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FATIGUE PERFORMANCE OF JOINTS BETWEEN CLOSED LONGITUDINAL STIFFENERS IN ORTHOTROPIC STEEL BRIDGE DECKS

Part 2: Optimalisation of the splice joint

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ABSTRACT

This report describes the results of the optimalisation of field-welded joints between closed longitudinal stiffeners in orthotropic steel bridge decks. To improve the quality respectively the fatigue life of the stiffener splice joint, first welding tests have been carried out for four different types of butt welds with backing strips.

The best quality has been obtained with the V-butt joint of 60° including the tack weld and a gap between the weld toe of the tack weld and the connecting plate of 4 mm. Based on the obtained results this detail with an angle of 30° has been chosen for the full scale fatigue testspecimens.

The butt welds of three specimens have been welded by manual metal arc welding and for one specimen the welds have been realised by metal inert gas welding. For all tests the number of cycles at the first visual observation of a crack are situated above the Eurocode fatigue strength curve Class 100.

1. INTRODUCTION

In most large orthotropic steel bridge decks, field welded joints have to be made because transportation of the complete bridge from the shop to the site is not always possible. In general, both longitudinal and transverse field splices have to be made. In the longitudinal splices, only the deck plate has to be connected. This is mostly done by butt welding as the weld is accessible both from above and from below, a good quality of the weld can be achieved. The same applies to the transverse butt splice weld in the deck plate. At the transverse splice, the longitudinal ribs have to be connected as well (see figure 1).

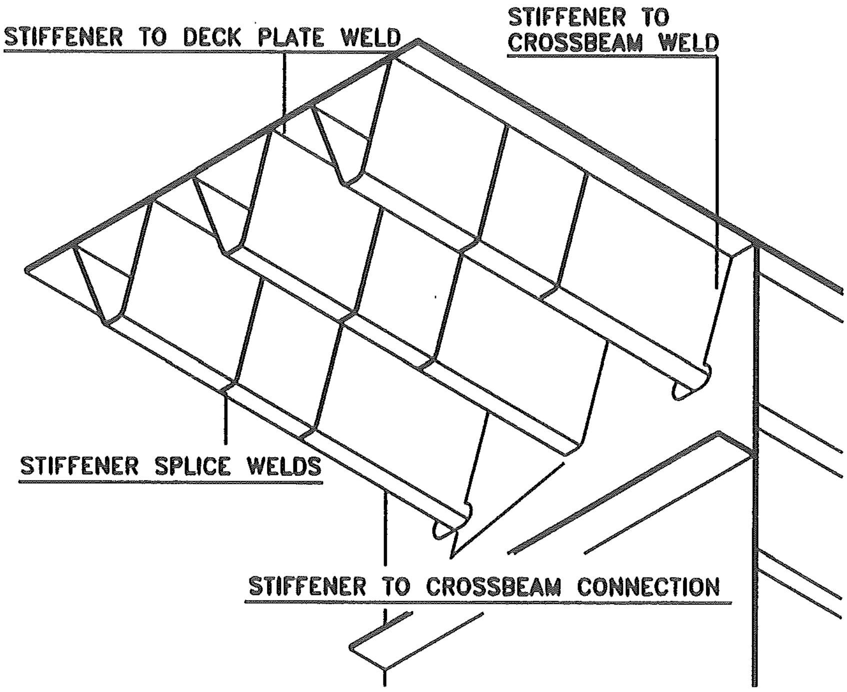


Figure 1. Main welded connections in a typical orthotropic bridge deck.

With closed ribs, mostly used in modern bridges, the most appropriate way of splicing is by welding but as the welds can only be made from the outside in an unfavourable overhead position (see figure 2), the quality of those welds will be dubious.

Figure 2. Welding position of the field welded trough rib joint.

Depending in the location of the splice in the deck, the load on the splice can have a fluctuating part due to the traffic load, dominating the static loading, so conditions for fatigue damage are present. As the splice in the ribs frequently occurs in a bridge deck, an investigation of the fatigue behaviour of these joints is necessery.

The last 25 years a lot of research has been carried on this welded joint. Constant amplitude fatigue tests and variable amplitude fatigue tests on full scale specimens with different welded joints resulted in first recommendaties for design and repair. Field measurements on the traffic loading and resulting stresses in the orthotropic steel bridge deck improved the knowledge about static as well as fatigue design of these structures. In some cases fatigue cracks developed in the welded joint between longitudinal trough stiffeners.

The state of the art available from the literature until now, has been reported in Part 1 of the current study [1]:

FATIGUE PERFORMANCE OF JOINTS BETWEEN CLOSED LONGITUDINAL
STIFFENERS IN ORTHOTROPIC STEEL BRIDGE DECKS
Part 1: Review of experimental data

Without going in further detail in that report some general remarks have been made considering the fatigue strength:

> The fatigue strength of the trough splice joint must be defined by full scale test specimens against strip specimens. There is a good agreement between the constant amplitude tests and the variable amplitude tests using the Miner calculation. Different types of splice joints has been studied by constant amplitude tests. The following conclusions has been made:
>
> - The unfavourable overhead position influences the quality of the welds extremly. Weldimperfections can be avoided, but ask special attention of the welder and extensive NDO research.
> - The fatigue strength of the single lap splice joint with fillet welds was quite low with respect to the butt splice joint with backing strips.
> - The fatigue strength of the single lap splice joint can be increased by using a double one.
> - The fatigue strength of the butt splice joint with backing strips is depending on the gap between the stiffener and the splice plate and the misalignment or gap between the back-up strip and the stiffener or splice plate.
> - The butt splice without backing strips, but with a thick joint plate can result in a relative high fatigue strength. However these good results can only be achieved if much care is taken of the fabrication. The required level is not practical for normal field splices in bridge construction.
> - Due to residual stresses the complete penetration butt welds resulted in a lower fatigue strength than the backing strip welds.
> - In general it seems to be necessery to define for these types of complete splice joints, seperated fatigue strengths in design codes.

Above mentioned conclusions have been discussed in the Netherlands with bridge designers and engineers with experience in the welding of orthotropic bridge decks. The prefential detail to be used in the longitudinal trough butt splice joint appeared to be a butt weld with backing strips. However a root gap of 10-12 mm and shaping the connecting plates is expensive.

Therefore it was decided to make **two** series of welding tests each with **four** different root gaps and shaping of the connecting plates to investigate the quality of the welds by NDO research. In addition **four** full scale fatigue tests with the best detail has been carried out to determine the fatigue strength.

The welding tests as well as the new performed full scale fatigue tests will be reported in this report.

2. WELDING TESTS

2.1. Specimens, edge preparation and tack weld

Two series of four specimens has been made according to figure 3. The edge preparation of specimen 30-1 and 30-2 are mostly used in the Netherlands. In specimen 30-3 and 30-4 the tack weld of the backing strip has been moved to the butt weld to avoid a second crack initiation point in this type of stiffener splice joint. Next to that, the gap between the connecting trough plates has been enlarged, because experimental tests [1] showed a high fatigue resistance using a gap of about 6-12 mm.

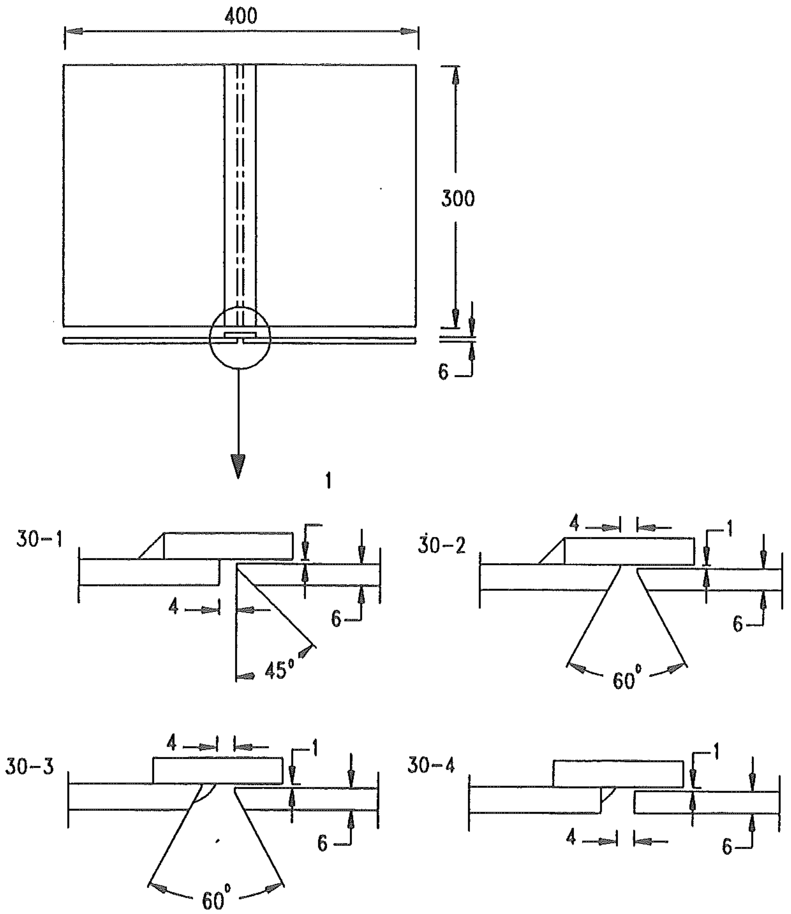


Figure 3. Specimens welding tests stiffener splice joint.

2.2. Welding procedure specification

The welding procedure specifications of the different specimen are given in Appendix A page A.2 - A.4. Figure 4 shows the bead sequences and welding sequences numbers. In all cases the welds were made by manual metal arc welding in the overhead position.

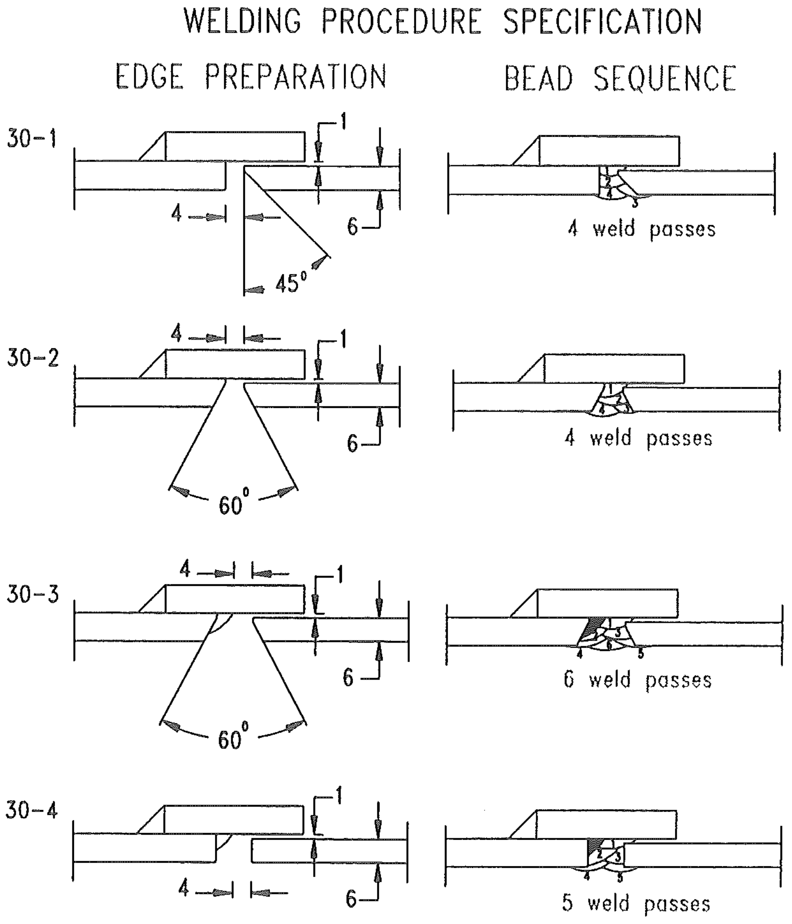


Figure 4. Welding procedure specification - welding tests.

2.3. Welding procedure qualification

During fabrication of the specimens of both series, welding procedure qualification reports have been made as given in Appendix A page A.6 - A.9 for Serie 1 and page A.11 - A.14 for Serie 2. Data considering the number of weld sequences are presented in figure 5 together with those from the welding procedure specification. There appears to be some difference between the theoretical and practical number of weld passes. Especially the specimen type 30-3 and 30-4 with a larger root gaps resulted in less weld passes.

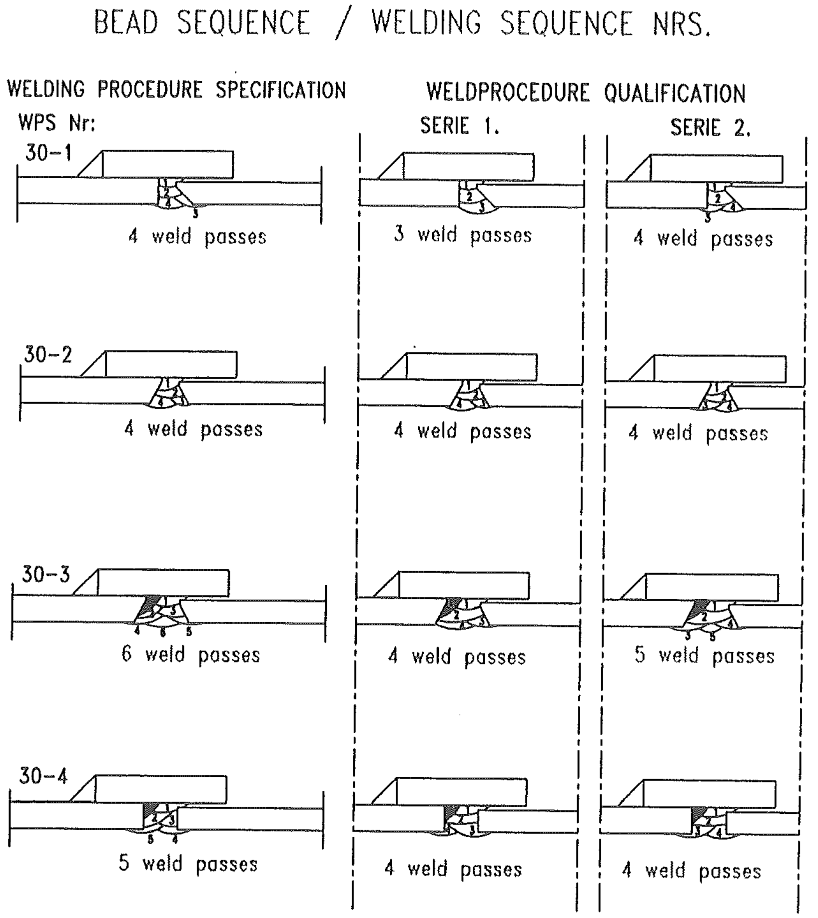


Figure 5. Weldprocedure qualification - welding tests Serie 1 and 2.

2.4. Non-destructive examination report

After welding the specimens have been X-rayed. The reports are given in Appendix A page A.10 for Serie 1 and page A.15 for Serie 2. A summary of both reports is presented in figure 6. Results show that the detail 30-3 contains fewest number of defects and the traditional detail 30-1 most defects.

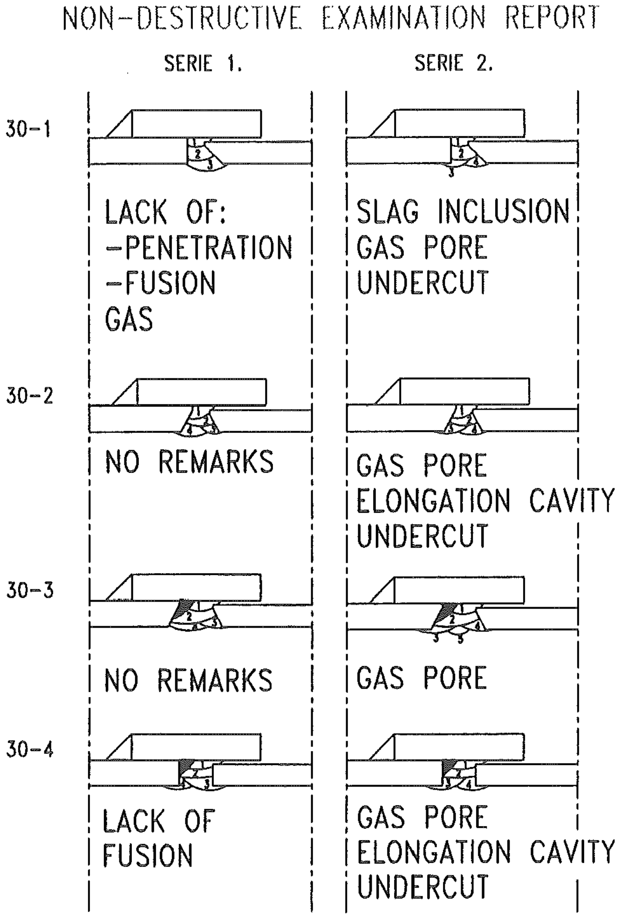


Figure 6. Non-destructive examination results - welding tests Serie 1 and 2.

2.5. Visual inspection

The welding defects and the surface of the weld has been inspected by more or less visual inspection of sections of the weld cut out from the specimens. Photos of these sections are given in Appendix A page A.16 until A.19. A typical example of each type is presented in figure 7.

It can be seen that:
- the root fusion of type 30-1 and 30-2 is less than the types with a larger root gap,
- in all cases the oversize of the weld, which results in an undercut at the weld toe, is the slightest for type 30-3.

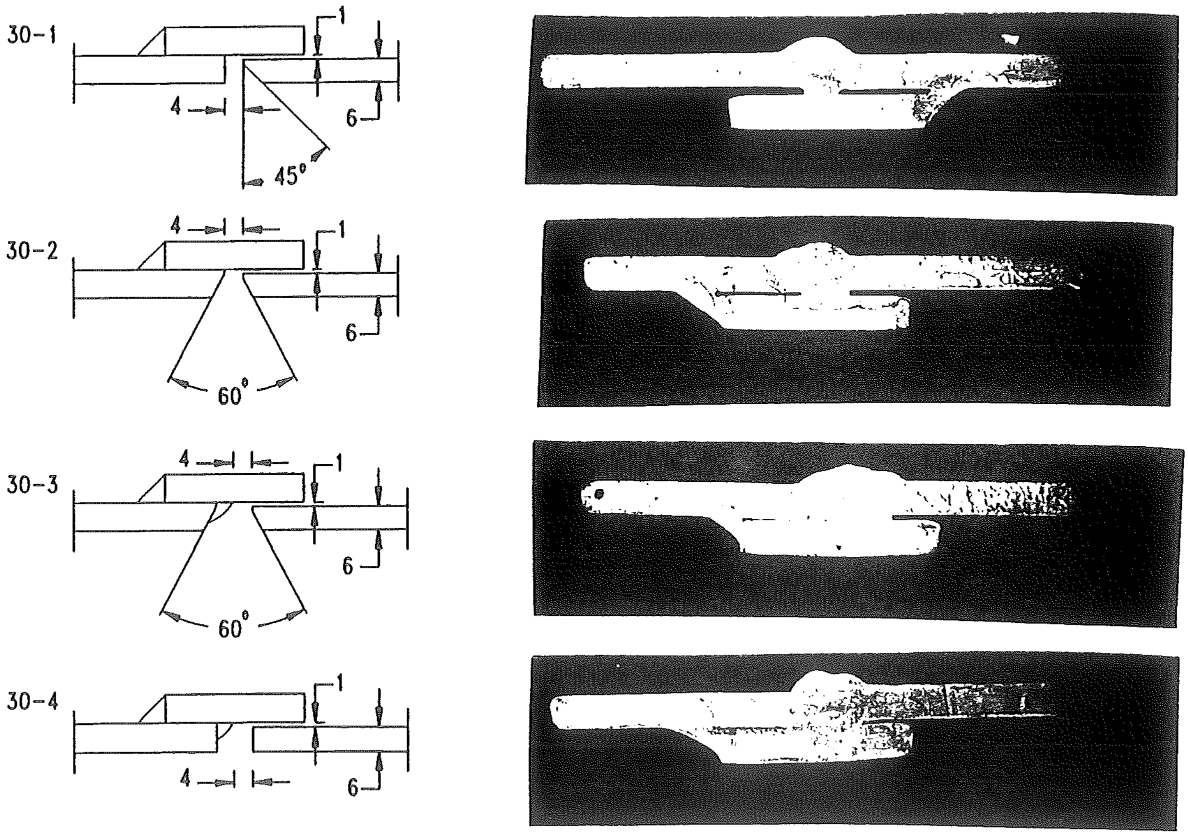


Figure 7. Sections of the welds - welding tests Serie 2.

2.6. Discussion

To improve the qualtiy respectively the fatigue life of the stiffener splice joint, welding tests have been carried out for four different types of butt welds with backing strip.

The following parameters have been varied:
- the root gap of the butt weld,
- the shape of the connecting plates,
- the location of the tack weld.

In all cases the lack-of-fit between the backing strip and the connecting plate amounts 1 mm.

The results of the welding procedure qualification showed that for all types the number of weld passes is about the same. So the welding costs are about the same for all types.

The results of the non-destructive examination reports as well as the visual inspection of the sections of the weld cut from the specimens, showed that the traditional detail with a root gap of 4 mm and one shaped plate contains the most defects. The best quality has been obtained with the V-butt weld of 60° including the tack weld and a gap between the weld toe of the tack weld and the connecting plate of 4 mm.

Based on these results the detail as given in figure 8 has been chosen for the full scale fatigue test specimens. To limite the amount of weld material the angle of the V-groove was chosen to be 30° in stead of 60° used at the welding tests.

3. CONSTANT AMPLITUDE TESTS

3.1. Testspecimens

The specimens for the bending tests were single rib specimens as depicted in figure 8, steel grade Fe 510. As the usual spacing of the ribs is 600 mm, the width of the deck plate in the specimens was also 600 mm, in order to get the same position of the neutral axis as in an actual bridge deck.

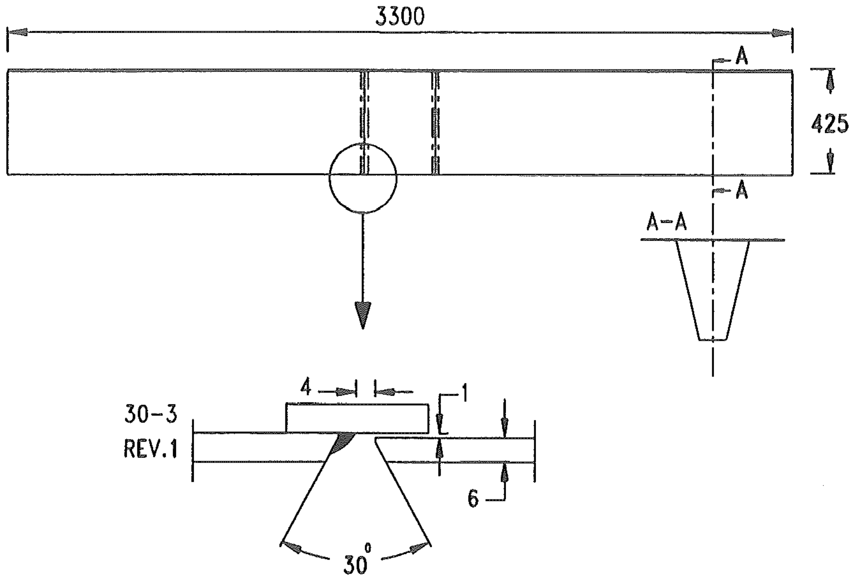


Figure 8. Testspecimen and type of trough splice joint.

At the fabrication of the test specimens, imitation of the welding conditions with a real bridge deck was pursued because test specimens made with special care under favourable conditions would not be representive. The welds in the bottom of the splice joint were made in an overhead position and the welds in the webs of the splice joint were made by upward welding. The test specimens were made by a fabricator with experience in making orthotropic steel bridge decks.

3.1.1. Types of trough splice joints

Based on the obtained results of the welding tests as described in the previous chapter and further discussions with bridge engineers and welding authorities the detail as given in figure 8 was chosen to be used in four fatigue test specimens.

3.1.2. Welding procedure specification

The welding sequence of the butt welds connecting the splice joint to the trough stiffener and the weld connecting the splice to the deck plate is given in Appendix B page B.2. and B.20. The butt weld of three specimens has been welded by manual metal arc welding (M.M.A.W.) and one test specimen has been welded by metal inert gas welding (M.I.G.W.). Both welding procedure specifications are given in Appendix B page B.3 and B.4 and summerizied in figure 9.

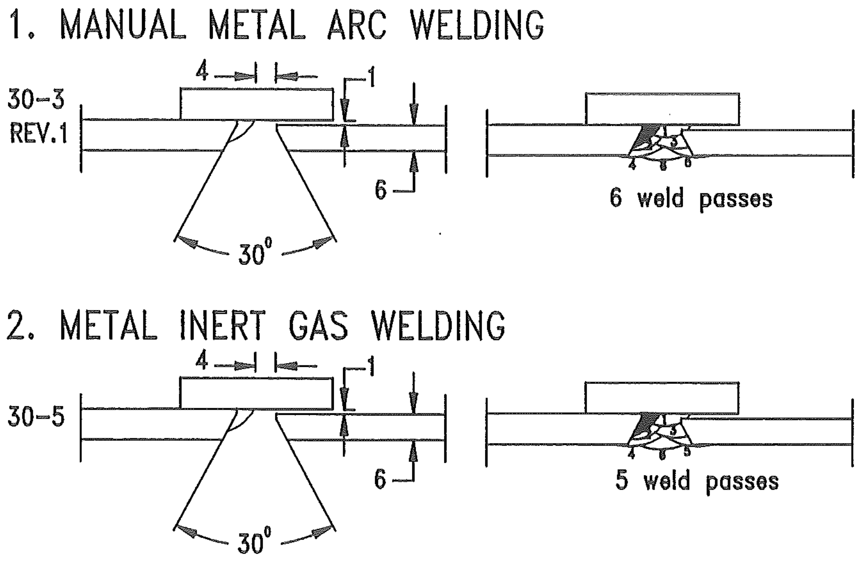


Figure 9. Weld procedure specification - edge preparation and bead sequence.

