measurements

Strain measurements to determine the hot spot strain will be done in accordance with the decisions of ECSC - WG III.
Crack growth will be measured. The number of cycles belonging to the failure criteria as laid down by WG III will be determined.

Table 1 : Testing programme (plate specimens, T-shape)

Influencing parameter	Testseries	Nr. of spec.	Weld flank angle		Weld toe finishing	Thick-ness	Environment		Stress ratio	Frequency
			60°	45°	(grinding)	mm	air	seawater	R	Hz
Thickness	A16-60-1- -N-L-G	10	x			16	x		0.1	5
(specimens stress-relieved)	A25-60-1- -N-L-G	10	x			25	x		0.1	5
	A40-60-1- -N-L-G	10	x			40	x		0.1	5
	A70-60-1- -N-L-G	10	x			70	x		0.1	5
Weld geometry	A16-45-4- -N-Z-0	4		x		16		x	0.1	0.2
-weld flank angle	A16-60-2- -N-Z-0	4	x			16		x	0.1	0.2
-weld toe curvature	A16-45-5- -V-Z-0	4		x	x	16		x	0.1	0.2
(specimens non-stress re-	A16-60-3- -V-Z-0	4	x		x	16		x	0.1	0.2
lieved)	A40-45-4- -N-Z-0	4		x		40		x	0.1	0.2
	A40-60-2- -N-Z-0	4	x			40		x	0.1	0.2
	A40-45-5- -V-Z-0	4		x	x	40		x	0.1	0.2
	A40-60-3- -V-Z-0	4	x		x	40		x	0.1	0.2
Seawater temperature ($5^{\circ}C$)	A40-60-6- -N-Z5-0	4	x			40		x	0.1	0.2
(specimens non-stress										
relieved)										



T mm.	W mm.	H mm.
16	220	37
25	220	57
40	220	90
70	220	160

FIG. 1 Fatigue plate specimens

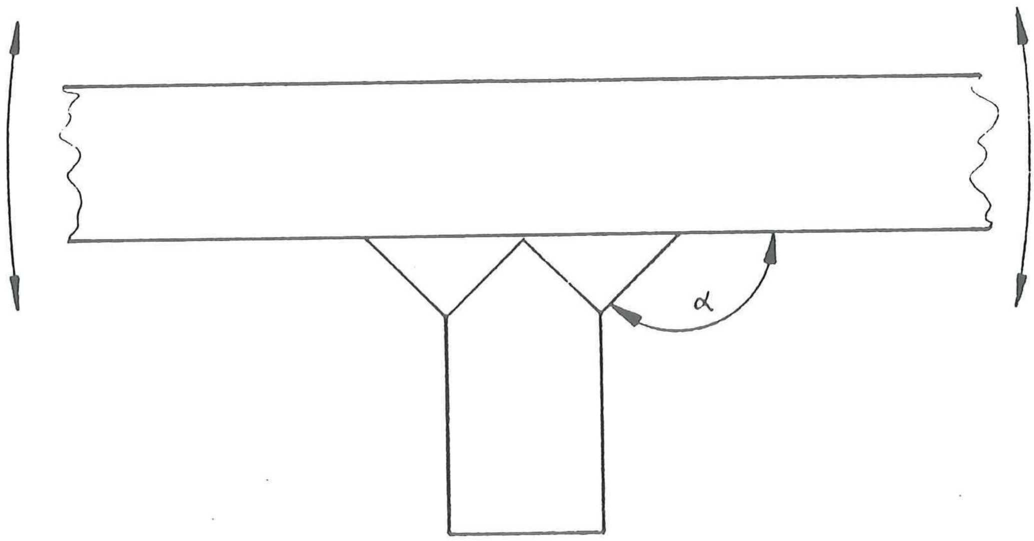


FIG. 2 Weld geometry :

- weld flank angle α :
  - 135^0
  - 150^0
- weld toe curvature :
  - as-welded
  - improved by finishing techniques