3.1.3. Weldprocedure qualification

The weldprocedure qualification reports made during the fabrication of the specimens are given in Appendix B page B.5 and B.6. A review of these reports and the perscribed welding procedure specifications are gathered in figure 10.

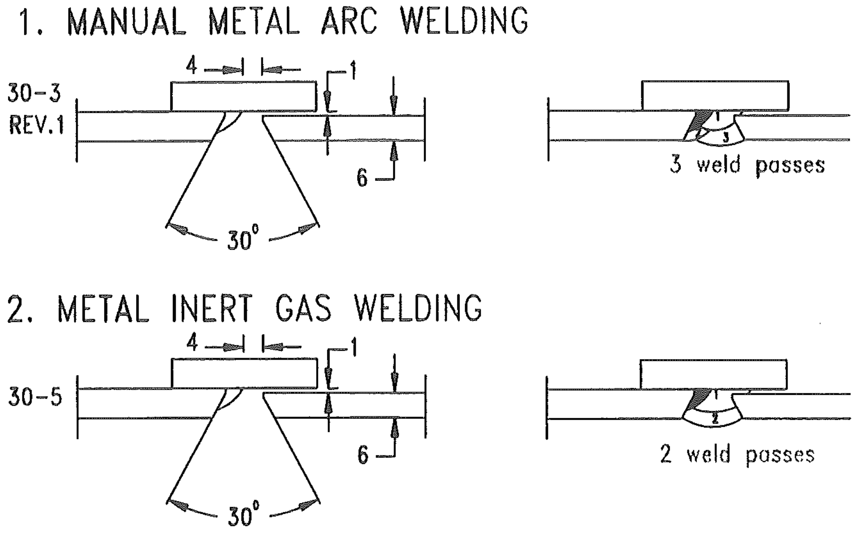


Figure 10. Weldprocedure qualification.

The number of weld passes during welding seemes to be much lower according to the welding procedure specifications.

3.1.4. Non-destructive examination report

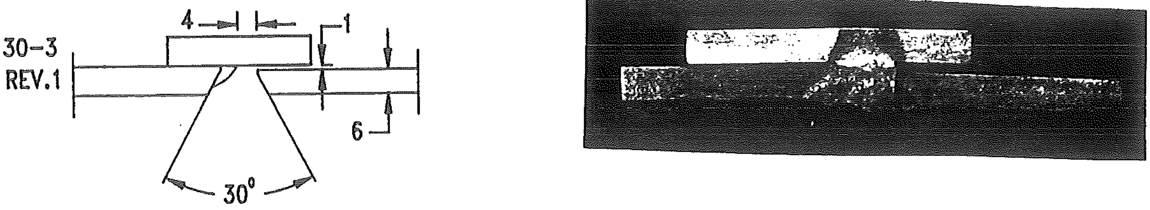
After welding the specimens have been X-rayed. The non-destructive examination report is presented in Appendix B page B.7. Results show that in a part of one weld made by M.M.A.-welding lack of fusion has been found.

3.1.5. Visual inspection

After welding the performance of the weld has been inspected by more or less visual inspection of sections of the weld cut out from the specimens. A typical example from each type is presented in figure 11.

It can be seen that:
- the root fusion of both types is the same,
- the oversize of the weld made by metal inert gas welding is neglectible with respect to the weld made by manual metal arc welding.

1. MANUAL METAL ARC WELDING



2. METAL INERT GAS WELDING

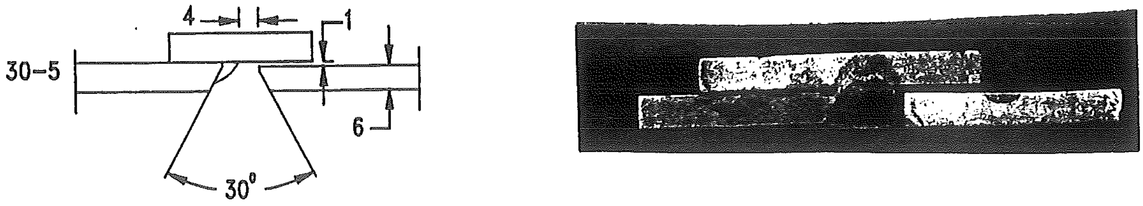


Figure 11. Sections of the welds.

3.2. Test method and loading

3.2.1. Test set-up

A four point bending test was chosen to study fatigue in the longitudinal stiffener splice joint (see figure 12). Constant amplitude fatigue tests has been carried out by using servo hydraulic test equipment operating in closed loop control with load feedback. To avoid any secondary effects, all supports in the test rig were provided with roller bearings.

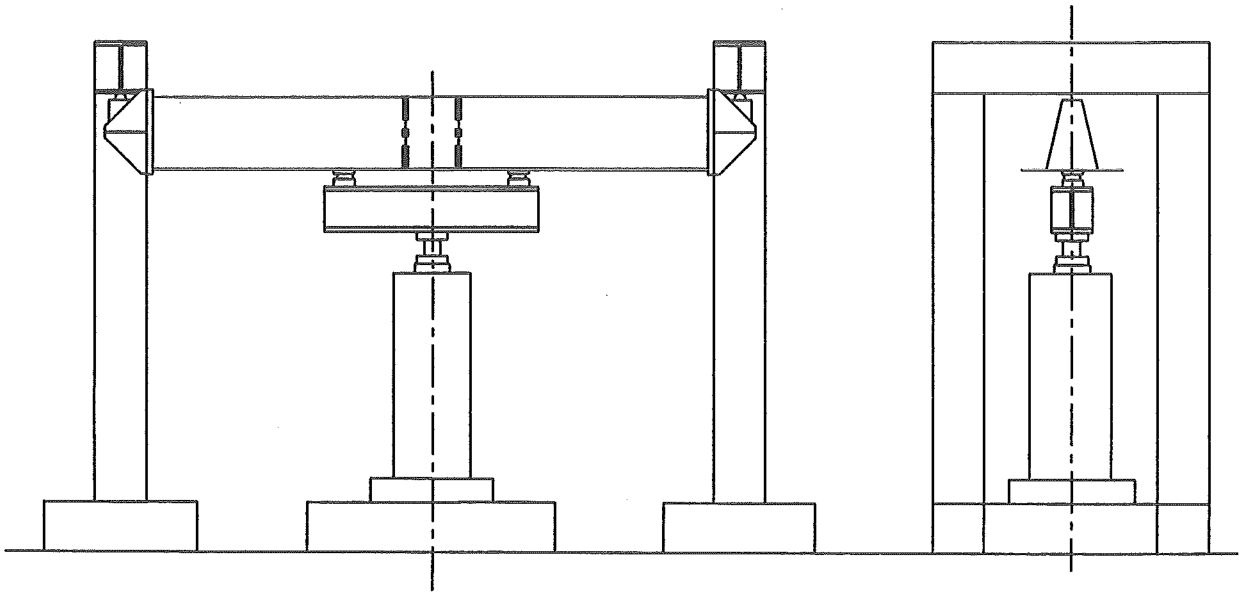


Figure 12. Test set-up stiffener splice joint.

3.2.2. Strain measurements

Each test specimen was instrumented with a number of strain gauges before testing. A review of the used strain gauge locations and numbers is given in figure 13.

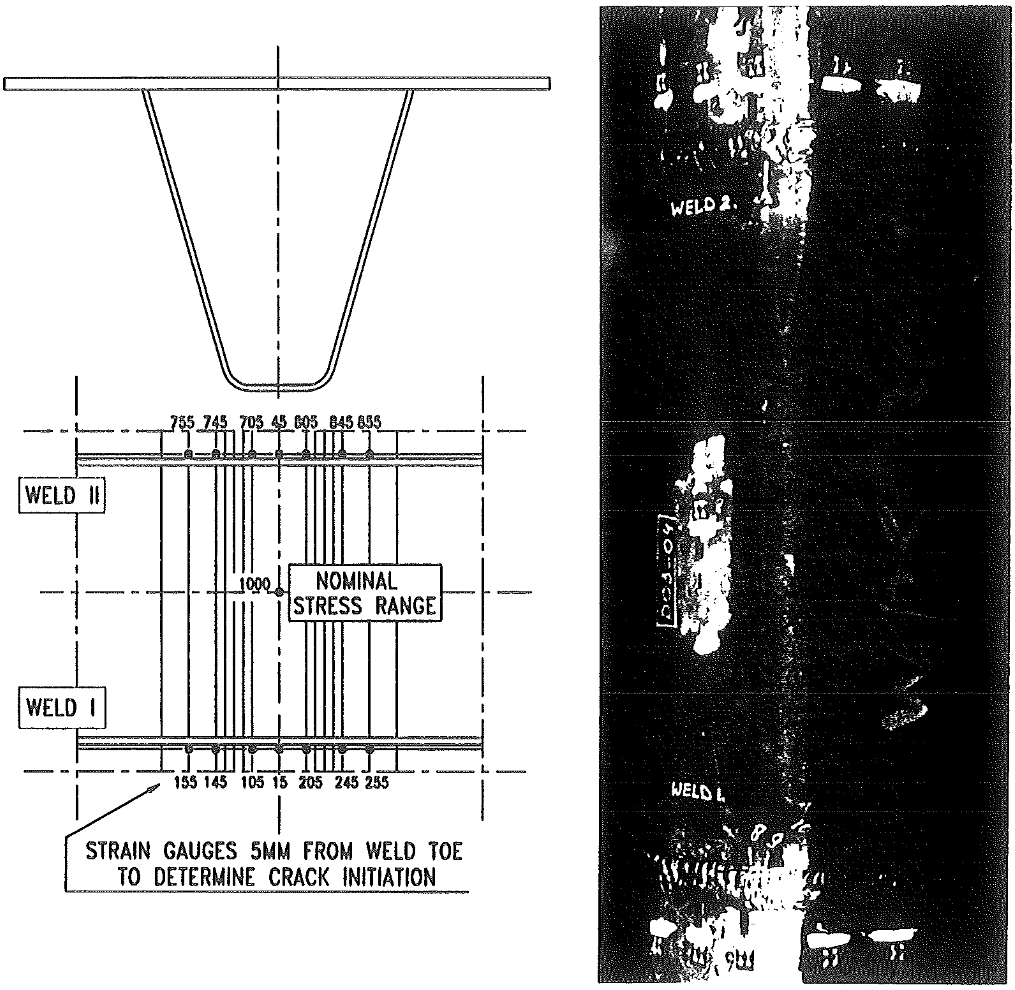


Figure 13. Strain gauge locations at bottom side of the splice.

One strain gauge numbered 1000 is located in the middle of the splice joint at the bottom side. At this location the measured stress range has been considered to be the nominal stress range situation for this splice joint. Strain measurements were carried out dynamically to check the applied stress range on the test specimen.

Furthermore, strain measurements were envisaged 24 hours a day to obtain information about moment and location of starting a crack. The required strain gauges have been positioned 5 mm from the weld toe along the weld at the bottom side of the splice joint.

3.2.3. Crack growth monotoring

Measurements of crack growth were carried out by more or less periodic visual inspection with a magnifying glass. It was only possible to measure crack length at the surface of the specimens.

3.2.4. Stages in fatigue failure

As far as possible four stages in fatigue failure are expressed in number of cycles:

N1: Moment of crack initiation given by 10 % strain fall off measured in the strain gauge nearest to the crack,

N2: Moment of visual crack initiation (by magnifying glass),

N3: A crack indicating the number of cycles when a surface crack length of 50 mm is reached,

N4: End of test by extensive through cross section cracking, leading to loss of specimen stiffness causing limitation of the actuator stroke and/or loss of symmetry causing unacceptable side load on the actuator bearing.

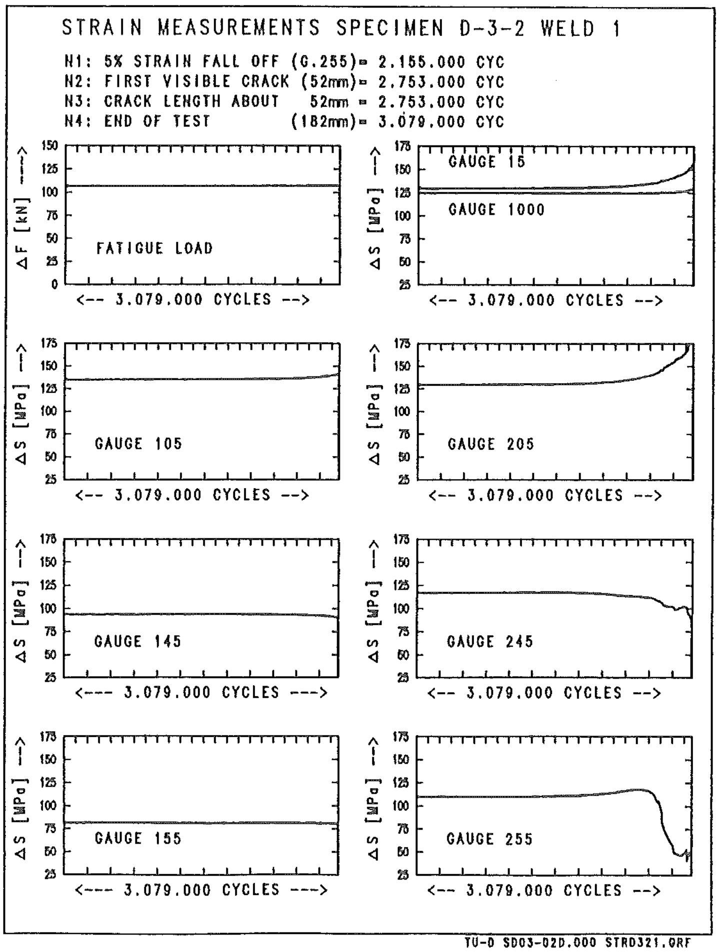


Figure 14. Typical strain measurements and different stages in fatigue failure.

3.3. Test results

All data obtained during the fatigue tests are gathered in Appendix B.

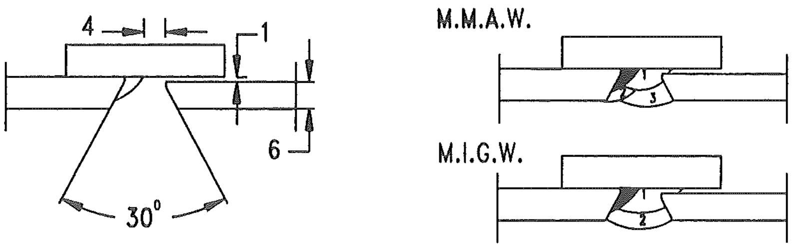
3.3.1. Definition of stress

The normal stress at the bottom of the rib in the middle of the splice, due to pure bending, was chosen as the main stress parameter. This stress was defined by the strain gauge numbered 1000 (see figure 13).

3.3.2. Review of test results

The fatigue results of the constant amplitude tests are tabulated in figure 15. This figure shows for each test specimen and belonging welds the several stages in fatigue failure expressed in number of cycles as defined in paragraph 3.2.4.

FULL SCALE FATIGUE TESTS



WELDING PROCES	TESTSPECIMEN	[MPa]	CYCLES * 10^6			
			N1	N2	N3	N4
M.M.A.W.	D.3.1. WELD 1	126	–	–	–	>2.74
	D.3.1. WELD 2	126	–	2.138	2.462	2.735
	D.3.2. WELD 1	125	2.155	2.753	2.753	3.079
	D.3.2. WELD 2	125	–	–	–	>3.08
	D.3.3. WELD 1	160	0.845	0.890	0.890	1.011
	D.3.3. WELD 2	160	0.496	0.508	0.508	1.011
M.I.G.W.	D.3.4. WELD 1	125	2.275	2.750	3.026	3.558
	D.3.4. WELD 2	125	2.275	2.280	3.553	3.558

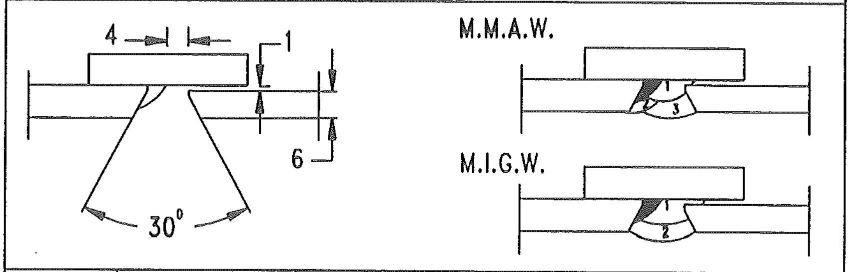
Figure 15. Review of test results.

Here it can be seen already, that in most cases the crack development is very fast and that there is hardly no influence of the different welding processes.

3.3.3. Crack initiation and crack development

In all the specimens, the crack started in a weld between the trough and the splice joint. In most cases, the starting point was located just above the bend between the bottom and web of the splice joint. The number of cycles N2 until the first crack was observed differs not much from the number of cycles N4 at the end of the test (see figure 16).

FULL SCALE FATIGUE TESTS



WELDING PROCES	TESTSPECIMEN	STRESS RANGE [MPa]	CRACK INITIAT. POINT	L2 [MM]	N2 [CYC.]	L4 [MM]	N4 [CYC.]
M.M.A.W.	D.3.1. WELD 2	126	TOE	10	2.138.000	26	2.735.000
			ROOT	78	2.471.000	229	
	D.3.2. WELD 1	125	ROOT	52	2.753.000	182	3.079.000
	D.3.3. WELD 2	160	ROOT	19	508.000	134	1.011.000
	D.3.3. WELD 1	160	ROOT	52	890.000	300	
M.I.G.W.	D.3.4. WELD 2	125	TOE	6	2.275.000	49	3.558.000
	D.3.4. WELD 1	125	ROOT	30	2.750.000	340	

L2 AND L4: CRACK LENGTH AT N2 OR N4 NUMBER OF CYCLES

Figure 16. Crack initiation and crack development.

It must be emphasized that inspection of the inside of the splice joint was not possible, so if a crack initiated at the root of the butt weld, it was not noticed until the crack reached the outside of the splice joint. In this failure mode the crack development was very fast.

The crack development of cracks initiating at the toe of the weld outside the splice joint was relatively slow. These cracks have been initiated probable by a combination of residual stresses and undercut of the weld profile.

3.3.4. Fatigue strength S-N relationship

The fatigue results of the constant amplitude as discussed before are presented in figure 17 as a S-N relation, on a double-log scale. In this figure, also the Eurocode fatigue strength curves [3] have been plotted.

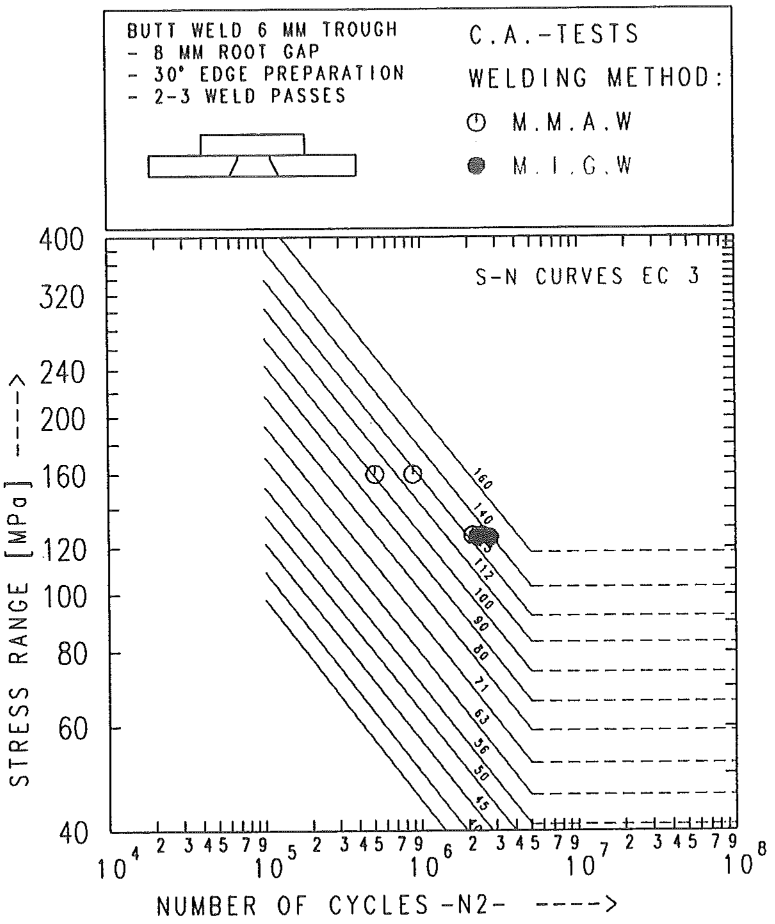


Figure 17. Full scale fatigue test results stiffener splice joint.

Comparison of the obtained fatigue results at the number of cycles "N2" with the Eurocode fatigue strength curves, shows, that they are all situated above Class 100.

It is clear that the influence of the different welding processes on the fatigue life is relative small.

4. CONCLUSIONS

To improve the quality respectively the fatigue life of the stiffener splice joint, first welding tests have beeen carried out for four different types of butt welds with backing strips. Based the obtained results one detail has been chosen for the full scale fatigue testspecimens.

For the welding tests the following parameters have been varied:
- the root gap of the butt weld,
- the shape of the connecting plates,
- the location of the tack weld.

In all cases the lack-of-fit between the backing strip and the connecting plate amounts 1 mm.

The results of the non-destructive examination reports as well as the visual inspection of the sections of the weld cut from the specimens, showed that the traditional detail with a root gap of 4 mm and one shaped plate contains the most defects. The best quality has been obtained with the V-butt joint of 60° including the tack weld and a gap between the weld toe of the tack weld and the connecting plate of 4 mm. This detail has been chosen for the full scale fatigue test specimens. To limite the amount of welding material the angle of the V-groove was chosen to be 30° in stead of 60° used at the welding tests.

The butt welds of three specimens have been welded by manual matal arc welding and to improve the quality, the welds for one test specimen have been realised by metal inert gas welding.

After welding the non-destructive examination report of the X-ray examination showed a lack of fusion in a part of one of the welds made by the manual metal arc welding process. Visual inspection of sections of the weld showed that the root fusion for both welding processes is the same. Furthermore the oversize of the welds made by the metal inert gas welding is neglectible with respect to the weld made by manual metal arc welding.
The results of the fatigue tests showed that there is no influence of the different welding processes on the fatigue endurance of the splice joint. For all tests the number of cycles N2 (first visual crack) are situated above the Eurocode fatigue strength curve Class 100. Comparison with previous tests carried out in the Netherlands showed that the new design of the butt splice joint results in a longer fatigue life.

5. REFERENCES

[1] Kolstein, M.H. "Fatigue Performance of Joints Between Closed Longitudinal Stiffeners in Orthotropic Steel Bridge Decks, Part 1: Review of experimental data", Stevinreport 25-6-93-9, Stevin Laboratory - Steelstructures, Delft University of Technology, The Netherlands, 1993.

[2] Tromp, W.A.J. "Fatigue of Field Splices in Ribs of Orthotropic Steel Bridge Decks", Stevin Report 6-74-15, Stevin Laboratory - Delft University of Technology, The Netherlands, 1974.

[3] Commission of the European Communities. Eurocode No. 3: "Design of Steel Structures.

3.4. Comparison with previous research

Next figure shows the new obtained test results with data obtained by Tromp [2] on the butt welded splice joint with backing strips and 4 mm root gap. It is clear that the new design behaves better than the traditional detail.

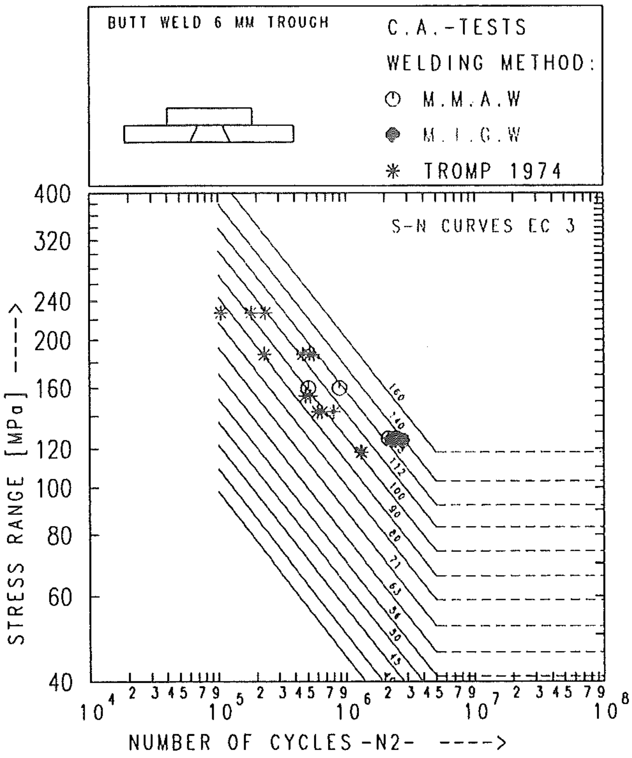


Figure 18. Comparison with backing strip splice joint with 4 mm root gap [2].

3.5. Discussion

Constant amplitude tests on full scale stiffener splice joints have been performed to investigate the fatigue performance of an improveded butt weld joint with backing strips fabricated with different welding processes.
The butt weld of three specimens has been welded by manual metal arc welding (M.M.A.W.) and one test specimen has been welded by metal inert gas welding (M.I.G.W.).

The weldingprocedure qualification reports showed that the number of weld passes during welding were much lower than the welding procedure specification. This aspect is important if the costs of the stiffener splice joint must be determined.
After welding the non-destructive examination report of the X-ray examination showed a lack of fusion in a part of one of the welds made by M.M.A.- welding. This defect has not been repaired to be able to see if it influences the crack initation point.

The performance of the weld has been inspected by more or less visual inspection of sections of the weld cut out from the specimens. It appeared that the root fusion of both types is the same. Furthermore the oversize of the weld made by metal inert gas welding is neglectible with respect to the weld made by manual metal arc welding. So it is to be expected that a crack initiation point at the weld toe may be avoided by using a particular weld proces.

The fatigue test results showed:
- the cracks grow very fast,
- there is hardly no difference between the different welding processes,
- the number of cycles N2 are all situated above the Eurocode Class 110,
- the new design of the butt splice joint results in a longer fatigue life.

APPENDIX A WELDING TESTS

Page:

A.2 Welding procedure specification WPS NR: 30-1 REV NR: 0
A.3 Welding procedure specification WPS NR: 30-2 REV NR: 0
A.4 Welding procedure specification WPS NR: 30-3 REV NR: 0
A.5 Welding procedure specification WPS NR: 30-4 REV NR: 0

A.6 Weld procedure qualification WPS NR: 30-1 Serie 1.
A.7 Weld procedure qualification WPS NR: 30-2 Serie 1.
A.8 Weld procedure qualification WPS NR: 30-3 Serie 1.
A.9 Weld procedure qualification WPS NR: 30-4 Serie 1.

A.10 Non-destructive examination report WPS 30-1,2,3,4 Serie 1.

A.11 Weld procedure qualification WPS NR: 30-1 Serie 2
A.12 Weld procedure qualification WPS NR: 30-2 Serie 2
A.13 Weld procedure qualification WPS NR: 30-3 Serie 2
A.14 Weld procedure qualification WPS NR: 30-4 Serie 2

A.15 Non-destructive examination report WPS 30-1,2,3,4 Serie 2.

A.16 Photo WPS NR: 30-1 Serie 1 en 2
A.17 Photo WPS NR: 30-2 Serie 1 en 2
A.18 Photo WPS NR: 30-3 Serie 1 en 2
A.19 Photo WPS NR: 30-4 Serie 1 en 2

hsm hollandsche staalbouw maatschappij bv

lasmethode-beschrijving
welding procedure specification

wps nr.: 30-1
rev. nr.: 0
geschr. prep. by : C.H

besteller (customer) T.U. DELFT.
inspectie (insp. by) : H.S.M.
hcg ordernr.: 21180.

toepassing (scope) : LASSEN VAN PROEFSTUK T.B.V. E.G.K.S. ONDERZOEK.
Tekening nr. (drawing nr.)

basismateriaal (base material)
1 Fe 520 mvb: afm. (dim.) : t=6 mm
2 Fe 520 mvb: afm. (dim.) : t=6 mm

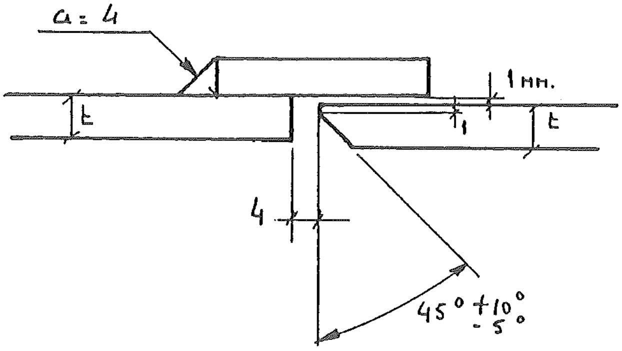
lasproces (welding process)
grondlaag (root) gl: S.M.A.W
vullagen (filling pass.) vl: S.M.A.W
tegenlas (back welding) tl: N.V.T.
oplassen (overlay welding) ol: N.V.T

laspositie (welding position) 4 G
hechten (tackwelding) proces (process) hl: S.M.A.W. min. temp. N.V.T.

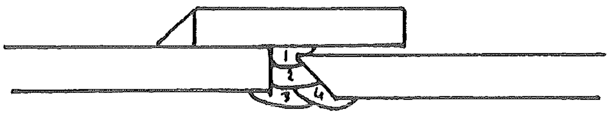
warmtebehandeling (heattreatment)
voorwarm temp. (pre-heating temp.) : N.V.T.
temp. tijdens lassen (interpass. temp.) : 250°C MAX
nawarm temp. (soaking temp.) N.V.T
voorwarmdetails (pre-heating details) : N.V.T.
isolatie (insulation) yes/no
nawarmtijd (soaking time) : N.V.T

gloeien (postweld heattr.) N.V.T.
gloeiinstr. : (h.t. instr.) N.V.T.

A.W.S. CLASS: E7018-1



lasnaadvorm (edge preparation) scale 1 :



lasvolgorde (bead sequence / welding seq. nrs.) scale 1 :

lasvolgorde (bead- or welding seq. nrs.)	betreft (appl. to)	lastoevoeg-materiaal (welding filler material)	afm. (dim.)	schutgas / poeder (shielding-gas / flux)	stroom (current)			voltage	toortsgas (inner sh. gas) l/min.	H.I KJ/MM	voortl. sn. (rate of travel mm/min) R.U.L
					=/∽ (dc/ac)	electrode polariteit (polarity)	ampèrage				
1	GL.	CONARC 49C	2.5		AC		70-80	24		1.3/2.0	55-70
2÷4	V/S.L.	CONARC 49C	3.2		AC		100-120	24-25		1.3/2.0	95-120
HOEKLAS		a=4									
		CONARC 49C	3.2	POS. 1G.	AC		120-140	25-26		1.8/2.0	100-200

bewerk. laskanten (prep. weld. edges) : BRANDEN + SLIJPEN
bewerk. tegenlas (treatment of root) : N.V.T.

opm. (remarks) : LASKANTEN VRIJ VAN VUIL EN VOCHT.

lmk rapport nr. (pqr. nr.) : N.V.T.
serial nr.:
volgens (acc.) :

geldigheidsgebied lmk (validity range procedure qual.) :
afm. (dim.): t=6
posities (pos.): 4G.
tot (untill):

lasserskwalifikaties volgens (welder performance qual. acc.) :
ASME IX
A.W.S. D1.1

inspectie (inspection) :
rt: 100%
QC
ut: N.V.T
mt/pt: 100%
other: VISUEEL.

datum (date) : 18.11.91
appr. Q.A. dep. hsm
appr. customer:
appr. insp. auth.:

model 226

hsm hollandsche staalbouw maatschappij bv	**lasmethode-beschrijving** **welding procedure specification**	wps nr.: 30-2 rev. nr.: 0 geschr. prep. by: C.H.

besteller (customer) T.U. DELFT.	inspectie (insp. by): H.S.M.	hcg ordernr.: 21180
toepassing (scope): LASSEN VAN PROEFSTUK T.B.V. E.G.K.S. ONDERZOEK.		Tekening nr. (drawing nr.)

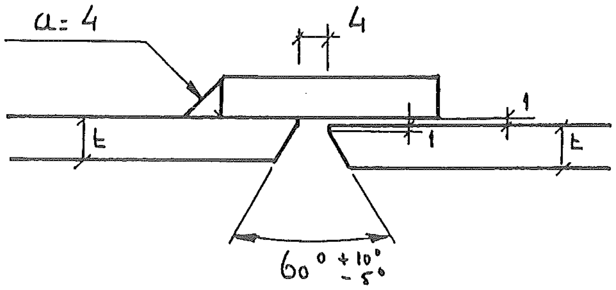
basismateriaal (base material)	1 Fe 520	mvb:	afm. (dim.): t = 6 mm
	2 Fe 520	mvb:	afm. (dim.): t = 6 mm

	grondlaag (root)	vullagen (filling pass.)	tegenlas (back welding)	oplassen (overlay welding)
lasproces (welding process)	gl: S.M.A.W	vl: S.M.A.W	tl: N.V.T.	ol: N.V.T.

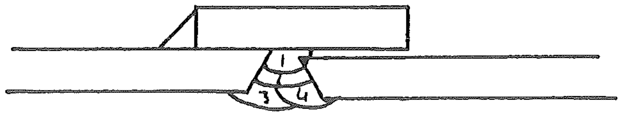
			proces (process)	min. temp.
laspositie (welding position)	4 G	hechten (tackwelding)	hl: S.M.A.W.	N.V.T.

warmtebehandeling (heattreatment)	voorwarm temp. (pre-heating temp.): N.V.T.	temp. tijdens lassen (interpass. temp.): 250°C MAX	nawarm temp. (soaking temp.) N.V.T.
	voorwarmdetails (pre-heating details): N.V.T.	isolatie (insulation) yes/no	nawarmtijd (soaking time): N.V.T.
gloeien (postweld heattr.)	N.V.T		gloeiinstr.: (h.t. instr.) N.V.T

A.W.S. CLASS: E7018-1



lasnaadvorm (edge preparation) scale 1 :



lasvolgorde (bead sequence / welding seq. nrs.) scale 1 :

lasvolgorde (bead- or welding seq. nrs.)	betreft (appl. to)	lastoevoeg-materiaal (welding filler material)	afm. (dim.)	schutgas / poeder (shielding-gas / flux)	stroom (current)			voltage	toortsgas (inner sh. gas) l / min.	H.I KJ /MM	voortl. sn. (rate of travel mm / min) R.O.L
					=/∽ (dc/ac)	electrode polariteit (polarity)	ampèrage				
1	G.L.	CONARC 49C	2.5		AC		70-80	24		1.3/2.0	55-70
2-3-4	V/S.L.	CONARC 49C	3.2		AC		100-120	24-25		1.3/2.0	95-120
HOEKLAS		a=4									
		CONARC 49C	3.2	POS. 1G.	AC		120-140	25-26		1.0/2.0	100-200

bewerk. laskanten (prep. weld. edges): BRANDEN + SLIJPEN	bewerk. tegenlas (treatment of root): N.V.T.

opm. (remarks): LASKANTEN VRIJ VAN VUIL EN VOCHT.

lmk rapport nr. (pqr. nr.): N.V.T. serial nr.: volgens (acc.):	geldigheidsgebied lmk (validity range procedure qual.): afm. (dim.): t = 6. posities (pos.): 4G. tot (untill):	lasserskwalifikaties volgens (welder performance qual. acc.): ASME IX A.W.S. D1.1

inspectie (inspection):	rt: 100%	ut: N.V.T.	mt/pt: 100%	other: VISUEEL.

datum (date): 18.11.91	appr. Q-A dep. hcg QC hsm	appr. customer:	appr. insp. auth.:

model 226

hsm hollandsche staalbouw maatschappij bv

lasmethode-beschrijving
welding procedure specification

wps nr.: 30-3
rev. nr.: 0
geschr. (prep. by) : C.H

bestelier (customer) TU-DELFT
inspectie (insp. by) : H.S.M.
hcg ordernr.: 21180

toepassing (scope) : LASSEN VAN PROEFSTUK T.B.V. E.G.K.S. ONDERZOEK.
Tekening nr. (drawing nr.)

basismateriaal (base material)	1 Fe 520	mvb:	afm. (dim.) : t = 6	mm
	2 Fe 520	mvb:	afm. (dim.) : t = 6	mm

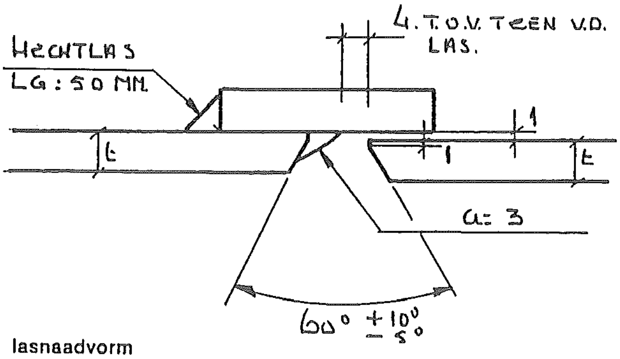
	grondlaag (root)	vullagen (filling pass.)	tegenlas (back welding)	oplassen (overlay welding)
lasproces (welding process)	gl: S.M.A.W	vl: S.M.A.W	tl: N.V.T.	ol: N.V.T.

laspositie (welding position): 4G.
hechten (tackwelding) — proces (process) hl: S.M.A.W. — min. temp. N.V.T.

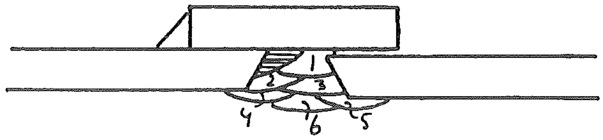
warmtebehandeling (heattreatment)
voorwarm temp. (pre-heating temp.) : N.V.T.
temp. tijdens lassen (interpass. temp.) : 250°C MAX
nawarm temp. (soaking temp.) N.V.T.
voorwarmdetails (pre-heating details) : N.V.T.
isolatie (insulation) yes/no
nawarmtijd (soaking time) : N.V.T.

gloeien (postweld heattr.) N.V.T.
gloeiinstr. : (h.t. instr.) N.V.T.

A.W.S. CLASS. E 7018-1



lasnaadvorm (edge preparation) scale 1 :



lasvolgorde (bead sequence / welding seq. nrs.) scale 1 :

lasvolgorde (bead- or welding seq. nrs.)	betreft (appl. to)	lastoevoeg-materiaal (welding filler material)	afm. (dim.)	schutgas / poeder (shielding-gas / flux)	stroom (current)			voltage	loortegas (inner sh. gas) l/min.	H.I KJ /MN	voortl. sn. (rate of travel mm / min) R.O.L
					=/∽ (dc/ac)	electrode polariteit (polarity)	ampèrage				
1	G.L	CONARC 49C	2.0		AC		70-80	24		1.3/2.0	55-70
2÷6	V/SL	CONARC 49C	3.2		AC		100-120	24-25		1.3/2.0	95-120
HOEKLAS		a: 3									
		CONARC 49C	3.2	Pos. 1G.	AC		120-140	25-26		1.0/2.0	100-200

bewerk. laskanten (prep. weld. edges) : BRANDEN + SLIJPEN
bewerk. tegenlas (treatment of root) : N.V.T

opm. (remarks) : LASKANTEN VRIJ VAN VUIL EN VOCHT.

lmk rapport nr. (pqr. nr.) : N.V.T.
serial nr.:
volgens (acc.) :

geldigheidsgebied lmk (validity range procedure qual.) :
afm. (dim.): t = 6
posities (pos.): 4G.
tot (untill):

lasserskwalifikaties volgens (welder performance qual. acc.) :
ASME IX
AWS D1.1

inspectie (inspection) :	rt: 100%	ut: N.V.T	mt/pt: 100%	other: VISUEEL.

datum (date) : 18.11.91
appr. Q.A dep. hcg: QC 1 hsm
appr. customer:
appr. insp. auth.:

model 226

hsm hollandsche staalbouw maatschappij bv	lasmethode-beschrijving welding procedure specification	wps nr.: 30-4 rev. nr.: 0 geschr. prep. by: C.H.

besteller (customer): TU-DELFT	inspectie (insp. by): H.S.M.	hcg ordernr.: 21180

toepassing (scope): LASSEN VAN PROEFSTUK. T.B.V. E.G.K.S. ONDERZOEK.

Tekening nr. (drawing nr.):

basismateriaal (base material)	1 Fe 520	mvb:	afm. (dim.): t = 6 mm
	2 Fe 520	mvb:	afm. (dim.): t = 6 mm

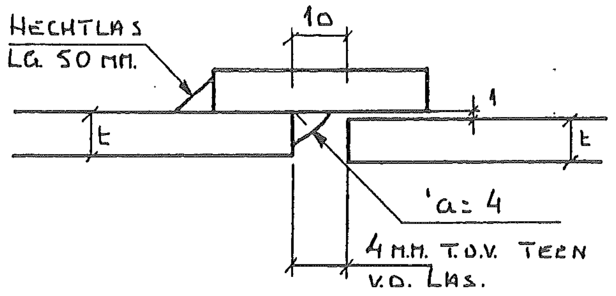
lasproces (welding process)	grondlaag (root)	vullagen (filling pass.)	tegenlas (back welding)	oplassen (overlay welding)
	gl: S.M.A.W.	vl: S.M.A.W	tl: N.V.T	ol: N.V.T.

		hechten (tackwelding)	proces (process)	min. temp.
lespositie (welding position)	4G		hl: S.M.A.W.	N.V.T.

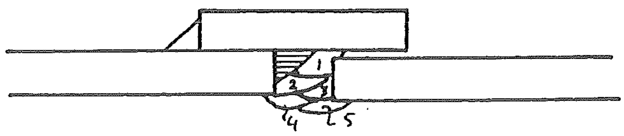
warmtebehandeling (heattreatment):
voorwarm temp. (pre-heating temp.): N.V.T.
temp. tijdens lassen (interpass. temp.): 250 °C MAX
nawarm temp. (soaking temp.) N.V.T.
voorwarmdetails (pre-heating details): N.V.T.
isolatie (insulation) yes/no
nawarmtijd (soaking time): N.V.T.

gloeien (postweld heattr.): N.V.T.
gloeiinstr. (h.t. instr.): N.V.T.

A.W.S. CLASS: E7018-1



lasnaadvorm (edge preparation) scale 1 :



lasvolgorde (bead sequence / welding seq. nrs.) scale 1 :

lasvolgorde (bead- or welding seq. nrs.)	betreft (appl. to)	lastoevoeg-materiaal (welding filler material)	afm. (dim.)	schutgas / poeder (shielding-gas / flux)	stroom (current) = / ∽ (dc/ac)	stroom (current) electrode polariteit (polarity)	stroom (current) ampèrage	voltage	loortages (inner sh. gas) l / min.	H.I KJ / MM	voortl. sn. (rate of travel mm / min) R.O.L
1	G.L.	CONARC 49C	2.0		AC		70-80	24		1.3/2.0	55-70
2 ÷ 5		CONARC 49C	3.2		AC		100-120	24-25		1.3/2.0	95-120
HOEKLAS		a: 4									
		CONARC 49C	3.2		AC		120-140	25-26		1.0/2.0	100-200

bewerk. laskanten (prep. weld. edges): BRANDEN + SLIJPEN
bewerk. tegenlas (treatment of root): N.V.T.

opm. (remarks): LASKANTEN VRIJ VAN VUIL EN VOCHT.

lmk rapport nr. (pqr. nr.): N.V.T. serial nr.: volgens (acc.):	geldigheidsgebied lmk (validity range procedure qual.): afm. (dim.): t=6 posities (pos.): 4G tot (untill):	lasserskwalifikaties volgens (welder performance qual. acc.): ASME IX A.W.S. D1.1.

inspectie (inspection):	rt: 100%	ut: N.V.T.	mt/pt: 100%	other: VISUEEL.

QC 1

datum (date): 18.11.91	appr. Q-A dep. hsm	appr. customer:	appr. insp. auth.:

model 226

hcg steel construction and offshore division

date 18.12.91

dept CKD SCHIEDAM

initials

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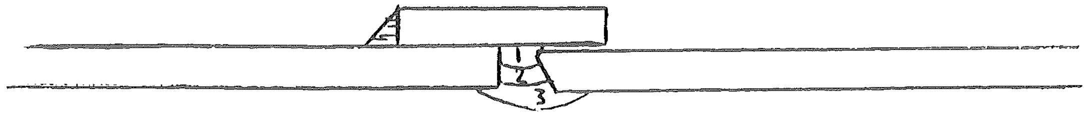
WELDPROCEDURE QUALIFICATION

WPS No : 30- 1 Rev0
Position: 4G
Welder : 82129

21180-09



SKETCH

Run No.	Electrode	ø	Amps	Volts	Run out Length	Time	R.O.L. Rate of Travel	H.I. kJ/mm ~~Interpass.~~
1	49C	2.5	80	25		50	70	1.4
2	49C	3.2	120	25		78	185	1.3
3	49C	3.2	120	25		78 =	110	2.1

QC 1

hcg

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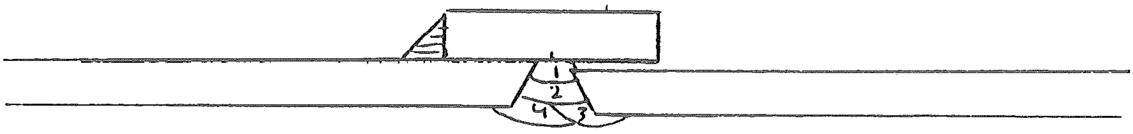
date 18.12.91
dept CKD SCHIEDAM
initials
page of

WELDPROCEDURE QUALIFICATION

WPS No : 30-2 Rev0
Position: 4G
Welder : 8339

21180-10



SKETCH

Run No.	Electrode	ø	Amps	Volts	Run out Length	Time	Rate of Travel	H.I KJ/mm ~~Interpass~~.
1	49C	2½	80	25	65	50		1.5
2	49C	3.2	120	25	150	65		1.3
3	49C	3.2	120	25	200	70		1.1
4	49C	3.2	120	25	170	70		1.2

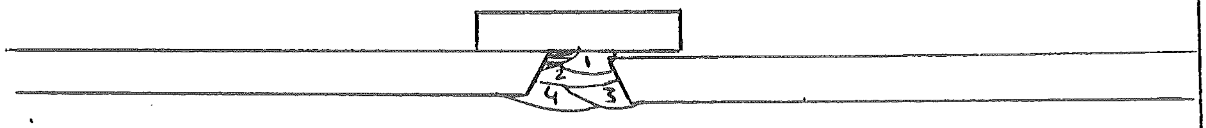
QC 1
hcg
18.12.91

hcg	steel construction and offshore division	date 18.12.91	dept CKD SCHIEDAM
		initials	page of

WELDPROCEDURE QUALIFICATION

WPS No : 30-3 Rev 0
Position: 4G
Welder : 8339

21180-11



SKETCH

Run No.	Electrode	Ø	Amps	Volts	Run out Length	Time	Rate of Travel	HI. KJ/MM ~~Interpass~~.
1	49C	2½	80	25	90	50		1.1
2	49C	3.2	120	25	130	70		1.6
3	49C	3.2	120	25	160	70		1.3
4	49C	3.2	120	25	160	70		1.3

18.12.91

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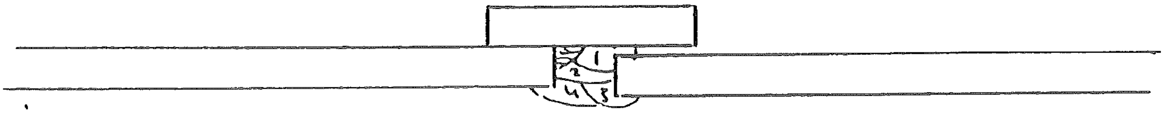
date 18.12.91
dept CKD SCHIEDAM
initials
page of

WELDPROCEDURE QUALIFICATION

WPS No : 30.4. Rev 0
Position: 4G
Welder : 82129

21180-12



SKETCH

Run No.	Electrode	ø	Amps	Volts	Run out Length	Time	Rate of Travel	H.I KJ/MN ~~Interpass.~~
1	49C	2½	80	25	100	50		1.0
2	49C	3.2	120	25	105	70		2.0
3	49C	3.2	120	25	190	70		1.1
4	49C	3.2	120	25	160	70		1.3

QC 1
hcg
18.12.91

incon

NIET-DESTRUCTIEF ONDERZOEK RAPPORT NON-DESTRUCTIVE EXAMINATION REPORT	RT	Incon Niet-Destructief Onderzoek b.v. Maxwellstraat 55 3316 GP Dordrecht	Tel.: 078 - 175311 Fax: 078 - 183917 Tlx.: 20370 incon nl

Klant / Cliënt H.S.M.

Adres / Address GOUDA.

Order Nr. / Order Nr. 21180.

Projekt / Project 4X PROEFPLATEN.

N.D.O. proc. Nr. / N.D.E. proc. Nr. RT WE 1 0 Rev. H

Code / Code R.W.S.

Keur / Inspection Authority ASME

Datum / Date 3-01-1992.

Rapport Nr. / Report Nr. I/129'/14.08.

Bladzijde / Page 1 van/of 1

Plaats onderzoek / Test location INCON

Ontwikkelplaats / Process location INCON LAB.