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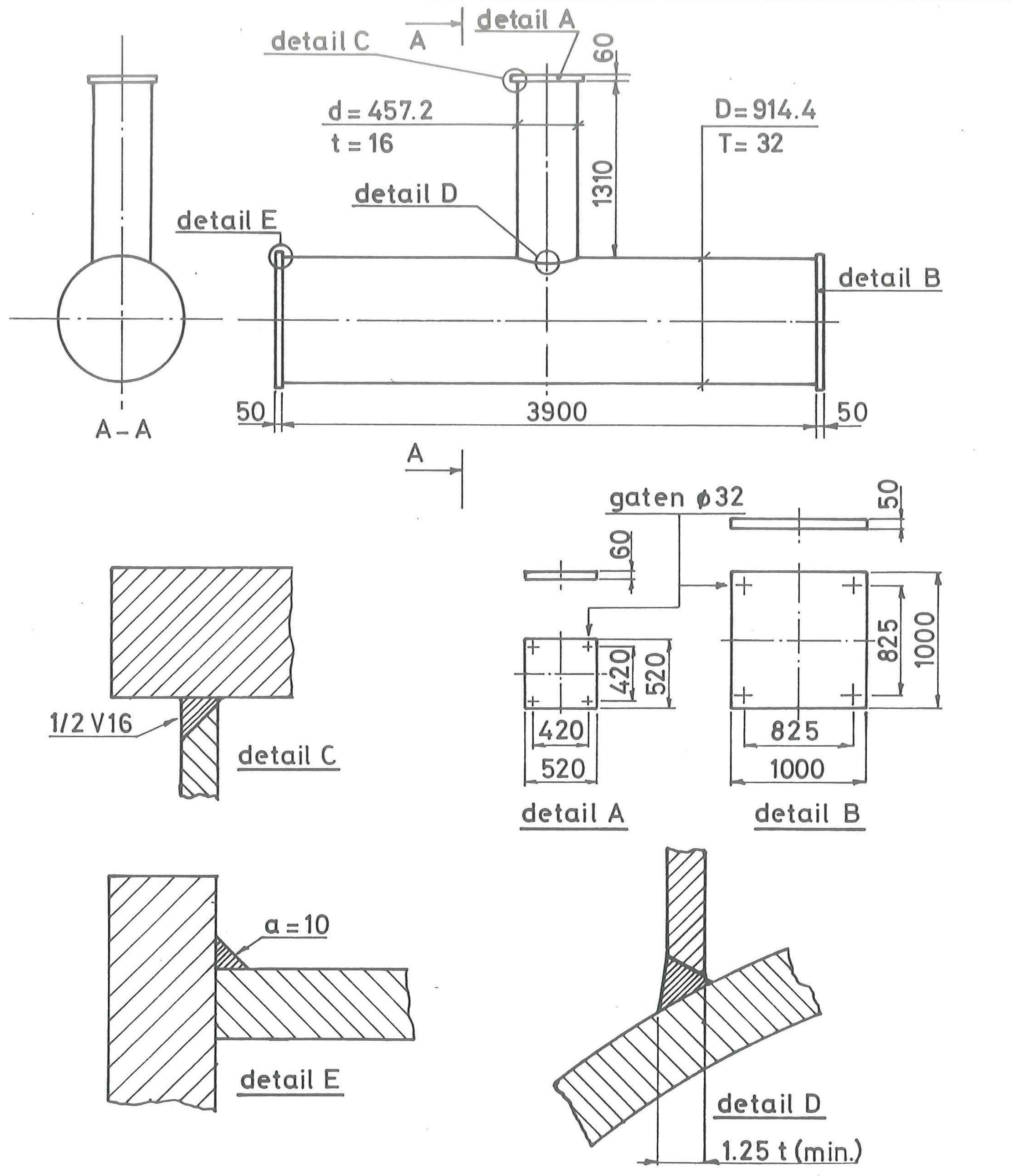

Figuur: 4 Tubular T_joint specimen

aantal	10
kwal. staal	buis: API-5LX-grade-X52
	kopplaat: Fe 360
toleranties	max. hoekafwijking = 1/4°
	max. afstand hartlijnen = 1mm

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TH DELFT