Film I.D. Nr.		Type Afwijking Defect Type	IIW	A	NA	Plaats afwijking Defect location	ϕ	Details	film soort type	film maat size
30-1	1	LOPEN. GAS LO. FUSION			X	START — 0 4-12/10-20/(END)		WELDER:- 82129	D7	10 40
30-4	1	LO. FUSION			X	0-13/at 28.		82129	↓	↓
30-2	1			✓				8339	↓	↓
30-3	1			✓				8339,	↓	↓

UG = 0,018

Film I D Nr	mat soort mat type	dikte thickn	lasdikte weld th	lasmethode weld process	lasvoorbew weld prep	techniek technique	buis/bron tube/source	I D Nr	afm brandvlek focus/source size	kV/Ci	mAm/ Cim	fla ffd/sfd
AS ABOVE.	C/S	6MM	±			SWSI	SCANRAY	A310	2X2	150	5	1M.

Type schermen/screens	Type BKI/IQI	Radiograaf/Radiographer	Radiograaf/Radiographer
Pb. 0·027.	DIN62FE 10ISO16.	R. DE BREY.	F. SINGER.
Filmlezer : Interpreter : A. TODD Datum : Date : 03.01.92	Fabrikant : Manufacturer : Datum : Date :	Klant : Cliënt : Datum : Date:	Keur : Inspection Authority : Datum : Date :

I 205

hcg
steel construction and
offshore division

date 3/2 92
initials
dept CXD SCHIEDAM
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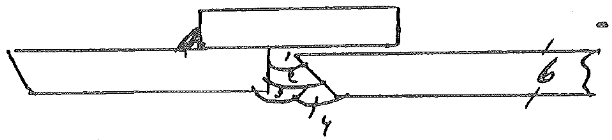
WELDPROCEDURE QUALIFICATION

WPS No : 30-1
Position: 4G
Welder : 8339

OR 21180

CHARGE CONARC 49^C 2½ 610161
-"- 49^C 3.2 630157



21180 - 13

MAATJENS
3/2 92

SKETCH.

Run No.	Electrode	Ø	Amps	Volts	Run out Length cm	Time	Rate of Travel	H.I ~~Interpass.~~
1	CONARC 49	2½	75	25	7	52		1.4
2	"	3.2	125	27	16	65		1.4
3	"	3.2	125	27	17	62 =		1.2
4	"	3.2	125	27	15	64		1.4

QC 1
hsm
03.02.92

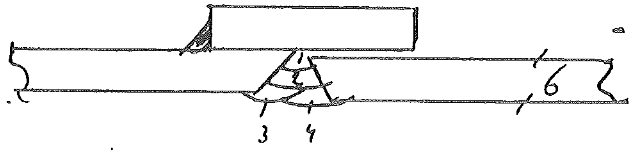
hcg steel construction and offshore division

date 3/2 92 | dept CKD SCHIEDAM
initials | page 1 of 1

WELDPROCEDURE QUALIFICATION

WPS No : 30-2
Position: 46
Welder : 8339

OR 21180



MAATJENS 3/2 '92

21180-14

SKETCH.

Run No.	Electrode	Ø	Amps	Volts	Run out Length	Time	Rate of Travel	H.I. Interpass.
1	CONARC 49	2½	80	25	7	50		1.4
2	-"-	3.2	130	27	14	65		1.6
3	-"-	3.2	125	27	17	62		1.2
4	-"-	3.2	125	27	16	63		1.3

QC 1 hcg 03.02.92

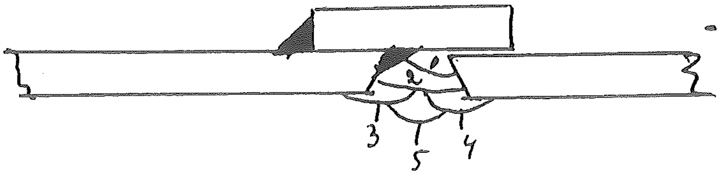
hcg steel construction and offshore division

date 3/2
dept CKD SCHIEDAM
initials
page 1 of 1

WELDPROCEDURE QUALIFICATION

WPS No : 30 - 3
Position: 4G
Welder : 8339

OR 21180



MAATJENS 3/2 '92

21180 - 15

SKETCH.

Run No.	Electrode	Ø	Amps	Volts	Run out Length	Time	Rate of Travel	Interpass.
1	CONARC 49	2½	80	25	7	51		1.4
2	— " —	3.2	130	28	11	63		2,0
3	— " —	3.2	125	27	15	65		1.5
4	— " —	3.2	125	27	15	62		1.4
5	— " —	3.2	125	27	17	65		1.3

QC 1 hsm 03.02.92

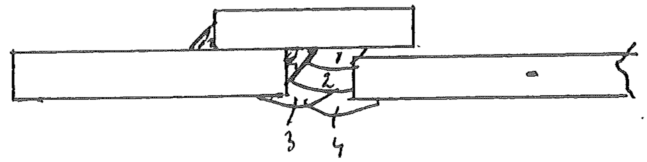
hcg
steel construction and
offshore division

date 3/2 92
dept CKD SCHIEDAM
initials
page 1 of 1

WELDPROCEDURE QUALIFICATION

WPS No : 30-4
Position: 4G
Welder : 8339

OL. 21180



Maatjens
3/2 92

21180-16

SKETCH.

Run No.	Electrode	Ø	Amps	Volts	Run out Length	Time	Rate of Travel	Interpass.
1	Conarc 49	2½	85	25	8	48		1.3
2	— " —	3.2	125	27	15	65		1.5
3	— " —	3.2	125	27	18	65		1.2
4	— " —	3.2	125	27	16	62		1.3

QC
hsm
03.02.92

incon

NIET-DESTRUCTIEF ONDERZOEK RAPPORT
NON-DESTRUCTIVE EXAMINATION REPORT

RT

Incon Niet-Destructief Onderzoek b.v.
Maxwellstraat 55
3316 GP Dordrecht
Tel.: 078 - 175311
Fax: 078 - 183917
Tlx.: 20370 incon nl

Klant Cliënt HSM	N.D.O. proc. Nr. N.D.E. proc. Nr. RT LA1 Nº1 Rev. A	Rapport Nr. Report Nr. I/129'RT/136
Adres Address GOUDA	Code Code IIW	Bladzijde Page 1 van/of 1
Order Nr. Order Nr. 21180	Keur Inspection Authority	Plaats onderzoek Test location BIB-INCON
Projekt Project TESTPLATES	Datum Date 05-02-92	Ontwikkelplaats Process location DORDRECHT

Film I.D. Nr.	Type Afwijking Defect Type	IIW	A	NA	Plaats afwijking Defect location	ϕ	Details				film soort type	film maat size
30-1	Ba Aa F	2									D7	10/40
30-2	Aa Ab F	2										
30-3	Aa	1										
30-4	Aa Ab F	2										

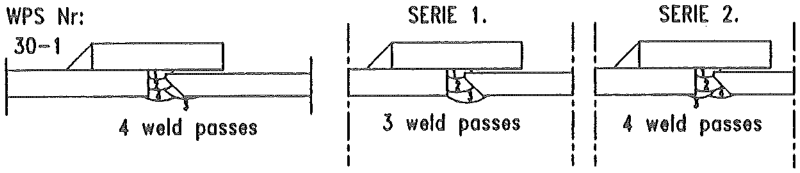
Film I D Nr	mat soort mat type	dikte thickn	lasdikte weld th	lasmethode weld process	lasvoorbew weld prep	techniek technique	buis/bron tube/source	I D Nr	afm brandvlek focus/source size	kV/Ci	mAm/ Cim	ffa ffd/sfd
AS ABOVE	c/s	6+4	+	SMAW	I	SWSI	CMA	A36D	3x3	190	4½	600

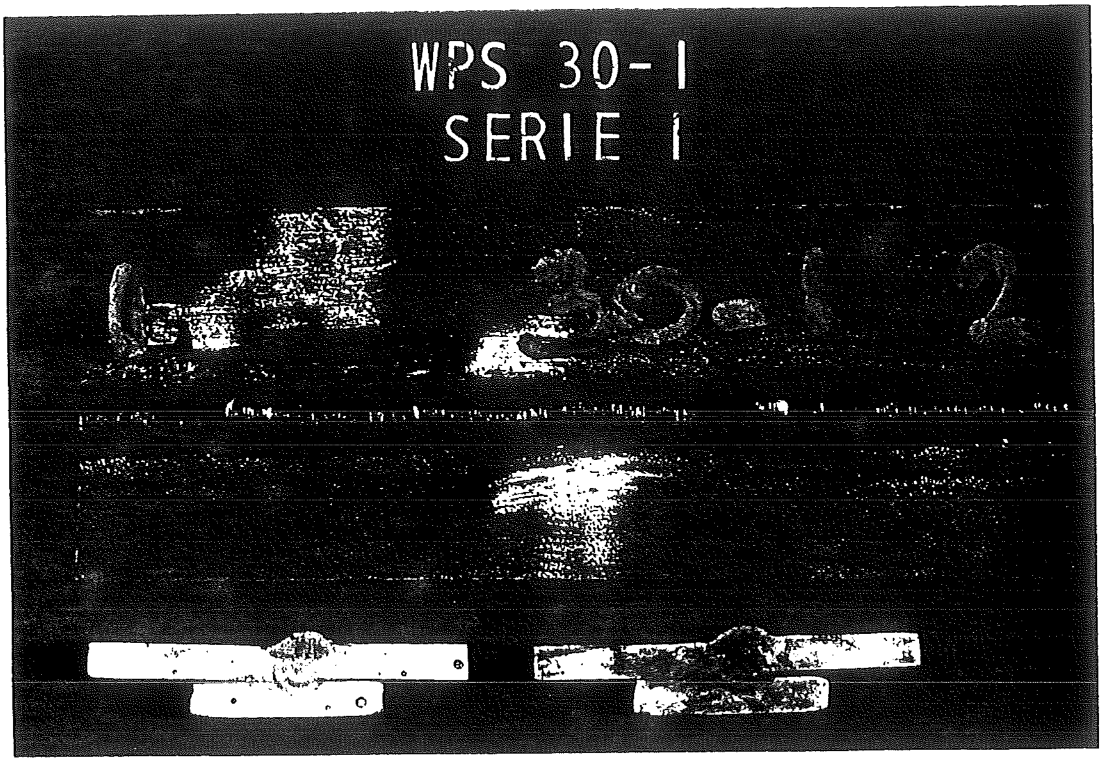
Type schermen/screens Pb	Type BKI/IQI DIN 62 FE 10-16	Radiograaf/Radiographer J. YELLOWLEY	Radiograaf/Radiographer –
Filmlezer Interpreter INCON N.D.O. J. Yellowley Level II Datum Date 5/2/92	Fabrikant : Manufacturer : Datum : Date :	Klant : Cliënt : Datum : Date:	Keur : Inspection Authority : Datum : Date :

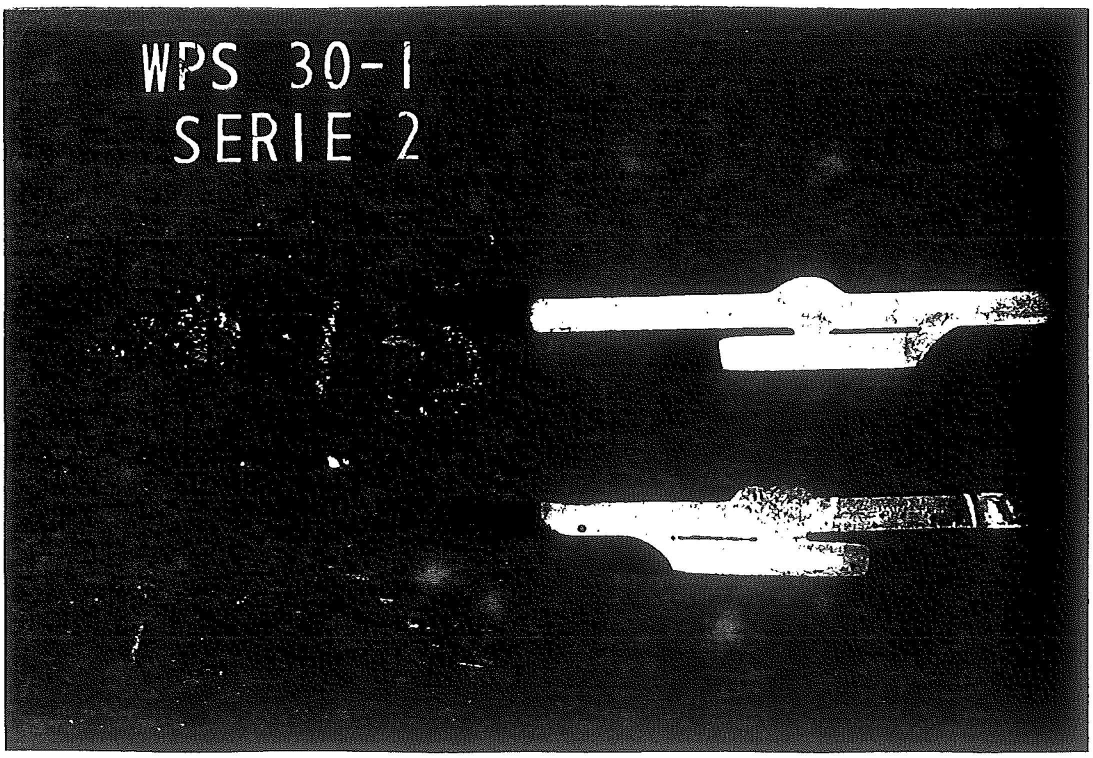
I 205

WELDING PROCEDURE SPECIFICATION

WELDPROCEDURE QUALIFICATION

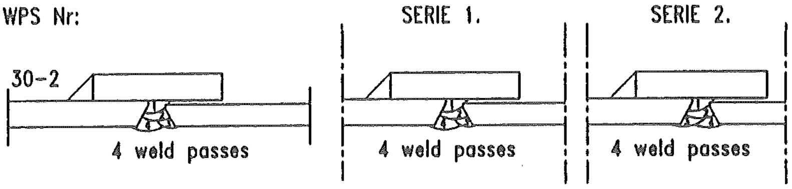


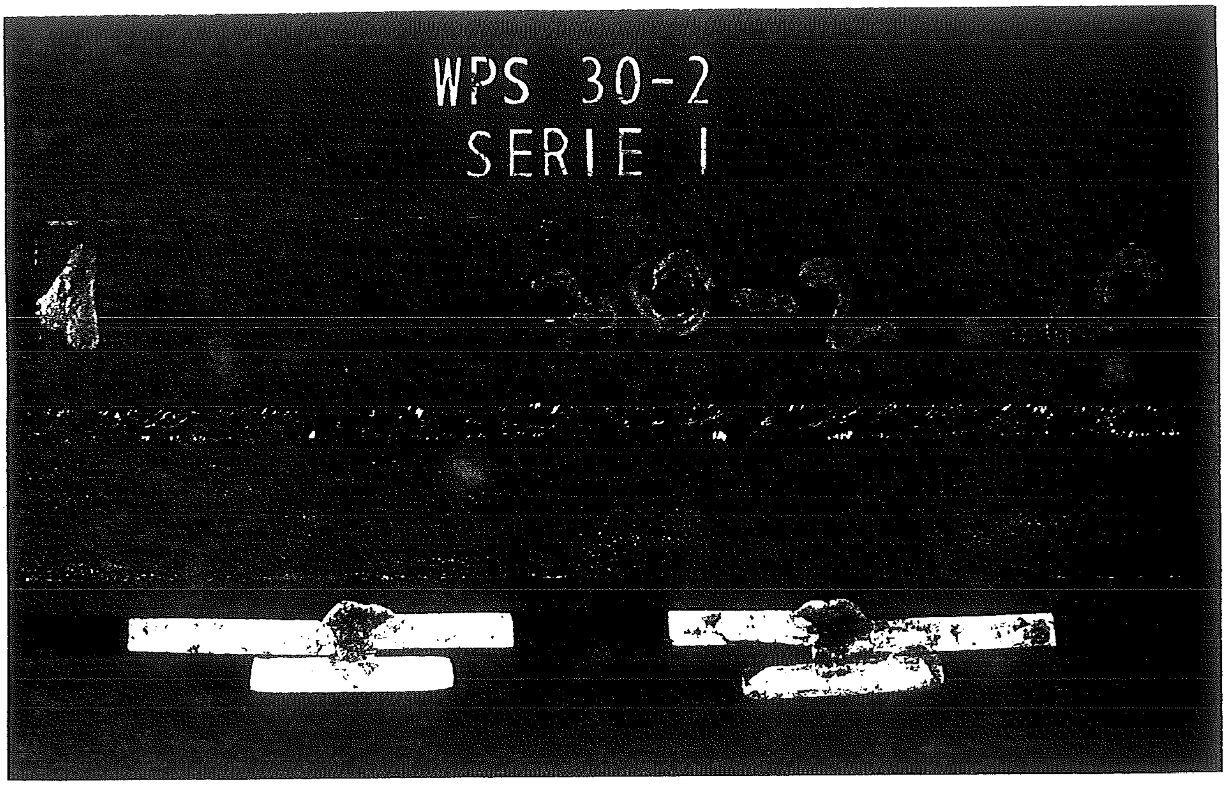


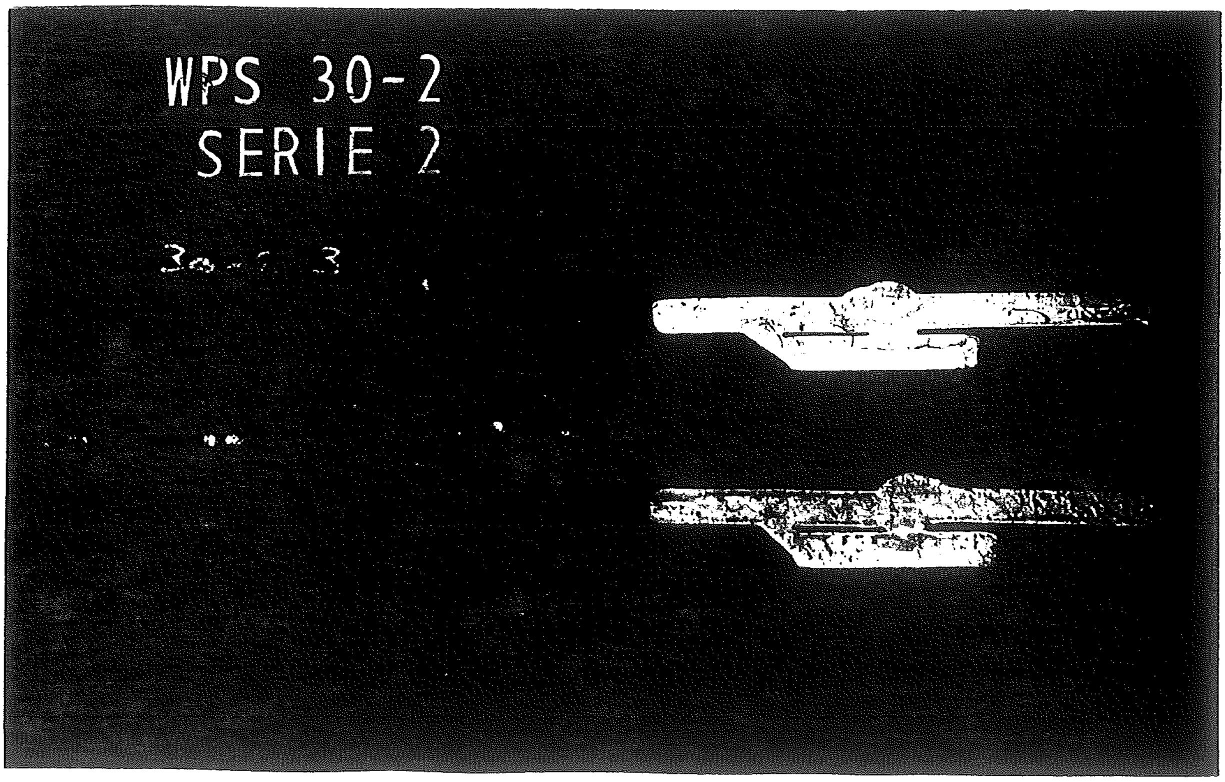


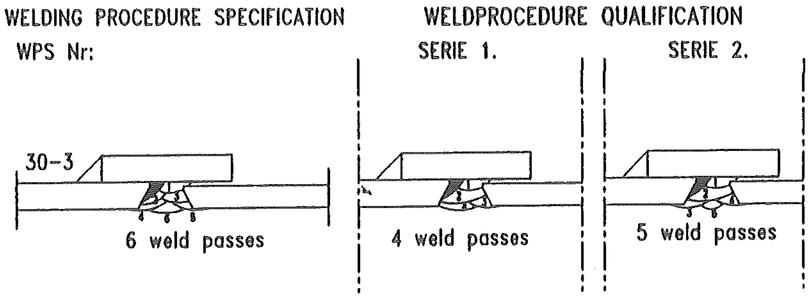
WELDING PROCEDURE SPECIFICATION WELDPROCEDURE QUALIFICATION

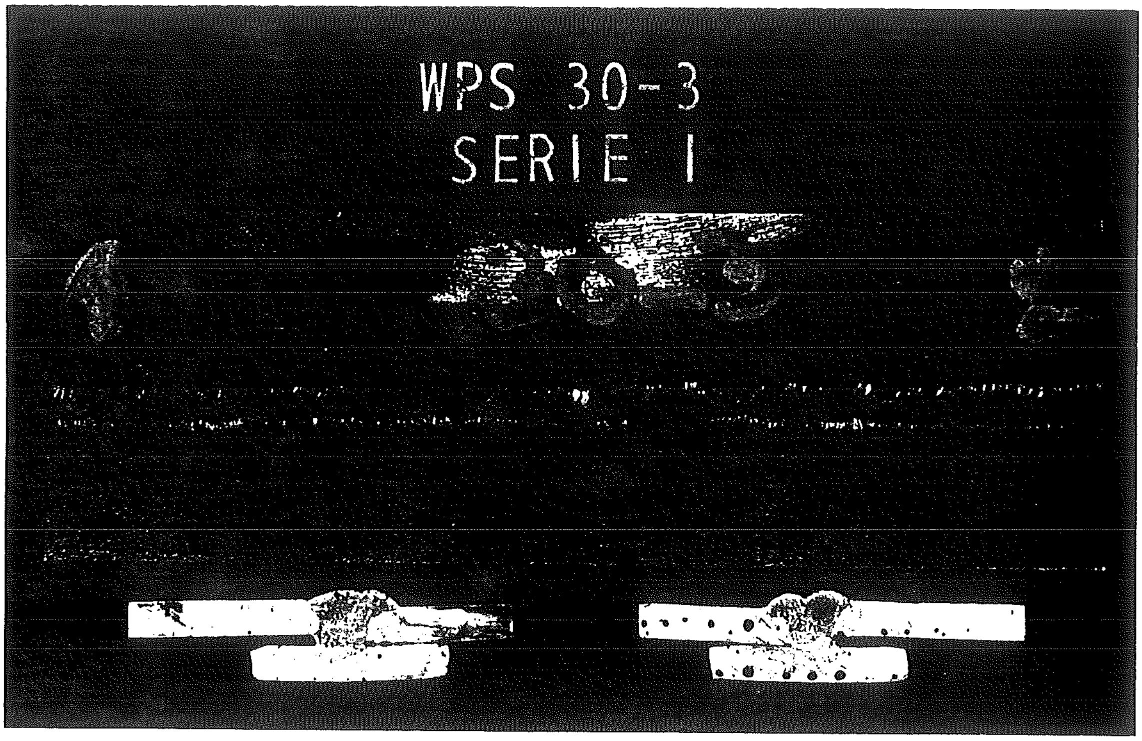
WPS Nr: SERIE 1. SERIE 2.

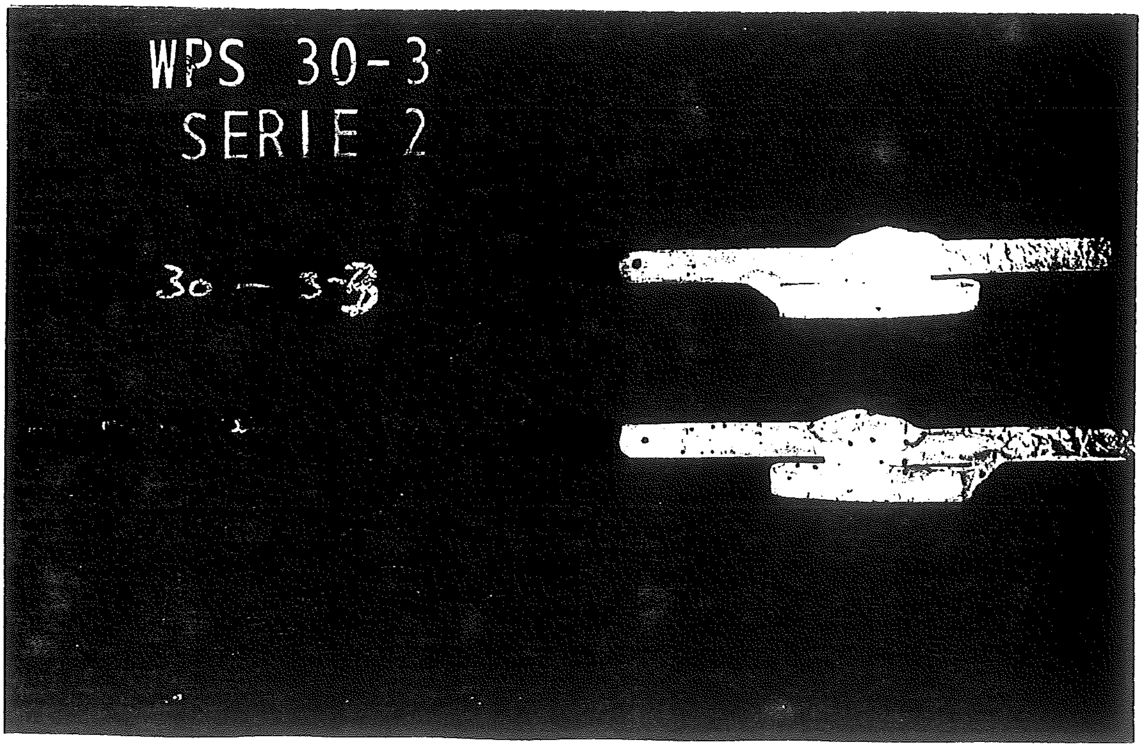


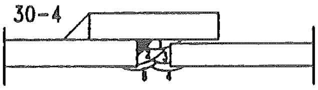
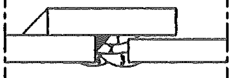
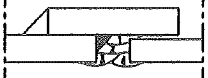


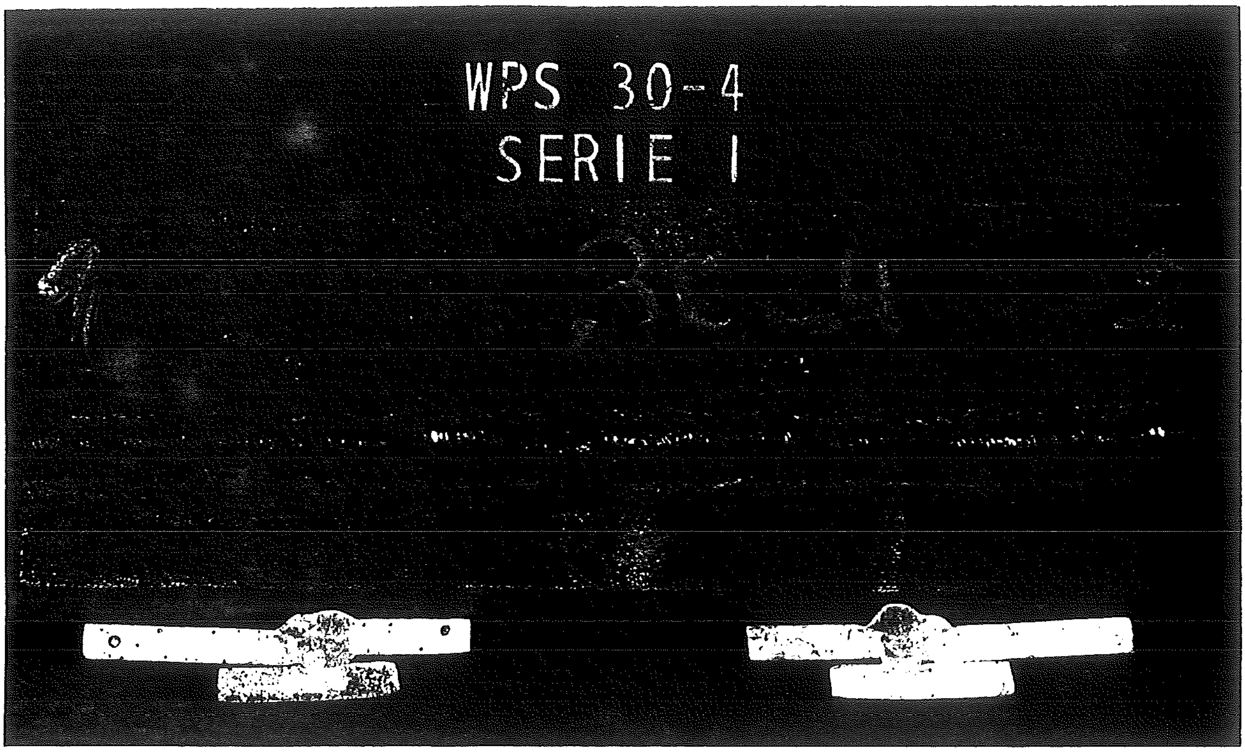


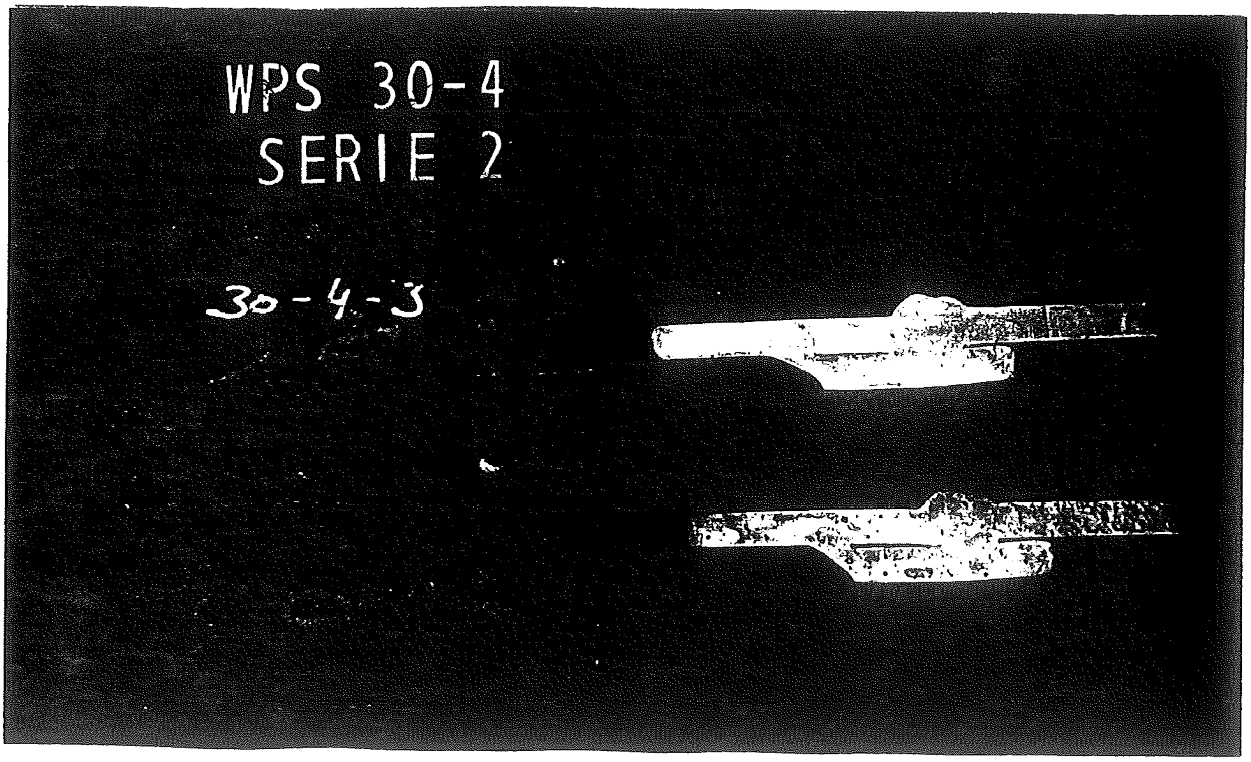

WELDING PROCEDURE SPECIFICATION
WPS Nr:
WELDPROCEDURE QUALIFICATION
SERIE 1.
SERIE 2.
30-3
6 weld passes
4 weld passes
5 weld passes


WPS 30-3
SERIE 1


WPS 30-3
SERIE 2
30 - 3-3

WELDING PROCEDURE SPECIFICATION	WELDPROCEDURE QUALIFICATION	
WPS Nr:	SERIE 1.	SERIE 2.
30-4 		
5 weld passes	4 weld passes	4 weld passes





APPENDIX B CONSTANT AMPLITUDE TESTS

Page:

B.2 Welding sequence testspecimens: D.3.1 - D.3.2 - D.3.3 - D.3.4

B.3 Welding procedure specification WPS NR: 30-3 REV NR: 1; Testspecimen: D.3.1
Welding procedure specification WPS NR: 30-3 REV NR: 1; Testspecimen: D.3.2
Welding procedure specification WPS NR: 30-3 REV NR: 1; Testspecimen: D.3.3

B.4 Welding procedure specification WPS NR: 30-5 REV NR: 0; Testspecimen: D.3.4

B.5 Weldprocedure qualification WPS NR: 30-3
B.6 Weldprocedure qualification WPS NR: 30-5

B.7 Non-destructive examination report testspecimens: D.3.1 - D.3.2 - D.3.3 - D.3.4

B.8 Fatigue cracks and such-like testspecimen D.3.1
B.9 Strain measurements testspecimen D.3.1 weld 1
B.10 Strain measurements testspecimen D.3.1 weld 2

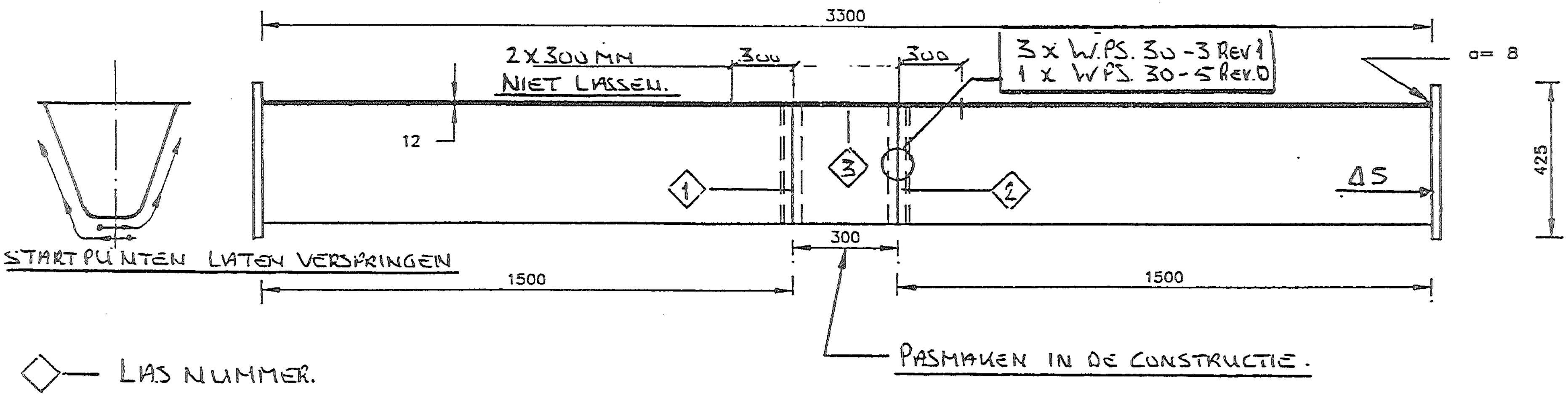
B.11 Fatigue cracks and such-like testspecimen D.3.2
B.12 Strain measurements testspecimen D.3.2 weld 1
B.13 Strain measurements testspecimen D.3.2 weld 2

B.14 Fatigue cracks and such-like testspecimen D.3.3
B.15 Strain measurements testspecimen D.3.3 weld 1
B.16 Strain measurements testspecimen D.3.3 weld 2

B.17 Fatigue cracks and such-like testspecimen D.3.4
B.18 Strain measurements testspecimen D.3.4 weld 1
B.19 Strain measurements testspecimen D.3.4 weld 2

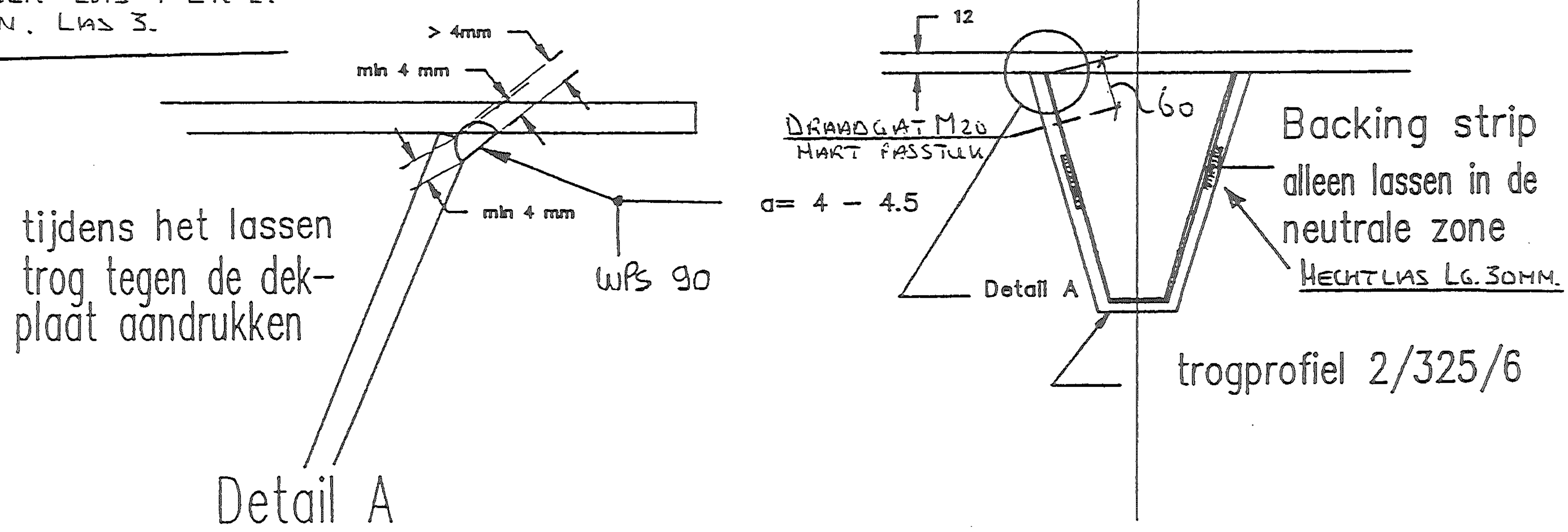
B.20 Welding procedure specification WPS NR: 90 REV NR: 0; Deckplate welding

B.21 Photos test specimen D.3.1
B.22 Photos test specimen D.3.2
B.23 Photos test specimen D.3.3
B.24 Photos test specimen D.3.4



◇— LAS NUMMER.

LAS VOLGORDE:
GRONDLAGEN + 2 VULLAGEN VAN LAS 1 EN 2. (VOOR LASRICHTING ZIE DOORSNEDE)
AFVULLEN LAS 1 EN 2.
LASSEN. LAS 3.



hollandsche staalbouw maatschappij bv	**lasmethode-beschrijving** **welding procedure specification**	wps nr.: 30-3 rev. nr.: 1 geschr. (prep. by): C.H

besteller (customer): TU-DELFT

inspectie (insp. by): H.S.M.

hcg ordernr.: 21180

toepassing (scope): LASSEN VAN PROEFSTUK T.B.V. E.G.K.S. ONDERZOEK.

Tekening nr. (drawing nr.):

basismateriaal (base material)		mvb	afm. (dim.)	
1	Fe 520	mvb:	t= 6	mm
2	Fe 520	mvb:	t= 6	mm

lasproces (welding process)	grondlaag (root)	vullagen (filling pass.)	tegenlas (back welding)	oplassen (overlay welding)
	gl: S.M.A.W	vl: S.M.A.W	tl: N.V.T.	ol: N.V.T.

laspositie (welding position): 5G.

hechten (tackwelding): proces (process) hl: S.M.A.W./FCAW. min. temp. N.V.T.

warmtebehandeling (heattreatment):

voorwarm temp. (pre-heating temp.): N.V.T.

temp. tijdens lassen (interpass. temp.): 250°C MAX

nawarm temp. (soaking temp.): N.V.T.

voorwarmdetails (pre-heating details): N.V.T.

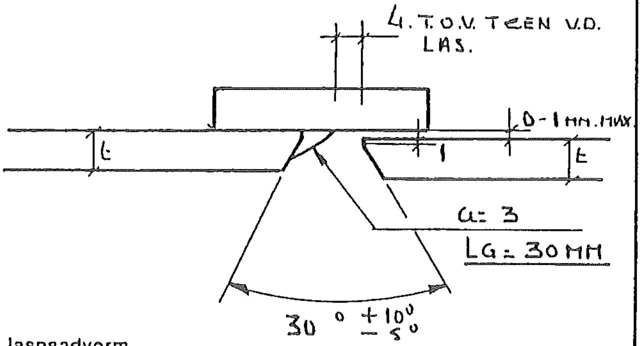
isolatie (insulation) yes/no

nawarmtijd (soaking time): NVT.

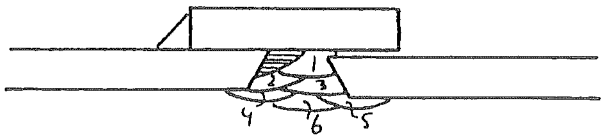
gloeien (postweld heattr.): NVT.

gloeiinstr. (h.t. instr.): NVT

A.W.S. CLASS. E 7018-1



lasnaadvorm (edge preparation) scale 1 :



lasvolgorde (bead sequence / welding seq. nrs.) scale 1 :

lasvolgorde (bead- or welding seq. nrs.)	betreft (appl. to)	lastoevoeg-materiaal (welding filler material)	afm. (dim.)	schutgas / poeder (shielding-gas / flux)	stroom (current)			voltage	toortsgas (inner sh. gas) l / min.	H.I KJ/MM	voortl. sn. (rate of travel mm / min) R.O.L
					=/~ (dc/ac)	electrode polariteit (polarity)	ampèrage				
1	G.L	CONARC 49C	2.0		AC		70-80	24		1.3/2.0	55-70
2 ÷ 6	V/S.L	CONARC 49C	3 0		AC		100-120	24-25		1.3/2.0	95-120
HOEK	LUS	a= 3		Pos. 3 G.							
		CONARC 49C	3.0		AC		100-120	24-25			LG 30 MM
		SAFDUAL 200	1. 2	85 AR 15 CO2	DC	+	115-120	19-20			LG 30 MM

bewerk. laskanten (prep. weld. edges): BRANDEN + SLIJPEN

bewerk. tegenlas (treatment of root): NVT

opm. (remarks): LASKANTEN VRIJ VAN VUIL EN VOCHT.

lmk rapport nr. (pqr. nr.): N.V.T.
serial nr.:
volgens (acc.):

geldigheidsgebied lmk (validity range procedure qual.):
afm. (dim.): t = 6
posities (pos.): 5G
tot (untill):

lasserskwalifikaties volgens (welder performance qual. acc.):
ASME IX
A.W.S. D1.1

inspectie (inspection):
rt: 100% 1
ut: N.V.T
mt / pt: 100%
other: VISUEEL.

datum (date): 04.03 92

appr. Q.A.:

appr. customer:

appr. insp. auth.:

hollandsche staalbouw maatschappij bv

lasmethode-beschrijving
welding procedure specification

wps nr.: 30-5
rev. nr.: 0
geschr. prep. by : C.H.

besteller (customer) TU-DELFT
inspectie (insp. by) : H.S.M.
hcg ordernr.: 21180

toepassing (scope) : LASSEN VAN PROEFSTUK T.B.V. E.G.K.S. ONDERZOEK.
Tekening nr. (drawing nr.)

basismateriaal (base material)	1 Fe 520	mvb :	afm. (dim.) : 6	mm
	2 Fe 520	mvb :	afm. (dim.) : 6	mm

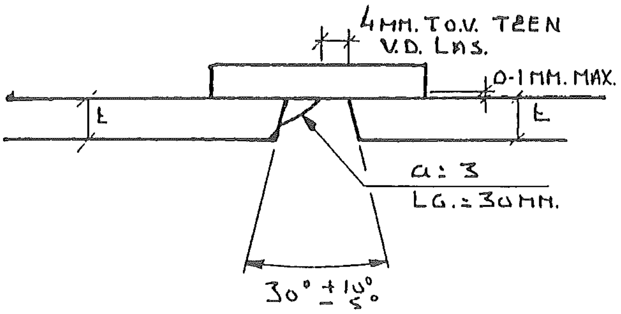
	grondlaag (root)	vullagen (filling pass.)	tegenlas (back welding)	oplassen (overlay welding)
lasproces (welding process)	gl: FCAW.	vl: FCAW	tl: N.V.T.	ol: N.V.T.

laspositie (welding position) 5G
hechten (tackwelding) proces (process) hl: FCAW. min. temp. N.V.T.

warmtebehandeling (heattreatment)
voorwarm temp. (pre-heating temp.) : N.V.T.
temp. tijdens lassen (interpass. temp.) : 250°C MAX.
nawarm temp. (soaking temp.) N.V.T.
voorwarmdetails (pre-heating details) : N.V.T.
isolatie (insulation) ~~yes~~/no
nawarmtijd (soaking time) : N.V.T.

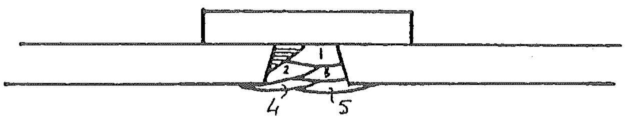
gloeien (postweld heattr.) N.V.T.
gloeiinstr. : (h.t. instr.) N.V.T.

A.W.S. CLASS.: E 71-T-5



lasnaadvorm (edge preparation) scale 1 :

MAX. LAAGDIKTE 3 MM.



lasvolgorde (bead sequence / welding seq. nrs.) scale 1 :

lasvolgorde (bead- or welding seq. nrs.)	betreft (appl. to)	lastoevoeg-materiaal (welding filler material)	afm. (dim.)	schutgas / poeder (shielding-gas / flux)	stroom (current)			voltage	toortsgas (inner sh. gas) l / min.	H.I KJ /MM	voortl. sn. (rate of travel mm / min) R.O.L
					=/~ (dc/ac)	electrode polariteit (polarity)	ampèrage				
1 ÷ 5		SAFDUAL200	1.2.	85AR15CO2	DC	+	115-120	19-20	±15	1.2/2.2	65-100
HOEKLAS		a = 3									
		SAFDUAL 200	1.2	85AR15CO2	DC	+	115-120	19-20			LG.30M

bewerk. laskanten (prep. weld. edges) : SNIJDEN + SLIJPEN
bewerk. tegenlas (treatment of root) : N.V.T.

opm. (remarks) : LASKANTEN VRIJ VAN VUIL EN VOCHT.

lmk rapport nr. (pqr. nr.) : N.V.T.
serial nr.:
volgens (acc.) :

geldigheidsgebied lmk (validity range procedure qual.) :
afm. (dim.): t = 6
posities (pos.): 5G.
tot (untill):

lasserskwalifikaties volgens (welder performance qual. acc.) :
ASME IX
AWS D1.1.

inspectie (inspection) : rt: 100% ut: N.V.T. mt/pt: 100% other: VISUEEL.

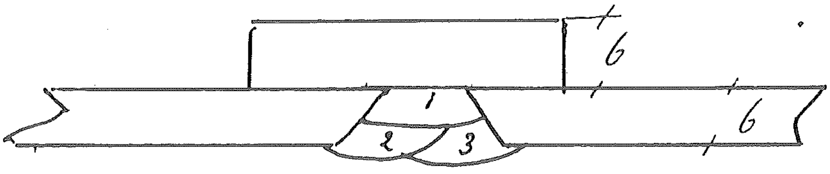
QC 1

datum (date) : 04.03.92
appr. Q.A. dept.:
appr. customer:
appr. insp. auth.:

hcg	steel construction and offshore division	date 9/4 92 initials	dept CKD SCHIEDAM page 1 of 1

WELDPROCEDURE QUALIFICATION

WPS No : 30-3
Position:
Welder : 784



21180-17

MAATJENS
13/4 92

SKETCH.

Run No.	Electrode	ø	Amps	Volts	Run out Length	Time	Rate of Travel	H.I KJ/MM ~~Interpass.~~
1	49C	3.2	120	25	100	70		2.1
2	49C	3.2	120	25	150	70		1.4
3	49C	3.2	120	25	170	70		1.2

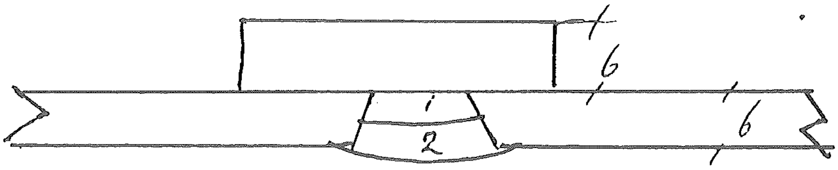
QC 1
hsm
10.04.92

hcg steel construction and offshore division

date 9/4 92
initials
dept CKD SCHIEDAM
page 1 of 1

WELDPROCEDURE QUALIFICATION

WPS No : 30-5
Position:
Welder : 732



21180 - 18

13/4 92

SKETCH.

Run No.	Electrode	Ø	Amps	Volts	Run out Length	Time	Rate of Travel	HI/ KJ/mm Interpass.
1	SAFDUAL 200	1.2	120	19		60	98	1.4
2	SAFDUAL 200	1.2	120	19		60	115	1.2

QC 1
hsm
10.04.92

incon

LET OP: Adres vanaf 01-02-92
Incon Niet-Destructief Onderzoek b.v.
Heusing 2
4817 ZB Breda
Tel. 076 - 71 22 88*
Fax 076 - 87 47 60
Tlx. 54976
nl

NIET-DESTRUCTIEF ONDERZOEK RAPPORT
NON-DESTRUCTIVE EXAMINATION REPORT

RT

Klant Cliënt HSM	N.D.O. proc. Nr. N.D.E. proc. Nr. RT WE 21 NMO Rev. 0	Rapport Nr. Report Nr. I/129'RT/137
Adres Address SCHIEDAM	Code Code	Bladzijde Page 1 van/of 1
Order Nr. Order Nr. 21180	Keur Inspection Authority	Plaats onderzoek Test location HSM SCHIEDAM
Projekt Project T.U. DELFT	Datum Date 13-04-92	Ontwikkelplaats Process location BREDA

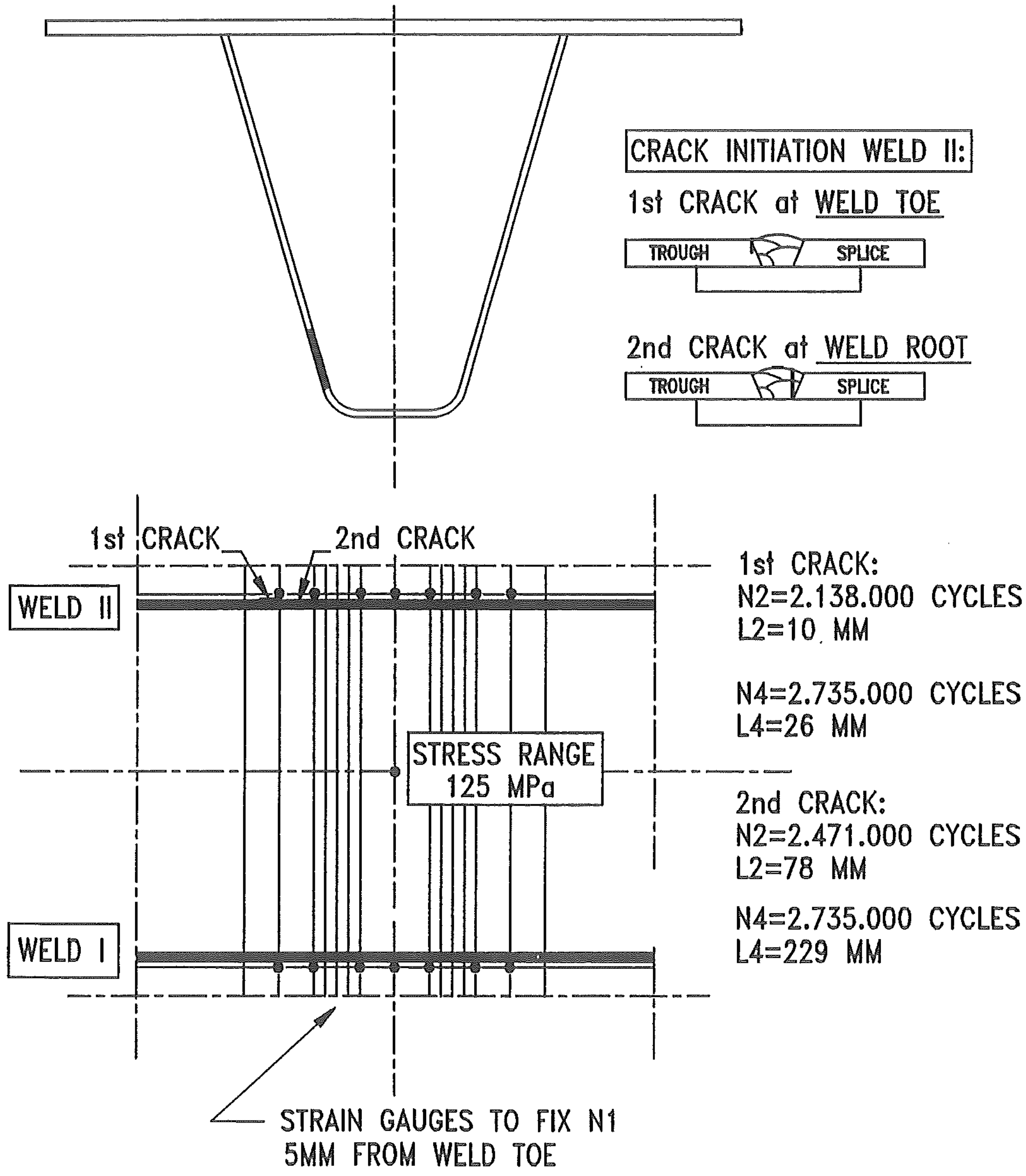
Film I.D. Nr.		Type Afwijking Defect Type	IIW	A	NA	Plaats afwijking Defect location	ϕ	Details WPS	WDR		film soort type	maat size
TP1W1	1			✓				30-3	784		D4	10/40
	2			✓								10/24
	3	L.O.F.			x	65-75						10/40
W2	1			✓				30-3				10/40
	2			✓								10/24
	3			✓								10/40
TP2W1	1			✓				30-3				10/40
	2			✓								10/24
	3			✓								10/40
W2	1			✓				30-3				10/40
	2			✓								10/24
	3			✓								10/40
TP3W1	1			✓				30-3				10/40
	2			✓								10/24
	3			✓								10/40
W2	1			✓				30-3				10/40
	2			✓								10/24
	3			✓								10/40
TP4W1	1			✓				30-5	732			10/40
	2			✓								10/24
	3			✓								10/40
W2	1			✓				30-5				10/40
	2			✓								10/24
	3			✓								10/40

Film I D Nr	mat soort mat type	dikte thickn	lasdikte weld th	lasmethode weld process	lasvoorbew weld prep	techniek technique	buis/bron tube/source	I D Nr	afm brandvlek focus/source size	kV/Ci	mAm/ Cim	ffa ffd/sfd
FILMS 1 AND 3	c/s	6+5	+	30-3/5	·	DWSI	IR192	66	2x2	34	60	260
FILMS 2	c/s	"	"	"		"	"	"	"	"	75	340

Type schermen/screens Pb	Type BKI/IQI D.S 62 FE 10-16	Radiograaf/Radiographer J. YALLOWAY	Radiograaf/Radiographer W. KNOWLES
Filmlezer Interpreter Datum : Date : 14/4/92	Fabrik Man WSY Datum : Date : 15.04.92.	Klant : Cliënt : Datum : Date:	Keur : Inspection Authority : Datum : Date :

FATIGUE TEST ON THE LONGITUDINAL STIFFENER SPLICE JOINT

● FATIGUE CRACKS TEST 6D31



1st CRACK:
N2=2.138.000 CYCLES
L2=10 MM

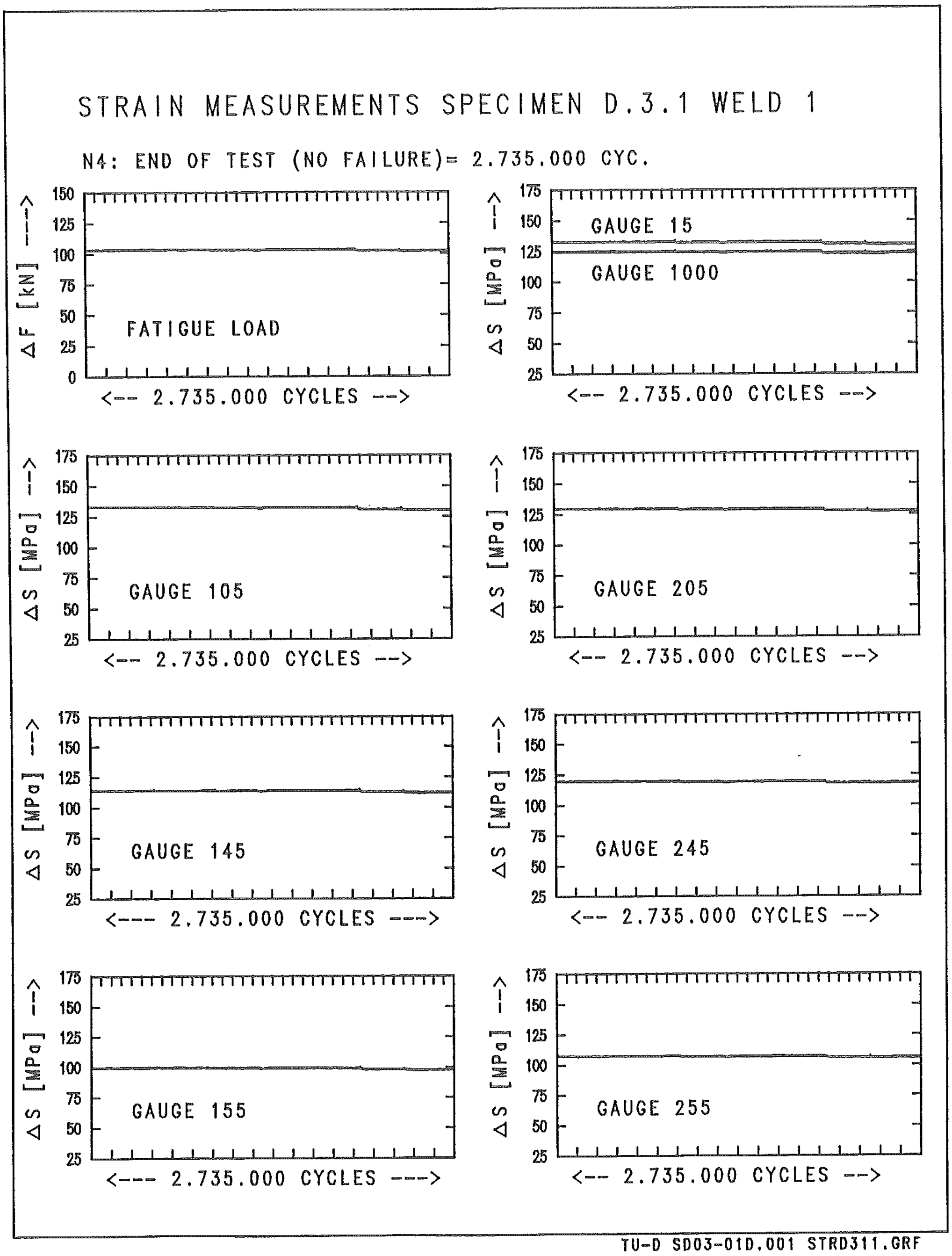
N4=2.735.000 CYCLES
L4=26 MM

2nd CRACK:
N2=2.471.000 CYCLES
L2=78 MM

N4=2.735.000 CYCLES
L4=229 MM

STRAIN GAUGES TO FIX N1
5MM FROM WELD TOE

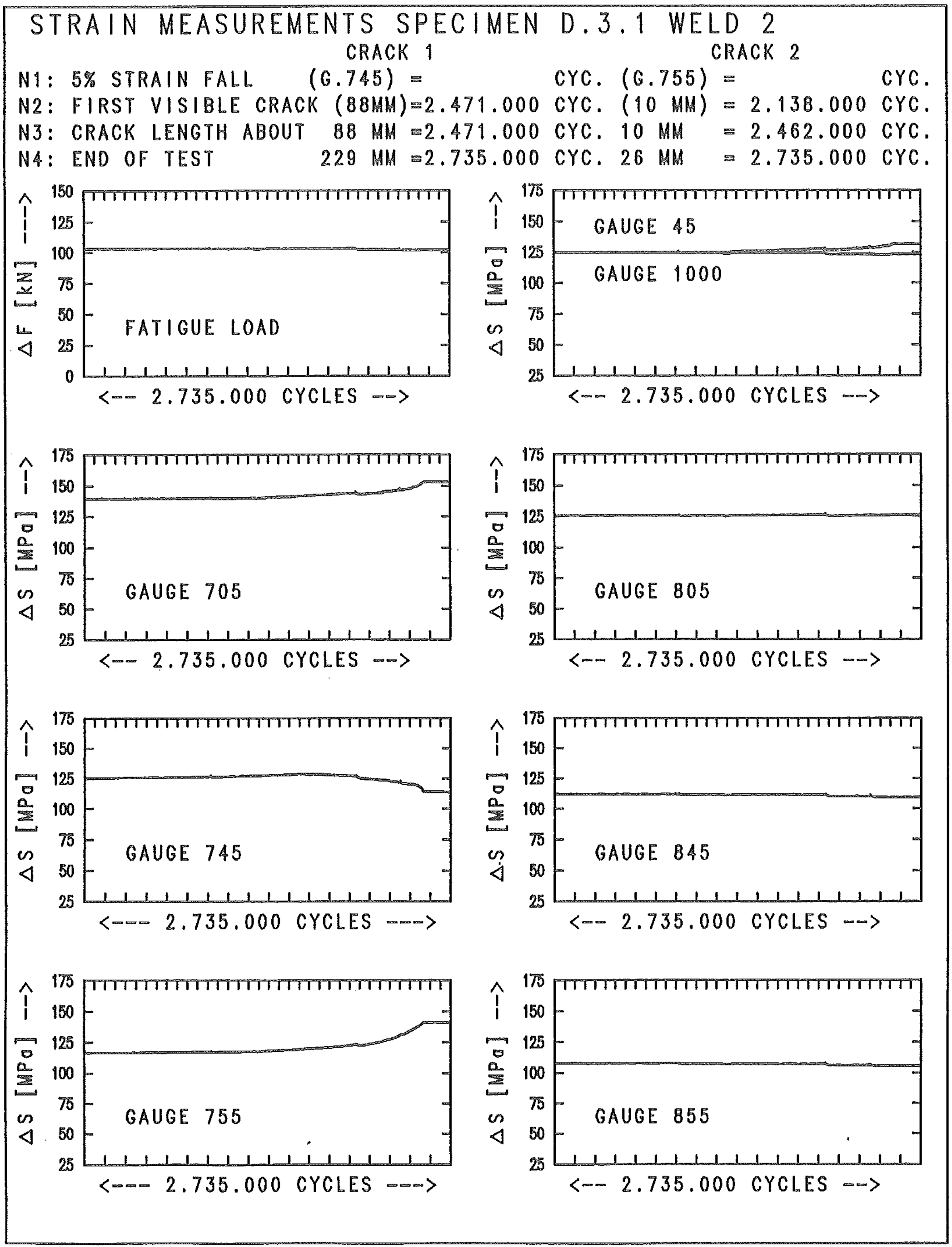
STEVIN lab TU-Delft



STRAIN MEASUREMENTS SPECIMEN D.3.1 WELD 1

N4: END OF TEST (NO FAILURE)= 2.735.000 CYC.

TU-D SD03-01D.001 STRD311.GRF



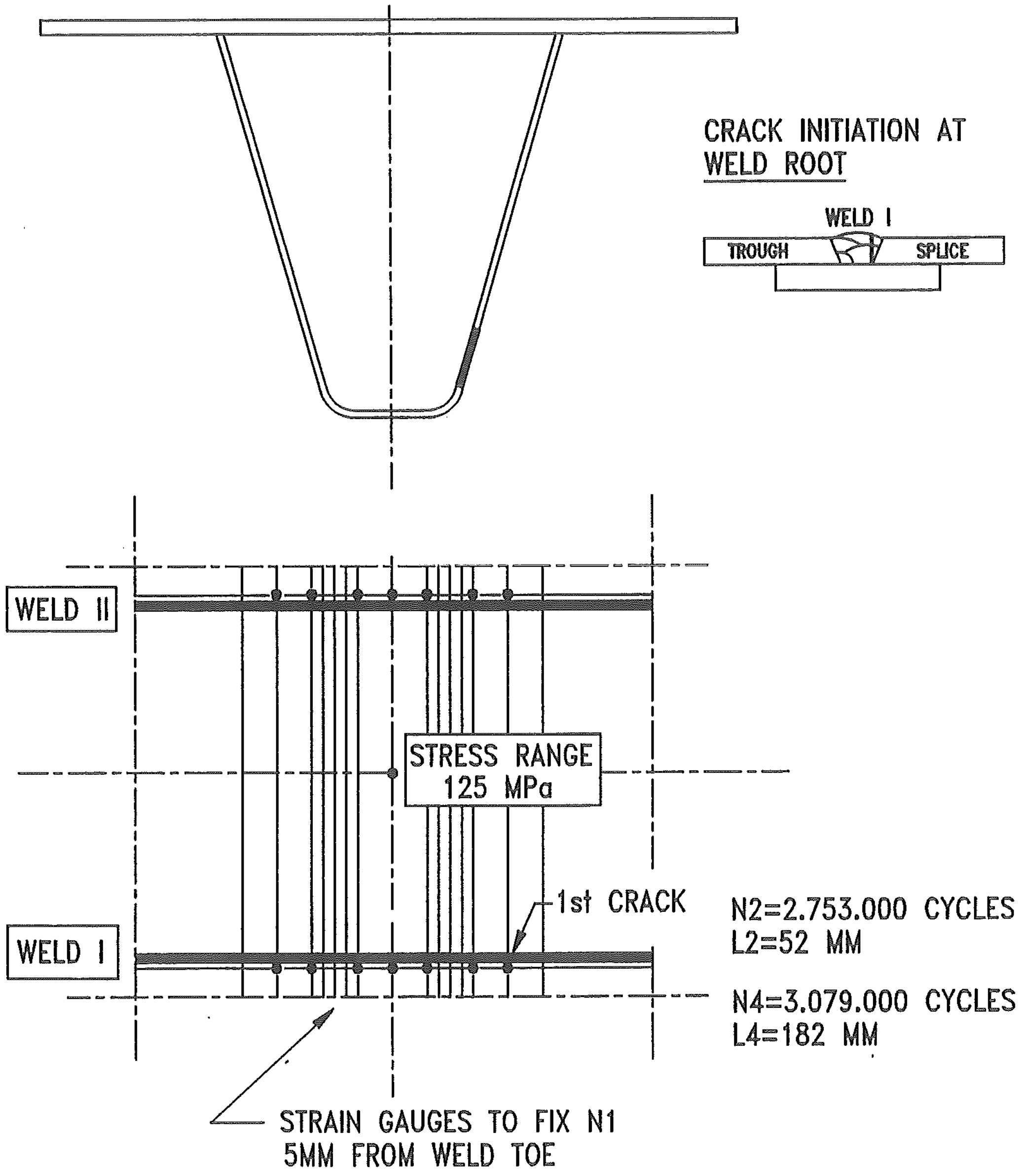
STRAIN MEASUREMENTS SPECIMEN D.3.1 WELD 2

```
                                 CRACK 1                      CRACK 2
N1: 5% STRAIN FALL    (G.745) =             CYC. (G.755) =              CYC.
N2: FIRST VISIBLE CRACK (88MM)=2.471.000 CYC. (10 MM) = 2.138.000 CYC.
N3: CRACK LENGTH ABOUT  88 MM =2.471.000 CYC. 10 MM   = 2.462.000 CYC.
N4: END OF TEST        229 MM =2.735.000 CYC. 26 MM   = 2.735.000 CYC.
```

TU-D SD03-01D.001 STRD312.GRF

FATIGUE TEST ON THE LONGITUDINAL STIFFENER SPLICE JOINT

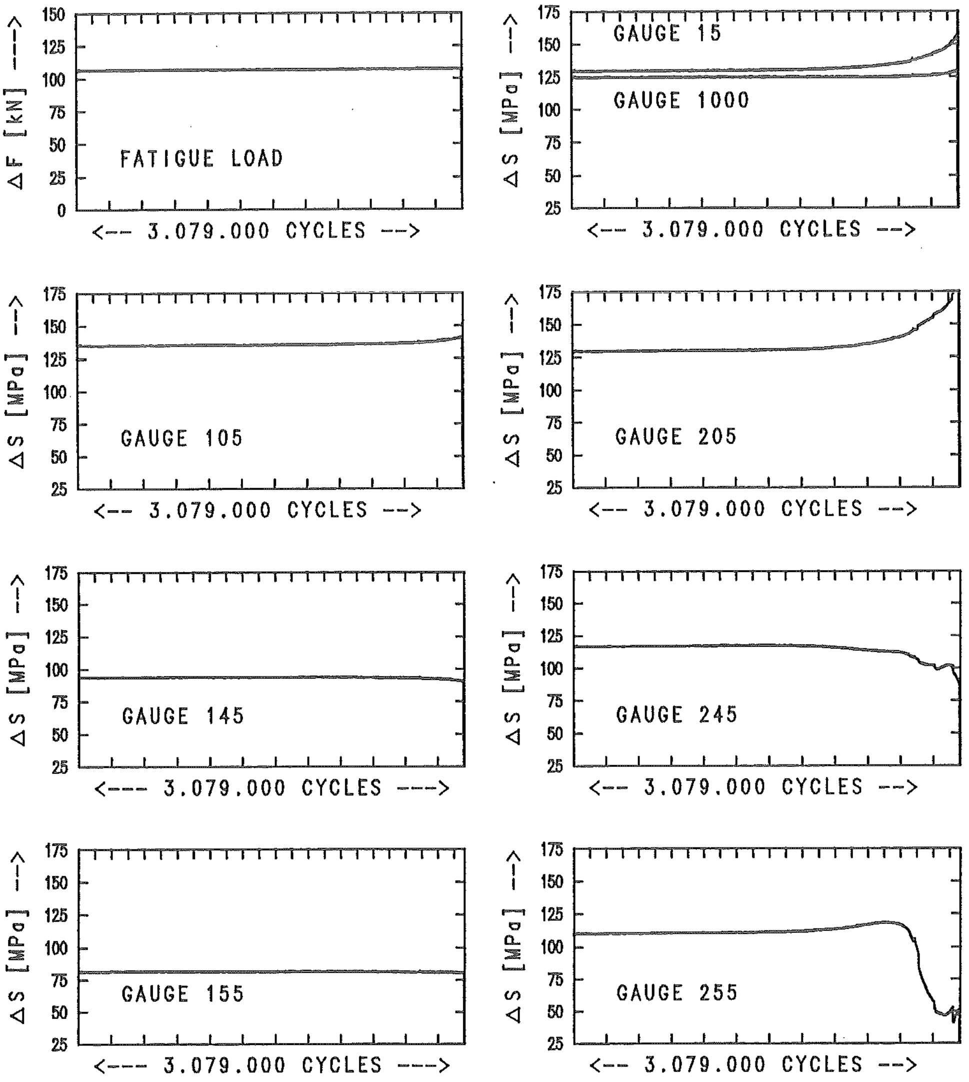
● FATIGUE CRACKS TEST 6D32



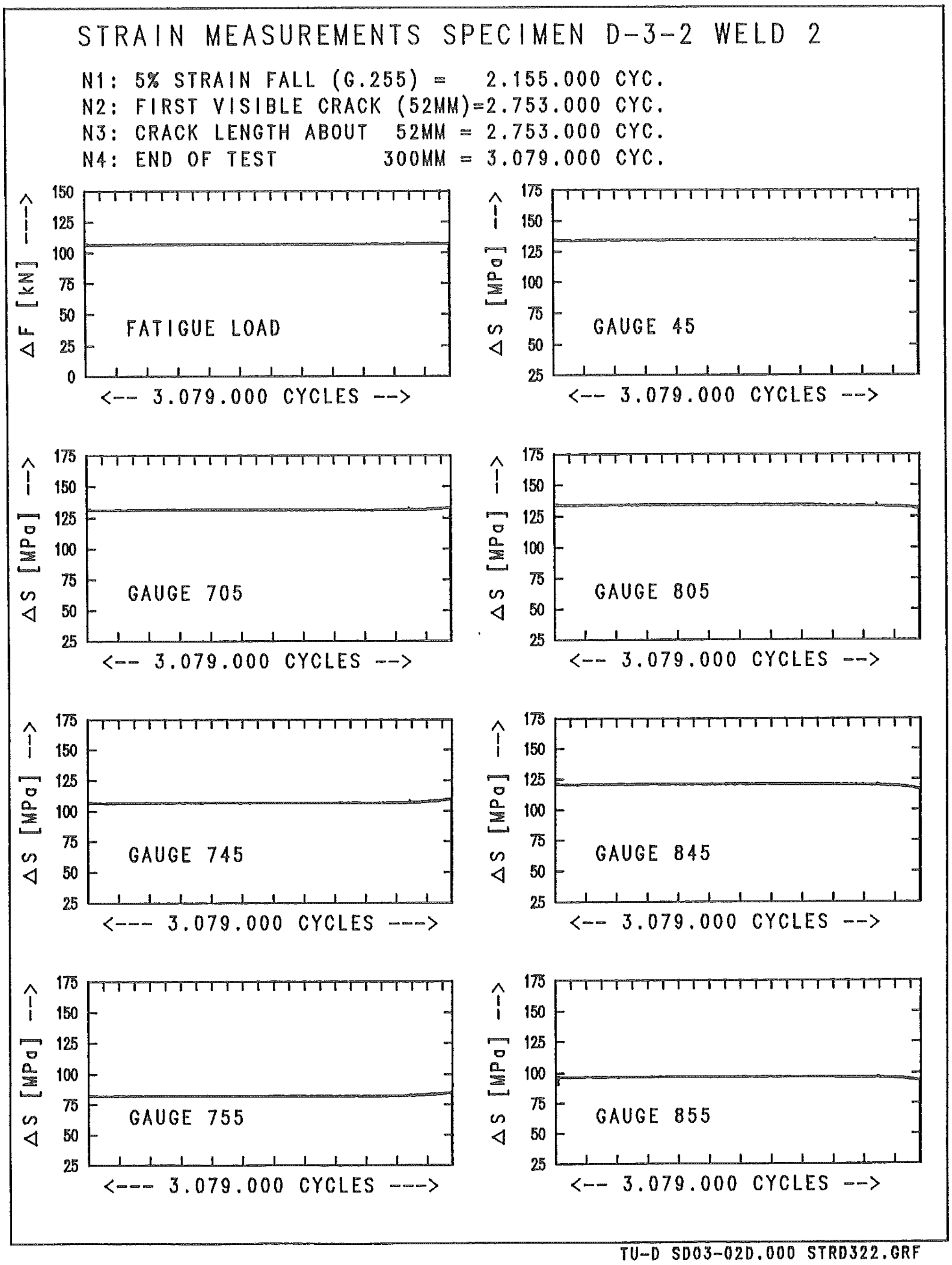
STEVIN lab TU–Delft

STRAIN MEASUREMENTS SPECIMEN D-3-2 WELD 1

N1: 5% STRAIN FALL OFF (G.255)= 2.155.000 CYC
N2: FIRST VISIBLE CRACK (52mm)= 2.753.000 CYC
N3: CRACK LENGTH ABOUT 52mm = 2.753.000 CYC
N4: END OF TEST (182mm)= 3.079.000 CYC



TU-D SD03-02D.000 STRD321.GRF



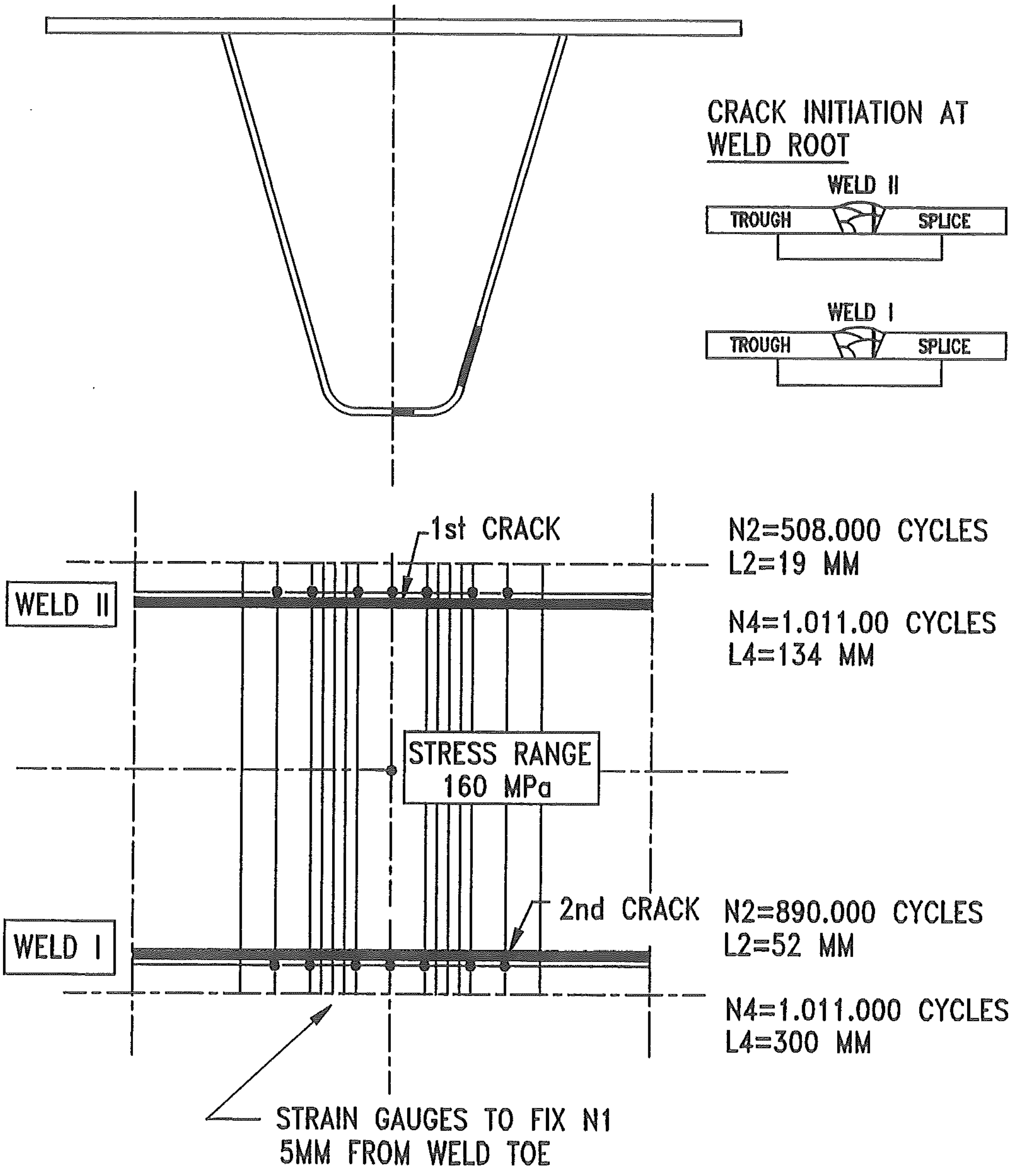
STRAIN MEASUREMENTS SPECIMEN D-3-2 WELD 2

N1: 5% STRAIN FALL (G.255) = 2.155.000 CYC.
N2: FIRST VISIBLE CRACK (52MM)=2.753.000 CYC.
N3: CRACK LENGTH ABOUT 52MM = 2.753.000 CYC.
N4: END OF TEST 300MM = 3.079.000 CYC.

TU-D SD03-02D.000 STRD322.GRF

FATIGUE TEST ON THE LONGITUDINAL STIFFENER SPLICE JOINT

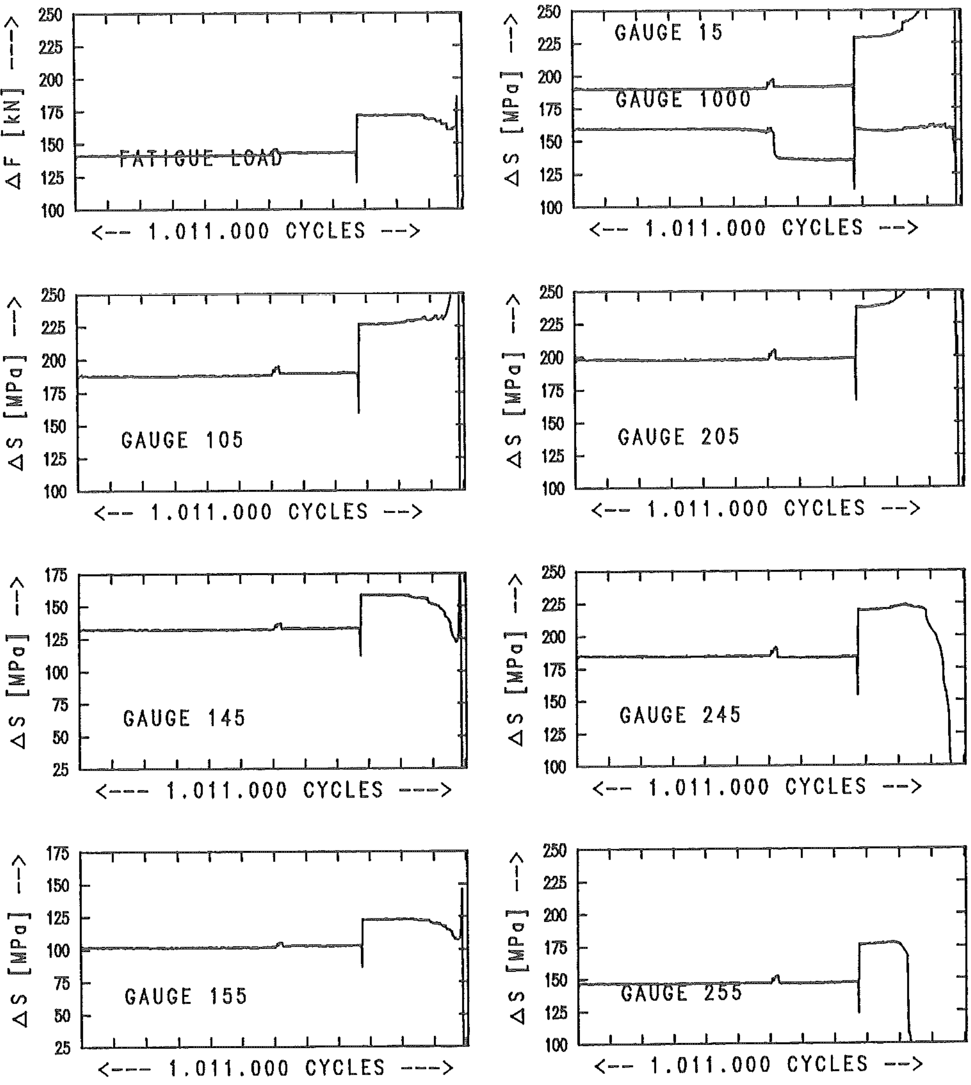
● FATIGUE CRACKS TEST 6D33



STEVIN lab TU-Delft

STRAIN MEASUREMENTS SPECIMEN D-3-3 WELD 1

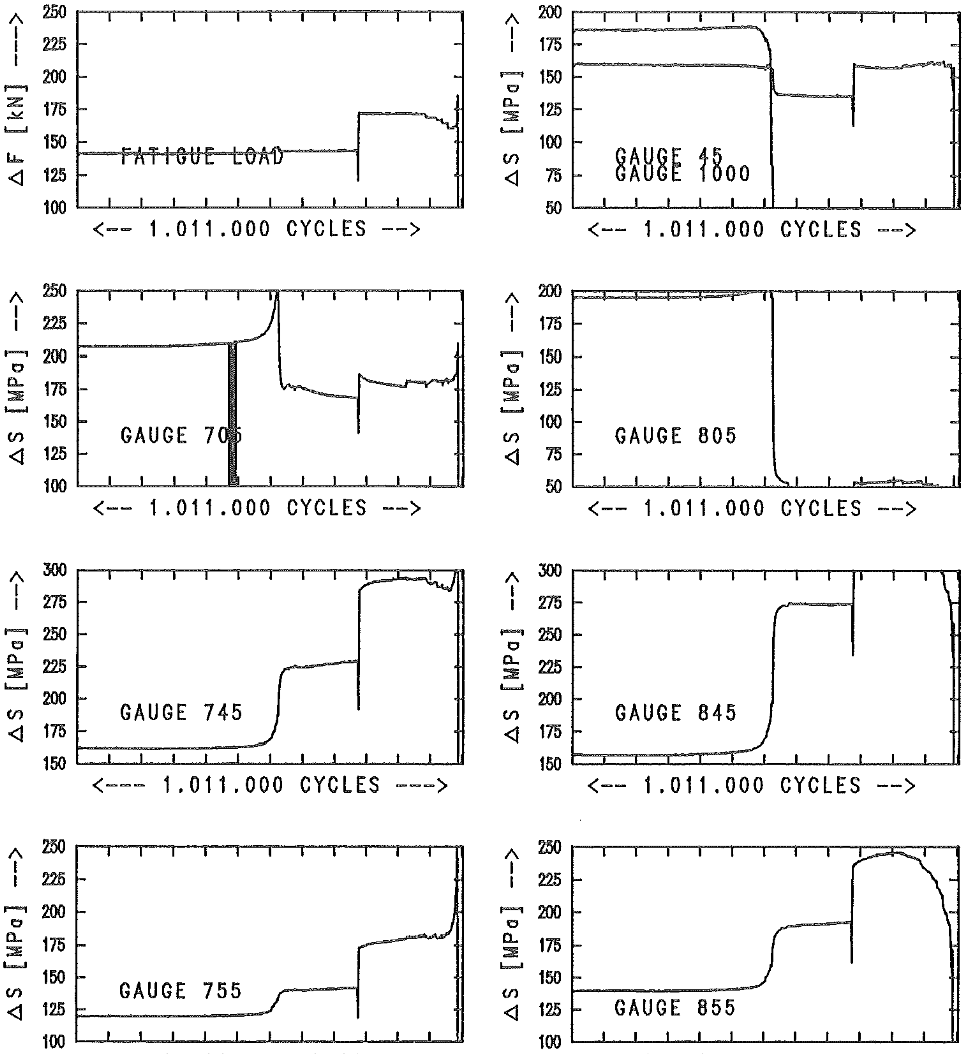
N1: 5% STRAIN FALL OFF (G.255)= 845.230 CYC
N2: FIRST VISIBLE CRACK (52mm)= 890.000 CYC
N3: CRACK LENGTH ABOUT 52mm = 890.000 CYC
N4: END OF TEST (300mm)= 1.011.000 CYC



TU-D SD03-03D.000 STRD331.GRF

STRAIN MEASUREMENTS SPECIMEN D-3-3 WELD 2

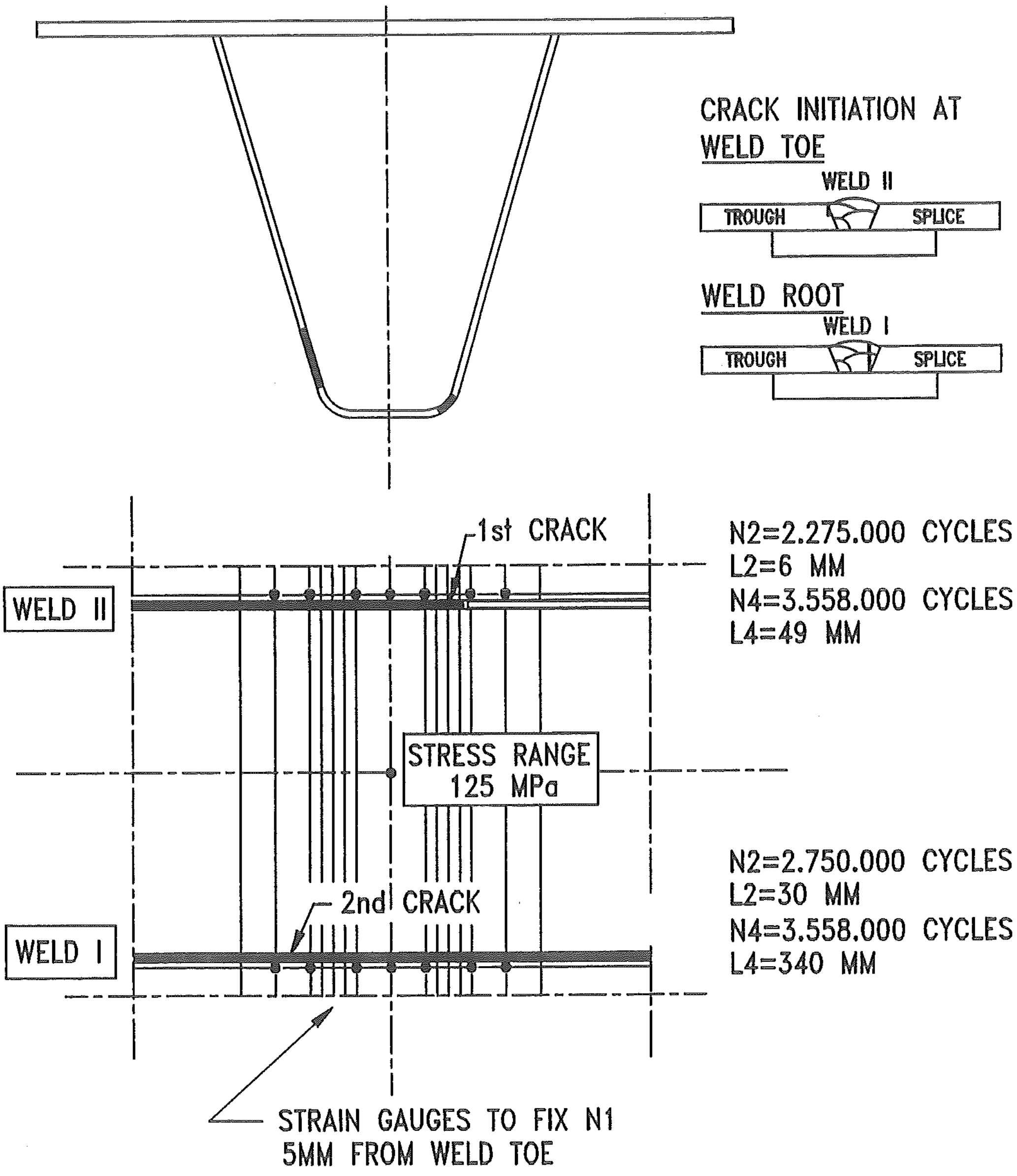
N1: 5% STRAIN FALL OFF (G.255) =845.230 CYC
N2: FIRST VISIBLE CRACK (52MM) =890.000 CYC
N3: CRACK LENGTH ABOUT 52MM =890.000 CYC
N4: END OF TEST (300MM) =1.011.000 CYC



TU-D SD03-03D.000 STRD332.GRF

FATIGUE TEST ON THE LONGITUDINAL STIFFENER SPLICE JOINT

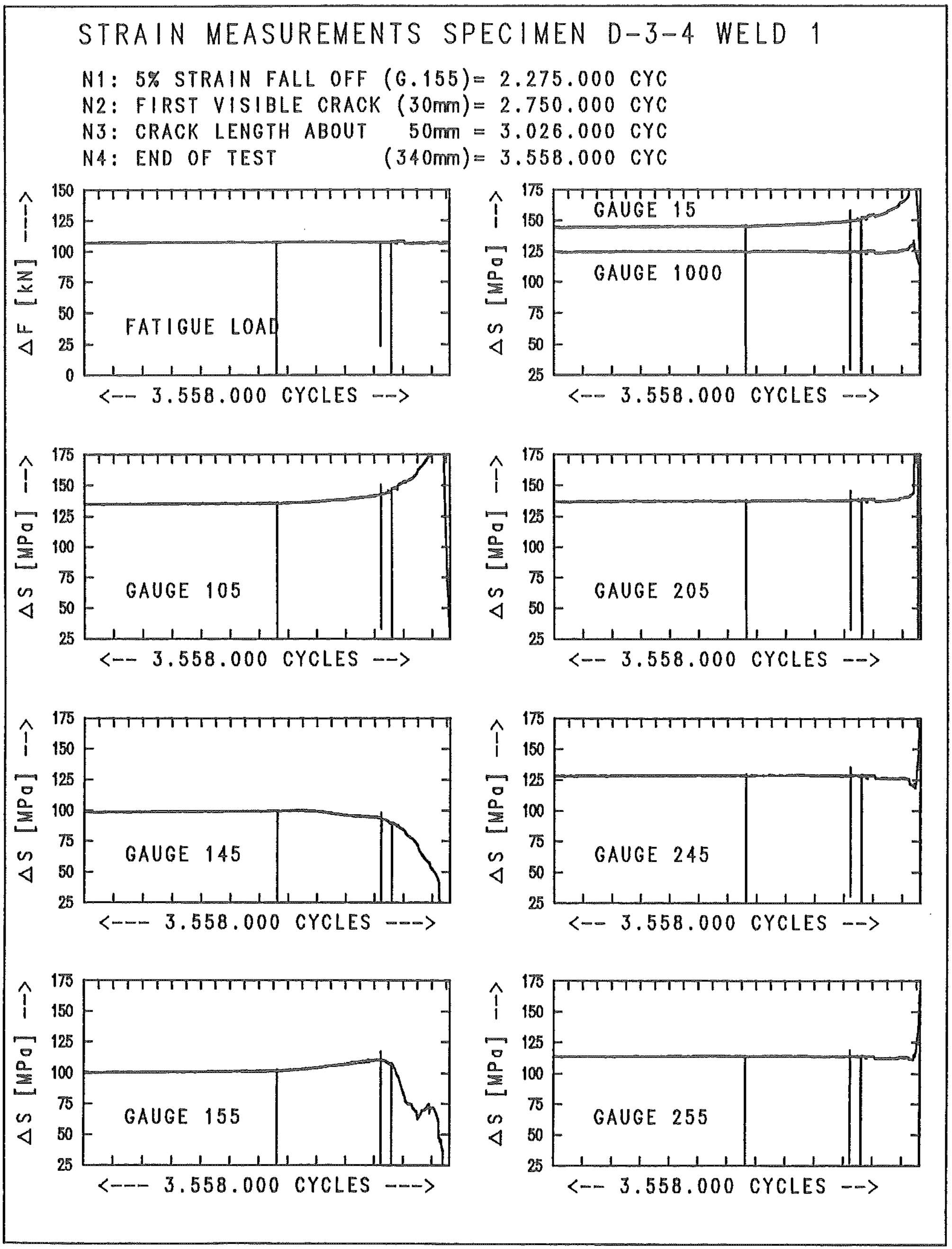
● FATIGUE CRACKS TEST 6D34



N2=2.275.000 CYCLES
L2=6 MM
N4=3.558.000 CYCLES
L4=49 MM

N2=2.750.000 CYCLES
L2=30 MM
N4=3.558.000 CYCLES
L4=340 MM

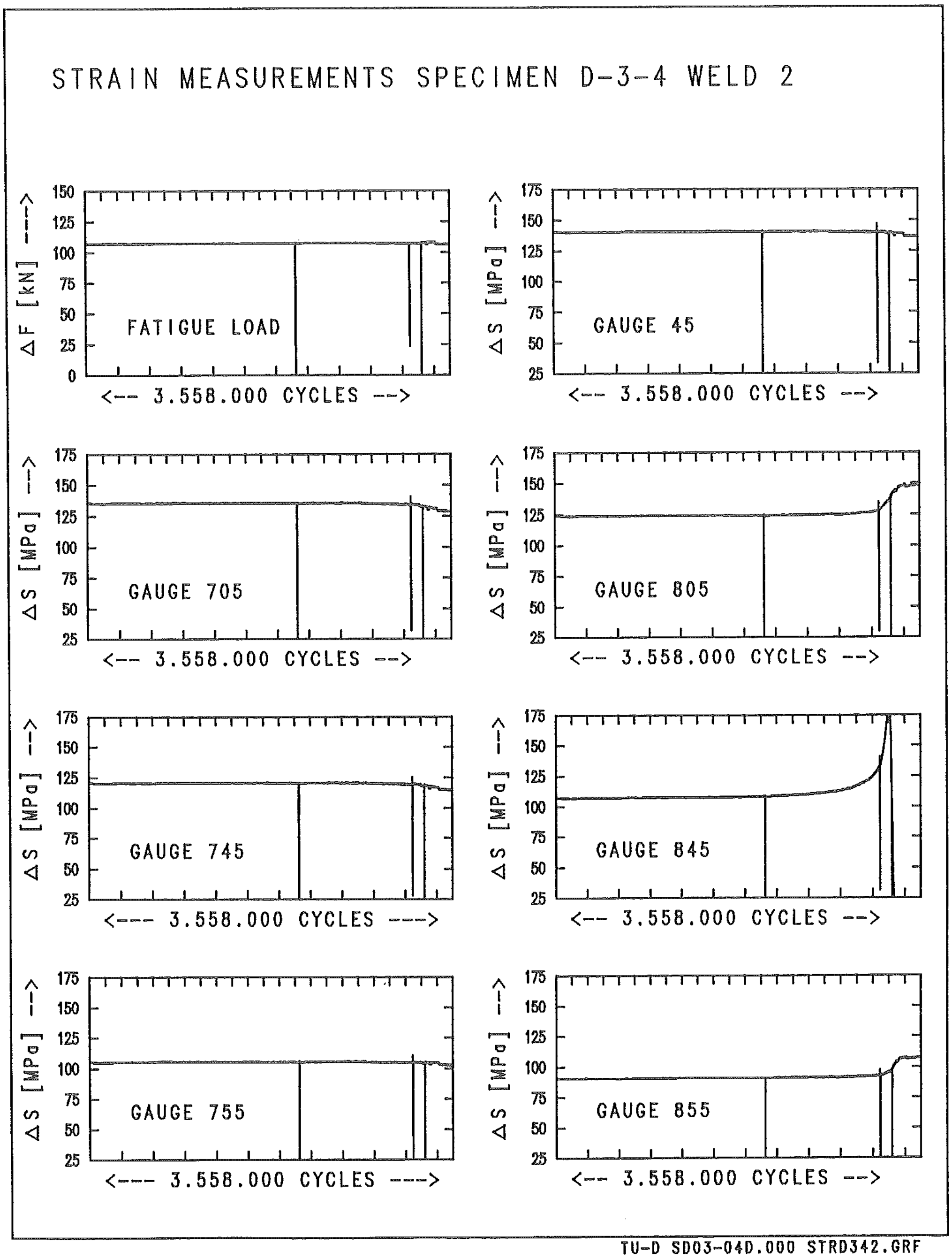
STEVIN lab TU–Delft



STRAIN MEASUREMENTS SPECIMEN D-3-4 WELD 1

N1: 5% STRAIN FALL OFF (G.155)= 2.275.000 CYC
N2: FIRST VISIBLE CRACK (30mm)= 2.750.000 CYC
N3: CRACK LENGTH ABOUT 50mm = 3.026.000 CYC
N4: END OF TEST (340mm)= 3.558.000 CYC

TU-D SD03-04D.000 STRD341.GRF



TU-D SD03-04D.000 STRD342.GRF

hollandsche staalbouw maatschappij bv

lasmethode-beschrijving
welding procedure specification

wps nr.: 90
rev. nr.: 0
geschr. prep. by : C.H.

besteller (customer) T.U. DELFT
inspectie (insp. by) : H.S.M.
hcg ordernr.: 21180

toepassing (scope) : LASSEN VAN PROEFSTUK T.B.V. E.G.K.S. ONDERZOEK.

Tekening nr. (drawing nr.)

basismateriaal (base material)	1 Fe 520	mvb:	afm. (dim.) : t = 6	mm
	2 Fe 520	mvb:	afm. (dim.) : t = 12	mm

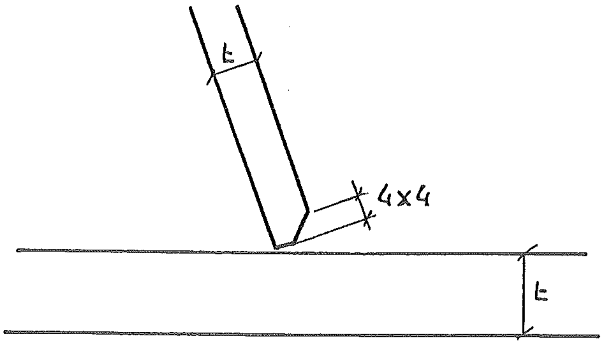
	grondlaag (root)	vullagen (filling pass.)	tegenlas (back welding)	oplassen (overlay welding)
lasproces (welding process)	gl: F.C.A.W	vl: N.V.T.	tl: N.V.T.	ol: N.V.T.

lasspositie (welding position) 2F
hechten (tackwelding) proces (process) hl: F.C.A.W
min. temp. N.V.T.

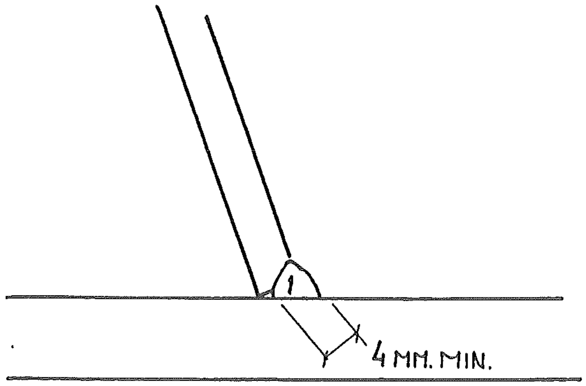
warmtebehandeling (heattreatment)
voorwarm temp. (pre-heating temp.) : N.V.T.
temp. tijdens lassen (interpass. temp.) : 250°C MAX.
nawarm temp. (soaking temp.) N.V.T.
voorwarmdetails (pre-heating details) : N.V.T.
isolatie (insulation) yes/no
nawarmtijd (soaking time) : N.V.T.

gloeien (postweld heattr.) N.V.T.
gloeiinstr. : (h.t. instr.) N.V.T.

A.W.S. CLASS. E71T-5



lasnaadvorm (edge preparation) scale 1 :



lasvolgorde (bead sequence / welding seq. nrs.) scale 1 :

lasvolgorde (bead- or welding seq. nrs.)	betreft (appl. to)	lastoevoeg-materiaal (welding filler material)	afm. (dim.)	schutgas / poeder (shielding-gas / flux)	stroom (current) =/∽ (dc/ac)	stroom (current) electrode polariteit (polarity)	stroom (current) ampèrage	voltage	soortgas (inner sh. gas) l/min.	H.I KJ /MN	voortl. sn. (rate of travel mm / min) R.O.L
1.		SAFDUAL 200	1.2	85AR/15CO2	DC	+	275-330	28-32	±15	1.5/2.1	±300

bewerk. laskanten (prep. weld. edges) : SLIJPEN.
bewerk. tegenlas (treatment of root) : N.V.T

opm. (remarks) : LASKANTEN VRIJ VAN VUIL EN VOCHT.

lmk rapport nr. (pqr. nr.) : N.V.T
serial nr.:
volgens (acc.) :

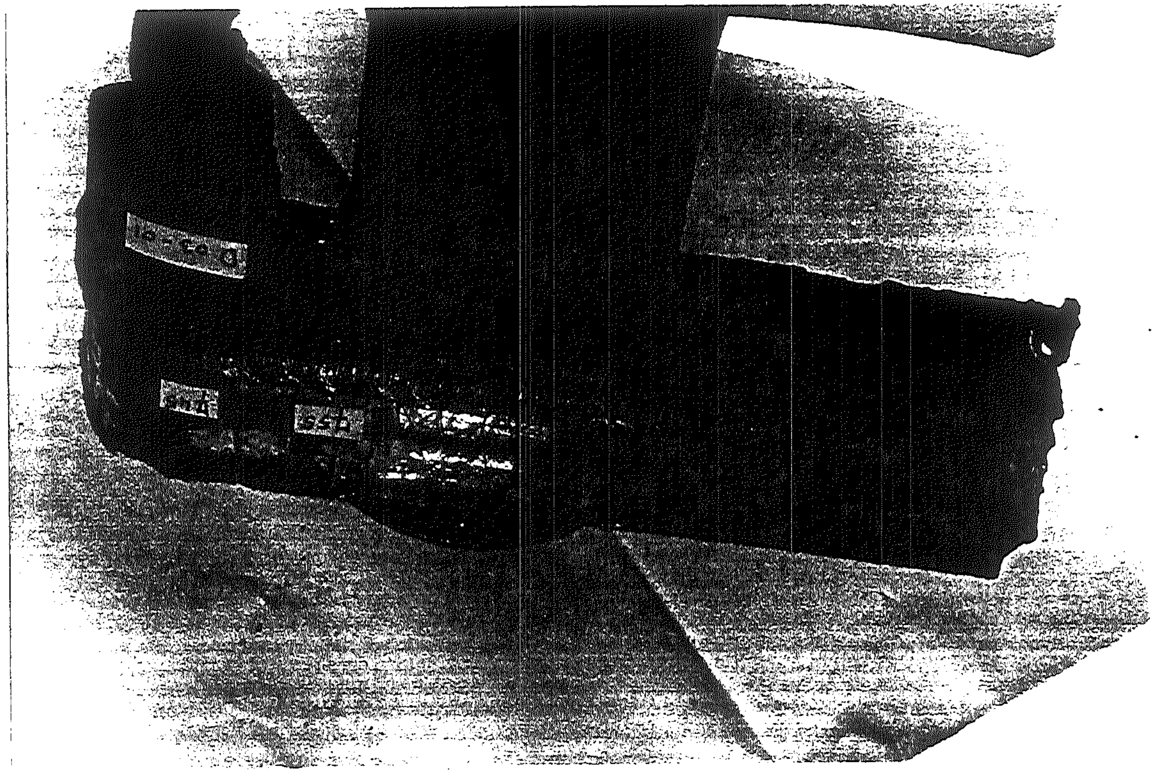
geldigheidsgebied lmk (validity range procedure qual.) :
afm. (dim.): t = 6
posities (pos.): 2F
tot (untill):

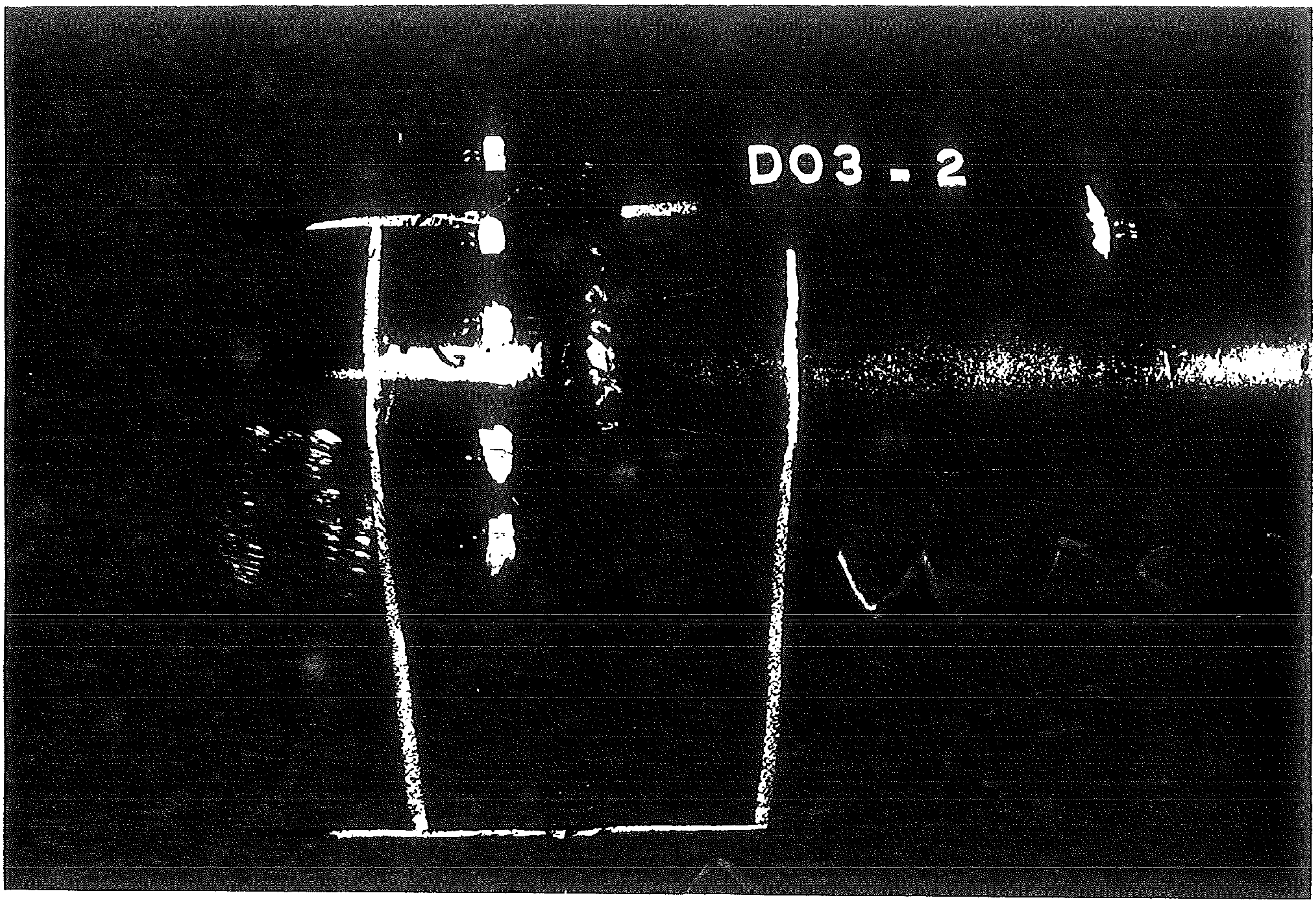
lasserskwalifikaties volgens (welder performance qual. acc.) :
ASME IX
A.W.S. D1.1.

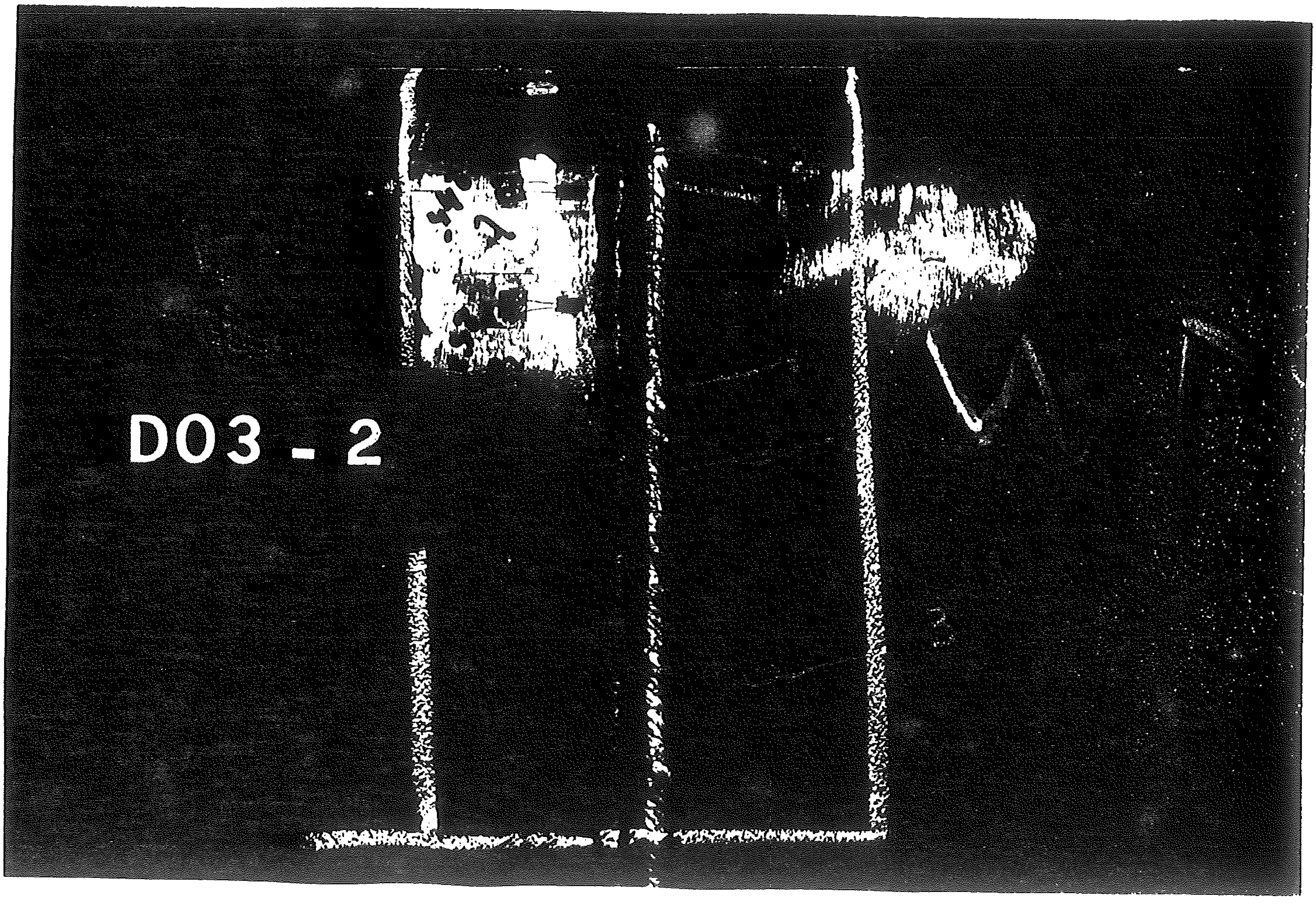
inspectie (inspection) : rt: N.V.T. ut: N.V.T mt/pt: 100% other: Visueel.

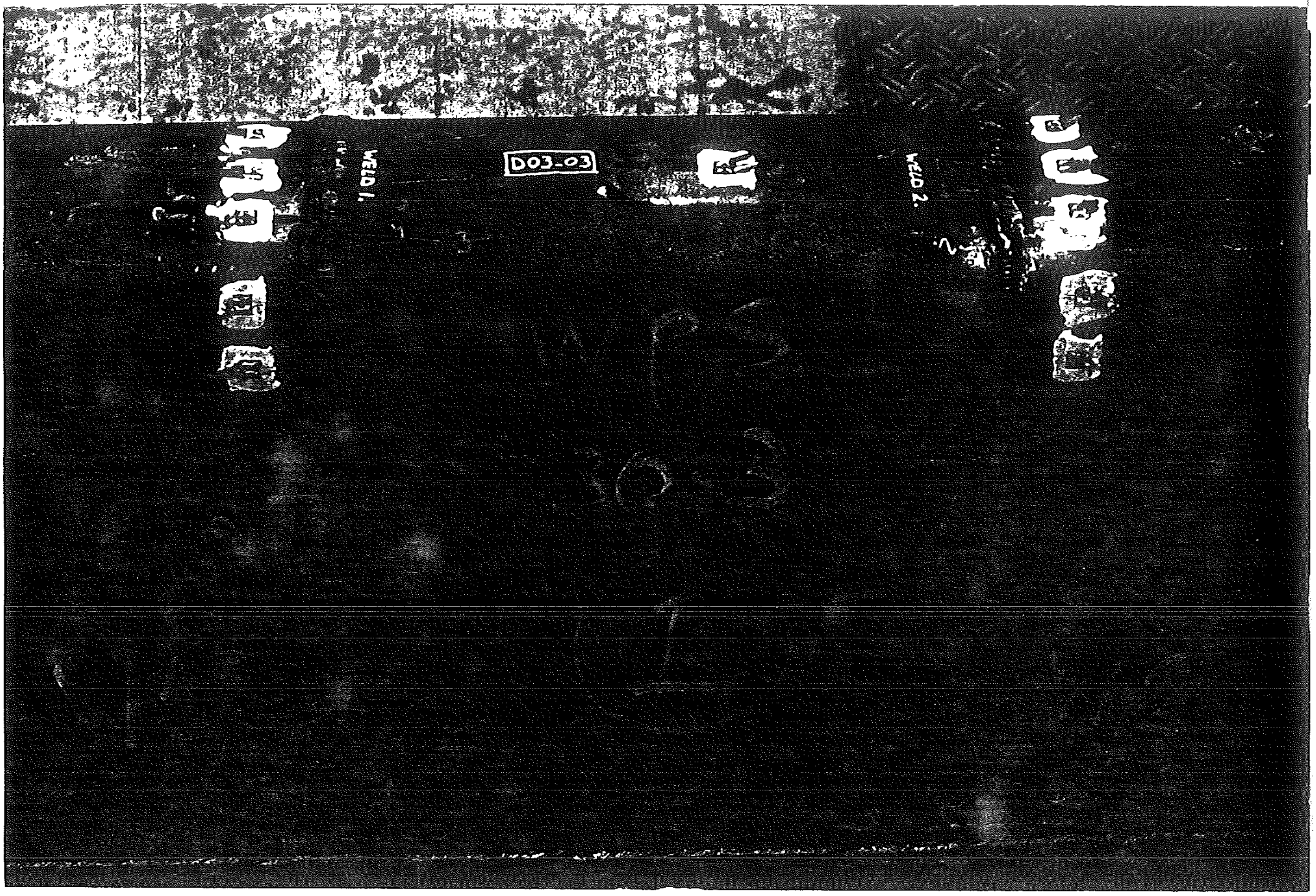
datum (date) : 18.11.91
appr. Q-A dep. hsm: QC 1
appr. customer:
appr. insp. auth.:

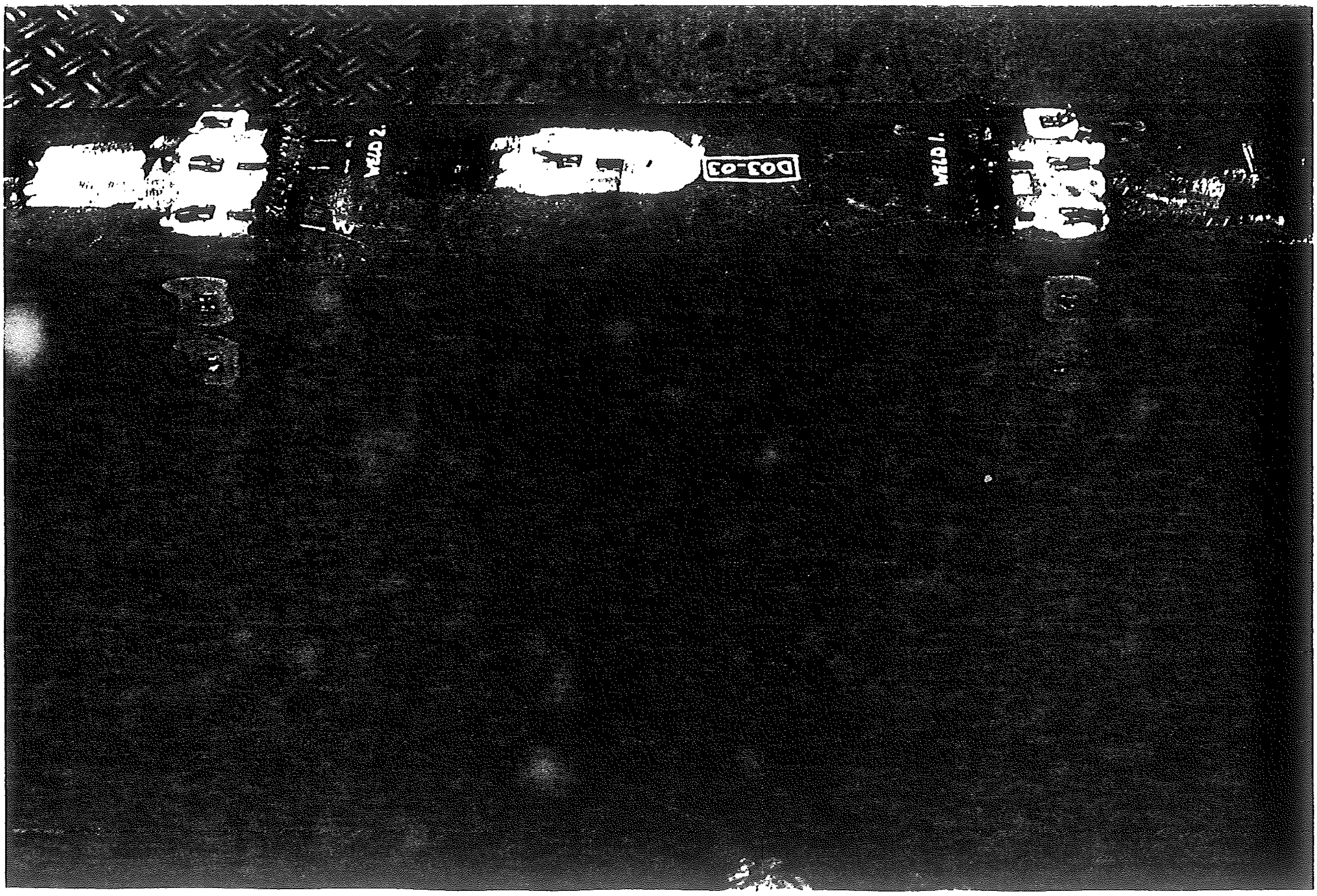
model 226



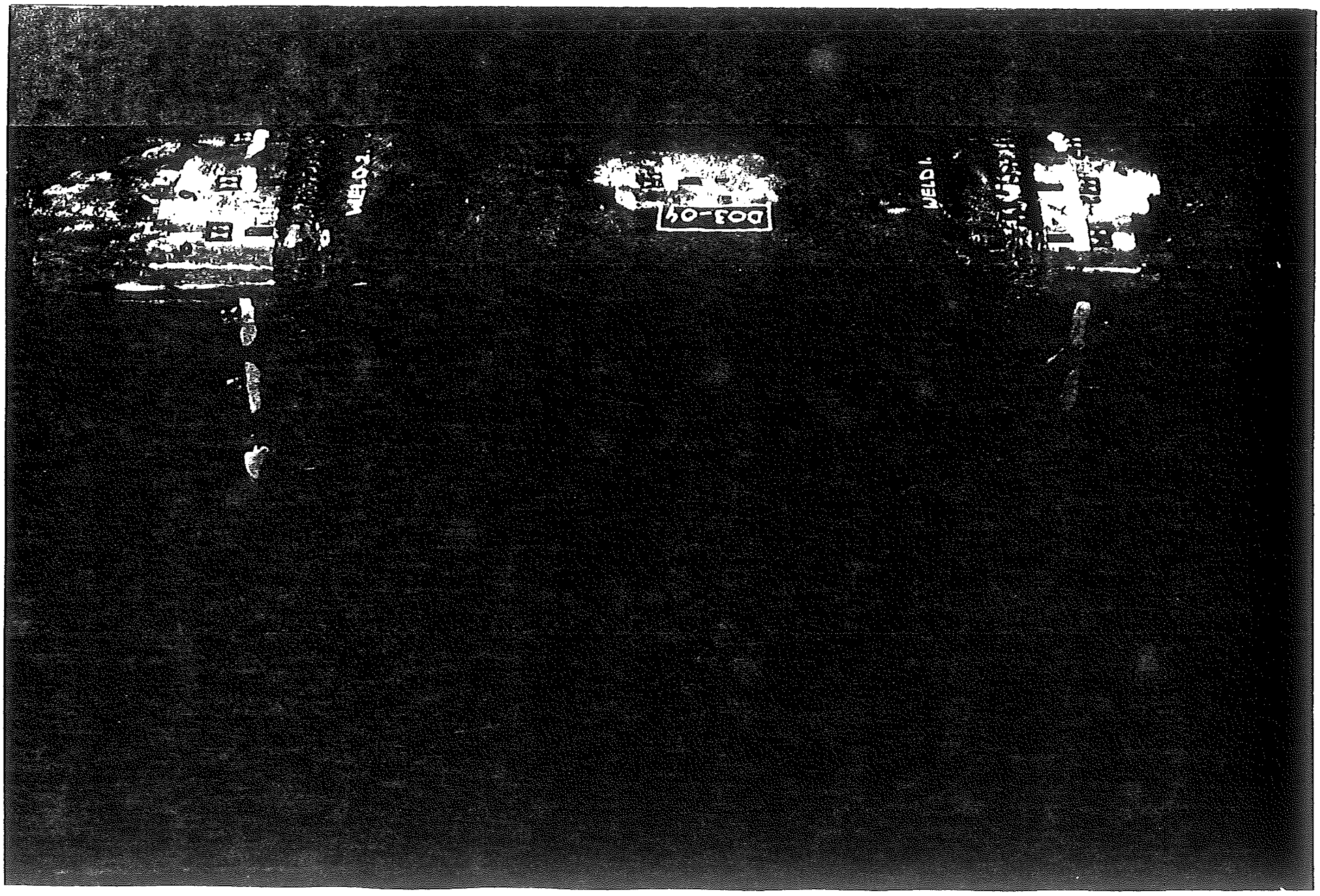

DO3 - 2


DO3 - 2


D03-03
WELD 1.
WELD 2.
WPS
303


D03-03
WELD 2.
WELD 1.


D03-04
WELD 1
WELD 2


D03-04
WELD 2
WELD 1